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THE EFFECTS OF COMPUTER PROGRAMMING ON SEVENTH-GRADE STUDENTS' USE AND UNDERSTANDING OF VARIABLE

The Ohio State University

Ph.D. 1986

University Microfilms International 300 N. Zeeb Road, Ann Arbor, MI 48106
THE EFFECTS OF COMPUTER PROGRAMMING ON SEVENTH-GRADE STUDENTS’ USE AND UNDERSTANDING OF VARIABLE DISSERTATION

Presented in Partial Fulfillment of the Requirements of the Degree Doctor of Philosophy in the Graduate School of The Ohio State University.

By

Claire L. Crook, B.S., M.Ed.

***

The Ohio State University
1986

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In Memory of my Parents
ACKNOWLEDGEMENTS

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I am especially indebted to my husband, Gregory, whose patience, confidence, and love made it possible for me to complete my doctoral program.
VITA

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>VITA</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
</tbody>
</table>

## CHAPTER

1. INTRODUCTION

- Benefits of Programming: 1
- Need for the Study: 4
- Problem Statement: 6

2. REVIEW OF THE LITERATURE

- Introduction: 8
- Selected Studies on Variable: 9
- Selected Studies on Computer Programming: 13

3. METHODS AND PROCEDURES

- Introduction: 19
- Sampling Procedures: 20
- Treatment: 21
- Instrumentation: 22
- Procedure: 24
- Experimental Design: 24
- Internal Validity: 26
- Hypotheses: 27

4. RESULTS

- Introduction: 29
- Analysis of Pre-test Data: 29
- Analysis of Mid-test Data: 32
- Analysis of Post-test Data: 33
- Item Analysis: Pre-, Mid-, and Post-Test: 34
- ANOVA for Repeated Measures: 35
- Comparisons Between Selected Items: 39
- Summary: 45
CHAPTER

5. SUMMARY AND DISCUSSION 47

Discussion: Pre-Test to Mid-Test 50
Mid-Test to Post-Test 54
Pre-Test to Post-Test 54
Recommendations 56

LIST OF REFERENCES 59

APPENDICIES

A. Homework Assignments for Computer Programming Treatment 66

B. Summary of Results of Statistical Analysis of Pre-Test 81

C. Pre-Test, Mid-Test and Post-Test 88

D. Frequency Distribution for Pre-Test, Mid-Test and Post-Test Data 101
<table>
<thead>
<tr>
<th>TABLE</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pre-Test Means and Standard Deviations.</td>
<td>30</td>
</tr>
<tr>
<td>2. Analysis of Variance Summary Table for Pre-Test Means.</td>
<td>31</td>
</tr>
<tr>
<td>3. Mid-Test Means and Standard Deviations.</td>
<td>33</td>
</tr>
<tr>
<td>4. Post-Test Means and Standard Deviations.</td>
<td>34</td>
</tr>
<tr>
<td>5. Kuder-Richardson 20 Estimates for Pre-, Mid-, and Post-Test Scores for Group I and Group II.</td>
<td>35</td>
</tr>
<tr>
<td>6. Analysis of Variance Summary Table for Repeated Measures Design.</td>
<td>36</td>
</tr>
<tr>
<td>7. Post Hoc Multiple Comparisons for Pre-, Mid-, and Post-Test.</td>
<td>38</td>
</tr>
<tr>
<td>8. Number of Correct Responses for Selected Items for Group I on the Pre-test and Mid-Test.</td>
<td>42</td>
</tr>
<tr>
<td>9. Number of Correct Responses for Selected Items for Group II from the Mid-Test to the Post-Test.</td>
<td>44</td>
</tr>
<tr>
<td>10. Number of Correct Responses for Group I from Pre-Test to Mid-Test for Selected Items.</td>
<td>44</td>
</tr>
<tr>
<td>11. Means and Standard Deviations for Grade 5, 6, and 7.</td>
<td>82</td>
</tr>
<tr>
<td>12. Summary Results of Item Analysis</td>
<td>86</td>
</tr>
<tr>
<td>13. Pearson Product Moment Correlation Total Test Score and Final Grade in Mathematics.</td>
<td>87</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>14. Frequency Distribution of Pre-, Mid-, and Post-Test Scores for Group I.</td>
<td>102</td>
</tr>
<tr>
<td>15. Frequency Distribution of Pre-, Mid-, and Post-Test Scores for Group II.</td>
<td>103</td>
</tr>
<tr>
<td>16. Mean Score and Number of Students Scoring in the Upper 27.5% and Lower 27.5% of Total Test Score.</td>
<td>104</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Experimental Design for the Study.</td>
<td>25</td>
</tr>
<tr>
<td>2. Pre-, Mid-, and Post-Test Scores.</td>
<td>37</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION

THE PROBLEM STATEMENT
With the growing use of microcomputers in the classroom, many educators believe that there is a relationship between programming and learning about variables. By manipulating variables through programming, the computer may be an effective way to teach the concept of variable.

