THE EFFECT OF USING HAND-HELD CALCULATORS
ON MATHEMATICAL PROBLEM-SOLVING ABILITY
AMONG SIXTH GRADE STUDENTS

By

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July, 1977

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PREFACE

This study investigates the use of hand-held calculators in the mathematics classroom. The purpose is to determine if students can improve their mathematical verbal problem-solving skills if they have access to calculators, not only as they practice problem-solving, but also on a test of verbal problem-solving ability.

I wish to express my deep appreciation to my thesis adviser, Dr. Donald A. Myers, for his support and assistance in the preparation of this thesis. A note of special appreciation to Dr. Vernon Troxel for his invaluable assistance during the statistical aspects of the study. I also wish to express appreciation to the other members of my committee, Dr. Gerald K. Goff, Dr. Joseph H. Pearl, and Dr. Marie C. Roos for their assistance in the final preparation of this thesis.

A special note of appreciation and love to my wife, Wilma, and my two children, David and Diana, whose patience, love, and understanding made this all possible.

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FIGURE

CHAPTER I

THE PROBLEM

There are more than 100 million calculators in use throughout the world according to information from Ronald Ritchie, vice-president of Texas Instruments calculator division. Ritchie says, "In just three years, calculators have become pervasive in our society, and millions more are on the way at prices virtually anyone can afford."[*] They have brought profound changes to the way mathematics can be applied to every-day problems, and have implications for schooling at all levels. Gerald Luecke, director of instructional programs for the Texas Instruments Learning Center says, "The calculator enables the student to engage in true analysis and problem-solving in a way never before possible."[**] The National Council of Teachers of Mathematics (1976) has justified the use of calculators in problem-solving situations with the following statement:

> The minicalculator can be used to solve problems that previously have been too time consuming or impractical to be done with paper and pencil (p. 94).

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[*] Quote from memorandum, Texas Instruments, entitled "Texas Instruments, Major Universities Work Together on Mathematics Education Program Using Calculators," p. 3, n.d.

[**] Ibid., p. 7.

Although The National Council of Teachers of Mathematics supports the position that hand-held calculators can be effectively used as instructional aids in stimulating students' thinking, there is not a unified position among teachers with respect to benefits gained or problems created by the use of hand-held calculators. Many parents believe that reliance on the calculator will make mathematical weaklings of their children.

Statement of the Problem

The specific problem of this study is: Can the use of calculators assist children to become better verbal problem-solvers? Ashlock and Herman (1970) state the problem very well:

> One of the thorniest problems besetting elementary school teachers is the improvement of verbal problem-solving ability. Indeed, many elementary teachers enjoy less success with this phase of mathematics instruction than with any other phase. Research studies suggest that mere practice in solving verbal problems usually result in <u>some</u> increased ability to solve such problems. But mathematics educators are searching for specific instructional procedures that a teacher can follow to improve the problem-solving ability of students (p. 193).

Research to date on the educational benefits of using calculators is inconclusive. Quinn's (1976) review of research indicates there is some evidence that students who use calculators: (a) learn to operate calculators easily at almost any level, (b) compute better with calculators than without, (c) are able to tackle more "real-life" problems, (d) suffer no loss in paper-pencil computational ability, and (e) enjoy using calculators (p. 79).

Purpose of Study

The purpose of this study was to investigate verbal problem-solving ability of students in mathematics. Four questions were posed:

(1) If students have access to the use of calculators, will they complete more practice problems than those students who do not have access to calculators?

(2) If students complete greater numbers of practice problems, will they then become better verbal problem-solvers than those students who do not solve more practice problems?

(3) If students have access to the use of calculators on a test of problem-solving ability, will their scores be greater than students who do not have access to calculators?

(4) If students do not practice problem-solving, will their problem-solving ability be as great as those students who practice problem-solving?

Background and Value of Study

The art of problem-solving has been the subject of study by many researchers throughout the twentieth century. Authorities such as Denbow and Goedicke (1959), Earp (1967), Brueckner and Bond (1955), Polya (1945) and others have listed anywhere from four to eight steps in the problem-solving process. These can be summarized into five basic steps:

(1) An understanding of the problem,

(2) Making a model,

(3) Determining the computation,

(4) Computing,

(5) Relating the answer back to the question asked.

The focus of this study will be upon the third and fourth steps of the process; i.e., determining the computation and computing. The reason for focusing on these two steps is because they seem to be the major obstacles to successful problem-solving. According to Learch and Hamilton (1966):

> Pupil difficulties in problem-solving as cited by authorities can be placed into two broad categories: (1) the inability to program or to determine the procedure to be followed in solving the problem; and (2) the inability to process or to perform the computation necessary to solve the problem (p. 242).

What can be done to overcome these difficulties: Learch and Hamilton (pp. 242-243) believe that a procedure that would improve students' ability in the procedure to be followed in solving the problem and which would be useful in all types of problem settings would be effective in assisting students to learn to solve word problems.

If the calculator assists students to solve problems, the study is of value because the calculator would reduce the computational concern so that the student can concentrate upon determining the correct operation required to solve the problem.

Assumptions

This study is subject to the following assumptions:

(1) The use of calculators can reduce students' concern for mathematical computation, allowing them to concentrate upon determining the correct computation to employ to solve the problem.

(2) Problem-solving skills can be taught to students.

(3) There are ways to teach problem-solving, some better than others.

Limitations

This study is subject to the following limitations:

(1) Time. Although the experimental schools were willing to allow students to participate in the study, the treatment period had to be organized around the regular school program. This study was limited to one problem-solving ability assessment session, two sessions on the use of calculators, nine treatment sessions, and one posttest session.

(2) Calculators. There are many different types of calculators on the market and many operate in different ways. Generalizations can only be made in reference to the calculator used in this study, the Texas Instrument 1200.

(3) Population. Generalization to populations other than those used in this study cannot be made unless the generalizations are so qualified.

Definition of Terms

The term "calculator" as used in this study refers to the small, hand-held, four function, eight-digit readout, battery operated calculator that can be bought for less than 12 dollars. The terms "calculator," "mini-calculator," or "hand-held calculator" are all used synonymously.

The term "verbal problem-solving" as used in this study refers to a statement in written form that requires a written response. This definition is in agreement with the standard reference in the field, the Mathematics Dictionary (1968):

> A question proposed for solution; a matter for examination; a proposition requiring an operation to be performed or a construction to be made (p. 280).

The terms "verbal problem," "word problem," "story problem," or simply "problem" are all used synonymously.

Summary

There is much to be learned regarding the use of calculators in the mathematics classroom. The sparse evidence to date seems to indicate that the calculator has a positive influence in the areas of computation and attitudes. However, computational ability is not the major goal of a mathematics curriculum. The ability to solve problems through the use of computation is seen as the major goal of mathematics education.

Learch and Hamilton (1966) have identified the two major obstacles to successful problem-solving as being the inability of students to determine the correct operation to employ in solving a problem, and the inability of students to perform the correct computation. Through the use of the calculator, one of the major obstacles is reduced so the student may concentrate upon determining the correct operation.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter will present a review of the available literature regarding mathematical problem-solving and the hand-held calculator. An attempt will be made to show a logical connection between problem-solving and the use of calculators.

Literature on Problem-Solving

The results of research on problem-solving in the past have been inconsistent. This leads to difficulty in developing a general theory of problem-solving. Three problems are evident. One, the types of problems from one study to the next have differed significantly. Two, few studies are cumulative. Three, most studies do not have a clear theoretical rationale.

This review will include a diversity of studies in mathematical problem-solving to provide information regarding various topics that have been investigated in the area of problem-solving and to indicate previous research related to the problem-solving procedure to be used in this study.

Dodson (1970) determined the characteristics of good problem-solvers in mathematics from data involving 1,500 tenth through twelfth grade students from the National Longitudinal Study of Mathematic Abilities. He concluded that good problem solvers:

(1) score high on verbal and general reasoning tests,

(2) determine spatial relationships successfully,

(3) resist distractions, identify critical elements, and remain independent of irrelevant elements,

(4) are divergent thinkers,

(5) have low debilitating test anxiety while his facilitating test anxiety remains high,

(6) have a positive attitude toward mathematics,

(7) have teachers who had the most credits beyond the bachelor's degree,

(8) have teachers who have the highest degrees,

(9) come from a family with a relatively high income,

(10) and have a socioeconomic index that is about the same as that of a poorer problem-solver (p. 5928-A).

It has been suggested by many persons that a major variable in problem-solving ability is reading ability. The argument is that if a student cannot read the problem then the student is going to have difficulty getting the correct answer. While the argument seems valid, it is not supported thus far by the evidence. Balow (1964, p. 21) involved 1,400 sixth graders and found that both reading ability and computational ability correlated with problem-solving ability. However, he found no significant positive correlation between computational and reading ability when I.Q. was controlled. When he compared F-ratios, he concluded that computation is a much more important factor in problem-solving than reading ability. Balow is supported by Knifong and Holtan (1976, pp. 106-112). In their study of sixth grade students they found computational errors were positively identified as the single source of difficulty on 52% of the incorrectly solved problems. The remaining 48% of incorrectly solved problems were attributed to not only reading difficulties but clerical errors, use of the wrong operation, no attempt at doing the problem, or any of 17 other variables. When this study is considered in conjunction with Balow's study, it is difficult to attribute major importance to reading as a source of failure in problem-solving.

There has probably been more research in problem-solving than in any other aspect of mathematics. Jerman (1971, p. 24) reports the analysis conducted by Gorman (1968) of 293 articles and dissertations that dealt with problem-solving to determine the reliability of previous research. Of these 293 articles, 178 were not included because they lacked internal validity, did not use students in grades 1-6, were not published between 1925 to 1965, were not available for review, or did not involve mathematical problem-solving. From the remaining 115 studies, Gorman determined that 37 met his requirements for internal validity. From the analysis the following recommendations were made for the teaching of problem-solving:

(1) Effect of using the following methods:

(a) Systematic instruction

1. Systematic instruction in which students are asked to explain how a problem is to be solved and why a particular process is appropriate produces greater gains in problem-solving than mere presentation of many problems.

2. The development of understanding is a gradual process that is aided by systematic instruction in the four fundamental processes.

3. The development of understanding of the four fundamental processes is a vital factor in the improvement of problem-solving.

(b) Intensive study of vocabulary

1. Pupils who studied quantitative vocabulary using the direct study technique (enable the child to establish a three-way association between the written symbol, the sound of the term, and at least one of its meanings) achieved significantly higher on a test of arithmetic problem-solving and concepts than pupils who had not devoted special attention to the study of quantitative vocabulary.

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

3. The direct study of quantitative vocabulary is not more effective with one sex than with the other.

4. The direct study of quantitative vocabulary is a method that is more effective with pupils of above average or average intelligence than it is with pupils of below average intelligence.

(c) Estimating answers

Practice in estimating answers to arithmetic problems is of no more value to sixth grade pupils than is the traditional practice in the solution of such problems.

(d) Group experience

Despite the superiority of the work performed by groups as compared to individual efforts in situations involving written problem-solving, there is no significant improvement in the ability of subjects to solve problems when trained in groups as compared to subjects who have worked by themselves continuously when evaluated under circumstances in which each subject must rely upon his own resources.

(e) Cuisenaire materials

Use of Cuisenaire materials in an elementary mathematics program resulted in significantly less achievement in computation and reasoning than was evident when such materials were not used.

(2) Comparison of methods:

(a) Cooperative versus individual effort

1. Children working together in pairs do solve more problems correctly than each child could do working alone.

2. Children working together in pairs do require more time to solve problems than each child would do working alone.

(b) Drill method with insight method

1. If skill in computation and solving verbal problems is the chief goal of instruction, the method a teacher employs should be determined by her own predilections.

2. If more generalized outcomes of instruction, particularly the ability to think mathematically, are significant goals, it makes a difference how pupils are taught.

3. Pupils of relatively low ability and good achievement learn better under a drill method.

4. Pupils of relatively high ability and low achievement learn better under a meaning method.

(c) Association, analysis, and vocabulary

The association method, or that technique by which difficult or incorrect problems are associated with a model, produce greater gain in student performance in problem-solving than the analysis or vocabulary methods.

(d) Dependencies, conventional-formula, and individual

1. The conventional-formula method of problem-solving (i.e., four steps: asked, given, how, answer) provided the least gain in ability when compared with the individual (absence of any formula) or dependencies method (graphic or diagrammatical).

2. When fourth and seventh graders are considered as a whole, there are no differences between the results of the dependencies and individual methods.

3. When the work of fourth graders alone is analyzed, the data indicates that the dependencies method is superior to the individual approach.

(e) Formal analysis and graphic analysis

Neither the conventional (formal analysis) nor the dependencies method (graphic analysis) produced changes that were statistically significant with respect to the following:

1. the grade level on which they were used,

2. the ability levels within the grade (average, superior, inferior),

3. retention of ability in problem-solving.

(f) Action sequence, wanted-given, and practice only

The major difference in the three programs is in the contents of the thought process of the child as he analyzes a problem and chooses the operation.

1. Emphasizing those attributes of the arithmetic operations termed the Wanted-Given produce statistically significant improvement in verbal problem-solving ability in arithmetic.

2. Emphasizing the Wanted-Given attributes of the operations produces statistically significant improvement in verbal problem-solving ability than comparable emphasis of the Action-Sequence attributes of the operation.

3. Emphasis on the Wanted-Given attributes produces a greater statistical improvement in verbal problem-solving than the mere provision of practice.

4. Emphasizing the Action-Sequence attributes of the operations produces no statistically significant improvement in verbal problem-solving.

One of the major summaries of journal-published articles on problem-solving for the years 1900-1968, grades 1-8 was conducted by Suydam and Riedesel (1969). They examined all the articles on arithmetic published in 47 American and English journals and synthesized the findings of 1,104 of the studies which were reports of actual experiments. Research conducted from 1950 to 1968 was emphasized, but significant findings previous to 1950 was also included. Their summary of problem-solving follows:

(1) How do pupils think in problem-solving?

Studies by Stevenson (1925) and Corle (1958) revealed that pupils often give little attention to the actual problems; instead, they almost randomly manipulate numbers. The use of techniques such as "problems without number" can often prevent such random attempts.

(2) What are the characteristics of good problem-solvers? Of poor problem-solvers?

Researchers have identified a number of factors that are associated with high achievement in problem-solving. Conversely, the lack of those factors is associated with poor problem-solvers. Some of these traits are intelligence, computational ability, ability to estimate answers, ability to use quantitative relative relationships that are social in nature, ability to note irrelevant detail, and knowledge of arithmetical concepts. (See Englehart, 1932; Stevens, 1932; Alexander, 1960; Hansen, 1944; Cruickshank, 1948; Chase, 1960; Beldon, 1960; Laughlin, 1960; Kliebhan, 1955; Klausmeir and Laughlin, 1961; Balow, 1964; Babcock, 1954).

(3) What is the importance of the problem setting?

Researchers such as Bowman (1929, 1932), Brownell (1931), Hensell (1956), Evans (1940), Sutherland (1941), Wheat (1929), and Lyda and Church (1964) have explored the problem setting. Findings are mixed, with some researchers suggesting true-to-life settings while others suggest more imaginative settings. While the evidence appears to be unclear, one thing does emerge: problems of interest to pupils promote greater achievement in problem-solving. With today's rapidly changing world it seems unreasonable that verbal problems used in elementary school mathematics could sample all of the situations that will be important to pupils now and in adult life. Perhaps the best suggestion for developing problem settings is to take situations that are relevant for the child. Thus, a problem on space travel may be more "real" to a sixth grader than a problem based upon the school lunch program.

(4) How does the order of the presentation of the process and numerical data affect the difficulty of multistep problems?

Burns and Yonally (1964) found that pupils made significantly higher scores on the test portions in which the numerical data were in proper solution order. Berglund-Gray and Young (1932) found that, when the direction operations (addition and multiplication) were used first in multistep problems, the problems were easier than when inverse operations (subtraction and division) were used first. Thus, an "add-then-subtract" problem was easier than a "subtract-then-add" problem.

(5) What is the effect of vocabulary and reading on problem-solving?

Direct teaching of reading skills and vocabulary directly related to problem-solving improves achievement (Robertson, 1931; Dresher, 1934; Johnson, 1944; Treacy, 1944; VanderLinde, 1964).

(6) How does wording affect problem difficulty?

Williams and McCreight (1965) report that pupils achieve slightly better when the question is asked first in a problem. Thus, since the majority of textbook series place the question last, it is suggested that the teacher develop and use some word problems in which the question is presented first.

(7) What is the readability of verbal problems in textbooks and in experimental materials?

Heddens and Smith (1964) and Smith and Heddens (1964) found that experimental materials were at a higher reading difficulty level than commercial textbook materials. However, they were both at a higher level of reading difficulty than that prescribed by reading formula analysis.

(8) What is the place of understanding and problem-solving?

Pace (1961) found that groups having systematic discussion concerning the meaning of problems made significant gains. Irish (1964) reports that children's problem-solving ability can be improved by (1) developing the ability to generalize the meanings of the number operations and the relationships among these operations, and (2) developing an ability to formulate original statements to express these generalizations as they are attained.

(9) Should the answers to verbal problems be labeled?

While Ullrich (1955) found that teachers prefer labeling, there are many cases in which labeling may be incorrect mathematically. For example:

Incorrect	Correct
$\begin{array}{r} 10 \text{ apples} \\ \underline{6 \text{ apples}} \\ 16 \text{ apples} \end{array}$	$\begin{array}{l} 10 \\ \underline{+6} \\ 16 \text{ apples} \end{array}$

(10) Does cooperative group problem-solving produce better achievement than individual problem-solving?

Klugman (1944) found that two children working together solved more problems correctly than pupils working individually. However, they took a greater deal of time to accomplish the problem solutions. Hudgins (1960) reported that group solutions to problems are no better than the independent solutions made by the most able member of the groups.

(11) What is the role of formal analysis in improving problem-solving?

The use of some step-by-step procedures for analyzing problems has had wide appeal in the teaching of elementary school mathematics. Evidence by Stevens (1932), Mitchell (1932), Hanna (1930), Bruch (1953), and Chase (1961) indicated that informal procedures are superior to following rigid steps such as the following: "Answer each of these questions: (1) What is given? (2) What is to be found? (3) What is to be done? (4) What is a close estimate of the answer? and (5) What is the answer to the problem?" If this analysis method is used, it is recommended that only one or two of the steps be tried with any one problem.

(12) What techniques are helpful in improving pupil's problem-solving ability?

Studies by Wilson (1922), Stevenson (1924), Washburne (1925), Thiele (1939), Luchins (1942), Bemis and Trow (1942), Hall (1942), Klausmeir (1964), and Riedesel (1964) suggest that a number of specific techniques will aid in improving pupils' problem-solving ability. These techniques include: (1) using drawings and diagrams, (2) following and discussing a model problem, (3) having pupils write their own problems and solve each others problems, (4) using problems without number, (5) using orally presented problems, (6) emphasizing vocabulary, (7) writing mathematical sentences, (8) using problems of proper difficulty level, (9) helping pupils to correct problems, (10) praising pupil progress, and (11) sequencing problem sets from easy to hard.

It is evident from the research presented that there is general agreement that problem-solving can be taught. The major disagreement is on how it should be taught. Providing systematic instruction in problem-solving has been shown to be effective in some studies (Wilson, 1967 and Jerman, 1971). This would seem to refute the contention that students learn to solve problems simply by solving lots of problems. However, from the study by Jerman (1971) the significance of computational ability in problem-solving remains an open question. Although students in Jerman's study were instructed in a systematic process of problem-solving, when they were confronted by difficult computation students were unable to work toward solution to the problem.

Studies by Balow (1964) and Knifong and Holtan (1976) indicate that computation is an important factor in problem-solving. In fact, computational errors were found as the single source of difficulty on 52 per cent of incorrectly solved problems. Knifong and Holtan (1976) state that if students could improve their computational skills, almost half of their problem-solving errors would be eliminated. Improving computational skills is highly recommended as a teaching strategy. Polya (1945) believes that students can become better problem-solvers through the constant practice of solving many problems. He believes that if one wishes to become a problem solver, one has to solve problems.

Literature on Calculators

Research on the use of calculators is lacking in two important aspects: (1) the research studies have been so few in number that it is hazardous to generalize, and (2) the research conducted has not been longitudinal.

This section on review of the literature on calculators will present the research that has been conducted to date. From the research, a rationale will be presented for using calculators in problem-solving situations.

The 48,000 members of the National Council of Teachers of Mathematics (1974) has given their formal endorsement to the use of calculators in the classroom with the following statement:

> With the decrease in cost of the minicalculator, its accessibility to students at all levels is increasing rapidly. Mathematics teachers should recognize the potential contribution of the calculator as a valuable instructional aid. In the classroom, the minicalculator should be used in imaginative ways to reinforce learning and to motivate the learner as he becomes proficient in mathematics (p. 3).

There are those persons who maintain that use of calculators will result in a loss of computational skills among students. There is a lack of evidence to support this position, in large part because of the lack of longitudinal studies. Hohlfeld (1973) investigated fifth grade students using calculators for learning the 100 basic multiplication combinations. Use of the calculator produced significant differences over the paper-pencil method on short term retention but not on long term retention.

The research to date suggests the use of calculators as an aid to students mathematical learning. The first question to be answered is, "Can students learn to use calculators?" Studies as far back as Betts (1927) have shown that elementary students can successfully operate calculating machines. Stultz (1975) states that kindergarten and first grade students enjoy using calculators to count. First grade students can make up their own addition and subtraction problems.

Another major question that arises is, "What effect does the calculator have upon computational ability?" In their studies of elementary students in grades four through seven, Hohlfeld (1973), Nelson (1976), and Jones (1976) have found that significant gains in computational skills can be made through the use of calculators.

Of concern to many is the belief that use of calculators will hamper or reduce the students' ability to learn paper-pencil computational skills. Studies by Durrance (1964), Longstaff (1968), Mastbaum (1969), Cech (1972), and Ladd (1974) have shown that, even though calculators were used, there was no loss of paper-pencil computational ability.

Another question that arises is, "What is the effect on student attitudes when calculators are used?" Studies by Fehr (1956), Quinn (1975), Longstaff (1968), Nelson (1976), and Jones (1976) have shown statistically significant attitude gains in favor of mathematics in the student groups using calculators.

Two studies have examined the effect of calculators upon low achieving mathematics students. Ladd (1973) investigated low achieving ninth grade students and Mastbaum (1969) investigated slow learners in mathematics in seventh and eighth grades. Both investigators concluded that the use of calculators does not increase or decrease mathematical achievement among these students. No studies were found involving low achieving elementary grade students.

One other area that has been investigated is the use of calculators upon reasoning ability. Durrance (1964) concluded that seventh grade students and Spencer (1974) concluded that fifth grade students showed a significant difference in favor of the calculator group in reasoning ability. Zepp (1975) determined that calculators did not contribute to improved reasoning ability among ninth grade and college level students.

Quinn (1976, p. 79) contends that research to date suggests:

(1) Students learn to operate calculators easily at almost any grade level.

(2) Students compute better with calculators than without.

(3) Students are able to tackle more "real-life" problems.

(4) Students suffer no loss in paper-pencil computational ability.

(5) Students enjoy using calculators.

Higgins (1974, p. 2) an associate professor of mathematics education at the Ohio State University, advises that teachers would do well to begin to experiment in their classroom with calculators, focusing on their use as a tool in successful problem-solving.

The Conference Board of the Mathematical Science National Advisory Committee on Mathematical Education (1975, p. 144) asserts that research is needed regarding the use of calculators in mathematics curriculum at all grade levels and their effect on a multitude of instructional objectives.