BENEFITS OF PROGRAMMING
In An Agenda for Action, The National Council of Teachers of Mathematics recommended that "mathematics programs take full advantage of the power of calculators and computers at all grade levels" (1980). Likewise, in its report to the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, the Conference Board on Mathematical Sciences stated that "...computers [should] be introduced into the mathematics classroom at the earliest grade practical...and computers should be utilized to enhance the understanding of mathematics as well as the learning of problem-solving" (1982).
The role of computers in education is a subject of considerable debate. Many educators feel that the capabilities of the computer to enhance learning extend far beyond the use of educational software. They feel that instruction in computer programming can be used effectively to enhance the delivery of instructional information and facilitate the development of mathematical concepts. In particular, recent research has indicated that programming experience results in improved understanding of the concept of variable (Shumway, 1985).

In 1972, Hatfield and Kieren described the activity of programming as an alternate strategy for learning mathematics. They found that computer programming significantly increased mathematical achievement for seventh- and eleventh-grade students. Additionally, Keiren (1973) reported claims from Johnson, Haven, Soloman, and Holoien that programming significantly enhanced learning of mathematics and facilitated understanding of concepts.

Elementary students who wrote computer programs that focused on mathematics properties showed greater improvement in mathematics skills than students who did not engage in programming (Krull, 1980). In addition,
Krull observed that students involved in programming exhibited more positive attitudes toward school and performed better in their daily work.

Camp & Marchionini (1984) described the computer as a tool, like chalkboards and textbooks, that gives both elementary and secondary students an opportunity to observe the meaning of variable in expressing equations and relations. Fey et al. (1984) also suggested that programming may help the development of the concept of variable, but they stressed the need for research in this area.

Another aspect of programming where research is needed is the use of the equal sign in programming statements, which has caused concern for some educators and mathematicians. Usiskin (1984) stated that the equal sign in computer language does not mean equality, but "replace." Although Usiskin's idea of calling the equal sign "replace" could help clarify misconceptions of the programming statement "N = N + 1," the effects of programming, positive or negative, on students' concept of equality are unknown.
NEED FOR THE STUDY

Mathematics teachers are shifting emphasis from development of computational skills to development of concepts. Consequently, students' misconceptions of variable have become more apparent. Many educators are investigating errors and searching for patterns to determine common misconceptions among students.

Wagner (1981) found that beginning algebra students viewed the solution of an equation as changing when the letter representing the unknown was changed. For example, many students thought that "a + 3 = 19" and "b + 3 = 19" had different solutions.

Harper (1980) interviewed students, whom he considered to be above average, from two different elementary schools. He concluded that relatively few students interpret letters as generalized numbers. Most view the letter as a specific unknown. Clement (1982) reported that college freshmen write algebraic symbols in the same order as the key words in the problem, and many interpret the variable as a label (e.g., "6S = P means 6 students for every professor").

A common error among primary grade students is that they perceive the equal sign as a left-to-right operator (Denmark et al., 1976). This misconception
continues into high school and even occurs at the college level. Davis (1975) found similar types of errors and concluded that, from early mathematics instruction, students need to use the equal sign in several different ways.

In an extensive study for the Concepts in Secondary Mathematics and Science Project (CSMS) in Britain, Kuchemann concluded that children’s errors in algebra are most likely a consequence of one or more of the following (Booth, 1984. p.91):

- falsely generalizing from previously established notions in arithmetic
- lack of appropriate arithmetic structures from which to generalize
- lack of development of particular cognitive structures which are necessary for the assimilation and processing of some of the concepts.

If misconceptions in algebra are the result of lack of development of cognitive structures, the computer may not be the proper tool to facilitate development of cognitive structures. However, if algebra errors are due to lack of appropriate arithmetic structures, or to falsely generalizing from previously established notions in arithmetic, then computer programming may be an effective tool to bridge the gap between instruction and understanding.
Manipulation of variables, through programming, may clarify misconceptions or produce appropriate mathematical structures that facilitate understanding of concepts of variable.

Traditionally, students' experience with variables before ninth-grade algebra is limited to filling in a box or a blank with a number. With the availability of computers in most elementary schools, children may be able to learn about variables at a much younger age.