The research presented seems to indicate that the use of calculators leads to increased computational ability, improves attitudes toward mathematics with no loss in paper-pencil ability.

Summary

Research has been presented regarding problem-solving and calculators. Studies relevant to this study have been highlighted in the summary of each review of literature.

The following conclusions are made:

(1) Studies by Balow (1967), Jerman (1971), and Knifong and Holtan (1976) indicate:

(a) Even though students are instructed in a systematic process of problem-solving, difficult computational problems still prevent solution to problems.

(b) Computational difficulty has accounted for as much as 52 per cent of the reason for inability to solve problems.

(c) A process to increase computational ability will lead to improved problem-solving ability.

(2) Studies by Hohlfeld (1973), Nelson (1976), and Jones (1976) indicate:

(a) Use of calculators in the mathematics classroom leads to increased computational ability.

(b) Student attitudes toward mathematics improves when calculators are introduced in the mathematics classroom.

The rationale for this study is that the use of the calculator will reduce the computational difficulty experienced by students, leading to improved problem-solving ability.

CHAPTER III

METHOD AND PROCEDURE

This chapter includes descriptions of the population involved in the study, the instrumentation used in the collection of data, and the method to be used in the analysis of the data.

Pilot Study

A pilot study was conducted at the request of the doctoral committee to determine if it was practical to undertake the research, whether the methodology was adequate, specifically whether the techniques were sufficiently sensitive to measure differences, and for the purpose of obtaining additional information by which the major study could be improved (see Appendix E).

The pilot study involved one school where 117 students were assessed as to their mathematical problem-solving ability. Students of high and low mathematical problem-solving ability were randomly selected to participate in the pilot study. Average ability students were not used in the pilot study.

A total of 48 students were selected to participate with 24 being high ability problem-solvers and 24 being low ability problem-solvers. Twelve high ability and twelve low ability students were assigned to use the calculator for practice problems. The remaining 12 high ability and 12 low ability students used paper-pencil only for practice problems.

As a result of the pilot study it was decided to change the design of the major study in the following manner:

(1) Include the average mathematical problem-solving ability group.

(2) Include a control group who will not participate in the treatment, but will take the problem-solving ability assessment posttest.

(3) Include a group that will use calculators not only for practice problems but also on the posttest.

(4) Include the following questions:

(a) If pupils have access to calculators, then do those pupils complete more practice problems than those pupils without calculaors?

(b) If pupils complete more practice problems, then will their verbal problem-solving scores be higher than those who do not solve more practice problems?

Population

The population for this study was the sixth grade students of a large suburban school district in a large south-central plains city. The student population (K-12) of the school district was approximately 20,000. The school district can best be described as primarily middle-class Caucasian.

Sample

From the 13 elementary schools in the district, four were selected at random to participate in the study. All sixth grade students (N=374) in the four randomly selected schools were given a test to determine their mathematical problem-solving ability. From the results of this test, students were placed into one of three groups: high ability problem-solvers, average ability problem-solvers, and low ability problem-solvers.

In each of the four schools, 10 students were randomly selected, using a table of random numbers, from the three ability groups, high, average, and low. These 30 students in each of the four schools were designated as participants in the study. Total number of students participating in the study was 120.

Each school was randomly assigned one of the four treatments:

(1) One school was assigned to use calculators to solve practice problems but to use paper-and-pencil on the posttest.

(2) One school was assigned to use calculators to solve practice problems and also to use calculators on the posttest.

(3) One school was assigned to use paper-and-pencil only on both the practice problems and the posttest.

(4) One school was the control group. They did not practice problem-solving. Their only assignment was to use paper-and-pencil on the posttest.

Treatment

The treatment consisted of all groups except the control group undertaking a series of problem-solving activities. The problems were taken from the SRA series, Kaleidoscope of Skills: Whole Number Computation, 1966. This series was selected because the format of the problems was similar to the posttest measure. That is, a story is presented and followed by a series of questions about the story.

There were 25 ditto sheets, each containing approximately three to five addition and subtraction problems, three to five multiplication problems, and two to three division problems for a total of 240 practice problems. Each ditto sheet contained problems of increasing difficulty.

The role of the investigator was to check and assign ditto sheets, to record all scores, and to assist any student having difficulty reading or understanding the problem.

Instrumentation

The instrument used for initial assessment of problem-solving ability was the California Achievement Test, Level 3, Form B, Mathematics Concepts and Problems subtest. This test spans grades four through six. A brief description follows:

(1) Concepts - this section contains 25 items which measure the student's understanding and use of mathematical concepts in a variety of contexts. Among the basic concepts presented are those which involve signs and symbols, various forms of measurement, number systems, money, geometry, and place

values. This test has a seven-minute time limit.

(2) Problems - this 15 item test is designed to measure the student's ability to comprehend and correctly answer a variety of word problems ranging from those which involve basic one-step questions to those which involve percentages and averages. These problems require both an understanding of fundamental concepts and an ability to perform basic computations. This test has a 12-minute time limit.

From the raw score, a mean and standard deviation were computed. All students scoring at or above one-half standard deviation above the mean were considered high ability problem-solvers. All students scoring at or less than one-half standard deviation below the mean were considered low ability problem-solvers. All students scoring within one-half standard deviation of the mean were considered average ability problem-solvers.

Support for this procedure is given by Feldt (1973):

> It is possible to improve the power of methods experiments by creating some control over the assignment of subjects to treatment conditions. One of the recognized techniques is called "blocking," or the use of stratified samples in the formation of treatment groups. Under this initial measure of ability, such as intelligence quotient or pretest score, or a classification on some relevant variable. Several levels (score intervals) on this measure are arbitrarily established, usually dividing the entire group into thirds, quarters, or fifths (pp. 224-225).

The instrument used as the posttest to determine if students differed in problem-solving ability was the Arithmetic Reasoning section of the _SRA Achievement Series, Multilevel Edition, Form D_, 1968.

The reasoning section of the Achievement Series uses a story format to measure understanding of the logical and mathematical steps that lead to the solution of the arithmetic problems. Problems require students to identify the facts relevant to a solution, select the arithmetical process to be used, and carry out the computation necessary to arrive at the solution.

The test is an 86-item test, spanning grades four through six, with a 45 minute time limit. The score was the actual number of correct responses within the alloted time limit. The 86 items were broken down further into the following:

(1) Responses related to selection of the arithmetical process required to solve the problem.

(2) Responses related to the computation necessary to arrive at the solution of the problem.

(3) Actual number of correct responses on the entire test.

One additional instrument was used that was not included in the data collection. To insure the investigator that participants in the study knew how to operate hand-held calculators, two class sessions were spent in practicing the use of calculators. Participants utilized SRA's _Diagnosis_: _Mathematics_, _Level B_, whole number computational addition, subtraction, multiplication, and division problems. There were 27 addition and subtraction problems and 25 multiplication and division problems. Students were to use the calculator to solve the problems, with all students scoring at 80 per cent or higher accuracy. All students reached this goal. Therefore, it was assumed that before students began working on problem-solving activities, they knew how to operate the calculator.

Data Collection

Data were collected from three different student assessments:

(1) Problem-solving ability. To determine the participants in the study, all sixth grade students in the randomly selected schools took the California Achievement Test, Mathematics Concepts and Problems subtest. All scores were compiled (N=374) to determine high, average, and low ability problem-solvers. Students were randomly selected from these groups to participate in this study.

(2) Problem-solving practice problems. Three groups, two using calculators and one using pencil-paper, worked their way through a series of mathematical word problems. Students worked independently and at their own rate, doing as many problems as possible within the alloted time. Data were collected for nine practice sessions, 50 minutes per session. As each student completed a set of problems, he brought them to the investigator for correction. The investigator recorded the number of correct responses for that set of problems. These data were collected to determine if use of the calculator leads students to complete more practice problems than students using paper-pencil only.

(3) Posttest. To determine if any of the treatments would lead to one group's obtaining a greater number of correct responses in mathematical problem-solving, data were collected on the Arithmetic Reasoning section of the SRA Achievement Series. Data were collected three ways:

(a) Number of correct responses on the entire test.

(b) Number of correct responses on questions that determine the computation to employ to solve the problem.

(c) Number of correct responses on questions that involve the actual computation required to solve the problem.

Analysis of Data

This study investigated four questions related to problem-solving and the use of calculators. To make a thorough analysis of the data, different techniques were required for each question.

(1) Does use of calculators lead to completing more practice problems? The technique employed to analyze these data was an analysis of variance, treatment-by-levels design. The three groups who participated in the practice of problem-solving were analyzed between and within groups.

If the F was significant at the .05 level of confidence, the next step was a test for interaction of A and B using the Scheffé Critical Difference method of post hoc analysis. The Scheffé was selected because it is the most conservative of the post hoc procedures, making it less likely for Type I error to occur.

$$\text{Scheffé C. D.} = \sqrt{(I-1)\,{}_{\alpha}F_{I-1,N-1}}\ \sqrt{\frac{2MS_w}{n}}$$

(2) If students complete greater numbers of practice problems, do they become better problem-solvers? The technique employed to analyze these data was the Pearson product-moment coefficient of correlation (r) to determine if there was a relationship between the number of practice problems completed and the posttest score.

$$r = \frac{N \Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{[N \Sigma X^2 - (\Sigma X)^2][N \Sigma Y^2 - (\Sigma Y)^2]}}$$

To test the significance of _r_, a _t_-test was computed. A _t_-test was selected because N was smaller than 30.

$$t = r\sqrt{(N - 2)/(1 - r^2)}$$

An _r_ was computed for each group that practiced problem-solving; the calculator for practice only group, the calculator for practice and posttest group, and the paper-pencil only group.

To determine if initial problem-solving ability had an effect upon the relationship of practice problems and the posttest score, a partial correlation was computed in order to eliminate the effect of the initial problem-solving ability.

$$r_{ab \cdot c} = \frac{r_{ab} - r_{ac} r_{bc}}{\sqrt{1 - r_{ac}^2}\sqrt{1 - r_{bc}^2}}$$

(a = practice problems) (b = posttest) (c = problem-solving)

(3) If students use calculators on the posttest, will their scores be greater than students who do not use calculators? The technique employed to analyze this data was a t-test for differences between two independent means.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left[\frac{\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1} + \Sigma X_2^2 - \frac{(\Sigma X_2)^2}{N_2}}{(N_1 + N_2) - 2}\right] \cdot \left[\frac{1}{N_1} + \frac{1}{N_2}\right]}}$$

To determine the answer to this question, a t-test was computed between the calculator for practice and posttest group and the remaining treatment groups, the calculator for practice only group, the paper-pencil only group, and the control group.

(4) If students do not practice problem-solving, will their scores be as great as those practicing problem solving? The technique employed to analyze these data was an analysis of variance, treatment-by-levels design. The four treatment groups had their posttest scores analyzed between and within groups. The posttest was further analyzed by breaking down the posttest into three sections:

(a) Questions related to determining the computation to employ to solve the problem.

(b) Questions related to the actual computation required to solve the problem.

(c) The total number of correct responses.

An F test was computed for all three sections. If the F was significant at the .05 level of confidence, a test of simple effects of A and B was computed to determine where the interaction took place using the Scheffé Critical Difference method of post hoc analysis.

Summary

A randomly selected sample was obtained from the population of a large suburban school district. Three groups underwent the treatment of practicing mathematical problem-solving. The control group did not practice problem-solving. The four groups took a posttest involving mathematical problem-solving. The data from practicing problem-solving and the posttest data were analyzed to determine if use of calculators has any effect upon mathematical problem-solving ability. Of special interest was the effect, if any, upon the three ability levels of problem solvers; high ability, average ability, and low ability.

CHAPTER IV

ANALYSIS OF THE DATA

The presentation and analysis of the data are divided into four major sections congruent to the four questions asked in this study: (1) do students complete more practice problems with calculators; (2) if so, do they become better problem-solvers than those who complete less problems; (3) if students use calculators on the posttest measure, will they have more correct responses than students who do not use calculators on the posttest; (4) if students do not practice problem-solving, will they have as many correct responses on the posttest measure than those students who do practice problem-solving? Refer to the next page for a figure including the 12 groups involved in the study and the designation for each group that will be used throughout this analysis.

Calculator and Practice Problems

To determine if students complete more practice problems in problem-solving if they have access to calculators, a treatment-by-levels ANOVA F-test was computed using data gathered during the treatment sessions. During a 50-minute session, each student completed as many practice problems as possible. At the end of each session, the investigator recorded the number of problems completed for each student.

	A_1	A_2	A_3	A_4
B_1	High Ability - Calculator for Practice Only (A_1B_1)	High Ability-Calculator for Practice and Posttest (A_2B_1)	High Ability-Paper-Pencil Only (A_3B_1)	High Ability-Control Group (A_4B_1)
B_2	Average Ability-Calculator for Practice Only (A_1B_2)	Average Ability-Calculator for Practice and Posttest (A_2B_2)	Average Ability-Paper-Pencil Only (A_3B_2)	Average Ability-Control Group (A_4B_2)
B_3	Low Ability-Calculator for Practice Only (A_1B_3)	Low Ability-Calculator for Practice and Posttest (A_2B_3)	Low Ability-Paper-Pencil Only (A_3B_3)	Low Ability-Control Group (A_4B_3)

Figure 1. Illustration of Twelve Groups Involved in the Study and Their Designation for Analytic Purposes

Two schools had students using calculators on the practice problems and one school had students using paper-and-pencil only for the practice problems. From the data, mean scores were computed for each treatment group in each ability group. Because of unequal number of subjects in one cell, adjustment was made on the ANOVA F-test through the use of harmonic means.

TABLE I

ANALYSIS OF VARIANCE TABLE.- COMPLETED PRACTICE PROBLEMS

	SS	df	ms	F	p.
Treatment	11126.9	2	5563.45	6.05	<.05
Levels	54124.1	2	27062.05	29.43	<.01
Treatment x Levels	17855.4	4	4463.85	4.85	<.05
Error	72648.0	79	919.60		
TOTAL	155754.4	87			

The data from Table I indicate the following:

(1) There is a significant difference at the .05 level of confidence between the three treatment groups in the number of practice problems completed.

(2) There is a significant difference at the .01 level of confidence between the three ability levels in the number of practice problems completed.

(3) There is a significant difference at the .05 level of confidence between the treatment groups and the ability levels in the number of practice problems completed.

The ANOVA F-test indicates a significant difference occurred in the treatment groups, the ability levels, and between treatment and ability levels. However, the F-test does not indicate specifically where this difference occurs. To determine where this difference occurs, the areas of significance were analyzed using the Scheffé method of post hoc analysis.

The first area of significance was the treatment groups.

TABLE II

SCHEFFÉ CRITICAL DIFFERENCE TABLE - TREATMENT

	Calculator for Posttest (A_2) $\overline{X}$ = 135.6	Paper-Pencil Only (A_3) $\overline{X}$ = 157.1	Calculator for Practice (A_1) X = 161.6
A_2	-	21.5	26.0
A_3		-	4.5
A_1			-

Since the calculated data do not exceed the Scheffé Critical Difference at the .05 level of confidence, the data indicate there is no significant difference in the number of practice problems completed between the three treatment groups.

The second area of significance was the ability levels.

TABLE III

SCHEFFÉ CRITICAL DIFFERENCE TABLE-LEVELS

	Low Ability (B_3) $\overline{X} = 125.2$	Average Ability (B_2) $\overline{X} = 146.8$	High Ability (B_1) $\overline{X} = 185.7$
B_3	-	21.6	60.5*
B_2		-	38.9*
B_1			-

*Exceeds the critical difference at the .05 level of confidence

The data indicate a significant difference in the number of practice problems completed between the high ability group and the average and low ability groups.

The third area of significance occurred between the treatment groups and the three ability levels.

The data from Table IV, page 39, indicate the following:

(1) The high ability calculator for practice group completed a significantly greater number of practice problems than any average or low ability group. There was no statistically significant difference between the calculator for posttest group and the paper-pencil group.

(2) The high ability paper-pencil group completed a significantly greater number of practice problems than every low ability treatment group.

(3) The high ability calculator for posttest group did not complete a greater number of practice problems than either treatment group in the low and average ability groups.

To summarize, the data seem to indicate that use of calculators for practice problems allowed one treatment group, the high ability calculator for practice group, to complete significantly greater numbers of practice problems than every average and low ability group. There was no difference between the high ability calculator for practice group and the remaining high ability groups. There was a significant difference between the high ability paper-pencil only group and the three low ability treatment groups and between the high ability paper-pencil only group and two of the three average ability treatment groups. There was no significant difference between the high ability paper-pencil only group and the average ability calculator for practice group.

TABLE IV

SCHEFFÉ CRITICAL DIFFERENCE TABLE - TREATMENT X LEVELS

$\overline{X}$ =	A_2B_3	A_2B_2	A_1B_3	A_3B_3	A_1B_2	A_3B_2	A_2B_1	A_3B_1	A_1B_1
	122.8	124.5	125.2	127.6	153.4	162.4	165.4	181.2	206.4
A_2B_3	-	1.7	2.4	4.8	30.6	39.6	42.6	58.4*	83.6*
A_2B_2		-	.07	3.1	28.9	37.9	40.9	56.7*	81.9*
A_1B_3			-	2.4	28.2	37.2	40.2	56.0*	81.2*
A_3B_3				-	25.8	34.8	37.8	53.6*	78.8*
A_1B_2					-	9.0	12.0	27.8	53.0*
A_3B_2						-	3.0	18.8	44.0*
A_2B_1							-	15.8	41.0
A_3B_1								-	25.2
A_1B_1									-

*Exceeds the critical difference at the .05 level of confidence

Practice Problems and Posttest

Do students become better problem-solvers if they complete greater numbers of practice problems? The Pearson product-moment correlation (r) was used to determine if there is a relationship between the number of practice problems completed and the number of correct responses on a test of problem-solving ability. Three correlations were computed because there were three groups involved: the calculator for practice only group, the calculator for practice and posttest group, and the paper-pencil only group.

TABLE V

CORRELATION OF NUMBER AND PRACTICE PROBLEMS AND POSTTEST SCORE

Category	Pearson $\underline{r}$
Calculator for Practice Only	+.82*
Calculator for Practice and Posttest	+.40*
Paper-Pencil Only	+.20

*Significant at the .05 level of confidence

The data indicate a significant correlation between the number of practice problems completed and the number of correct responses on a test of problem-solving ability. This was true for both the calculator for practice only group and the calculator for practice and posttest group. There was no significant correlation for the paper-pencil only group.

To determine if initial problem-solving ability is a factor in obtaining the significant positive correlation, a partial correlation was computed with problem-solving ability partialed out from the practice problems and posttest scores for those groups that had a significant correlation.

TABLE VI

PARTIAL CORRELATION OF NUMBER OF PRACTICE PROBLEMS AND POSTTEST SCORE WITH PROBLEM-SOLVING ABILITY PARTIALED OUT

Category	Partial Correlation $r_{ab.c}$
Calculator for Practice Only	+.56*
Calculator for Practice and Posttest	+.31

*Significant at the .05 level of confidence

The data indicate a significant positive relationship between the number of completed practice problems and the number of correct responses on a test of problem-solving ability when problem-solving ability has been factored out for the calculator for practice only group.

The data do not indicate a significant relationship between the number of completed practice problems and the number of correct responses on a test of problem-solving ability when problem-solving ability has been partialed out for the calculator for practice and posttest group.

In summarizing this section, the results are confusing. The first analysis showed that there is a significant relationship between the number of completed practice problems and the number of correct responses on a test of problem-solving ability. However, when problem-solving ability is partialed out of the relationship, the calculator for practice only group demonstrated the only significant relationship. Use of calculators for the posttest did not produce a significant correlation.

Calculators and Posttest

To determine if the use of calculators leads students to become better mathematical problem-solvers than students using paper-and-pencil only, or students who do not practice problem-solving, a treatment-by-levels ANOVA F-test was computed between the four groups involved in this study. The data used in this analysis were the actual number of correct responses on a test of problem-solving ability. The data were further broken down to investigate two important aspects of problem-solving; questions that relate to the students ability to determine the correct operation to employ to solve the problem and questions related to the students' ability to do the actual computation required to solve the problem. Total number of subjects involved in this analysis was 108. Because of unequal number of subjects in each cell, adjustment was made in the analysis through the use of harmonic means.

The analysis is in three parts: (a) data relevant to the total number of correct responses on the posttest of problem-solving ability, (b) data relevant to the number of correct responses for questions that determine the correct computation to employ to solve the problem, and (c) data relevant to the number of correct responses for questions that require the actual computation to solve the problem.

(a) Treatment-by-levels ANOVA F-test to determine if there is a significant difference in the number of correct responses on the total score of the posttest measure between the groups when calculators are employed.

TABLE VII

ANALYSIS OF VARIANCE TABLE CORRECT RESPONSES - TOTAL SCORE

	SS	df	ms	F	p.
Treatment	50.15	3	16.72	1.16	$<.50$
Levels	4384.98	2	2192.49	151.83	$<.001$
Treatment x Levels	2759.71	6	459.95	31.85	$<.001$
Error	1386.16	96	14.44		
TOTAL	8581.00	107			

The data from this analysis indicate the following:

(1) There is a significant difference between the three ability levels in the number of correct responses on the posttest measure of problem-solving ability.

(2) There is a significant difference at the .001 level of confidence between the three ability levels and the four treatment groups in the number of correct responses on the measure of problem-solving ability.

The ANOVA F-test indicates a significant difference in the three ability levels and in the treatment-by-levels interaction. However, it did not indicate where this difference occurs. To determine where this difference occurs, the areas of significance were further analyzed using the Scheffé method of post hoc analysis.

The first area of significance occurred between the three ability levels.

TABLE VIII

SCHEFFÉ CRITICAL DIFFERENCE TABLE - LEVELS

	Low Ability (B_3) $\overline{X} = 25.37$	Average Ability (B_2) $\overline{X} = 31.24$	High Ability (B_1) $\overline{X} = 41.03$
B_3	-	5.87*	15.66*
B_2		-	9.79*
B_1			-

*Exceeds the critical difference at the .05 level of confidence

The data indicates that the high ability group solved significantly greater numbers of problems than the average or low ability groups. The data also seems to indicate that the average ability group solved significantly greater numbers of problems than the low ability groups.

The second area of significance occurred between the treatment and ability levels. The data from Table IX, page 46, indicate the following:

(1) The high ability calculator for practice group solved significantly greater numbers of problems on the posttest measure of problem-solving ability than every average and low ability group.

(2) The average ability calculator for practice group solved a significantly greater number of problems on the posttest than the low ability control group.

(3) The high ability calculator for posttest group solved a significantly greater number of problems on the posttest than every low ability group except the low ability calculator for posttest group.

(4) The average and low ability calculator groups solved significantly greater numbers of problems on the posttest than the low ability control group.

To summarize this section, the data seem to indicate significant differences between ability groups. Since this difference was evident before the treatment period, it is difficult to attribute this difference to the use of calculators. The expected difference between treatment groups within ability levels through the use of calculators was not evident.

TABLE IX

SCHEFFÉ CRITICAL DIFFERENCE TABLE - TREATMENT X LEVELS

	A_4B_3	A_3B_3	A_1B_3	A_1B_2	A_4B_2	A_2B_3	A_3B_2	A_2B_2	A_2B_1	A_3B_1	A_1B_1	A_4B_1
$\overline{X}$ =	21.33	24.89	25.11	30.44	30.67	30.75	31.60	32.10	37.86	40.00	42.60	42.78
A_4B_3	-	3.56	3.78	9.11*	9.34*	9.42*	10.27*	10.77*	16.53*	18.67*	21.27*	21.45*
A_3B_3		-	.22	5.55	5.78	5.86	6.71	7.21	12.97*	15.11*	17.71*	17.89*
A_1B_3			-	5.33	5.56	5.64	6.49	6.99	12.75*	14.89*	17.49*	17.67*
A_1B_2				-	.23	.31	1.16	1.66	7.42	9.56*	12.16*	12.34*
A_4B_2					-	.08	.93	1.43	7.19	9.33*	11.93*	12.11*
A_2B_3						-	.85	1.35	7.11	9.25*	11.85*	12.03*
A_3B_2							-	.50	6.26	8.40	11.00*	11.18*
A_2B_2								-	5.75	7.90	10.50*	10.68*
A_2B_1									-	2.14	4.74	4.92
A_3B_1										-	2.60	2.78
A_1B_1											-	.18
A_4B_1												-

*Exceeds the critical difference at the .05 level of confidence

(b) Treatment-by-levels ANOVA F-test to determine if there is a significant difference in the number of correct responses for questions related to determining the correct computations to employ when calculators are used for practice and the posttest.

TABLE X

ANALYSIS OF VARIANCE TABLE - CORRECT RESPONSE DETERMINING COMPUTATION

	SS	df	ms	F	p.
Treatment	17.62	3	5.87	1.85	<.25
Levels	308.38	2	154.19	48.49	<.001
Treatment x Levels	278.63	6	46.44	14.60	<.001
Error	305.01	96	3.18		
TOTAL	909.63	107			

The data from this analysis indicate the following:

(1) There is a significant difference at the .001 level of confidence between the three ability levels in the number of correct responses on questions related to determining the correct operation to employ to solve the problem.

(2) There is a significant difference at the .001 level of confidence between the treatment groups and the three ability levels in the number of correct responses on questions related to determining the correct operation.

The ANOVA F-test indicates a significant difference occurs. However, it did not indicate where this difference occurs. To determine this, the areas of significance were further analyzed using the Scheffé method of post hoc analysis.

The first area of significance occurred between the three ability levels.

TABLE XI

SCHEFFÉ CRITICAL DIFFERENCE TABLE - LEVELS

	Low Ability (B_3) $\overline{X}$ = 8.14	Average Ability (B_2) $\overline{X}$ = 9.26	High Ability (B_1) $\overline{X}$ = 12.20
B_3	-	1.12*	4.06*
B_2		-	2.94*
B_1			-

*Exceeds the critical difference at the .05 level of confidence

The data indicate that the high ability group solved significantly greater numbers of determining operation questions than the average or low ability groups. The data also seem to indicate that the average ability group solved significantly greater numbers of determining operation questions than the low ability group.

The second area of significance on the ANOVA F-test occurred between the treatment and ability levels.

The data from Table XII, page 50, indicate the following:

(1) The high ability calculator for practice group solved a significantly greater number of determining operation questions than every low ability group except the calculator for post-test group.

(2) The high ability calculator for practice group solved a significantly greater number of determining operation questions than the average ability paper-pencil group and the average ability control group.

(3) The high ability calculator for posttest group solved a significantly greater number of determining operation questions than the low ability control group.

(4) There was no significant difference between the group that had the highest mean score, the calculator for practice group, and the low ability calculator for posttest group.

TABLE XII

SCHEFFÉ CRITICAL DIFFERENCE TABLE - TREATMENT X LEVELS

	A_4B_3	A_1B_3	A_3B_2	A_4B_2	A_3B_3	A_2B_3	A_2B_2	A_1B_2	A_2B_1	A_3B_1	A_4B_1	A_1B_1
$\overline{X}$ =	6.78	7.22	8.30	9.00	9.11	9.63	9.70	10.11	11.14	11.78	12.11	13.40
A_4B_3	-	.44	1.52	2.22	2.33	2.85	2.92	3.33	4.36*	5.00*	5.33*	6.62*
A_1B_3		-	1.08	1.78	1.89	2.41	2.48	2.89	3.92	4.56*	4.89*	6.18*
A_3B_2			-	.70	.81	1.33	1.40	1.81	2.84	3.48	3.81	5.10*
A_4B_2				-	.11	.63	.70	1.11	2.14	2.78	3.11	4.40*
A_3B_3					-	.52	.59	1.00	2.03	2.67	3.00	4.29*
A_2B_3						-	.07	.48	1.51	2.15	2.48	3.77
A_2B_2							-	.41	1.44	2.08	2.41	3.70
A_1B_2								-	1.03	1.67	2.00	3.29
A_2B_1									-	.64	.97	2.26
A_3B_1										-	.33	1.62
A_4B_1											-	1.29
A_1B_1												-

*Exceeds the critical difference at the .05 level of confidence

To summarize this section, the data seems to indicate a significant difference between the three ability levels. As in the previous analysis, this difference existed before the treatment period began. There is no difference within ability groups between treatments as was expected. It is important to note that a difference of "no difference" between the group with the highest mean score and the low ability calculator for posttest group.

(c) Treatment-by-levels ANOVA F-test to determine if there is a significant difference in the number of correct responses on questions related to the actual computation required to solve the problems on a posttest of problem-solving ability.

TABLE XIII

ANALYSIS OF VARIANCE TABLE - CORRECT RESPONSES - COMPUTATION

	SS	df	ms	F	p.
Treatment	77.57	3	25.86	2.82	$<.05$
Levels	1050.69	2	525.35	57.23	$<.001$
Treatment x Levels	718.21	6	119.70	13.03	$<.001$
Error	881.27	96	9.18		
TOTAL	2727.74	107			

The data from this analysis seem to indicate the following:

(1) There is a significant difference at the .05 level of confidence between the four treatment groups in the number of correct responses on questions related to computation.

(2) There is a significant difference at the .001 level of confidence between the three ability levels in the number of correct responses related to computation.

(3) There is a significant difference at the .001 level of confidence between the treatment groups and the three ability levels in the number of correct responses on questions related to computation.

The ANOVA F-test indicates a difference occurs. However, it does not indicate where this difference occurs. To determine where this difference occurred, the areas of significance were further analyzed using the Scheffé method of post hoc analysis.

The first area of significance occurred among the four treatment groups.

The data indicate that the calculator for posttest group solved significantly greater numbers of problems related to computation than the control group.

The second area of significance occurred between the three ability levels (Table XIV, page 53).

TABLE XIV

SCHEFFÉ CRITICAL DIFFERENCE TABLE - TREATMENT

	Control Group (A_4) $\overline{X}$ = 15.04	Calculator for Practice (A_1) $\overline{X}$ = 16.25	Paper-Pencil Group A_3) $\overline{X}$ = 16.29	Calculator for Posttest A_2) $\overline{X}$ = 17.48
A_4	-	1.21	1.25	2.44*
A_1		-	.04	1.23
A_3			-	1.19
A_2				-

*Exceeds the critical difference at the .05 level of confidence

TABLE XV

SCHEFFÉ CRITICAL DIFFERENCE TABLE - LEVELS

	Low Ability (B_3) $\overline{X}$ = 12.46	Average Ability (B_2) $\overline{X}$ = 16.08	High Ability (B_1) $\overline{X}$ = 20.20
B_3	-	3.62*	7.74*
B_2		-	4.12*
B_1			-

*Exceeds the critical difference at the .05 level of confidence

The data indicate that the high ability group solved greater numbers of problems related to computation than the average or low ability group. The data also indicate that the average ability group solved greater numbers of problems related to computation than the low ability group.

The third area of significance occurred between the treatment groups and the ability levels.

The data from Table XVI, page 55, seem to indicate the following:

(1) The high ability calculator groups solved significantly greater numbers of problems related to computation than the low ability non-calculator groups.

TABLE XVI

SCHEFFÉ CRITICAL DIFFERENCE TABLE - TREATMENT X LEVELS

	A_4B_3	A_3B_3	A_1B_3	A_4B_2	A_1B_2	A_2B_3	A_2B_2	A_3B_2	A_3B_1	A_1B_1	A_2B_1	A_4B_1
$\overline{X}$ =	9.33	11.44	13.44	14.55	15.00	16.00	16.80	17.70	19.56	19.90	20.14	21.22
A_4B_3	-	2.11	4.11	5.22	5.67	6.67	7.47*	8.37*	10.23*	10.57*	10.81*	11.89*
A_3B_3		-	2.00	3.11	3.56	4.56	5.36	6.26	8.12*	8.46*	8.70*	9.78*
A_1B_3			-	1.11	1.56	2.56	3.36	4.26	6.12	6.46	6.70	7.78*
A_4B_2				-	.45	1.45	2.25	3.15	5.01	5.35	5.59	6.67
A_1B_2					-	1.00	1.80	2.70	4.56	4.90	5.14	6.22
A_2B_3						-	.80	1.70	3.56	3.90	4.14	5.22
A_2B_2							-	.90	2.76	3.10	3.34	4.42
A_3B_2								-	1.86	2.20	2.44	3.52
A_3B_1									-	.34	.58	1.66
A_1B_1										-	.24	1.32
A_2B_1											-	1.08
A_4B_1												-

*Exceeds the critical difference at the .05 level of confidence

(2) The average ability calculator for posttest group was the only average ability group to solve greater numbers of problems than the low ability control group.

(3) There was no difference between the low ability calculator for posttest group and the group with the highest mean score, the high ability control group.

To summarize this section, differences were found among the three ability levels. However, this difference existed before the treatment period began. Of significance is the indication of "no significant difference" between the highest mean score and the low ability calculator for posttest group. The first significant difference to occur between treatment groups was an indication of a significant difference between the control group and the calculator for posttest group.

Calculators for Posttest

To focus on the rationale for this study that use of the calculator will reduce the computational difficulty experienced by students, leading to improved problem-solving ability, one treatment group utilized the calculator on the posttest measure of problem-solving ability. This final analysis will attempt to determine if use of calculators on the posttest leads to students having a greater number of correct responses on a test of problem-solving ability than students who do not use calculators on a test of problem-solving ability.

In an attempt to determine the specific area of problem-solving the calculator could assist, this analysis was computed for three types of questions: questions for the total posttest measure, questions related to determining the operation required to solve the problem, and questions related to determining the computation required to solve the problem.

A *t*-test for a difference between two independent means was computed between the calculator for posttest group and the three treatment groups who did not use calculators for the posttest, the calculator for practice only group, the paper-pencil only group, and the control group.

(a) Calculator for posttest group and calculator for practice only group. With 51 degrees of freedom, a tabled *t* value of 2.011 is significant at the .05 level of confidence.

TABLE XVII

NON-CORRELATED *t*-TEST, CALCULATOR FOR POSTTEST VS. CALCULATOR FOR PRACTICE ONLY

Category	*t*
Total Score	.09
Determining Computation	.32
Computation	1.11

The data from this analysis indicate that there is no significant difference between the calculator for posttest group and the calculator for practice only group in the number of correct responses on a test of problem-solving ability for the total score, questions related to determining computation, or the actual computation.

(b) Calculator for posttest group and the paper-pencil only group. With 51 degrees of freedom, a tabled t value of 2.011 is significant at the .05 level of confidence.

TABLE XVIII

NON-CORRELATED t-TEST, CALCULATOR FOR POSTTEST VS. PAPER-PENCIL ONLY

Category	t
Total Score	.53
Determining Computation	.55
Computation	.95

The data from this analysis indicate that there is no significant difference between the calculator for posttest group and the paper-pencil only group in the number of correst responses on a test of problem-solving ability for the total score, questions related to determining computation, or the actual computation.

(c) Calculator for posttest group and control group. With 50 degrees of freedom, a tabled t value of 2.010 is significant at the .05 level of confidence.

The data from Table XIX, indicate that there is no significant difference between the calculator for posttest group and the control group in the number of correct responses on a test of problem-solving ability for the total score, questions related to determining computation, or the actual computation.

TABLE XIX

NON-CORRELATED t-TEST, CALCULATOR FOR POSTTEST VS. CONTROL GROUP

Category	*t*
Total Score	.66
Determining Computation	.99
Computation	1.64

To summarize this section, the data seems to indicate that use of calculators on a test of problem-solving ability does not lead students to have a greater number of correct responses in three areas of problem-solving; the total score, questions that determine the operation to use to solve the problem, or in the actual computation required to solve the problem.

Summary

An analysis of the data has been presented congruent to the four questions asked in this study. Throughout this analysis, the data seem to indicate significant differences among the three ability levels rather than the treatment groups as expected. The difference among the three ability levels existed before the treatment period began.

CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter presents a summary of the study along with the conclusions drawn from the analysis of the data, the educational implications, and recommendations for further research.

Summary

The purpose of this study was to attempt to determine if use of calculators in the mathematics classroom leads to improved mathematical problem-solving ability among sixth grade students.

Four schools were randomly selected from a large suburban, central-plains school district. All sixth grade students in the four selected schools were assessed as to their mathematical problem-solving ability. All sixth grade students were classified into one of three ability levels; low ability, average ability, or high ability. Ten students were randomly selected from each of the three ability levels in each of the four schools to participate in the study.

The four schools were randomly assigned to one of three treatment groups and one control group--one school was assigned to use calculators for practice problems but not for the posttest, one school was assigned to use calculators for practice problems and also for the posttest, one school was assigned to use paper-and pencil only for practice problems and the posttest, and the control school did not practice problem-solving but took the posttest.

Treatment consisted of students working their way through a series of progressively more difficult problem-solving questions to improve their problem-solving ability. Students practiced problem-solving for nine treatment sessions consisting of 50 minutes per session.

To determine if calculators and/or practice with problem-solving leads to better problem-solving ability, all four groups were given an 86-item problem-solving test. Within the 86 items, questions that related to determining the computation to employ to solve the problem and questions related to the actual computation required to solve the problem were subjected to further analysis.

Analysis of the data included a Pearson product-moment correlation to determine if a positive correlation existed between numbers of practice problems completed and the number of correct responses on the posttest measure, a treatment-by-levels analysis of variance F-test to determine if significant differences occurred between and among groups in problem-solving ability after the treatment period, and a non-correlated _t_-test to determine if a performance difference occurred between the calculator for posttest group and the three remaining groups who did not use calculators for the posttest.

Conclusions

From an analysis of the data, the following conclusions were made congruent to the four questions posed in Chapter I:

1. Use of calculators for practice problems does not assist students to complete more practice problems than students who do not use calculators for practice problems.

2. The more practice problems students complete with calculators the more likely they will solve more problems on a test of problem-solving ability.
3. The use of calculators on a test of problem-solving ability does not assist high ability and average ability problem-solvers to solve more problems than high ability and average ability who do not use calculators.
4. The use of calculators on a test of problem-solving ability does assist low ability problem-solvers to solve more problems than low ability problem-solvers who do not use calculators.
5. The use of calculators assists average and low ability students to solve a greater number of questions that determine computation than average and low ability students who do not use calculators.
6. The highest group on computation questions, the high ability control group, solved significantly greater numbers of computation problems than every low ability group except the low ability calculator for posttest group.
7. In a comparison of the calculator for posttest group with the remaining three groups who did not use calculators for the posttest, it was found that the calculator does not aid students to solve more problems than groups that do not have use of calculators.
8. The use of calculators assisted one group in this study, the low ability for posttest group. The use of the calculator prevented any significant difference from occurring between

it and other high ability groups when significant differences occurred with the remaining low ability groups.

Educational Implications

This study reports that low ability problem-solvers narrow the gap between them and high ability problem-solvers when calculators are utilized for answering problem-solving questions.

The results indicate that use of calculators in the mathematics classroom seems to have some value for low ability problem-solvers, more so than average or high ability problem-solvers.

If the major obstacle for low ability problem-solving students is an inability to do the computation necessary to solve problems, the use of calculators should be considered as one method to improve the problem-solving skills of low ability problem-solving students.

Further Research

The results of this study indicate the need for the following research:

1. Similar methodology should be employed over a longer treatment period. This study indicated that although differences did occur between and among groups, these differences were not significant. Significant differences may occur if students are allowed a longer period of time to practice problem-solving.

2. Calculators should be employed in a structured problem-solving such as Wilson's (1967) wanted-given program or Jerman's (1971) productive thinking program of developing problem-solving skills.

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APPENDIXES

APPENDIX A

TEST OF PROBLEM-SOLVING ABILITY

MATHEMATICS CONCEPTS

These items measure how well you understand some mathematics concepts.

This section contains 25 items. Read each item and choose the answer you think is correct. If the correct answer is not given, choose "none of these." Circle the letter on your answer sheet that matches the letter of the answer you choose.

Read Item A:

Which numeral means the same as three?

SAMPLE ITEM A

A. 1
B. 2
C. 3
D. 4
E. None of these

Look at the section of your answer sheet under the word "Concepts" and see how the correct answer is circled. Answer space C is circled for Sample Item A because three means the same as "3."

Do Sample Item B. Circle the letter on your answer sheet that matches the letter of the answer you choos.

Which number belongs in the blank?

1 2 3 4 ____

SAMPLE ITEM B

A. 1
B. 3
C. 6
D. 7
E. None of these

You should have circled answer E for Sample Item B because "5," the next number in the sequence, is not given.

STOP

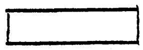
DO NOT WRITE ON THE TEST BOOKLET. USE THE ANSWER SHEET. DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.

MATHEMATICS CONCEPTS <u>DO NOT WRITE ON TEST BOOKLET</u>

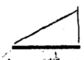
Do items 1-25 and circle your answers on the answer sheet.

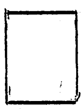
1. Which figure below has the largest area?

A. 

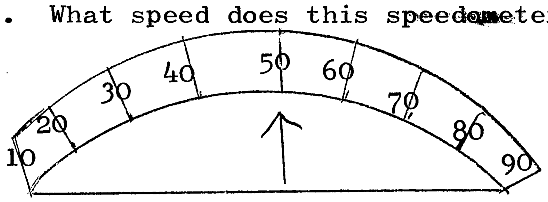
B. 

C. 

D. 

E. 

2. What speed does this speedometer show?



A. 40 miles per hour

B. 50 miles per hour

C. 55 miles per hour

D. 58 miles per hour

E. None of these

3. What number belongs in the box?

$5 \times 8 = \square$

A. $\frac{5}{8}$ D. 40

B. $1\frac{3}{5}$ E. None of these

C. 13

MATHEMATICS CONCEPTS

4. Which of the following numerals names the largest number?

   A. 209

   B. 220

   C. 198

   D. 213

   E. 218

5. How much money is three quarters and two nichels?

   A. $.25

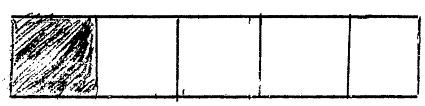
   B. $.75

   C. $.85

   D. $1.25

   E. None of these

6. What fraction of the rectangle is shaded?



   A. $\frac{1}{6}$

   B. $\frac{1}{5}$

   C. $\frac{1}{4}$

   D. $\frac{1}{3}$

   E. None of these

7. Which of the following numerals names the smallest number?

   A. 321

   B. 226

   C. 128

   D. 190

   E. 202

8. Which of the following symbols belongs in both boxes?

   $3 \boxed{} 1 = 1 \boxed{} 3$

   A. +

   B. -

   C. ÷

   D.

   E.

9. ¢ means

   A. dime

   B. dollar

   C. nickel

   D. quarter

   E. None of these

MATHEMATICS CONCEPTS

10. What numeral belongs in the box?

$$5 \times 2 = \boxed{} \times 5$$

A. 2

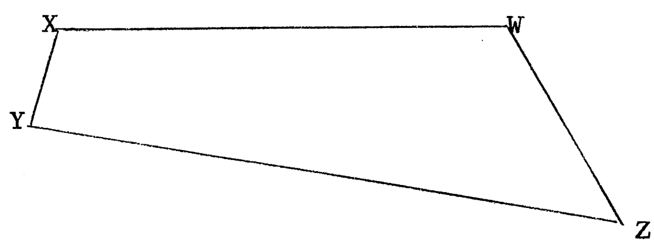
B. 5

C. 7

D. 10

E. None of these

11. In the figure below, what is the name of the longest side?



A. XY

B. YZ

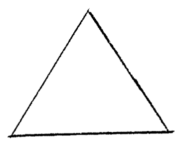
C. ZW

D. WX

E. WY

MATHEMATICS CONCEPTS

12. The sides of the triangle below each measure 6 feet in length. What is the distance around the triangle?



A. 6 feet

B. 12 feet

C. 18 feet

D. 24 feet

E. None of these

13. Which of the following means the same as lb.?

A. ounce

B. pi

C. pound

D. yard

E. None of these

14. Which digit in the numeral 487,023 is in the hundred's place?

A. 0

B. 2

C. 4

D. 7

E. None of these

15. Which of the following figures has only three angles?

A. rectangle

B. square

C. trapezoid

D. triangle

E. none of these

16. Which of the following means the same as one hundred eleven?

A. 1,011

B. 1,101

C. 10,011

D. 100,011

E. None of these

17. Which of the following means the same as four dollars and four cents?

A. \$4.4¢

B. \$4.4

C. \$4.04

D. \$4.44

E. None of these

MATHEMATICS CONCEPTS

18. Which of the following has **more** than four sides?

A. pentagon

B. rectangle

C. square

D. triangle

E. None of these

19. Which of the following means the same as three thousand five?

A. 305

B. 3,005

C. 3,500

D. 3,000,005

E. None of these

20. % means

A. degree

B. inch

C. per cent

D. ratio

E. None of these

21. Which of the following means the same as $\frac{15}{3}$?

A. $8\frac{1}{3}$

B. $8\frac{2}{3}$

21. (Continued)

C. $9\frac{1}{3}$

D. $9\frac{2}{3}$

E. None of these

22. The Roman numeral C means the same as

A. 100

B. 200

C. 300

D. 500

E. None of these

23. 2 hours 105 minutes =

A. 3 hours 5 minutes

B. 3 hours 45 minutes

C. 3 hours 55 minutes

D. 4 hours 5 minutes

E. None of these

24. In the numeral 426.1, which digit is in the hundred's place?

A. 1

B. 2

C. 4

D. 6

E. None of these

25. Which of the following means the same as forty dollars and six cents?

A. \$40.6¢

B. \$40.6

C. 40.06

D. \$40.06

E. None of these

STOP! DO NOT DO ANY MORE PROBLEMS UNTIL TOLD TO DO SO.

YOU MAY GO BACK AND CHECK YOUR ANSWERS.

MATHEMATICS PROBLEMS

These items measure your ability to work mathematics problems.

This section contains 15 problems. Work each item on scratch paper and circle the answer you think is correct. If the correct answer is not given, circle "none of these." Circle the letter on your answer sheet that matches the letter of the answer you choose.

Read Sample Item A below.

SAMPLE ITEM A

Jennie had 3 rings. She gave 1 ring away. How many rings did she have left?

A. 2

B. 3

C. 4

D. 5

E. None of these

Look at the section of your answer sheet under "Mathematics Problems" and see how the correct answer is marked. Answer space A is circled for Sample Item A because 3 rings minus 1 ring equals "2" rings.

Do Sample Item B. Circle the letter on your answer sheet that matches the letter of the answer you choose.

SAMPLE ITEM B

Mrs. Herbert had 25 children in her fourth-grade class. If two new boys joined her class, how many students would she have?

A. 23

B. 25

C. 26

D. 27

E. None of these

You should have circled letter D for Sample Item B because 25 children plus 2 children equals "27" children.

STOP! DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.