**PROBLEM STATEMENT**

This study will attempt to:

1. Verify the hypothesis that, through programming in BASIC, the computer is an effective way to teach the concept of variable to seventh-grade students who have had no formal instruction on variable or concepts of variable.

2. Verify the hypothesis that computer programming experience in BASIC enhances an understanding of the concept of variable that seventh-grade students have previously learned through (formal) classroom instruction.
3. Determine which sequence—computer programming experience preceding, or following, classroom instruction on variable—more effectively enhances the understanding of variable.
CHAPTER 2

REVIEW OF THE LITERATURE

INTRODUCTION

Mathematics teachers are shifting emphasis from development of computational skills to development of concepts. Consequently, misconceptions of variable have become more apparent. Educators realize the importance of conceptual understanding for successful study of algebra. Algebraic understanding depends on understanding variables.

Many educators believe that the computer may be an effective way to teach the concept of variable by manipulating variables through programming. Some believe the activity of programming provides a means of teaching mathematical concepts and testing the students' understanding of them (Hatfield and Kieren, 1972).

The relationship between programming and understanding concepts of variable has not yet been determined by educational research. Therefore, the literature review for this study includes research on computer programming and variables.
SELECTED STUDIES ON VARIABLE

Most mathematicians present a simplistic definition of variable for beginning students of algebra. Saxon (1983, p. 81) explained that "In algebra we often use letters as variables to stand for or to take the places of numbers. The letters themselves have no value. The value of the expression \( x + 4 \) depends on the number we use for \( x \)." In another algebra textbook, Bumby and Klutch (1978, p. 3) define variable as "a word or symbol that may be replaced by any member of some appropriate set."

Usiskin (1984) defined variable as a letter that stands for a number or a set of numbers so that it may vary from time to time. Similarly, Wagner (1983) defined variable as a literal symbol that represents a number, a constant, or a set of numbers simultaneously, yet individually.

Wagner described differences and likenesses between literal symbols, or variables, and numerals, literal symbols, and words. Literal symbols have certain characteristics similar to numerals, other characteristics similar to words, and still other characteristics that are uniquely their own.
Literal symbols are similar to numerals because they have an underlying "natural" order. Because both are ordered, many students think that the linear ordering of the alphabet corresponds to the linear ordering of the number system. This misconception can be found even among high school students.

Literal symbols and numerals are also similar because they often appear together in mathematical statements. One of the first ways students see literal symbols is when they appear with numerals in open sentences like $6 + N = 15$. Because they appear with numerals in a familiar format they look as though they should behave like numbers.

Literal symbols and numerals differ because numerals can only represent one number and literal symbols can represent one or many numbers simultaneously, depending on the context. Literal symbols and numerals are both used to identify or name things besides numbers, but they differ since numerals label or name specific elements of a set, such as an address or a social security number, and literal symbols, in the context of mathematics, identify variable elements such as naming a point P.
One similarity between letters and words is that both can act as placeholders in certain expressions. Just as some words can be replaced by other words to make a sentence true or false ("he" can be replaced by different names), literal symbols in mathematical statements can be replaced by different numbers to make true or false statements.

Another similarity between words and literal symbols is that the meaning of both depends on the context in which they are used. They differ, however, because words can change meanings in the same context; for example, "His leg fell asleep during the last leg of the trip." Literal symbols have the same meaning throughout the same context; for example, \(6a + 7 = a/5\).

Finally, Wagner stated that the most significant difference between literal symbols and words is that literal symbols are not associated with a fixed set of meanings as words are. Words in a sentence change referents if they are changed (even synonyms cause a subtle change), while literal symbols do not change the referent if they are changed (\(a + 5\) is the same as \(b + 5\)).

In the Concepts in Secondary Mathematics and Science Project (CSMS), Kuchemann identified a
progression in the way in which letters are interpreted (Booth, 1984). He identified the following six categories of letter usage:

1. **Letter evaluated**  Children on this level avoid operating on a specific unknown simply by working with a given value for the unknown. The category also refers to items where children are asked to find a specific value for an unknown.

   \[ a + 5 = 8 \quad \text{If } u = v + 3 \text{ and } v = 1 \]
   \[ a = ? \quad \quad u = ? \]

   For the first problem, all the child needs to do is recall a familiar number bond. The second is more difficult because it has two unknowns; however, the solution requires no manipulation of unknowns.

2. **Letter ignored**  Here the child ignores the letter. The letter plays no part in the solution.

   \[ a + b = 43 \quad \text{add 4 onto } n + 5 \]
   \[ a + b + 2 = ? \]

   Letters \( a, b, \) and \( n \) can be ignored. There is no need to handle or transform the expression to get the answer.

3. **Letter as object**  The letter is regarded as shorthand for an object.

   \[ 2a + 5a = 7a \quad \text{(2 apples + 5 apples = 7 apples)} \]
4. **Letter as specific unknown** The child regards a letter as a specific but unknown number which can not be evaluated but he or she can operate upon it directly.

Multiply each of these by 4:

\[ n + 5 \]
\[ 3n \]

5. **Letter as generalized number** The letter can represent several values instead of just one.

\[ c + d = 10 \]
\[ c < d \]
\[ c = ? \]

6. **Letter as variable** The letter is seen as representing a range of unspecified values and a relationship exists between two sets of values.

Which is larger? \( 2n \) or \( n + 2 \)

**SELECTED STUDIES ON COMPUTER PROGRAMMING**

Many advocates of computer programming believe programming facilitates the development of mathematical concepts. Hatfield and Kieren (1972) described the activity of programming as an alternate strategy for learning mathematics. They believed that programming provides a means of teaching the concepts involved and
testing the student's understanding of them. Their rationale for using programming to teach mathematics was based on the assumption that in order to program successfully, a student must be able to analyze a problem situation. This analysis requires a more careful study of the concepts involved than may otherwise occur. From their study of seventh-grade and eleventh-grade students, Hatfield and Kieren reported that even though seventh-grade students who are low achievers can learn to successfully program mathematical problems, the average and above-average seventh-grade achievers seemed to benefit relatively more from computer programming. At the eleventh-grade level, however, programming seemed to have a stronger facilitating effect on the average achiever as opposed to the above-average group. Additionally, Kieren (1973) reported claims by other researchers that programming a computer significantly aids learning of mathematics and facilitates understanding of concepts (Johnson, 1966; Haven, 1970; Soloman, 1972; and Holoen, 1971).

Some educators feel that programming is an ideal way to learn an algorithmic approach to problem-solving. Programming teaches a student to
develop and test a model, critically examine the model, and therefore gain a deeper understanding of the situation (Wiechers, 1974). According to Wiechers, programming improves a student's general mathematical ability and also develops a thinking attitude.

In a report by Overton (1981), studies by Krull (1979) and Milner (1972) showed a significant increase in mathematics achievement due to programming. Both studies were at the elementary level.

Washburn's study (1969) coordinated computer programming activities with mathematics topics at the junior high, twelfth-grade, and college freshman levels. The experimental groups received programming exercises pertaining to the mathematical topics that the students encountered in their mathematics classes. The students in the experimental group wrote, executed, and corrected computer programs, while students in the control group did homework and assignments in a conventional manner. Washburn concluded that programming helped to strengthen the understanding of mathematical concepts at all levels. He found that students of higher intelligence benefited more than those of average or below average intelligence.
More recently, Soloway, Lochhead, & Clement (1982) reported a positive relationship between programming and the use of variables and equations among secondary students. Likewise, Oprea (1985) found that 20 hours of programming instruction enhanced sixth-grade students' understanding of variable.

When working with computer programs, students frequently use variables and equations in assignment statements. This experience with variable, Blume and Schoen (1985) believe, may be the reason that eighth-grade students with programming experience appeared to use equations to solve problems more frequently, and more effectively, than students with no programming experience.

Shumway (1986) claimed that programming requires the student to understand the mathematics involved since the computer requires specific instructions. Programming assists teaching problem-solving and more generalized concepts of mathematical thinking such as variables and generalization (Shumway, 1984).

Papert (1980), a strong advocate of programming, proclaims that computers create a mathematical environment where children verbalize, communicate, and experience mathematics through problem-solving.
strategies. Students are discovering facts, making generalizations, developing skills, and exploring and understanding mathematical ideas. Papert believes that advanced mathematical ideas can be learned by presenting these concepts in simple structures. These simple structures can be explored in concrete terms through computer programming.

Some research did not confirm the value of programming. In 1971, Johnson found that computer programming did not improve achievement for seventh-grade students in number theory. Robitaille (1977) analyzed data from ninth-grade algebra classes from two schools concerning student attitude and achievement. Results showed a significant difference in achievement favoring the non-computer group in both schools.

Lecuyer (1977) found no significant difference in mathematics achievement between sections of an undergraduate survey course in mathematics. One class used computer programming and the other was taught the same topics, with the same textbook, but without computer programming.