MATHEMATICS PROBLEMS

Do items 1-15 below and circle your answers on the answer sheet.

1. Leslie has 5 white chickens and 8 brown chickens. How many chickens does she have in all?

   A. 3

   B. 5

   C. 8

   D. 13

   E. None of these

2. A rancher had 15 cows. He sold 5 of them. How many cows did he have left?

   A. 9

   B. 16

   C. 21

   D. 80

   E. None of these

3. Leon had 12 pieces of candy. He gave 3 pieces to Lauren and 5 pieces to Jorge. How many did he have left?

   A. 2

   B. 4

   C. 7

   D. 9

   E. None of these

4. Earl has 4 model airplanes. Klaus has 2 times as many. How many model airplanes does Klaus have?

   A. 2

   B. 6

   C. 8

   D. 16

   E. None of these

5. Ted solved 4 problems. Sam solved 3 times as many. How many problems did Sam solve?

   A. 3

   B. 5

   C. 7

   D. 12

   E. None of these

6. The Oak Street School Chess Club had 6 members. Three of the members quit and then 1 new member joined. How many members were finally in the club?

   A. 2

   B. 4

   C. 8

   D. 10

   E. None of these

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7. James raised 40 rabbits and sold 24 of them. He divided those remaining evenly among 4 friends. How many rabbits did each receive?

   A. 4

   B. 8

   C. 10

   D. 16

   E. None of these

8. Katie spent 42 cents on pencils. Each pencil cost 6 cents. How many pencils did she buy?

   A. 3

   B. 6

   C. 7

   D. 36

   E. None of these

9. Ethel had $5.00. She paid 35 cents for a ribbon, $1.65 for a new book, and 50 cents for lunch. Then she spent the amount she had left for Christmas gifts. How much did the Christmas gifts cost?

   A. $2.00

   B. $2.50

   C. $3.00

   D. $5.00

   E. None of these

10. A room had 6 rows of desks with 7 desks in each row. Five desks were removed from the room. How many desks remained?

   A. 8

   B. 13

   C. 37

   D. 42

   E. None of these

11. How many square yards are there in a rug which is 3 yards wide and 4 yards long?

   A. 6

   B. 7

   C. 9

   D. 12

   E. None of these

12. On a map, 1 inch represents 80 miles. The distance between two cities on the map is 2 inches. How many miles apart are the two cities?

   A. 40

   B. 100

   C. 120

   D. 160

   E. None of these

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13. For a Thanksgiving party, two thirds of a class brought food. If there were 30 students in the class, how many students brought food?

    A. 10

    B. 15

    C. 20

    D. 27

    E. None of these

14. Theresa had 12 cookies. She divided them equally among 3 other girls and herself. How many cookies did each girl receive?

    A. 3

    B. 4

    C. 9

    D. 11

    E. None of these

15. Jack weighed 95 pounds. Peter weighs 75 pounds, and Robert weighs 100 pounds. What is their average weight in pounds?

    A. 85 pounds

    B. 87½ pounds

    C. 90 pounds

    D. 92½ pounds

    E. None of these

STOP! YOU MAY GO BACK AND CHECK YOUR ANSWERS IF THERE IS TIME REMAINING.

APPENDIX B

LESSON TOPICS

ADDITION AND SUBTRACTION OF WHOLE NUMBERS

LESSON	TOPIC	EXAMPLE
1.	Basic addition and subtraction facts.	3 + 8 = ___ 16 - 9 = ___
2.	Adding and subtracting two-digit multiples of tens (sums not more than 100).	30 + 50 = ___ 90 - 6 = ___
3.	Adding and subtracting one- and two digit numbers, without regrouping (sums less than 100).	61 + 7 = ___ 57 - 5 = ___
4.	Adding and subtracting two-digit multiples of ten and two-digit numbers (sums less than 100).	20 + ___ 46 71 - 30 = ___
5.	Adding one- and two-digit numbers, with regrouping (sums less than 100).	58 + 6 = ___ 66 + 5
6.	Subtracting one-digit numbers from two-digit numbers, with regrouping.	51 --7 = ___ 42 - 8
7.	Adding and subtracting two-digit numbers, without regrouping (sums less than 100).	36 + 42 = ___ 96 - 64 = ___
8.	Adding two-digit numbers, with regrouping (sums less than 100).	37 + 25 = ___ 62 +29
9.	Subtracting two-digit numbers, with regrouping.	60 - 37 = ___ 95 -68
10.	Adding two-digit multiples of ten and subtracting two-digit multiples of ten from three-digit multiples of ten (differences less than 100).	70 + 60 = ___ 120 - 70
11.	Adding two-digit numbers and multiples of ten (sums less than 200).	120 + 45 = ___ 96 +80

12.	Subtracting two-digit numbers from three-digit multiples of ten (differences less than 100).	110 - 23 = __ 170 - 86
13.	Subtracting two-digit multiples of ten from three-digit numbers (differences less than 100).	115 - 20 = __ 135 - 70
14.	Adding two two-digit numbers (sums between 100 and 200).	74 + 74 = ___ 83 +44
15.	Subtracting two-digit numbers from three-digit numbers (differences less than 100).	126 - 62 = __ 156 - 81 = __
16.	Adding two two-digit numbers, with regrouping (sums between 100 and 200).	67 + 67 = ___ 35 +95
17.	Subtracting two-digit numbers from three-digit numbers, with regrouping.	121 - 34 = __ 254 - 95
18.	Adding more than two one- and two-digit numbers.	21 9 34 + 6
19.	Adding three-digit numbers, with regrouping (sums less than 1000).	279 = 113 = __ 444 +236
20.	Subtracting two- and three-digit numbers from three-digit numbers.	381 - 62 = ___ 663 -445
21.	Adding two- and three-digit numbers, with regrouping.	888 + 999 = __ 573 + 98
22.	Subtracting one-, two-, and three-digit numbers from three-digit numbers, with regrouping.	607 - 98 = ___ 712 -223
23.	Adding more than two multidigit numbers.	4003 + 102 + 70 + 7649 = ____
24.	Subtracting multidigit numbers, with regrouping.	7451 - 4563 = ___ 8000 - 3625 = ___

MULTIPLICATION OF WHOLE NUMBERS

LESSON	TOPIC	EXAMPLE
1.	Basic multiplication facts; meaning of multiplication.	27 = 9 x ___ 12 = ___ x 4
2.	Multiplying with one and with ten (products less than 200).	1 x 9 = ___ 11 x 10 = ___
3.	Multiplying one-digit numbers and two-digit numbers less than 20).	6 x 13 = ___ 17 x 7
4.	Multiplying one-digit numbers and two-digit multiples of ten.	3 x 70 = ___ 90 x 5 = ___
5.	Multiplying one- and two-digit numbers.	5 x 37 = ___ 86 x 4
6.	Multiplying three one-digit numbers.	3 x 4 x 6 = ___ 6 x 4 x 2 = ___
7.	Multiplying one-digit numbers and three-digit multiples of one hundred.	3 x 100 = ___ 700 x 7
8.	Multiplying one-digit numbers and three-digit multiples of ten.	7 x 360 = ___ 730 x 3
9.	Multiplying one-digit numbers and three-digit numbers with zero in the tens place.	607 x 5 = ___ 9 x204
10.	Multiplying one- and three-digit numbers.	9 x 567 = ___ 146 x 6
11.	Multiplying two-digit numbers and ten, and multiplying two two-digit multiples of ten.	10 x 63 = ___ 70 x 40 = ___
12.	Multiplying two-digit numbers and two-digit multiples of ten.	40 x 48 = ___ 43 x60

13.	Multiplying two two-digit numbers.	14 x 16 = ___ 66 x27
14.	Multiplying three-digit numbers and ten; and multiplying two-digit multiples of ten and three-digit multiples of one hundred.	60 x 800 = ___ 280 x 10
15.	Multiplying two-digit numbers and three-digit multiples of one hundred.	700 x 15 = ___ 84 x600
16.	Multiplying two- and three digit multiples of ten.	30 x 750 = ___ 390 x 40
17.	Multiplying two-digit numbers and three-digit multiples of ten.	350 x 14 = ___ 11 x 140= ___
18.	Multiplying three-digit numbers and two-digit multiples of ten.	894 x 50 = ___ 80 x475
19.	Multiplying two- and three-digit numbers.	387 x 36 = ___ 57 x483
20.	Multiplying three-digit multiples of one hundred and three-digit multiples of ten.	580 x 600 = ___ 900 x480
21.	Multiplying three-digit numbers and three-digit multiples of one.hundred.	949 x 400 = ___ 500 x464
22.	Multiplying two three-digit multiples of ten.	660 x 660 = ___ 920 x860
23.	Multiplying three-digit numbers and three-digit multiples of ten.	784 x 560 = ___ 670 x943
24.	Multiplying three-digit numbers and three-digit numbers with zero in the tens place.	407 x 306 = ___ 609 x943
25.	Multiplying two three-digit numbers.	348 x129 948 x637

DIVISION OF WHOLE NUMBERS

LESSON	TOPIC	EXAMPLE
1.	Meaning of division.	$\left\{\begin{array}{l} \_\_ \times 6 = 18 \\ 18 \div 6 = \_\_ \end{array}\right\}$
2.	Basic Division facts.	$21 \div 7 = \_\_$ $\left\{\begin{array}{l} 21 - 7 = 14 \\ 14 - 7 = 7 \\ 7 - 7 = 0 \end{array}\right\}$
3.	Dividing two-digit dividends by one-digit divisors (quotients with remainders).	$65 \div 9 = \_\_$, r. __ $32 \div 5 = \_\_$. r/__
4.	Dividing three-digit multiples of ten by one-digit divisors (quotients multiples of ten).	$140 \div 2 = \_\_$
5.	Dividing two- and three-digit dividends by one-digit divisors (quotients between 10 and 20).	$65 \div 5 = \_\_$ $8\overline{)120}$
6.	Dividing three-digit dividends by one-digit divisors (two-digit quotients).	$116 \div 2 = \_\_$ $9\overline{)864}$
7.	Dividing two- and three-digit dividends by one-digit divisors (two-digit quotients with remainders).	$59 \div 5 = \_\_$ $6\overline{)359}$
8.	Dividing muldigit dividends ending in zeros by divisors of ten, one hundred, and one thousand.	$9300 \div 100 = \_\_$ $47{,}000 \div 1000 = \_\_$
9.	Dividing four- and five-digit dividends ending in zeros by multiples of ten, one hundred, and one thousand.	$3600 \div 90 = \_\_$ $54{,}000 \div 6000 = \_\_$
10.	Dividing three-digit dividends by two-digit multiples of ten (one-digit quotients with remainders).	$40\overline{)316}$ $90\overline{)808}$
11.	Dividing three- and four-digit dividends by two-digit multiples of ten (two-digit quotients with remainders).	$60\overline{)940}$ $80\overline{)2525}$

12.	Dividing three- and four-digit multiples of ten by one-digit divisors (three-digit quotients).	5) 750 9) 3960
13.	Dividing three- and four-digit dividends by one-digit divisors (three-digit quotients with zero in the tens place).	309 ÷ 3 = ___ 6) 616
14.	Dividing three- and four-digit dividends by one-digit divisors (three-digit quotients with remainders).	3) 431 5) 3595
15.	Dividing four- and five-digit dividends by one-digit divisors (four-digit quotients with remainders).	7) 9139 9) 10,145
16	Dividing two- and three-digit dividends by two-digit divisors (one-digit quotients-estimated digit is correct).	48 ÷ 24 = ___ 37) 148
17.	Dividing two- and three-digit dividends by two-digit divisors (one=digit quotients-estimated digit is not correct).	84 ÷ 12 = ___ 28) 196
18.	Dividing two- and three-digit dividends by two-digit divisors (one-digit quotients with remainders).	11) 69 67) 480
19.	Dividing three- and four-digit multiples of ten by two-digit divisors (quotients multiples of ten--estimated digit is correct).	11) 880 92) 6440
20.	Dividing three- and four-digit multiples of ten by two-digit divisors (quotients multiples of ten--estimated digit is not correct).	13) 780 35) 3150
21.	Dividing three- and four-digit dividends by two-digit divisors (two-digit quotients--estimated digit is correct).	13) 156 94) 3196
22.	Dividing three- and four-digit dividends by two-digit divisors (two-digit quotients).	28) 476 69) 1863
23.	Dividing three- and four-digit dividends by two-digit divisors (two-digit quotients with remainders).	13) 175 95) 3400
24.	Finding quotients without using paper and pencil.	65 ÷ 5 = ___ 360 ÷ 60 = ___
25.	Estimating quotients.	269 ÷ 30 = ___ 3362 ÷ 99 = ___

APPENDIX C

PRACTICE PROBLEMS

1. It was a third down for the Mudcats. The ball was on the 10-yard line. The quarterback trotted back 7 yards to the 30-yard line and sent a pass spinning through the air. His brother caught it on the 15-yard line, tore away from a nearby tackle, tucked the ball under his arm, and started for the far goal. On the 18-yard line he slipped in the mud and fell. His team had a first down, but when he got up he had tears in his eyes. The quarterback threw a pass of ________ yards, The Mudcats gained ______ yards on the play.

2. 5 + 9 = 9 + ________ 14 = 8 + ________

   17 + 8 = 8 + ________ 16 = 9 + ________

3. At one o'clock in the afternoon patches of fog began to roll in from the sea. Three hours later fishing village was completely hidden from view. Two hours earlier one of the men in the village had noticed that the fog was getting worse and had sounded the alarm. Six hours after the alarm had been sounded, the town radio operator had radioed the men at sea, warning them not to come in until the fog had cleared. Their boats might crash on the rocks. When the boats were finally able to dock, the crews found the village deserted. The radio operator had warned the boat crews at ________ o'clock not to come in until the fog had cleared.

4. Addends: 7, 8 Sum: ________

5. The neighborhood milkman owns a miniture cow that gives him 9 gallons of milk per day. Through a secret formula, he is able to get 2 pints of cream from each gallon. He exchanges this cream with his neighbors for the grass in their backyards. Naturally this grass is given to the cows.

   The milkman gets _______ pints of cream in 1 day.

   The milkman gets _______ gallons of milk in 8 days.

6. As the man dropped a nickel down the well, he wished for a ham sandwich. Unfortunately, the nickel landed on a rock in the center of the well instead of in the water. Nothing happened. The man quickly tossed 2 more nickels into the well, but these also landed on the rock. Discouraged, he flung a dime down the well and stamped off. Had he waited, he would have seen some ham sandwiches appear on the edge of the well.

   If a person receives 5 wishes for each nichel that falls into the water, and if the man's nickels had fallen into the water, he would have received _______ wishes for his nickels.

7. An array of 24 black buttons was so arranged that each row contained 4 buttons. These bits of black plastic represented the 24 hours of the day. As each row was removed, a big bell rang. How many times did the bell ring? ________

8. There was once a dragon which threatened to destroy the entire town unless it was given 5 cows every year. Eventually all 45 cows owned by the townsfolk had been given to the dragon. Fortunately the dragon had become quite fond of the townspeople over the years, so instead of carrying out his threat, he appointed himself the town's protector and often led the parades. How many years did the townspeople give cows to the dragon? ________

9. On April 2 a robin appeared on the branch outside Henry's window. On April 26 it disappeared, leaving Henry a patch of cloth for every 8 days it had used the branch. Henry's mother sewed the cloth patches over holes in the boy's shirt and soon he could fly as well as any bird. The robin left ______ patches of cloth.

10. Write yes or no at the end of each question.

$1 \times 0 = 1 \times 0$, but does $1 \times 0 = 0 \times 1$? ________

$0 \times 1 = 1 \times 0$, but does $1 \times 1 = 0 \times 0$? ________

$6 \times 7 = 7 \times 6$, but does $7 \times 7 = 6 \times 6$? ________

$5 \times 2 = 5 \times 2$, but does $5 \times 2 = 2 \times 5$? ________

$9 \times 8 = 8 \times 9$, but does $8 \times 9 = 9 \times 8$? ________

1. A man had 4 sons whose ages were 12, 16, 20, and 24. One day he divided 40 pieces of gold equally among them. He told his sons to use the gold wisely. The youngest buried his and forgot where. The oldest bought a horse which refused to carry him. The other two put their gold pieces together and bought a farm filled with rocks. The father promised to help all 4 of them as soon as he stopped laughing. The youngest brother buried _______ pieces of gold in the ground.

2. Dividend: 56   Divisor: 7   Quotient: __________

3. Many people wondered why Hiram didn't bump his head when he walked through a door. He was so tall that he didn't even breathe the same air that other people breathed. His legs were so long that with every step he covered a distance of 5 feet, while an ordinary man covered only 3 feet. Despite this, Hiram did an excellent job as the town policeman. People could always see him when they were in trouble. Hiram could cover a distance of 35 feet in _____ steps.

4. The names of the persons sitting at the banquet table had been written on separate slips of paper and placed in a high silk hat. The owner of the hat was a millionaire. He drew half of the names from the hat. He gave the persons whose names were drawn gold pens and asked them to go. There were 40 people left. He then drew some of the remaining names from the hat, gave gold wristwatches to the winners, and asked them to go. There were 20 persons left at the table. Smiling, he took out half of the slips still in the hat. To each of those whose names were drawn he gave a 100-dollar bill. Plane tickets to Europe were given to those whose names were still in the hat.
   __________ persons received gold pens.
   __________ persons received gold wristwatches.
   __________ persons received 100-dollar bills.
   __________ persons received tickets to Europe.

5. A magic chicken laid 40 eggs in the morning and 50 eggs in the afternoon. The owner of the magic chicken was overjoyed that his hen could lay ________ eggs in one day.

6. Snow began to fall as the first 10 covered wagons of the wagon train reached the mouth of the valley. In spite of the storm they managed to stay on the trail. The ones that followed, however, became lost in the storm; 30 wagons went off to the left, 20 to the right, and the last 10 were scattered all over the valley. It took two days to regroup the wagons, and by that time the snow had sealed off both ends of the valley. There were _______ covered wagons together in the wagon train before the storm began.

7. A rubber ball fell from the top of a 14-story building and, after hitting the ground, bounced back to the top of the seventh story. Just as it was about to fall back down again, an eagle grabbed it in her claws and carried it to the top of the building. The foolish bird thought it was an egg.

   If one story of the building is 10 feet high, how far down did the ball travel by itself? __________
   How far did the ball bounce up? __________
   The eagle carried the ball _______ feet.

8. It has been 16 decades since the Great Quake shook the mountain. A decade is 10 years. How many years passed since the Great Quake shook the mountain? __________

9. The fence zigzags. First it zigs for 10 feet, then it zags for 10 feet. The fence zigs 13 times and zags 13 times. How long is the zigzag fence? ____________

1. Each time the door of the drugstore opened, the owner's canary would chirp 3 times. When the cash register rang, he would chirp 2 times. One day 12 boy scouts walked in together. At different times each bought a comic book. Then they all left together to take a mile hike. The canary chirped _______ times.

2. In 4 years there are _______ months.

3. One tube holds 18 golf balls. Nine tubes hold ______ golf balls.

4. The old butcher, waiting for the bus, carefully pushed his glasses back up on his nose. There were 6 red foxes looking up at him with their tongues hanging out. In the distance he heard dogs barking. Suddenly the foxes jumped into his shopping bag just as a pack of 23 hounds raced by. After the dogs had gone, the foxes climbed out of the bag and ran into an alley, each with a sausage in its mouth. The butcher saw _______ animals.

5. On Mars at forty-two o'clock the temperature was 62 degrees. At forty-three o'clock it had risen 7 degrees. At forty-three o'clock the temperature was _______ degrees.

6. The senator reached into his pocket and drew out a tiny bottle of pills. Opening it, he shook 29 pills onto the desk in front of him. He then divided them into colors: 4 blues, 5 yellows, and the rest green. Turning to his audience, they stated that anyone who took one pill from each group would never catch a cold.
   _____ pills were not blue.
   _____ pills were not yellow.
   _____ pills were green.

7. If you subtract 5 biddle-de-boos from 97 biddle-de-boos, you get _________ biddle-de-boos.

8. At one time 51 ships used the city's docks to unload cotton. Then, every year for 7 years, 7 fewer ships used the docks. When the mayor asked the captains what was wrong, they refused to tell him. Finally the mayor learned from one of the sailors that a ghost ship was frightening the ships away. After 7 years there were ________ ships still using the city's docks.

9. Once there was a man who could understand the language of dogs. One day he happened to overhear a collie and a beagle talking about 20 one-dollar bills that were stuck high in the fork of a tree. The man told the dogs that he would climb the tree and get the money for them if they would share it with him. They agreed. After the three had divided the money into three equal parts, there was less than $3 left. The man received the extra money for climing the tree. The collie and the beagle each received _______ dollars. The man received ________ extra dollars.

1. Ron was already late for class when he put his penny into the gum machine. He twisted the knob, but nothing happened. He shoved in another penny, but still nothing happened. Ron banged the side of the machine, but no gum came out. He put one more penny into the box, and then another. Disgusted, Ron hit the machine with his book and ran to class. Two minutes later 160 pieces of gum tumbled onto the floor. If he had waited, Ron would have received ________ pieces of gum for each penny he had put into the gum machine.

2. Dividend: 810 Divisor: 9 Quotient: ________

3. All the leaves seemed to fall at once that second week in October. In fact, one area of 120 houses was so flooded with leaves that people were afraid to burn them because fire might sweep over their lawns and destroy their homes. Things looked hopeless until 6 leaf-eaters appeared. They were fuzzy and round, much like fuzzy round beach balls. No one knew where they had come from, but wherever they went, the leaves disappeared. The leaf-eaters just seemed to suck them up. When all the leaves had been eaten, the animals rolled away. About a week later someone noticed that the fire hydrants were gone. If each fuzzy leaf-eater ate the leaves from the same number of lawns, each leaf-eater ate leaves from ________ lawns.

4. Mounting his horse, the knight traveled 40 miles across the desert. Then the horse, worn out and thirsty, had to rest. However, the knight could lose no time in rescuing the princess who was imprisoned in the castle. So, with the horse mounted on his back, the knight traveled the remaining 50 miles across the mountains to the castle.
   Knight and horse traveled ________ miles.
   If they had traveled the same distance 5 times, they would have traveled ________ miles.

5. The cost of 9 twenty-cent postage stamps is ________.

6. Forty rows of 7 trading stamps each contain ________ stamps.

7. Little did the magician realize something might go wrong when he prepared for his show. Carefully he placed 24 eggs along the inside hem of his long cape. Then, just to be sure he had enough, he put in 20 more. How could he know that a strong gust of wind would blow him against the building as he stepped outside the door?
   The magician put ________ eggs inside his cape.
   If only 30 of the eggs got broken, the magician would still have ________ eggs.
   Would this be enough if his trick required two dozen eggs?________

8. The girl had two older brothers. The age of the older of the two equaled the sum of the ages of the girl and the younger brother. The girl was 18 and the older brother was 38. The younger brother was ________ years old.
   2 dozen = ________ things 1 dozen = ________ things
   ½ dozen = ________ things

1. The freight train was already 23 minutes late when the stationmaster was informed that the train seemed to have disappeared. The 7 box cars that carried 6 horses and 45 sheep had pulled out of the last station on time, but no trace could be found of the animals or the boxcars now. _________ animals had vanished.

2. As he opened the door to his hotel room, the man saw three masked visitors sitting on his bed. Stunned at first, he became calmer when the first handed him 29 pearls, the second gave him an ivory box, and the third gave him a jewel box. He found that each box contained 6 emeralds. Then the three silently walked out. The man, a prince in disguise, immediately hid the treasure.
   The prince was given _______ gems by the first two visitors.
   The prince was given _______ gems in all.

3. As the squirrel watched, the oddly dressed man knocked 6 times on the trunk of the tree and held a bag beneath a small round hole. The squirrel nearly fell off the branch when he saw 108 acorns rush into the bag. When the last acorn had dropped, the man closed the bag and walked away, whistling. The squirrel immediately dashed to the hole, knocked 6 times, and waited. Finally a hand reached out and held up a sign that read OUT OF ORDER. The man received _________ acorns for each knock.

4. It was really Henry Pymmer who invented the silence machine. When he turned the dial, his machine sucked up all the noise within a 9-foot circle. Every time he turned the dial there was 9 more feet of silence. One night Henry took his machine to a concert and fixed it so that it swallowed all the noise made by the audience, but not the sound of the music. Naturally people were frightened by the silence and left, but Henry stayed and heard the whole concert. If the silence machine sucked up noise within a circle of 108 feet, Henry had turned the dial ______ times.

5. It took 27 minutes for the captain of the team to swim across the river. His coach later told him that he had averaged 8 feet per minute. The swimmer was not happy about the length of time it had taken him, but he did show his coach the fish he had grabbed as he swam across. The river was ______________ wide.

6. There were 63 diamonds scattered on a table in the back room, ready to be made into pins. Each would be mounted inside a ring of 6 rubbies. The jeweler put all the rubies for the pins in the bottom of a brown paper bag and placed the diamonds on top of them. Then he walked out into the street carrying the bag as if it were his lunch. There were ________ rubies in the bag.

7. The queen was the first to sit, and then her guests. Next she picked up one of her gold spoons and began to eat her soup. The other 26 people at the table picked up their silver spoons and began to eat. In fact, everyone was so eager to act just like the queen that they giggled when she giggled. If each person at the table had 3 spoons, the queen and her guests had _______ spoons.

1. The sun was unusually hot the day Mr. Cranston laid his new concrete sidewalk. In fact, Mr. Cranston was 5 pounds lighter when the job was finished. He was quite proud of himself and, even though he was hot and tired, took time to point out the job to his neighbor. Poor Mr. Cranston! The next morning he discovered 348 rabbit tracks running the length of the sidewalk, all just as hard as the rest of the concrete. If the rabbit made one set of 4 tracks every 2 seconds, it took him ________ seconds to make 348 tracks.

2. The Chipmunk family had a most unusual way of deciding who was going to clear away the snow from the front doorstep. Father Chipmunk lined up the 7 children across the living room and gave each of them a supply of acorns. When Mother gave the signal, the children scurried about the room, hiding the acorns in the most secret places. The Chipmunk child who finished last had to clear away the snow. If Father Chipmunk divided 119 acorns equally among his children, how many acorns did each hide? ________

3. Everyone went to see the parade. There were 5 rows of 7 drummers in blue uniforms. Each drummer had 4 drumsticks. The band librarian, Lilly, had little labels to put on each drumstick. Lilly used ________ labels.

4. The ants were busy getting ready for cold weather. With great difficulty they rolled jelly beans into one of their storerooms. Wanting to use as little space as possible so that they could save room for the gumdrops, they placed the jelly beans in 5 rows of 6 each. With great care they stacked up 7 layers. Then - Oops! The ants stacked up ________ jelly beans before . . .

5. Arlene promised that she would bake peanut cookies for the all-school party on Saturday. To make sure she put the same number of peanuts into each of 9 batches of cookie dough, she divided the peanuts for each batch into 7 rows of 5 peanuts each. Arlene used ________ peanuts.

6. The chimpanzee, told to show off for the visitors, was given 73 subtraction exercises to work. He missed only 8. The chimpanzee got ________ exercises right.

7. Of the 51 oranges in the barrel, all except 3 had been marked with a bright red X. These 3 had been grown in a secret valley in California. The owner of these 3 oranges was very proud of them and had brought them home to display for his family and friends. One morning at breakfast he noticed that his orange juice tasted unusually good. When he mentioned this to his wife, she told him that she had used 3 oranges she had found lying around. There was a bright red X on ________ oranges.

8. There were 73 boys lined up for a 20-mile hike. The gun went off and the boys moved down the road - some quickly, others at a slower pace. After the first 5 miles, 7 boys sat down at the side of the road, rested 14 minutes, and then turned around and went home. At the end of the second 5 miles, another 8 dropped out, and at the end of the third 5 miles, 9 more refused to go on. Those who finally reached the finish line were given bicycles as prizes so that they could ride back home.

____________ boys started the second 5 miles.

____________ boys were left at the beginning of the third 5 miles.

____________ boys were left at the beginning of the fourth 5 miles.

____________ boys finished the race.

1. The leopard wanted to have his coat dry-cleaned; it had spots on it. Knowing that the cost would depend on the number of spots, and suspecting that he did not have enough money, he decided to find a clear pool of water to use as a mirror and count the number of spots on his coat. To make his job easier he imagined that his body was divided into four parts. Each part had the same number of spots. After counting 300 spots, he could count no more because he could not see the back of his neck and shoulders. The 300 spots covered 3 parts of his body; he decided that the spots he could not count covered the fourth part.

   The leopard counted _______ spots on 3 parts of his body.

   The leopard decided that he had ______ spots on the other part of his body.

   The leopard decided that he must have ______ spots all together.

   If each spot cost 1 cent to be dry-cleaned, it would cost the leopard _______ to have his coat dry-cleaned.

2. If a picture book has 8 pictures on each page and there are 200 pages in the book, there are _________ pictures.

3. A small tornado moved across the barnyard. As it chased the animals, it managed to pluck 878 feathers. These feathers became a huge ball which rolled across the countryside, frightening man and beast alike. By the time it reached Texas, it glowed in the dark. If the same number of feathers had been plucked from each of 9 chickens and fewer than 9 feathers came from a duck, each chicken had lost _______ feathers. The duck had contributed _________ feathers to the ball.

4. That first cold day everyone came to school all bundled up. One child was especially well dressed for the weather. In fact, all the teacher could see was a red scarf wound around him from the top of his head to the tip of his toes. She began to unwrap the child, but no one appeared. The scarf didn't seem to have any end. When the teacher had finally unwound all 102 feet of the scarf, she still had no student - only a worried look on her face. Each time the teacher unwound the scarf, she spun off 6 feet of it. She unwound the scarf ______ times.

5. Cold winds had left only 89 leaves on the elm tree. A small girl on the sidewalk below watched these remaining leaves fight to stay. Soon, however, they too were blown away - 23 with each gust of wind. In twenty minutes the branches were bare, but the squirrels, storing their nuts away in the tree, didn't even notice.

   There were _______ leaves left after the first gust.

   There were _______ leaves left after the second gust.

   There were _______ leaves left after the third gust.

6. On Monday 34 persons were notified that their electricity would be cut off for two hours on Tuesday. On Tuesday 63 other persons were notified that their water would be shut off for three hours on Wednesday. Neither the electricity nor the water was shut off, but all this was done to show the ______ persons how much they depended on others.

1. One of the outlaws tried to lift the chest, but it was too heavy. This was not surprising, since it contained 290 pieces of gold and each piece weighed 3 pounds. He called to his buddy to come and help, but together they could not lift it high enough to place it on the back of the waiting horse. And even if they could have, the animal probably could not have carried such a heavy load. There were 8 such chests, and each contained the same number of 3-pound gold pieces. Finally the two outlaws decided to move the chests by dragging them, so they tied them to the saddles of their horses. Two hours later the outlaws were captured by the sheriff and his posse, who had followed the trail left by the heavy chests.
   In all there were ________ pieces of gold.
   The contents of 1 chest weighed ________ pounds.
   The contents of all 8 chests weighed ________ pounds.

2. Each night the walrus dreamed he dug up 210 clams from the bottom of the sea. At the end of one week he had dreamed that he had dug up ______ clams.

3. There was once a country where the weather was cloudy and rainy 58 days of the year, snowy for 13, and sunny all the rest of the time. No one knew how this happened, but everyone was so happy about it that no one would have it any different. There were _____________ days of the year that were not sunny.

4. An owl bobbed up and down on a branch 62 times in the morning and 19 times in the afternoon. Then he got sick at his stomach and flew away. Enough was enough! The owl bobbed up and down ________ times before he got sick.

5. Four brothers owned a 59-acre ranch in Utah. At Christmas they were given 29 acres of land. Unfortunately, the area was covered with rocks and there did not seem to be much they could do with it. But the oldest brother solved the problem. He put up a sign on the main highway inviting people to come and take all the rocks they wanted for only 25 cents. The land was cleared in one week. After the rocks had been removed, the brothers had ________ acres of land to use.

6. A barrel found in an alley contained 1800 small round seeds. No one could decide what kind they were, but the seeds were planted in the city park just the same. Eventually a number of plants appeared, but still no one could figure out what kind of plants they were. It was only when pennies were discovered inside the pods that people appreciated what they had found. If 100 seeds made one money plant, how many money plants were growing in the city park? _________

7. The man stopped every 10 feet, bent over and picked up something from the sidewalk. Naturally he attracted a large crowd of followers. After he had walked a distance of 180 feet, he turned to the people behind him and held up the pieces of string he had picked up. Since string collectors don't happen along every day, the people listened patiently as he described the various kinds of string he had found during his lifetime. The man stopped ____ times.

8. Because of the cold, high winds, the mountain climbers were forced to set up a tent every 1,000 feet. By doing this they kept themselves from freezing to death, but they also lost precious time. Thick clouds were closing in upon them, making it increasingly difficult to find their way. Finally the 3 men were forced to stop at 21,000 feet. They had used all their tents. The mountain climbers had set up ________ tents.

1. Three hundred children waited impatiently for the whistle to blow. When it did, the group dashed across the beach toward the water. However, the sand was too hot for their tender feet. Every 10 feet, 20 children sat down on their towels, rubbed their burning toes, and watched the rest continue. As a result, only 20 children actually made it to the water, which turned out to be too cold to swim in. The children had to run a distance of _________ feet to get to the edge of the water.

2. A truck loaded with 3,200 pounds of coal rumbled along the highway. As it traveled, it crossed 80 sets of railroad tracks. Now no truck can cross railroad tracks without bouncing up and down, and this truck was so old that it bounced more than other trucks. At each crossing it left the same amount of coal behind. In fact, the driver delivered only half his load. The truck lost _____ pounds of coal at each set of tracks.

3. A man was told that if he could divide $200 equally among 30 men in 30 different cities, he would receive a prize of $800. He thought about it for quite some time and then hired a secretary to check on the names and addresses of the men and to prepare the envelopes for mailing. He paid her $20. The next day he borrowed $10 from his secretary, added it to the $200, mailed the checks, collected his $800 prize, returned the $10 to his secretary, and spent the rest on a gold-plated shoehorn. He sent each man a check for ______ dollars.

4. The 6 aircraft carriers moved into position. They were waiting for the space capsule to land. Prepared for any emergency, each carrier had 259 jet planes aboard. All but 52 planes on each carrier were ready to take off instantly. Sparkling like a diamond, the capsule splashed down right on schedule and well within view. Because of the nearness, only 6 planes from each carrier took off, as a salute to the astronauts.

   _________ planes on each carrier were ready to take off instantly.

   _________ planes in all were ready to take off instantly.

5. The huge palace had 202 rooms. Each of the rooms had 2 roomy closets, and in each closet hung 2 robes. In the left-hand pocket of each robe were 2 pieces of gold. The man who owned the palace was a duke. He never slept in the same room 2 nights in a row because he didn't want the palace ghost to know where he was sleeping.

   There were ________ rooms in the palace.

   There were ________ closets in the _______ rooms in the palace.

   There were ________ robes in the ________ closets in the ________ rooms in the palace.

   There were ________ pieces of gold in the left-hand pockets of the ________ robes in the ________ closets in the ________ rooms in the palace.

6. The owner of the horse wasn't thinking when he put the animal into the pasture to graze. Near the opposite fence was an apple tree covered with delicious ripe fruit. Because the horse wanted the good things in life to last, he allowed himself to eat only 13 apples a day. After 4 days the farmer noticed that the lower branches were bare of fruit, so he moved the horse. By an earlier count, he knew that there had been 93 apples on the tree. The farmer had _______ apples left.

7. The granite statue was over 75 years old and beginning to show its age. The statue was originally 61 feet high, but it was now 12 feet shorter. Each time it was knocked over by strong winds, a new base had to be built for it. The general had won battles, but he could not conquer the weather. The statue was now ________ feet high.

8. When the day was over, the merchant counted his cakes and found that some were missing. He had opened his stall that morning with 76 cakes and had sold 48 throughout the day. But now he counted only 19. As he mounted his mule to go tell the police, he noticed cake crumbs around his mule's mouth. The merchant guessed that the mule had eaten the ________ missing cakes.

1. One by one, 379 people walked up to the painting hanging on the gallery wall. The painting was without a title, but everyone was quite sure that it was a masterpiece because the newspapers had said so. It was a small boy, the last person in line, who noticed that the painting was upside down. If each person looked at the painting for 7 minutes, it took __________ minutes for the entire group to look at it.

2. When the January 1 census was taken, there were 478 families living in the ghost town. Each family had at least 2 boys and not more than 3 girls. At the end of the year, when the December 31 census was taken, there were only 429 families living in the town. The others had mysteriously disappeared.

   When the January 1 census was taken, there were at least _______ boys living in the town.

   When the December 31 census was taken, there were _______ children living in the town if each family still living there had 2 boys and 3 girls.

3. The Penguin Aquatic Club was putting on a water show. Admission to the performance was 3 fish per penguin. For 23 days after the performance the club members feasted on the ________ fish brought by the 982 penguins who came to see the show.

4. Five puzzled boys stood around the teeter-totter on the playground. They all wanted to get on at once, but they could not figure out a way to sit so that their weights would balance. John weighed 40 pounds, Tom 60 pounds, Steve 70 pounds, Pete 50 pounds, and Frank 80 pounds. Just as they were about to give up, Pete's father came home from work. Seeing their problem, he quickly put three of the boys on one side and two on the other so that they balanced. Up and down they flew, singing cowboy songs.

   ____________, ____________, and _________________ were on one side.

   ____________ and ____________ were on the other side.

   If Tom went home for dinner, ____________ and _____________ would have to get on one side.

   If John, rather than Tom, went home for dinner, ____________ and ____________ would have to get on one side.

5. A 10-pound wheelbarrow loaded with 90 pounds of stones started to roll downhill. The men started after it, yelling for those below to watch out. As the wheelbarrow bounced over the rocky ground, 50 pounds of stones flew right and left. The wheelbarrow and stones weighed _________ pounds by the time they reached the bottom.

6. The passage beneath the house had been there for centuries. It went to the right for a distance of 50 feet and then went to the left a distance of 70 feet. At the bend of the passage was a green door; at the end of the passage was a blue door. A man stood at the entrance to the passage trying to decide which door to enter. He heard music behind the green door and running water behind the blue. Slowly he moved toward the blue door. The man walked ______ feet to reach it.

7. The most unusual thing about the city library was the water fountain on the first floor. Many thought it behaved so strange because it was so close to the science-fiction section. Whatever the cause, the fountain could shoot a stream of water 120 inches into the air. For every 20 inches, the stream of water had a red-and-white bubble. The water was hot or cold depending on the mood of the librarian. Yet no one really paid much attention to the fountain. You cannot imagine how the city traffic light behaved! In one stream there were ______ bubbles.

8. Clearly his horse was in no condition to pull the wagon. The fruit peddler unhitched the animal and got into the harness himself. He made 70 stops that day and sold the same amount of fruit at each stop. His horse followed him around and occasionally bought some fruit. At the end of the day the peddler had sold 216 pounds of fruit, including the 6 pounds the horse had bought. He sold ______ pounds at each stop.

1. A dark green arrow whistled through the air and hit the bull's-eye. The peasant scored 90 points and won the match. His closest opponent was a knight who had scored only 78 points. Applause filled the air as the peasant went forward toward the queen to receive his prize, a gold arrow. Then he turned and ran into the forest before she could discover who he was. The peasant and the knight scored a total of ________ points.

2. Farmer Jones had 150 five-dollar trees in his five-dollar orchard and 24 fifty-dollar trees in his fifty-dollar orchard. These he did not cultivate as he did his hundred-dollar and five-hundred-dollar trees, but he kept his eye on them just the same! Farmer Jones had ______ five-dollar and fifty-dollar trees.

3. A famous writer of short stories was being honored for his latest story. It was only 90 words long. During the party someone asked the author if he could write an even shorter story. He immediately picked up a paper napkin and wrote: "The last man earth sat down and started to read. Suddenly there was a knock at the door." The two stories contained ________ words in all.

4. Quickly the princess lowered 86 feet of yarn she had unraveled from her scarf, but it did not touch the ground. She needed another piece 30 feet long. The window of her tower prison was ______ feet from the ground.

5. When the office building was first completed, it had 76 stories, each 10 feet tall. One year later a man riding in the elevator noticed that there didn't seem to be a floor 59. When he asked about this, he was informed that the floor had been removed from the building because not enough people were using it. He was puzzled at first and curious as to how a floor could be removed without disturbing the rest of the building. But he soon forgot the incident and didn't even care when 8 other floors disappeared. Eventually his own floor was taken away and, unfortunately, he was on it at the time. If at the end of several years the building had become 150 feet shorter, it had lost ________ stories.

6. The boy found the flute in the grass by his back fence. It had 6 holes in it, and a strange design was painted around the holes. He stuffed it into his pocket. That night he took it out and blew into it. With every puff 20 notes came out, and the funny thing was that he could actually see the notes. They just hung in the air, all black and shiny. Slowly he reached out and touched one of the notes. It fell apart, but as it did, a musical sound was heard. The flute disappeared when the boy went to bed, but the next day he found a trumpet. In all, 1840 notes had appeared. The boy puffed ______ times into the flute.

7. A fisherman found 3 open boxes floating on the sea. Each contained 20 eggs. He brought the boxes home, covered them with a blanket, and went to bed. The next morning he was awakened by a scratching sound. Lifting the blanket, he saw baby turtles clawing the sides of the boxes. A second box was filled with turtles 20 minutes later, and 20 minutes after that the third group of eggs hatched. Being a smart man, the fisherman took the turtles to a pet store and traded them for 20 times their number in worms.

The fisherman found ___________ eggs.

He exchanged the turtles for _________ worms.

1. The senator's desk was piled high with 2160 letters as a result of his speech on television commercials. He had suggested that the sponsors be required to have only one commercial per program, and that it should be at the end of the show. He separated the letters into 6 equal piles, according to what the letters said. Into one pile went "The best idea I've ever heard!" Into another went "But the commercials are better than the shows!" One pile was from sponsors explaining that no one would watch the commercials if they were at the end of the shows. The television stations wrote that the sponsors wouldn't let them do it. These letters went into the fourth pile. The fifth pile was from people who didn't watch television anyway, and the sixth was in favor of doing away with television. The senator never lost an election after that. There were __________ letters in each pile.

2. The road from New York to London was finished one year ahead of schedule. A person could now travel beneath the Atlantic Ocean a distance of 3420 miles and arrive in London without even getting his hair wet. Every 9 miles there was a gas station, yet people still managed to run out of gas. Huge windows let the motorists look out into the ocean, and there were places to pull off the road for picnic lunches. There were ________ gas stations.

3. By drinking nothing but Fizz-Up for breakfast, lunch, and dinner, Tom's family had managed to collect 2720 bottle caps. If they mailed the bottle caps by midnight that night they could receive free tickets for a vacation in Alaska. Tom's father found a huge cardboard box and poured the caps into it. Naturally the bottom fell out when it was lifted. Then they tried a wooden crate, which took all 8 members of the family to move. Finally they shipped off the crate, and their plane tickets came the following week. Once in Alaska, they lived with the Eskimos and drank nothing but Fizz-Up. It was the only liquid that never froze. If each member of Tom's family drank the same number of bottles, each one had to drink _____ bottles of Fizz-Up apiece to get enough bottle caps for the free tickets.

4. An American flag flew from each of the 21 flagpoles circling the building. As sundown neared, taps were sounded and the flags were slowly lowered. Silently the 2 soldiers waiting at the base of each flagpole folded the flags, turned, and stood at attention. Then, at the command of the officer of the day, they closed ranks and, in formation, marched toward the building. There were __________ stars on the flags that they carried.

5. One farmer at the market was selling baskets of apples. Each basket contained 30 apples. There were 5 baskets of yellow apples and 9 baskets of green apples. All the other baskets contained red apples. As customers gathered around the 62 baskets, the farmer warned them what to expect if they bought the apples. But since the customers knew that eating one of each color of these particular apples would prevent baldness, they were willing to trade with each other to get the colors they wanted.

5. (Continued)

The farmer had a total of ________ apples.
The farmer had ________ red apples.
The farmer had ________ yellow and green apples.

6. 20 dozen eggs are ________ eggs.

7. There are ________ hours in 30 days, even when one of the days is December 21, the shortest day of the year.

8. The prospector had been out in the sun all day looking for gold. Most of the afternoon the temperature had been 110 degrees, but now night was approaching and the temperature was dropping. By six o'clock it had fallen to 76 degrees, by seven-thirty it was 39 degrees, and by ten it was a cool 28 degrees. The prospector and his burro hugged the small fire and listened to the howls of the coyotes. The temperature had dropped ________ degrees in all.

9. "You must reduce," said the doctor to the 180 pound armadillo. "I order you to take off 95 pounds by two o'clock next summer." Sadly the armadillo left. He knew what he had to do. And, sure enough, by two o'clock the next summer he had done what he had had to do. He weighed only a slight __________ pounds, which is only a jot for a blot like an armadillo.

10. A truck came roaring down the country road. It hit a sudden bump and 67 of the 150 boxes of firecrackers flew out of the truck and landed in a barnyard. The force of the fall cracked open the cases, and when all was quiet again the chickens came over to investigate. Later in the week the farmer accidentally dropped an egg. The egg exploded. Only _______ boxes of firecrackers remained in the truck.

1. A cool breeze blew across the sunny meadow and brought with it the sound of humming bees. The beekeeper kept 16 hives, and all 97 bees from each hive were busy collecting nectar. The humming was such a steady sound and the sun so warm that the keeper decided to take a short nap. When he awoke, he looked and saw hundreds of bees trying to get nectar from the flowers on his shirt. The beekeeper had ____________ bees in all.

2. The teacher had a narrow-mouthed jar filled with 444 marbles on her desk. She told each of her 28 students that if he could put his hand into the jar, get at least 13 marbles in his hand by using his fingers to roll them in, and then pull out his doubled-up fist without dropping the marbles, he could keep the marbles. If each student had removed 13 marbles, ________ marbles would have been left in the jar.

3. In the month of January there are ________ hours.

4. It was the day of the auction. Excitedly the baroness bid on the 37 items she was determined to take home with her, no matter what the cost. After bidding wildly against everyone at the auction, she finally pushed the price so high that no one could meet it. Soon the 37 treasures were hers - at the fantastic price of $4.90 each. On the way to her limousine, she asked her chauffeur to open one of the boxes so she could have her first happy look at what she had bought. Inside each box were 83 pieces of banana-flavored bubble gum. She needed all _____________ pieces because her poodle liked to hear bubbles pop.

5. Mr. Mowler traveled 13 hours at an average speed of 45 miles an hour. He traveled ____________ miles.

6. During the last election 141 townspeople voted to elect a mayor. The man already in office received 50 votes, and his opponent, the judge, received 40. The rest of the citizens voted for the mailman because they thought he knew more people. The ___________ won the election with ___________ votes.

7. On a clear day the ranger could see all of the 117 mountain peaks that surrounded his valley of trees, but not today. A heavy fog had settled over the valley and blocked out all but 60 of the peaks. Crows, hidden by the fog, flew noisily about, telling the ranger that a huge bear had entered the valley. _______________ mountains were hidden by the fog.

8. One Saturday morning Ted went to an army surplus sale. He had 178 pennies in his pocket to spend. After much looking and thinking about what he could afford, he finally made his decision. He bought a giraffe for 90 pennies. Happily Ted started for home, leading his giraffe by a thin rope around its neck. What a day! He had not only his giraffe, which he had been wanting for ages, but ________ pennies in his pocket for the next army surplus sale.

9. When the moon was at its brightest, 1616 turtles came out of the sea. They arranged themselves into 4 equal groups, all with their eyes to the sky. Then the sound began. It was a low rumble at first. Then it sounded like people walking, and finally it sounded like a thunderstorm. The turtles made this sound by bouncing up and down in their shells. The groups were in tune with each other, and eventually, when the sound had the effect they wanted, a huge dragon appeared offshore. Then a cloud passed across the moon and the turtles vanished. There were __________ turtles in each group.

10. The jet airliner was traveling at a speed of 624 miles per hour. One of the passengers happened to look out the window and noticed a duck flying alongside the plane. At first it didn't bother him, but then he realized that ducks just can't fly 624 miles per hour. He called the stewardess, motioned toward the duck, and said that the plane must be losing speed. She smiled and pointed out 6 tiny engines beneath the bird's wings. She explained that these small planes, designed as ducks, were the latest thing for carrying secret messages. The duck used only one engine at a time and would use all 6 engines an equal amount of time in one hour. Each engine ran _________ minutes in one hour. In one hour, each engine carried the duck __________ miles.

1. The fisherman's mouth fell open - 81 feet in front of him he saw a hand and arm reach out of the water. The hand held a gold sword which it whirled 3 times and then threw at the fisherman. The sword landed 47 feet beyond his boat, and then it changed into a gold trout. The sword was thrown ________ feet.

2. The deeper the explorers dug, the more of the ancient city they unearthed. After months of hard work they had uncovered 76 buildings; 62 were houses and the rest were stores. The explorers felt sure that the city must have been larger than this, so they began to dig on the other side of the river that flowed past the city. There they unearthed 56 houses of an ancient suburb. The explorers uncovered ____________ houses in all.

3. The tiny elf quickly flew to the aid of his cousin, the leprechaun. With 83 high leaps through the ferns and 44 medium-sized leaps through the jack-in-the-pulpits, he reached the spot. Grabbing the leprechaun's hair, the elf pulled and pulled with all his might. Finally the tiny creature was freed from the earthworm hole into which he had fallen while looking for gold. The elf made ____________ leaps to reach his cousin.

4. The grocer had worked for an hour arranging the 210 cans of peas. Canned peas, 7 stacks all the same height, were now the first thing customers saw when they entered the store. The grocer didn't see the little boy at the far end of the aisle with the watermelon in his arms, and before his mother could stop him the child rolled the melon down the aisle with amazing accuracy. The grocer never did find all the cans. There were ___________ cans of peas in each stack.

5. The instructions on the side of the black bottle stated that the oily liquid inside was to be used to help roses grow. The label also indicated that the container held 1125 drops, and that 2 drops per day were all that should be used on a growing plant. But the woman was in a hurry to have beautiful roses, so she sprinkled all the liquid over her 9 bushes. She poured the same amount on each plant. When she got up the next morning, she found roses growing through the floor. The woman had soaked each plant with ___________ drops of the liquid.

6. The river was filled with logs floating downstream to the lumber mill. The lumberjack knew that 683 logs floated past him every minute. As he watched, he noticed that some of the logs had the word MINE painted on them. When he asked about this, his boss told him that these logs had once been the various homes of an absentminded squirrel. In 10 minutes the lumberjack saw _______ logs.

7. When Sam opened the door of the bank and stepped inside, he suddenly found himself surrounded by laughing, cheering, shouting men and women. Just as suddenly everyone was quiet. The crowd parted as a red-faced old gentleman came forward to shake Sam's hand. He congratulated Sam on being the bank's thousandth customer that year and handed him a check for $800. He mentioned in his little speech that the bank had given away $800 to the thousandth customer every year for the last 90 years. Sam thanked him and congratulated himself on being so lucky. He had only come inside to get out of the cold. The bank had given away _________ dollars during the last 90 years.

8. The snow was rapidly covering the trail, but the Mountie's dog could still follow it. The kidnapped fur trader had dropped a bag filled with 300 beans every 100 feet along the trail, hoping that someone would realize he had been kidnapped and come to his rescue. Fortunately the Mountie's dog was especially trained to follow the scent of dried beans. Within an hour the Mountie had captured the bears who had kidnapped the trader. That night the Mountie, his dog, and the trader ate hot bean soup. If the trader dropped 70 bags of beans, he dropped ___________ beans.

1. The upright sword in the statue's hand was exactly 3 feet long, and the tip was 12 feet from the ground. On April 14 the sun rose behind the statue and caused the sword to cast a shadow 22 feet long. The shadow ended at a metal ring buried in the ground. If someone had pulled on the ring, he would have lifted a metal cover and exposed a hole 4 feet wide, 7 feet long, and 12,402 feet deep. Had he been brave enough to climb down the ladder inside, he would have found the blueprints for the original bathtub. If the numbers that appear above in this problem are added together and divided by 8, the answer is ______________.

2. The clock chimed twice, 8 trucks pulled up to the warehouse, and 103 boys and girls came running out to unload the cargo of 7992 ping-pong balls. They unloaded the same number from each truck. The trucks were emptied in a matter of minutes and the world's largest ping-pong tournament could continue. Three days later all the balls were cracked and useless, but a winner had been declared. It was someone's pet gorilla. Of course, the animal saw white spots in front of his eyes for the next month, but he had won. There were _______ ping-pong balls in each truck.

3. There was once a pencil that would write nothing but good stories. As soon as a person placed this pencil between his fingers and held it above a piece of paper, the pencil would begin to write words that the author himself could never have thought of. But, being a pencil, it wore down and had to be sharpened. In its lifetime this pencil wrote 6 short stories, 2 poems, and 1 play each containing the same number of words. If the pencil was responsible for 19,224 words, each piece of writing contained ______________ words.

4. A grocer buys 300 boxes of apples. The apples in each box weigh 45 pounds. The grocer buys ______ pounds of apples in all.

5. An airplane travels an average of 500 miles per hour. In 34 hours it has traveled ______________ miles.

6. A book of 300 pages has an average of 40 lines on a page. The book has _________ lines.

7. In a circle round a large flat rock stood 17 giant oak trees, each about 600 feet from the stone. Every Halloween a funny little witch suddenly appeared on the rock and, pointing to each tree in turn, changed it into a black cat. Then she took 17 pieces of string each 600 feet long, tied bits of catnip onto them and threw the strings out so that the bits of catnip were under the noses of the cats. As she wound up the strings, the cats came and stood beside her. When all 17 cats were on the rock, the witch said a few magic words and she and the cats vanished. By sunrise the trees were back in place. Now the rock is part of a superhighway and the trees have become daily newspapers. The witch used ________________ feet of string.

1. The 40 boxcars, each containing 670 pounds of feathers, were on their way to a pillow factory. There were enough feathers to make at least 5000 pillows. Unfortunately, the engineer was allergic to feathers. Finally he could stand it no longer, so he let loose all the feathers. In a nearby town several children ran to get out their sleds. They thought it was snowing. The scratching engineer let loose ____________ pounds of feathers.

2. Definitely something was wrong! The electric current that went into one end of the 50-foot cord was only 220 volts, but the meter at the other end showed 50 times that amount. As the scientist puzzled over this, he wondered if the metal from which the wire had been made had anything to do with it. After all, wire usually wasn't made from metal found in a meteor. The meter showed ___________ volts coming out of the wire.

3. There were 30 statues in the prince's garden, and each wore a crown of grapevines. There were 470 grapes among the leaves of each crown. The statues had been brought from Rome and were believed to be at least 560 years old. Of course, the plot to kidnap the prince was revealed when 18 of the statues scratched their heads. There were ___________ grapes on all the crowns.

4. A column of men, women, and children - 66 in all - walked silently down the road. They soon reached the edge of a large meadow and stopped. At that moment another group of 66 appeared on the other side of the meadow. As if by signal, 9 men from each group ran onto the meadow. A whistle blew and the baseball game began. _______________ persons watched the game.

5. A traffic jam involved a backup of 86 cars for 6 blocks one way and 98 cars for 7 blocks the other way. When the policemen on horseback finally fought their way through to the cause of the snarl, they found a cow standing in the intersection. She was so frightened that she could not move. The police acted like cowboys and herded her off to a grassy vacant lot. There were ___________ cars in the traffic jam.

6. In one hand the little man held the strings of 49 helium-filled balloons. In the other he carried a shopping bag filled with 55 bags of peanuts. As he walked through the park, he felt a sneeze coming on. Reaching into his pocket for his bright red handkerchief, he lost hold of the balloons. Wildly he grabbed for the strings, dropping the peanuts. Quickly the pigeons came to have a feast. The little man sat down on a park bench and laughed. The peanuts were all gone and the sky was filled with balloons. He had lost ________ balloons and bags of peanuts, but the sky was pretty and the pigeons were happy.

7. Two men watched silently, not daring to speak. A huge eagle flew overhead with a basket clutched in its talons. When the eagle was above a clearing, it dropped 17 blocks of salt from the basket onto the meadow below. The bird did this 17 times and so formed a circle of white. As soon as the last salt block had been dropped, a hole appeared in the center of the circle and 17 bears climbed out. They rushed to the salt. Each carried the same number of blocks back to the hole and disappeared. One man turned to the other and asked, "Think anyone will believe us?" Each bear carried away _________ blocks of salt.

8. Boy Scout Troop No. 56 was having its first overnight hike. As the 73 boys settled down in their tents, more than one wished he were back home. The forest was dark, the ground hard, and the moaning wind kept them awake. The wind also blew 438 balls of fuzz, but then the groundhogs burrowed into the boys' sleeping bags to keep warm. The same number of groundhogs burrowed into each sleeping bag so each bag had _________ groundhogs keeping warm.

9. At the beginning of August there were 638 streetlight bulbs in the town of Twine. Each day the same number of bulbs disappeared. Three weeks later there were 491. The mayor could not explain the disappearance, nor could the town's electrician. Nevertheless the bulbs were gone and the streets were dark at night. Eventually it occurred to someone to look for the light bulbs in the town's doghouses. Of course, that's where they were. How many bulbs disappeared each day? _____________

1. The school playground had a slide 232 feet long. It was the shiniest, smoothest, and most magnificent slide in the whole world. Every child in the neighborhood shot down that hill of steel in exactly 58 seconds, dreaming and screaming that he or she was a pilot or champion diver. But the best part was soaring into the air at the end of the slide. Some landed in the sand with a thud, others skidded to a stop. The children traveled an average of ____________ feet per second.

2. A Roman emperor once ordered a group of 196 soldiers and their captain to march from the city and to continue marching until ordered to stop. The men set out. They passed from city to city and from country to country, but the order to halt never came, because the emperor had forgotten about them. At the end of the first year the captain counted his men and found 28 missing. Still he ordered the men to march on, and he lost 28 of them each year that passed. Finally only the captain was left. He was older and wiser by then, so he stopped marching and became a farmer. The captain's men had all disappeared at the end of _________ years.

3. An elf will eat 67 dandelions a week. If he is especially hungry, he will usually swallow a few sunflowers as well. _________ elves would eat 268 dandelions a week.

4. The floor of the ocean was at least 181 fathoms deep, and the diver's body could only withstand the pressure of 93 fathoms. Calmly he radioed the captain to have him surfaced. A submarine would have to do this job. A sub could descend to the ocean floor ____________ fathoms deeper than he could.

5. A scientist once invented a machine that could turn out 177 metal ashtrays per hour. One day it only turned out 99 ashtrays per hour. The scientist noticed that these latest ashtrays had the letters IHAC stamped on them. Since he was a good friend of the machine, he asked it what was wrong. On the next ashtrays were the words I HAVE A COLD. The scientist quickly gave his friend a squirt of oil wrapped it in a warm blanket, and sang it to sleep. The machine turned out ________ fewer ashtrays when it had a cold.

6. A jet fighter streked over the helicopter at 525 miles per hour, shot up through the clouds, and was lost to view. The copter pilot shrugged his shoulders and kept on chugging along at 78 miles per hour. He didn't care that the jet was going ________ miles per hour faster than he was.

7. When Oscar walked onto his front porch that morning, he nearly tripped over 27 wooden crates. Thinking that a mistake had been made and that the crates had been delivered to the wrong address, he looked at the address tag. But no, they were all for him! Each was 2 feet wide, 2 feet long, and 2 feet deep, and weighed about 50 pounds. Inside each box Oscar found 660 baby mushrooms and a note. He was the lucky person to have been awarded a lifetime supply of mushrooms that could be grown in his basement. Oscar could raise ___________ mushrooms if he wanted to.

8. 390 dozen ice-cream cones = ____________ ice-cream cones.

9. A line of 150 chinchillas, each 12 inches long, makes a line ________ inches long. A line of 730 chameleons, each 16 centimeters long, makes a line ____________ centimeters long.

10. The jeweler quietly locked the front door and slipped away into the night. The 32 alarm clocks that lined the shelves seemed to tick just a little louder. Then one alarm went off. It rang for 760 seconds. The very instant it stopped, the clock next to it started to ring. It also rang for 760 seconds. Each of the 32 clocks rang, one right after the other, for the same length of time. Then a small mouse went around and pushed in all the alarm buttons. The last clock stopped ringing ________ seconds after the first one began.

1. All morning the boy had been walking along the beach. He had collected 14 seashells, 38 stones, 21 dead fish, and 46 pieces of driftwood. He planned to open a seaside museum and make enough money by charging admission to retire at the age of 10. The boy had collected ___________ objects.

2. With amazement the old woman hid behind a tree and watched the parade. Headed straight for the side of the mountain were a man playing a flute, 49 boys, 63 girls, 11 goats, 16 lions, 23 men on white horses, and a rooster. Just as they were about to reach the mountain, a door opened in front of them and the parade entered. As the last tail feather of the rooster cleared the opening, the door slammed shut, and they were never seen or heard of again. ________ persons disappeared, and ________ animals disappeared.

3. It was the day of the annual frog-jumping contest. From all over the country 847 persons had come to San Francisco to enter the contest. All hoped to win the grand prize of $1000 but, more than that, they wanted to show off their frogs. In case some of the frogs got sick, each contestant had brought along at least 20 frogs. The winning frog would be the one that covered the greatest distance in 3 leaps. The contest lasted all day long, and at the end of the day, with great fanfare and excitement, the winner was announced. It was a large bullfrog from New Orleans, and it ate nothing but Mexican jumping beans. At least ______ frogs were brought to the contest.

4. The politician's press conference was attended by 117 photographers. While he spoke, each photographer took pictures from every angle. Each used a complete roll of film. The politician spoke about the need for better schools, better roads, and lower taxes. Later, after the pictures had been printed, it was discovered that the politician's socks didn't match. If each roll of film contained 30 exposures, ____________ pictures were taken.

5. An apple tree was planted at one end of the block and a pear tree at the other. Not one of the 29 families living between the two knew who planted them, but they did know that the total of 145 pieces of fruit that grew on the trees was always sweet. The apple tree had a bandage around its trunk where a boy had tried to carve his initials. The pear tree had a red flag to show that it had been burned down once. Now, with the help of the people on the block, these trees lived happily. How many pieces of fruit would each family have if all pieces of fruit were picked at one time and divided equally among the families? ____________

6. There were 693 steps from the sidewalk to the entrance of the music hall. When anyone stepped on the first step, a single, clear musical note could be heard. As the person climbed, a different note would sound with each step. On the 77th step a melody would be completed. The same thing happened on the next 77 steps, only with a different melody. Stepping on the last step caused the doors of the hall to swing open. The steps played _____________ melodies.

1. The 57 collectors stood around the glass case. They stared in awe at the single stamp inside. Each of them had brought his 853 most valuable stamps with him to the exhibit, but no one had brought a stamp as rare as the one in the case. The picture on the unusual stamp was that of a cow with her right hind foot stuck in a milk pail. Finally the guard admitted that his daughter had found the stamp on the side of a milk carton, and he had placed it in the case as a joke. All together, the collectors had brought ____________ stamps to the exhibit.

2. A merry-go-round owner bought 36 new wooden animals for his big merry-go-round. If each animal weighed 165 pounds, the total weight of the new animals was ________________.

3. The caravan of 32 camels had stopped for the night. Now the animals knelt beside the water hole, filling their stomachs for the days ahead. The Arab's wares lay on the ground - 189 rolls of silk for each camel. The moon was bright that night, so if the guards had been awake they could easily have seen a large white camel move slowly toward the camp. They also could have seen the other camels stir, then rise and follow the great white beast into the desert. The Arab was left with ___________ rolls of silk.

4. There was no doubt about it, a spaceship had landed in the center of the baseball diamond. The 5520 people in the stands all blinked their eyes at the same time, but the spaceship didn't go away. As they watched, a door opened and a robot came out. The mechanical man moved over to home plate and blew a whistle, and 91 other robots came out and formed a line behind him. The people hadn't budged an inch. The first robot then announced that for the next hour he and the others would be giving away tickets for a ride in the spaceship. At that the spectators all rushed from their seats, grabbed the free tickets from the robots, and boarded the ship. Unfortunately, no one had enough money for the return trip. If the robots each gave away an equal number of tickets, each robot gave ______ tickets away.

5. The zoo's seal barked, clapped its flippers, swam underwater, leaped out of the water, and rang a bell. He gave this performance 6 times an hour, 6 hours a day, 5 days a week, 2 weeks a year. The rest of the year was spent storing up energy. As a reward for its efforts, the seal was fed 12 extra fish at the end of the 2 weeks. Now this may not seem like fun to you, but then you aren't a seal! This meant the seal must perform _________ times to receive 1 extra fish.

6. The book had a dull-green cover, no title, no author, and all the pages were blank. John had just found it on the sidewalk that day. When he opened it later, he found words on the first page that had not been there before. As John finished reading the words on the first page, that page became blank again and words suddenly appeared on the second page. All 560 pages went along like this. In addition, the last page of each of the 28 chapters contained a photograph of a city, a machine, or a person John had never seen before. John lived to see many of the things described in the book come true. If all

6. (Continued)

the chapters were the same length, each chapter contained ________ pages.

7. An airplane reached the clouds 167 minutes after takeoff. It appeared over New York City 229 minutes later, its wings covered with ice so that its speed had been greatly reduced. The plane appeared over New York City __________ minutes after takeoff.

8. During the last two months Mr. Bass, the owner of a fish market, has sold 115 whitefish and 721 trout. He has sold ___________ whitefish and trout during the last two months.

9. As the businessman drifted to the ground securely buckled in his parachute, the wind suddenly tore his briefcase from his hands, and soon the air was filled with ten-dollar bills. The birds used 856 bills that landed in a forest to build nests. The remaining 137 fell into a chicken yard and were never seen again. The businessman cried all the way to the ground. There were _________ ten-dollar bills originally in the briefcase.

1. As the music-box ballerina turned, Susan noticed that the dress changed color every 36 turns. After watching for 2 hours, she also realized that each time the dress changed color, the ballerina moved a bit closer to the edge of the box. When the dress had finished changing color, the ballerina jumped onto the bed, remained there for 20 minutes, then took 3 steps to the windowsill. There the lovely ballerina turned 4 times, leaped 5 feet to the ground, and disappeared. If the ballerina turned 2160 times, the dress changed color ________ times.

2. Joe decided that what the world needed was a pair of eyeglasses with windshield wipers. It was hard for him to see in the rain while wearing his glasses. Running down to the junkyard, he bought the wipers from a truck, used his chemistry set to reduce their size, and found a motor in an old clock to make them automatic. Joe was most unhappy to find that his wipers worked only in the sunlight. The wipers wiped 24 times per minute, so they wiped 1920 times in ________ minutes.

3. At last count a baseball umpire had received 547 letters praising him for benching the star player. When he looked at the handwriting however, he noticed that 438 of the letters had been written by the same person - the opposing team's coach. The umpire recieved ______ letters from people other than the coach.

4. For weeks and weeks Jane had saved the bubble gum she bought with her allowance. Finally she had 453 sticks. Then she gave 125 to her mother for a birthday present. Jane had ______ sticks of bubble gum left.

5. The inspector carefully sorted through the 982 coffee beans in front of him. Carefully he picked up one, studied it under his magnifying glass, and then dropped it into a huge grinder. It took him 1 minute per coffee bean to do all this. At the end of 2 hours and 26 minutes, he stopped sorting and turned off the machine. He now had enough coffee to make one cup for his morning coffee break. The inspector did not grind ________ coffee beans.

6. At first everyone thought the appearance of 190 clowns in Central Park every day was some kind of advertising trick. Perhaps the clowns were calling attention to a new toy on the market. But after 200 days people began to wonder. The children who played in the park were the first to notice that the bushes changed color when a clown's costume brushed against them. If a different group of clowns appeared in Central Park every day, how many clowns had appeared all together when people began to wonder about them? ______

7. Once there was an unusual breed of centipede. There were only 800 centipedes like them in the whole world. Each wormlike animal was unusually long and had 750 legs. All together, the 800 unusual centipedes ________ legs.

8. He saw the mountain simply fall apart. Then he heard the blast. Now there were 680 tons of rock and dirt waiting to be loaded by steam shovels into the trucks. The foreman figured it would take 1 day to remove 680 tons of rock and dirt. He also figured it would take 299 more days moving 680 tons each day to remove the other mountains and make way for the first shopping center in the Alps. There would be __________ tons of rock and dirt after 300 days.

1. He found the coin when he was trying to fix the loose floorboard. It was stuck in the dirt. According to the date, it was 900 years old. Thinking that there might be others and that they must be extremely valuable, he started to rip up the floor. Board after board he removed, but the man could find no more coins. Finally he found a bag containing 872 coins just like the first one. Then, turning one over in his hand, he read that the coin could be used to purchase 400 peppercorns from Thailand. How many peppercorns could have been purchased with all the coins? ______________

2. A wise man once sat at the foot of a throne telling a story to anyone who wanted to listen. The king had promised him food and shelter for as long as he wanted, provided he would tell a story for one hour each day. He had now been talking for 363 days and had spoken no fewer than 900 words an hour. Yet his story seemed no closer to the end than when he had begun. One day a knight asked him how he could talk so long about one person. "It is easy," the wise man answered, "I am speaking of myself and so will spend the rest of my life here." The wise man had spoken no fewer than ______ words at the end of the last day.

3. Paul has 336 U.S. postage stamps and 188 foreign stamps in his collection. He has a total of __________ stamps.

4. The knight's armor weighed 166 pounds. The knight weighed 257 pounds. Therefore no one but the knight was surprised when the small wooden bridge he was crossing collapsed under him. The knight and his armor weighed ___________ pounds.

5. According to the map, the treasure was buried just 638 feet to the north and 576 feet to the east. The three men eagerly paced off the distance, but they did not find the big rock they had expected to see. Looking at the map again, they noticed for the first time the words PACIFIC OCEAN. They were in the wrong ocean. The men walked _____________ feet to get to the rock.

6. The moment had come! As the skydiver stood in the doorway of the plane, he realized that he would actually have to jump. With his heart beating wildly, he remembered the last time. On his way down he had met a checkered parakeet flying up. The bird perched on his nose and announced in a booming voice, "The next man to invade my air will have to eat the same amount of birdseed each day for 12 days in a row, a total of 144 boxes in all." The skydiver, still frightened by these words, closed his eyes and jumped. After what seemed to be 2 hours, he opened his eyes again, relieved that all had gone well. "Next time," he said to himself, "I'll try it with the plane in the air." If he had met the checkered parakeet again, the skydiver would have had to eat ________ boxes of birdseed a day for 12 days.

7. As the moon slid behind the odd-shaped clouds, 52 Indians crept from behind a nearby tree and began their snow dance. When the chief, who was 79 years old, decided that he was getting tired, he called the dance to a halt. If they were to have snow, arrows must be shot. Without a sound, the Indians shot 676 peppermint-flavored arrows into the air, each Indian shooting the same number of arrows. Each Indian shot __________ peppermint-flavored arrows.

1. The apartment building was supposed to be 912 feet tall when it was finished. Unfortunately, the construction company could not hire workmen who would work that high above the ground. So construction stopped at 476 feet. The top apartments were rented to the birds. The building was ________ feet short of the goal.

2. The detective opened the telephone book to page 658 and found a red circle drawn around the name Sharon Mendeles. Since he did not think the name itself to be important, he counted the names above it - 725. Then he counted the names below it - 197. He subtracted and got a difference of __________. Thus he discovered the number of the apartment where the money was hidden.

3. Susie loved peanuts. One day she ate 931 and got sick at her stomach. She decided that she had eaten 434 too many. "I must count," Susie said, "and stop when I have eaten ______ peanuts." So she did. Susie was a smart elephant.

4. As the ant procession headed toward the huge chocolate cake, the fourth ant in line tripped and fell, causing all 36 to fall. Relieved that they weren't carrying cake at the time, the ants began to line up again. But Number 4 forgot his place in line. Not knowing what to do, he took Number 5's place, who in turn took the space assigned to Number 6. Number 6 had no choice but to go to Number 7's place, and so on down the line. By the time they had finally figured out who went where, the cake was stale. If 2196 crumbs were to be carried away and they all carried the same load, each ant carried __________ crumbs of stale cake.

5. It was the night of the annual party sponsored by the town council. All the people were dancing, laughing, and enjoying themselves when, with no warning, the lights went out. The 58 persons present moaned, "Oh, no ..." There was no other building in town large enough for the dance. Then suddenly Harvey Seamore came up with an idea. He had only to say one word to get everyone moving. "Fireflies!" said Harvey. Soon the town square was alive with 58 people, jars in hand, catching the glowing fireflies. Shortly after nine o'clock the party was under way again, the room glowing brightly. If 2146 fireflies were caught, and each person caught the same number, each person's jar contained _______ fireflies.

6. The president prided himself on making speeches exactly 870 words long. At the end of the president's first year in office, a reporter was assigned the task of writing an article about his speeches. The reporter discovered that the president had made exactly 170 speeches during the year and had used exactly ______ words.

7. Mr. Langstrom had a large backyard, but nothing would grow there. The bugs, squirrels, birds, and bad weather stopped anything from taking root. One day Mr. Langstrom planted a dark thorny tree in the center of the yard. Its 583 berries were so sour and its 992 thorns so sharp that the birds and squirrels would not go near it. When 674 bugs tried to eat the leaves, they curled up and died. The worse the weather was, the faster the tree grew. Unfortunately, it smelled so bad that Mr. Langstrom decided to chop it down. He chopped and chopped, but he could not chop it down. For 870 days, from morning until night, he worked, making 730 ax cuts each day. Mr. Langstrom thought he could hear the squirrels laughing.
Mr. Langstrom made __________ ax cuts in the tree but still could not chop it down.

1. The tailor was puzzled when he received the black envelope in the morning mail. Inside was a message that read "Come to the corner of 12th and Crackerly tonight at 12:01 - alone." Frightened, but curious, the tailor went. After waiting 20 minutes, he was about to leave when a 31-inch-tall elf popped out of the ground. She looked just like anyone else except that she was smaller and had a yellow flower growing out of her head. She explained that she and her friends had decided to give the tailor 1116 pieces of cloth which would keep people warm in the winter and cool in the summer. It would be waiting for him when he got home. After thanking her, the tailor ran home in great excitement. By using all the cloth, he could make 36 suits. It wasn't until 26 days later that he discovered that the material melted in the rain. Each suit required ______ pieces of cloth.

2. Most of the people in town pointed in disbelief at the sight of the fish flying overhead. The radio reported that there were 3404 fish in all, but no one could tell for sure. An emergency meeting was called and after 3 hours it was officially decided that because the lake was drying up, the fish must be searching for water. Suddenly they heard the splashing of water. Without looking, the people knew that the fish had found the 74 swimming pools in town. There were the same number of fish in each pool. By 7:45 P.M. there were ______ fish in each pool.

3. It was a very modern city and most of its bigger buildings were made of steel and glass. Because of this the city employed the largest number of window washers in the country. There were 761 to be exact. Each washer had the same number of windows to keep clean, and each took real pride in his work. The day after Halloween each complained bitterly as he tried to get soap off his windows. If each window washer was responsible for 540 windows, how many windows did all the window washers wash? ______

4. The highway was jammed with 163 buses traveling to the hockey game. Each bus carried 160 singing, shouting passengers who were all former hockey stars. After they had arrived and the game had begun, some of them became so excited that they leaped onto the ice and began to play. The buses held ______ passengers.

5. The steam whistle on the riverboat had to be blown 260 times on the way down the river and the same number of times coming back up the river. The riverboat made 338 round trips each season. The whistle was blown ______ times in a season.

6. A wealthy farmer owned 6429 chickens, 1538 cows, 2779 pigs, 3681 ducks, and 1 horse. He used the chickens for Sunday dinners, the cows for beef, the pigs for ham and bacon, the ducks for pillows. He then rode the horse to the city and sold it. He took a job as a zoo keeper.

   The farmer owned ______ four-legged animals.
   The farmer owned ______ feathered friends.
   The farmer owned ______ animals.

7. Her rocket ship was in orbit. Right on schedule Polly opened the door and stepped out. Going first one way then another, it was obvious that she was looking fore something. She walked 5682 miles in one direction, 328 in another, and 8943 miles in still another. Polly walked ____________ miles looking for her cracker.

1. The rays of the morning sun had just crept over the mountains when the sound of a horse's hoofs echoed across the desert. It was then that a great stallion appeared in the center of a flat plain, his head high, signaling to his herd to follow. They did, all 583 of them. The same thing happened the next day, the day after that, and for the following 206 days. There was a different herd and a different stallion each day. The horses were fleeing from men who wanted them for their ranches. In all ________ horses fled.

2. A piano tinkled in the next room. The small boy was practicing again. The piece he played had 923 notes, and although he played each note only once, it seemed to him that the piece must have 923,000 notes. But he kept at it, day after day, until playing the notes was as easy as eating bread and butter. It took him 103 days to do it, but he finally learned to play "Happy Birthday." In 103 days the boy played __________ notes.

3. It was cold and an icy wind was blowing snow across the mountain. George had 2863 feet to go to reach the peak. His dog, Nut, had gone ahead and had only 1201 feet to climb that day. Both George and Nut made it to the top safely and then descended to receive cheers of the skiers and a medal from the prime minister. George got the bigger medal from the prime minister, since he had climbed ______ more feet than Nut that day. Just as the prime minister reached out his hand in congratulations, Nut nudged George and knocked him out of his hammock.

4. A band of 1123 musicians filled the stage. Just as the conductor raised his baton, the basson player sneezed. Soon 1009 adults and 3 children were sneezing. Those who weren't sneezing were laughing. _________ persons were sneezing. ____________ were laughing.

5. By June the city pound had found homes for 6982 dogs and cats. It had also found homes for 8749 rats and mice. The city pound had found homes for _____ more rats and mice than dogs and cats.

6. One day Charlie decided to fly over to visit his cousin George. As he took off from his favorite tree, thud! - down he went. "Why can't robins fly the way they used to?" Charlie wondered as he pecked his feathers 9 times to smooth them down. Then he waddled behind a chocolate bush to think. After thinking for 17 minutes, Charlie realized that he had been eating too many worms from the chocolate bushes lately and had become too fat to fly. If Charlie had eaten 315 worms from 9 chocolate bushes, the same number from each bush, how many worms had he eaten from each bush? ___________

7. It was circus time at Maplewood. People had come from all over the world to see the Magic Carbons. There were 3 performances each day, and each performance was more exciting than the last. The show turned into a disaster, however, when Norman's Dog Snowy limped by. It seems that dogs aren't welcome at a flea circus. If the Magic Carbons performed 963 times in Maplewood, how many days did they perform? ___________________

1. Twelve tiny bugs made their home 26 inches deep inside a large striped watermelon that grew on a vine in Mr. Liggett's garden. They had the best melon on the vine. There was a bedroom for each bug and an elegant living room for all 12 to share. One day the weather turned cold and the tiny bugs discovered that they had no heat. They turned and twisted the watermelon seeds, but no heat came. Finally they decided that they would have to move. Since it took one bug 284 bites to eat his way out, it took him about ______ bites per inch.

2. One fine spring day about four o'clock in the afternoon, Sue decided to go for a walk. As she passed the drugstore, she looked up to see a herd of 294 baby elephants coming down the north side of the street. Every third elephant raised his left front leg and kicked a parked car. That afternoon about ________ cars had to be put in the repair shops.

3. Every painting shown at the art fair was 32 inches long and 24 inches wide. Most of the paintings were flashy and bright, but some were very mysterious. Of the 753 paintings on exhibit, all were painted on canvas. If each painting required 235 strokes to complete, the artists used _________ strokes all together.

4. One generator in the city had 322 cables running from it. Each cable supplied electricity to 479 homes. The city was always sending men to inspect the cables to make sure that they were never in danger of falling to the ground. However, all this attention did not stop birds from pecking at them. Eventually the cables were covered with birdseed as a peace offering to the birds. The generator supplied electricity to __________ homes.

APPENDIX D

POSTTEST OF PROBLEM-SOLVING ABILITY

Arithmetic Reasoning

This is a test to see how well you can do number problems. You will find some arithmetic stories and then some questions about the stories. Study the story and sample questions below.

Sam had 6 puppies at home just 5 weeks old. He gave his cousin Betty one puppy and kept one for himself. He sold the rest of the puppies for $2.25 each.

S1. In this story we are told

- A. how many puppies Sam sold
- B. how much Betty gave Sam for her puppy
- C. how much money Sam received all together for the puppies he sold
- D. how many puppies Sam had at home before he gave away or sold any
- E. None of these

S2. Before we can figure how much Sam received for the puppies he sold, we will first need to figure

- A. how old the puppies were
- B. how much Sam got for each puppy
- C. how many puppies he sold
- D. how much he would have received if he had sold all the puppies
- E. None of these

S3. To figure how much Sam received for the puppies he sold, we will need to

- A. divide $2.25 by four
- B. multiply $2.25 by four
- C. multiply $2.25 by five
- D. add $2.25 to the cost of the puppies
- E. None of these

S4. The amount of money Sam received for the puppies he sold was

- A. $ 2.25
- B. $ 8.00
- C. $11.25
- D. $13.50
- E. None of these

The answers to these sample questions are to be marked in the section called "Arithmetic Reasoning" on Side 1 of your answer sheet.

In this test you are often asked a question like sample question S1. You can find the answer to this kind of question without doing any figuring at all. Without figuring we know how many puppies Sam had at home before he gave away or sold any, so the space for answer D has been marked in row S1 on your answer sheet.

Now mark the answer to question S2 in row S2 on your answer sheet.

In row S2 you should have marked the space for answer C, because we must know how many puppies Sam sold before we can figure how much money he received.

Now mark the answers to questions S3 and S4. If you need to figure, use the scratch paper you were given. Do not mark in the test booklet.

In row S3 you should have marked the space for answer B, because Sam sold four puppies for $2.25 each. We have to multiply $2.25 by four to figure how much Sam received for the puppies he sold.

To find the answer to question S4, you must work the problem on scratch paper. Sam sold 4 puppies for $2.25 each, so he received $9.00. Because none of the figures given is the right answer, you should have marked the space for answer E in row S4. There will be other problems in this test for which the right answer is not given. Work the problem before looking at any of the answers. If your answer does not agree with any of the answers given, make sure your figuring is correct, then mark space E, and go on to the next problem.

Be sure to mark the answer to each question in the answer row numbered the same as the question. Remember to mark only one answer for each question. Make your marks heavy and black. If you change your mind about an answer, be sure to erase your first mark completely.

Look at the table to see where you are to start and stop.

Answer Sheet Color	Start with	Stop after
Blue	Question 1, page 4	Question 43, page 9
Green	Question 21, page 7	Question 63, page 12
Red	Question 44, page 10	Question 86, page 15

Blue Answer Sheet Starts Here

JIM AND LUCY COUNT THEIR PETS

Jim and Lucy counted their pets.

Jim had	Lucy had
3 puppies	10 baby chicks
2 turtles	2 kittens
5 white mice	5 ducks
6 rabbits	3 rabbits

1. We are told in the story
   A. how many pets Lucy was given
   B. how many pets Lucy feeds every noon
   C. how many turtles Jim would like to have
   D. how many rabbits Jim had
   E. None of these

2. If Jim wanted to find out how many pets he had all together, he could
   A. add 10 and 5
   B. add 3, 2, 5, and 6
   C. add 3, 5, 2, and 10
   D. take 3 from 10
   E. None of these

3. If Lucy wanted to know how many more baby chicks than ducks she had, which of these examples could she work?
   A. $\begin{array}{r} 2 \\ +\ 10 \\ \hline \end{array}$
   B. $\begin{array}{r} 5 \\ +\ 10 \\ \hline \end{array}$
   C. $\begin{array}{r} 10 \\ -\ 2 \\ \hline \end{array}$
   D. $\begin{array}{r} 10 \\ -\ 5 \\ \hline \end{array}$
   E. None of these

4. To find out how many more rabbits he had than Lucy, Jim could
   A. add 3, 2, 5, and 6
   B. add 6 and 3
   C. take 3 from 6
   D. take 6 from 3
   E. None of these

5. How many more pets of all kinds did Lucy have than Jim?
   A. 36
   B. 20
   C. 16
   D. 7
   E. None of these

6. How many more chicks than ducks did Lucy have?
   A. 5
   B. 8
   C. 15
   D. 50
   E. None of these

MARY AND JACK WORK IN THE GARDEN

Last month, Jack and his older sister, Mary, helped Mother and Dad in the garden almost every Saturday.

Mary worked 12 hours for \$.25 an hour.

Jack worked 15 hours for \$.20 an hour.

7. We are told in the story that
   - A. Mary worked 15 hours
   - B. Jack was paid 20 cents an hour
   - C. Jack worked 12 hours
   - D. Mary was paid 20 cents an hour
   - E. None of these

8. What could Jack do to find out how much money he has earned?
   - A. Add 12 hours and 15 hours
   - B. Add \$.25 and \$.20
   - C. Multiply \$.20 by 12
   - D. Multiply \$.25 by 15
   - E. None of these

9. Which of these examples shows what Dad could do to find out how much he should pay Mary and Jack for their work last month?
   - A. $\begin{array}{r} 12 \\ \underline{+\ 15} \end{array}$ times $\begin{array}{r} \$.20 \\ \underline{+\ \ .25} \end{array}$
   - B. $\begin{array}{r} \$.20 \\ \underline{\times\ \ 12} \end{array}$ and add $\begin{array}{r} \$.25 \\ \underline{\times\ \ 15} \end{array}$
   - C. $\begin{array}{r} \$.25 \\ \underline{\times\ \ 12} \end{array}$ and add $\begin{array}{r} \$.20 \\ \underline{\times\ \ 15} \end{array}$
   - D. $\begin{array}{r} \$.20 \\ \underline{\times\ \ .25} \end{array}$ and add $\begin{array}{r} 15 \\ \underline{\times\ 12} \end{array}$
   - E. None of these

10. Mary earned
    - A. \$2.00
    - B. \$2.40
    - C. \$3.00
    - D. \$3.75
    - E. None of these

11. Jack earned
    - A. \$2.40
    - B. \$2.75
    - C. \$3.75
    - D. \$5.00
    - E. None of these

12. Mary and Jack together earned
    - A. \$12.15
    - B. \$ 6.75
    - C. \$ 6.00
    - D. \$ 5.40
    - E. None of these

13. How much more did Mary earn than Jack?
    - A. No more
    - B. \$ .60
    - C. \$1.35
    - D. \$2.00
    - E. None of these

THE BOY SCOUT PAPER DRIVE

The Wolf Patrol and the Bear Patrol had a paper drive to raise money for their clubhouse. The patrol that brought in the most paper would win a prize.

The Wolf Patrol brought in 386 pounds the first day, 498 pounds the second day, and 537 pounds the third day.

The Bear Patrol brought in 299 pounds the first day, 504 pounds the second day, and 628 pounds the third day.

14. We are told in the story
    - A. the total number of pounds of paper brought in by the Wolf Patrol
    - B. the number of pounds needed to win the contest
    - C. what we need to know to find out who won the prize
    - D. the total number of pounds brought in by the Bear Patrol
    - E. None of these

15. To find out which patrol won the prize, we will need to figure out
    - A. the total number of pounds of paper brought in by both patrols the first day
    - B. which patrol brought in the most paper on the last day
    - C. which patrol brought in the most paper on the second day
    - D. how many pounds were brought in by each patrol for all three days
    - E. None of these

16. To find out which patrol won the prize, we could
    - A. add then subtract
    - B. add then multiply
    - C. divide then add
    - D. subtract then multiply
    - E. None of these

17. Which of these examples could the Bear Patrol work to find out how many pounds of paper they brought in all together?
    - A. 628+504+299
    - B. 386−299
    - C. 386+498+537
    - D. 386+498+537+628+504+299
    - E. None of these

18. The Wolf Patrol brought in all together
    - A. 1411 pounds of paper
    - B. 1421 pounds of paper
    - C. 1431 pounds of paper
    - D. 1441 pounds of paper
    - E. None of these

19. The two Boy Scout patrols together brought in
    - A. 2822 pounds of paper
    - B. 2832 pounds of paper
    - C. 2842 pounds of paper
    - D. 2862 pounds of paper
    - E. None of these

20. How much more paper did the winning patrol bring in than the losing patrol?
    - A. 11 pounds
    - B. 20 pounds
    - C. 21 pounds
    - D. 30 pounds
    - E. None of these

Green Answer Sheet Starts Here

Blue Answer Sheet Continues

A CHRISTMAS PRESENT FOR FATHER

Fred and Pam planned to buy their father a Christmas present. Fred had saved \$3.49. Pam had saved \$4.83.

At the store they found that neckties cost \$2 each, but that three neckties could be bought at the same time for \$5.

21. We are told in the story
    - A. how much Pam and Fred together had saved
    - B. how much three neckties would cost
    - C. how much Fred and Pam wanted to spend
    - D. how much could be saved by buying three neckties at once
    - E. None of these

22. To find out whether they had enough money to buy three neckties, Fred and Pam could figure
    - A. how much Fred had saved
    - B. how much they had saved together
    - C. how much one necktie cost
    - D. how much three neckties cost
    - E. None of these

23. To find out how much one necktie cost at the rate of three for \$5, which of these examples could Fred and Pam have worked?
    - A. $\begin{array}{r} \$4.83 \\ \underline{+\ 3.49} \end{array}$
    - B. \$5 ÷ 3
    - C. 3 × \$2
    - D. \$6 ÷ 3
    - E. None of these

24. Fred and Pam found that together they had saved
    - A. \$5.00
    - B. \$7.32
    - C. \$8.22
    - D. \$8.32
    - E. None of these

25. How much more money had Pam saved than Fred?
    - A. \$ .34
    - B. \$ .44
    - C. \$1.34
    - D. \$1.44
    - E. None of these

26. When Fred and Pam decided to buy three neckties for their father, they found that they had
    - A. \$3.32 more than they needed
    - B. \$2.32 more than they needed
    - C. \$2.32 less than they needed
    - D. \$3.22 less than they needed
    - E. None of these

27. If Fred and Pam had bought three neckties one at a time, they would have had to pay
    - A. \$2.77
    - B. \$5.00
    - C. \$6.00
    - D. \$7.00
    - E. None of these

SALLY AND NED GO SHOPPING

Sally and Ned were sent to the store with a list of groceries to buy. Their mother gave them $5 and said they should be home by noon. The children left home at ten minutes past eleven.

Here is the list of things Sally and Ned were to buy:

$1\frac{1}{2}$ pounds of ground beef
3 quarts of milk
2 boxes of cornflakes
$\frac{1}{2}$ dozen rolls

At the store they found that:

a pound of ground beef cost	$.86
one quart of milk cost	$.23
a box of cornflakes cost	$.29
one dozen rolls cost	$.48

28. We are told in the story

    A. the time when Sally and Ned returned from the store
    B. the total cost of all the groceries Sally and Ned were to buy
    C. the cost of three quarts of milk
    D. how much of each thing Sally and Ned were to buy
    E. None of these

29. Which of these examples could Sally and Ned have used to tell how much one-half dozen rolls would cost?

    A. $.48 × 6
    B. $.48 ÷ 6
    C. $.48 × 2
    D. $.48 ÷ 2
    E. None of these

30. Which of these examples shows how Sally and Ned could have figured how much all the ground beef their mother ordered would cost?

    A. $.86 ÷ 2 plus $.86
    B. $.86 × 2
    C. $.86 × 3
    D. $.86 plus 2 × $.86
    E. None of these

31. Sally and Ned figured that the half-dozen rolls would cost

    A. $ .24
    B. $ .43
    C. $ .96
    D. $2.88
    E. None of these

32. Sally and Ned figured that the milk would cost

    A. $.29
    B. $.32
    C. $.46
    D. $.69
    E. None of these

33. Sally and Ned figured that the cornflakes would cost

    A. $.23
    B. $.48
    C. $.58
    D. $.87
    E. None of these

34. They figured that the cost of all the groceries was

    A. $2.90
    B. $2.80
    C. $2.70
    D. $1.86
    E. None of these

35. How much change should Sally and Ned have received from the grocer?

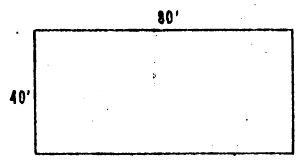
    A. $2.10
    B. $2.20
    C. $2.50
    D. $7.80
    E. None of these

36. Sally and Ned returned home at 11:55. The number of minutes they had been gone was

    A. 25
    B. 35
    C. 40
    D. 45
    E. None of these

GETTING READY TO PLANT THE SCHOOL GARDEN

Miss Brown's class was given a piece of land 80 feet long and 40 feet wide near the school building to use as a school garden. This is the way the garden plot looked:



There were 12 boys and 20 girls in Miss Brown's class. They voted to divide the land equally among all the members of the class.

37. We are told in the story that

   A. the boys were to plant one-half the garden
   B. there were more boys than girls in the class
   C. each pupil was to get the same amount of land
   D. each pupil promised to do his share of planting
   E. None of these

38. Before the class could find how many square feet of garden each pupil would get, they would need to figure

   A. how much larger $\frac{1}{12}$ is than $\frac{1}{20}$
   B. how large a fraction of the class each pupil represented
   C. how large a share of the garden the boys would get
   D. how to measure the width of the garden
   E. None of these

39. Which of these examples shows a way to figure the *area* of the garden plot?

   A.
   $$\begin{array}{r} 80 \text{ feet} \\ 40 \text{ feet} \\ 80 \text{ feet} \\ \underline{+\ 40 \text{ feet}} \end{array}$$
   B. 80 feet ÷ 40 feet
   C. 80 feet + 40 feet
   D. 80 feet × 40 feet
   E. None of these

40. Which of these examples shows a way to find the fraction of the garden that would be given to all the boys together?

   A. $32 \times \frac{1}{12}$
   B. $12 \times \frac{1}{20}$
   C. 20 ÷ 32
   D. 12 ÷ 32
   E. None of these

41. The fraction of the garden that each pupil would receive is

   A. $\frac{1}{32}$
   B. $\frac{1}{20}$
   C. $\frac{1}{12}$
   D. $\frac{12}{20}$
   E. None of these

42. Each pupil would get as a share of the garden about

   A. 320 square feet
   B. 100 square feet
   C. 32 square feet
   D. 10 square feet
   E. None of these

43. The number of boys in the class was what percent of the number of girls in the class?

   A. 60
   B. 32
   C. 12
   D. $\frac{3}{8}$
   E. None of these

BLUE ANSWER SHEET STOPS HERE

Green Answer Sheet Continues

Red Answer Sheet Starts Here

Green Answer Sheet Continues

MONEY FOR CAMP

Jack and Mary each needed $120 for camp. Their father gave them $1.00 a week each for bus fare. Jack worked 8 hours on Saturday and 5 more hours during the week for 20 weeks. He earned 75 cents an hour. Mary worked 4 hours on Saturday and 3 more hours each week for 22 weeks. She was paid 60 cents an hour.

If they saved all they earned, would each of them have enough money to go to camp?

44. Jack and Mary needed to know
    - A. who had earned the most
    - B. how much it cost for camp
    - C. the amount each had earned
    - D. how many weeks they had worked
    - E. None of these

45. Which of these facts is NOT needed in figuring whether both could go to camp?
    - A. Jack worked 8 hours on Saturdays.
    - B. Each received $1.00 a week for bus fare.
    - C. Mary earned 60 cents an hour.
    - D. Jack earned 75 cents an hour.
    - E. Mary worked for 22 weeks.

46. Which of the following shows a way to find how many hours Jack worked in all?
    - A. $8 \times 20 + 5$
    - B. $20 + 8 \times 5$
    - C. $5 + 5 \times 8 \times 20$
    - D. $20 + 8 + 5$
    - E. None of these

47. Which of the following shows a way to find how much Jack earned in all?
    - A. $20 \times \$.75 \times 8$
    - B. $8 + 5 \times \$.75$
    - C. $13 \times 20 \times \$.75$
    - D. $5 \times \$.75 \times 20$
    - E. None of these

48. The total amount earned by Jack was
    - A. $210
    - B. $195
    - C. $120
    - D. $ 15
    - E. None of these

49. Together Jack and Mary earned
    - A. $287.40
    - B. $247.80
    - C. $172.80
    - D. $ 28.20
    - E. None of these

50. Which of these statements is true?
    - A. Mary earned enough money to go to camp.
    - B. Jack did not earn enough money to go to camp.
    - C. Neither Jack nor Mary earned enough money to go to camp.
    - D. Jack and Mary each earned enough money to go to camp.
    - E. Both Jack and Mary could go to camp if they put their earnings together.

THE HIGH SCHOOL BAND PLANS A TRIP

The forty boys and girls of the Coalport High School Band put on a special concert to raise $400 for a trip to the band contest at the state fair.

The members of the band sold 500 tickets at 75 cents each. Twenty persons who had bought tickets did not come to the concert.

During the intermission students sold 432 candy bars at 10 cents each. They cost $1.20 for a box of 2 dozen bars.

The students also sold 360 cold drinks at 10 cents a bottle. The drinks cost $1.20 for each case of 20 bottles.

Did the band make enough money to go to the fair?

64. What is the main question the band needed to answer?
    - A. Did the band take in $400 from the sale of tickets?
    - B. Did the total profit from the concert equal $400?
    - C. Was there a profit from the sale of cold drinks?
    - D. Was there a profit from the sale of candy?
    - E. None of these

65. Which of these facts is NOT needed in finding out whether the band can go to the fair?
    - A. Tickets to the concert were sold for 75 cents each..
    - B. 432 candy bars were sold.
    - C. Each case of cold drinks cost $1.20.
    - D. 40 members of the band hoped to make the trip.
    - E. One box held 2 dozen candy bars.

66. Which of the following shows a way to figure the cost of the cold drinks?
    - A. $360 \times 20 \div \$.10$
    - B. $360 \div \$1.20 \times 20$
    - C. $360 \times \$.10 \div 20$
    - D. $360 \div 20 \times \$1.20$
    - E. None of these

67. Which of the following shows a way to find the profit from the sale of the candy bars?
    - A. $(432 \div 24 \times \$1.20) - (432 \times \$.10)$
    - B. $(432 \times \$.10) - (432 \times 24 \div \$1.20)$
    - C. $(432 \times \$.10) - (432 \div 24 \times \$1.20)$
    - D. $432 \times 24 \div \$1.20$
    - E. None of these

68. The amount of money made from the sale of tickets was
    - A. $360.00
    - B. $375.00
    - C. $640.00
    - D. $666.67
    - E. None of these

69. The profit from the sale of cold drinks was
    - A. $43.20
    - B. $14.40
    - C. $21.60
    - D. $36.00
    - E. None of these

70. The total profit from the band concert was
    - A. $375
    - B. $396
    - C. $411
    - D. $676
    - E. None of these

71. Did the band raise enough money for the trip?
    - A. No, they needed $25 more than they made.
    - B. No, they needed $4 more than they made.
    - C. Yes, they had $11 more than they needed.
    - D. Yes, they had $276 more than they needed.
    - E. None of these

THE TYPING CLASS

Mr. Hoffman's typing class helped him order typing supplies for the next term. Mr. Hoffman wrote these facts on the chalkboard:

20 weeks of 5 days each in the term
30 pupils in the class
3 sheets of copy paper per day per pupil
2 sheets of bond paper per day per pupil
2 typewriter ribbons per pupil per term
Cost of typewriter ribbons—$1.75 each
1 sheet of carbon paper per pupil per week
Cost of carbon paper—4¢ per sheet

What was the total amount of all kinds of typing supplies needed by the class for the term?

57. To find the total amount of supplies needed by the class for the term, it would be most important for the pupils to know

   A. the total amount of paper used by each pupil each week
   B. the total number of sheets of carbon paper used by each pupil for the term
   C. the total number of typewriter ribbons needed by the class
   D. the total amount of supplies used by each pupil during the term
   E. the cost of the typewriter ribbons

58. Which of these facts is NOT necessary to find the supplies needed next term?

   A. Each pupil uses 1 sheet of carbon paper each week.
   B. There are 5 school days in each week of the term.
   C. Carbon paper costs 4¢ per sheet.
   D. There are 30 pupils in the class.
   E. Each pupil uses 2 sheets of copy paper per day.

59. Which of the following shows a way to find the number of sheets of bond paper needed for the term?

   A. 30 × 2 × 5 × 20
   B. 30 × 2 × 5
   C. 5 × 2 × 20
   D. (30 × 2) + (20 × 5)
   E. None of these

60. Which of the following shows a way to find the cost of the typewriter ribbons for the term?

   A. 30 × $1.75
   B. 2 × $1.75
   C. 30 × 3 × $1.75
   D. 30 × 20 × $1.75
   E. None of these

61. The total amount of bond paper needed was

   A. 200 sheets
   B. 600 sheets
   C. 1200 sheets
   D. 3000 sheets
   E. None of these

62. The total cost of carbon paper needed for the term was

   A. $2400.00
   B. $ 24.00
   C. $ 8.00
   D. $ 1.20
   E. None of these

63. If copy paper costs $1.00 for 500 sheets and bond paper cost $3.00 for 500 sheets, the total cost of paper for the class for the term would be

   A. $ 52
   B. $ 66
   C. $230
   D. $270
   E. None of these

GREEN ANSWER SHEET STOPS HERE

Red Answer Sheet Continues

THE CLASS PICNIC

This year 128 pupils plan to go to the annual picnic for eighth-graders at Lowell Junior High School. Twenty-three pupils have decided not to go.

The food committee plans to serve two cups of lemonade and two hot-dog sandwiches to each person who goes to the picnic.

The lemonade costs 74 cents per gallon and each pint makes two cups.

Eight hot dogs weigh a pound, which costs 69 cents.

Rolls come in boxes of 16 and cost 36 cents a box.

The class has already earned $36.50. Is this enough to pay for the picnic?

51. The class has to find whether it has enough money to pay for
    - A. just the lemonade
    - B. just the rolls
    - C. just the hot dogs
    - D. transportation to the picnic
    - E. all the food and drink

52. Which of these facts will NOT be used in deciding whether the class has enough money for the picnic?
    - A. 23 eighth-graders have decided not to go.
    - B. Eight hot dogs make a pound package.
    - C. Lemonade costs 74 cents a gallon.
    - D. 128 pupils plan to go to the picnic.
    - E. There are 16 rolls in a box.

53. Which of the following shows a way to find the cost of the lemonade?
    - A. $128 \times 2 \div 16 \times \$.74$
    - B. $128 \div 2 \times 16 \times \$.74$
    - C. $128 \times 16 \div 2 \div \$.74$
    - D. $128 \times 2 \times 16 \times \$.74$
    - E. None of these

54. The number of pounds of hot dogs the class will need is
    - A. 256
    - B. 138
    - C. 16
    - D. 8
    - E. None of these

55. The lemonade for the picnic will cost
    - A. $11.84
    - B. $11.64
    - C. $10.36
    - D. $ 5.92
    - E. None of these

56. When the total cost of the picnic is figured, which of these statements is true?
    - A. The class has just enough to pay for the picnic.
    - B. The class needs $3.18 more to meet all expenses.
    - C. The class will have $7.86 left after paying for the picnic.
    - D. The class will have $13.78 left after paying for the picnic.
    - E. None of these

JOE AND HIS FRIENDS VISIT DISNEYLAND

Joe's father took Joe and four of his friends on a trip to Disneyland. He said he would charge the boys just what it cost him to drive his car, but not more than \$20 each, no matter how much it cost.

Here are some facts about the trip:

Speedometer reading at beginning of the trip – 18,970
Speedometer reading at end of the trip – 20,320
Distance from Joe's home to Disneyland – 615 miles
Gasoline used (on trip) – 90 gallons at 32¢ a gallon
Oil used – 3 quarts at 60¢ a quart
Other car costs – 6¢ a mile
Motel rooms – 3 nights at \$20 per night

How much will each boy have to pay Joe's father for the trip?

72. What is the first question the boys need to answer about the trip before they can pay Joe's father?
    A. How many miles did the car travel per gallon of gasoline?
    B. What was the total cost of driving the car per mile?
    C. How far was it to Disneyland?
    D. Will all the transportation costs come to less than \$20 each?
    E. None of these

73. Which of these facts will NOT be needed in figuring the cost of riding in the car for each boy?
    A. Number of miles traveled on the trip
    B. Cost of gasoline per gallon
    C. Distance from Joe's home to Disneyland
    D. Cost of the oil used
    E. Number of gallons of gasoline used

74. Which of the following shows a way to find the cost of driving the car for everything except gasoline?
    A. (20,320 − 18,970) × \$.06 + \$1.80
    B. (20,320 − 18,970) ÷ \$.06 + (3 × \$.60)
    C. (20,320 − 18,970) × \$.06 + (90 × \$.32)
    D. (3 × \$.60) + (20,320 − 18,970) × \$.32
    E. None of these

75. Which of the following shows a way to figure the number of miles traveled per gallon of gasoline?
    A. (20,320 − 18,970) ÷ 90
    B. 90 ÷ (20,320 − 18,970)
    C. (20,320 − 18,970) × \$.32 ÷ 90
    D. 90 × \$.32 ÷ (20,320 − 18,970)
    E. None of these

76. Which of the following shows a way to figure the amount each of the travelers paid for motel rooms?
    A. \$20 + 3 + 6
    B. \$20 ÷ 5 × 3
    C. \$20 × 3 ÷ 6
    D. \$20 ÷ 3 × 6
    E. None of these

77. The total amount paid for gasoline and oil on the trip was
    A. \$289.80
    B. \$ 30.60
    C. \$ 29.40
    D. \$ 6.60
    E. None of these

78. How much will each boy pay Joe's father?
    A. \$22.80
    B. \$21.93
    C. \$20.00
    D. \$19.90
    E. None of these

BUYING A CAMERA

Roger decided to buy a camera and some color films. Here are some facts Mr. Brown at the camera shop told Roger:

The Grayfill camera sells for $75, less 20% discount.
The Paxton camera sells for $60, less 20% discount.
Films for Grayfill camera sell for $1.75 per roll.
Films for Paxton camera sell for $2.50 per roll.
There is also a 20% discount on the rolls of film.
Flash bulbs for either camera sell for $1.80 per dozen.

Roger told Mr. Brown that he wanted to buy a camera and 20 rolls of film to take with him on his vacation. Mr. Brown said he thought the Paxton would be cheaper to buy and use.

Was he right?

79. What was the main question Roger had to answer?
    - A. Which camera had the lowest actual sales price?
    - B. For which camera were flash bulbs least expensive?
    - C. How much would the films cost?
    - D. For which camera was the cost of camera and film lowest?
    - E. None of these

80. Which of these facts is NOT needed in deciding whether Mr. Brown was right?
    - A. The discount was 20% of the list price.
    - B. Roger planned to buy 20 rolls of film.
    - C. Film for the Grayfill camera sold for $1.75 per roll.
    - D. Flash bulbs sold for $1.80 per dozen.
    - E. The list price for the Paxton camera was $60.

81. To find out how much Roger would have to pay for the Grayfill camera, we could
    - A. divide $75 by .20 and subtract from $75
    - B. subtract .20 from $75
    - C. multiply $75 by .20 and add to $75
    - D. multiply $75 by .20 and subtract from $75
    - E. None of these

82. Which of the following shows a way to find the total cost of 20 rolls of film for the Paxton camera?
    - A. 20 ($2.50 − .20 × $2.50)
    - B. $2.50 × 20 − .20
    - C. 20 × .20 × $2.50
    - D. 20 × $2.50
    - E. None of these

83. Roger could have bought the Paxton camera from Mr. Brown for
    - A. $72.00
    - B. $58.80
    - C. $48.00
    - D. $30.00
    - E. None of these

84. The cost to Roger of the 20 rolls of film for the Paxton camera would be
    - A. $10
    - B. $40
    - C. $50
    - D. $60
    - E. None of these

85. The cost to Roger of the Grayfill camera and 20 rolls of film would be
    - A. $ 88
    - B. $ 95
    - C. $103
    - D. $110
    - E. None of these

86. If Roger considers carefully which camera to buy, he will recognize that one of the following statements is correct. Which one is correct?
    - A. The Grayfill camera and film will cost less if more than 20 rolls of film are bought.
    - B. The Paxton camera and 20 rolls of film will cost less than the Grayfill and the same amount of film.
    - C. The Paxton camera and film will cost less if more than 20 rolls of film are bought.
    - D. The Grayfill camera and 20 rolls of film will cost less than the Paxton and the same amount of film.
    - E. None of these

RED ANSWER SHEET STOPS HERE

APPENDIX E

PILOT STUDY

The Effects on Mathematical Problem-Solving Ability Among Fifth and Sixth Grade Students Using Hand-Held Calculators: A Pilot Study

Michael J. Kasnic

This pilot study was undertaken to determine if it was practical to undertake the research, whether the methodology was adequate, specifically whether the techniques were sufficiently sensitive to measure differences, and for the purpose of obtaining additional information by which the major study can be improved.

The problem was to determine if the use of a hand-held calculator can assist children of low mathematical problem-solving ability to become better problem solvers.

The subjects for this pilot study were fifth and sixth grade students at Wiley Post Elementary School, Putnam City Public Schools, Oklahoma City, Oklahoma.

From a population of approximately 300 students, 117 boys and girls were selected to be assessed as to their mathematical problem-solving ability. Students were placed into one of three levels of ability; high, low, or average. The students randomly selected to participate in this study were selected from the high and low ability levels. Students of average ability were not used in this study. There were a total of 48 students selected to participate with 24 being high ability problem-solvers and 24 being low ability problem-solvers. The 24 were then divided into two major groups so that each group contained 12 high ability and 12 low ability problem-solvers. A flip of a coin determined which group would use the calculators. This is illustrated below:

Group 1 High Ability with calculator n=12	Group 2 High Ability without calculator n=12
Group 3 Low Ability with calculator n=12	Group 4 Low Ability without calculator n=12

Figure 1.

The instrument to assess problem-solving ability was the California Achievement Test, Level 3, Form B, Mathematics Concepts and Problems subtest, 1970. The instrument used in the posttest was the Arithmetic Reasoning section of the SRA Achievement Series, Multi-Level Edition, Form D, 1968.

Using the Pearson Product-Moment Correlation, there was a correlation of .71 between the two instruments.

The treatment instrument was the problem-solving activities in the SRA series, Kaleidscope of Skills: Whole Number Computation, 1966.

The 48 students met with the investigator three days a week for three weeks, working through a series of problem-solving activities. There were 25 sets of problems, with a total of 197 problems. The first two weeks the students were to work the problems, self-check their answers which were posted on the wall, re-do any problem they missed, turn in their paper, and go on to the next set of problems.

The third week this changed. After students completed their problems, they turned them into the investigator who checked each paper and returned them to the students if they missed any problems. Data were collected on the number of wrong answers from each student. This collection of data resulted in the following:

1) High Ability-Calculator Group (HC): n=11

(a) Of a possible 726 problems, the group attempted 604, or 82%.

(b) Of these 604 problems attempted, they got 519, or 85% of them correct.

2) High Ability-No Calculator Group (H$\not{C}$): n=11

(a) Of a possible 726 problems, the group attempted 475, or 65%.

(b) Of these 475 problems attempted, they got 390, or 82% of them correct.

3) Low Ability-Calculator Group (LC): n=10

(a) Of a possible 660 problems, the group attempted 240, or 36%.

(b) Of these 240 problems attempted, they got 199, or 82% of them correct.

4) Low Ability-No Calculator Group (L$\not{C}$): n=12

(a) Of a possible 792 problems, the group attempted 295, or 37%.

(b) Of these 295 problems attempted, they got 227, or 76% of them correct.

Data were also collected on a posttest measure. After nine treatment sessions, the tenth session the students were given the SRA Achievement Test to determine if the treatment had improved mathematical problem-solving ability.

Analysis of Data

The posttest measure was broken down into three parts; the total score (n=86), questions that involve determining the computation (n=27), and questions that involve actual computation (n=40). Two scores were computed; the actual number of correct responses (raw score) and the number of correct responses divided by the number of problems (percent score), ignoring the problems that were not attempted. The following tables represent the data:

TABLE I

RAW SCORE AND PERCENT ON TOTAL SCORE

	HC	HȻ	LC	LȻ
Raw Score				
n	86	86	86	86
Mean	45.00	45.82	34.80	35.58
Std. Dev.	6.47	6.36	4.17	5.33
Percent				
Mean	70.90	63.55	51.00	53.50
Std. Dev.	8.24	11.79	8.27	9.36

TABLE II

RAW SCORE AND PERCENT ON DETERMINING COMPUTATION

	HC	H$\not{C}$	LC	L$\not{C}$
Raw Score				
n	27	27	27	27
Mean	14.00	14.36	10.10	10.08
Std. Dev.	1.90	2.64	2.30	1.61
Percent				
Mean	69.90	62.55	45.50	48.50
Std. Dev.	9.30	13.76	8.87	11.14

TABLE III

RAW SCORE AND PERCENT ON COMPUTATION

	HC	H$\not{C}$	LC	L$\not{C}$
Raw Score				
n	40	40	40	40
Mean	20.90	21.55	18.20	18.50
Std. Dev.	3.65	3.03	2.52	3.66
Percent				
Mean	69.10	63.18	57.20	59.25
Std. Dev.	10.72	11.91	11.45	12.82

An ANOVA F-test was computed for each raw score and each percent score for each of the three parts of the test; total, determining computation, and computing. The next series of tables present the analysis of variance parameters for each possible combination. The A source is the comparison of calculator and no calculator groups and the B source is the comparison of the high and low problem-solving ability.

TABLE IV

ANOVA TABLE - RAW SCORE - TOTAL SCORE

Source	SS	df	MS	F	p
A	3	1	3	.085	n.s.
B	1118	1	1118	31.62	.001
AB	3	1	3	.085	n.s.
Error	1379	39	35.36		
Total	2503	42			

TABLE V

ANOVA TABLE - PERCENT - TOTAL SCORE

Source	SS	df	MS	F	p
A	75	1	75	.74	.50
B	2317	1	2317	22.91	.001
AB	242	1	242	2.39	.25
Error	3943	39	101.1		
Total	6577	42			

TABLE VI

ANOVA TABLE - RAW SCORE - DETERMINING COMPUTATION

Source	SS	df	MS	F	p
A	0	1	0	0	-
B	181	1	181	35.98	.001
AB	1	1	1	.198	n.s.
Error	196	39	5.03		
Total	378	42			

TABLE VII

ANOVA TABLE - PERCENT - DETERMINING COMPUTATION

Source	SS	df	MS	F	p
A	66	1	66	.49	.50
B	3842	1	3842	28.70	.001
AB	267	1	267	2.00	.25
Error	5223	39	133.92		
Total	9398	42			

TABLE VIII

ANOVA TABLE - RAW SCORE - COMPUTATION

Source	SS	df	MS	F	p
A	2	1	2	.17	n.s.
B	89	1	89	7.56	.01
AB	0	1	0	0	-
Error	459	39	11.77		
Total	550	42			

TABLE IX

ANOVA TABLE - PERCENT - COMPUTATION

Source	SS	df	MS	F	p
A	44	1	44	.295	n.s.
B	634	1	634	4.255	.05
AB	162	1	162	1.087	.50
Error	5811	39	149		
Total	6651	42			

Conclusions

The data seem to indicate that the use of a calculator in this pilot study did not lead to improved problem-solving ability among low ability problem-solvers. Both groups remained the same; that is, the high group remained high and the low group remained low.

Of significance, however, is the data obtained during the treatment period. This is listed on page 3 and 4. The high ability-calculator group not only attempted more practice problems than any other group but also got more of them correct. The low ability - calculator group did not attempt as many practice problems as the other groups, but of those attempted, they got as many correct as the high ability - no calculator group, and almost the same percentage as the high ability - calculator group. Use of the calculator seemed to help the low ability group during the treatment period but did not carry over into the posttest measure.

Recommendations

From the results of this pilot study, it is recommended that the major study be revised in the following manner:

1) The major questions/hypothesis should be:

   (a) If pupils have access to calculators, then do those pupils solve more practice problems than those pupils without calculators?

   (b) If pupils solve more practice problems, then will their verbal problem-solving scores be higher than those who do not solve more practice problems?

2) Two additional groups should be added:

   (a) A group that will use the calculator not only for practice problems but also on the posttest.

   (b) A control group who just take the problem-solving ability assessment test and the posttest.

3) Data be kept during the treatment period so that a correlation can be made between treatment scores and posttest scores.

VITA 2

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Doctor of Education

Thesis: THE EFFECT OF USING HAND-HELD CALCULATORS ON MATHEMATICAL PROBLEM-SOLVING ABILITY AMONG SIXTH GRADE STUDENTS

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