The possibilities of using computer programming to enhance concepts of variable are not yet realized by
educators. Research has just begun to scratch the surface in regard to the relationship between computer programming and mathematical concepts such as variable. Although educational journals are publishing numerous articles on computer programming and a variety of programming activities, the effectiveness of these activities for all students has not been determined.
CHAPTER 3

METHODS AND PROCEDURES

INTRODUCTION

Research indicates there may be a relationship between programming and mathematical concepts such as variable. Many educators are skeptical about the benefits of programming. They perceive the computer as an effective tool primarily for computer-assisted instruction--drill and practice programs, tutorials, and demonstrations.

Presently, much research concerning the use of computers in mathematics education focuses on computer-assisted instruction. Research is not yet available to aid educators in determining how to use computers most effectively or how computers enhance skill or concept development.

The purpose was to verify (a) the belief that through programming in BASIC, the computer is an effective way to teach concepts of variable, and (b) that computer programming in BASIC enhances understanding of the concepts of variable that students have previously learned through formal classroom instruction.
SAMPLING PROCEDURES

Two experimental groups consisted of seventh-grade students from an alternative traditional school of a large city school system. Parents in the school district have the option of sending their students to their regular home school or of applying for one of several alternative schools. The traditional school setting is one of the alternative school choices. Students whose parents have applied for the alternative school are selected by a lottery system. All students in the school system may apply.

There were six seventh-grade classes in the school. Two classes, consisting of twenty-nine students each, were used. The experimenter was the regular mathematics teacher for both classes. Six students were eliminated from the study because they had previous experience in computer programming. The remaining 52 students were randomly assigned to a treatment group.

Before the experiment, the two classes had been regrouped several times throughout the school year for various instructional purposes. They were regrouped before the introduction of various topics in mathematics and language arts. Thus, regrouping for the experiment was considered a normal part of
classroom routine. The students were not informed that an experiment was taking place.

**TREATMENT**

The programming treatment consisted of fifteen one-hour classes of instruction on programming in BASIC. The instructional materials were Program Power Pack.

Program Power Pack is a series of eight booklets developed by the TABS-Math Project under the direction of Suzanne K. Damarin at The Ohio State University. The series consists of a set of eight booklets designed to introduce programming in BASIC to elementary school students. The series includes the following booklets:

FOR... NEXT, INPUT, IF... THEN, INTEGER, GRAPHICS, and RANDOM. These six booklets were used for the programming treatment.

During the programming treatment the subjects' only experience with variables was directly related to programming. The TABS booklets were the only materials used for the programming treatment, and the experimenter was careful to use the same terminology that was used in the TABS booklets.
A written homework assignment of approximately 30 minutes in length was given each day, except on Fridays. Homework was a paper-and-pencil assignment since few students had access to computers. Examples of homework assignments are provided in Appendix A.

The classroom instruction treatment consisted of fifteen one-hour classes designed to teach the concept of variable. A written homework assignment of approximately 30 minutes in length was given daily, except Fridays. Assignments were taken from the exercises provided in the textbooks used.

Instructional materials consisted of the following:

- **Essentials for Algebra**, a pre-algebra textbook published by Houghton Mifflin Publishing Company. Chapter One and selected exercises from Chapter Two were used.

- "Making a Table to Solve a Problem" and "Using a Formula to Solve a Problem," from *Addison-Wesley Mathematics: Book 7*.

**INSTRUMENTATION**

The pre-test was a twenty-six item multiple choice examination developed to assess fifth-, sixth-, and seventh-grade students' understanding of variable. The test was developed in two phases. During Phase I students' answers to algebra problems were analyzed and
classified into error types. Descriptive statistics were obtained and item data were subjected to factor analysis to determine whether there was any grouping of items.

During Phase II, a twenty-six item multiple choice test was developed to assess children's knowledge of variable. Knowledge of the kinds of errors that were made, and the common incorrect responses that occurred on the tests given during Phase I, formed the basis for creating distractors for the multiple choice items.

The pre-test was first administered to fifth-, sixth-, and seventh-grade children from three different schools in a large city school system. Item analysis, factor analysis, and multiple regression were used to determine the validity and reliability of the instrument. These statistics are provided in Appendix B. The pre-, mid-, and post-test are included in Appendix C.

The mid-test and the post-test are parallel tests. In a pilot study, each test was administered to a different group of ninety seventh-grade students; Chronbach's alpha reliability scores of .83 and .88, respectively, were obtained. To determine correlation coefficients, the pre-test was administered to thirty
seventh-grade students. Three weeks later, the mid-test was given to the same group, and the post-test was administered to the same group three weeks following the mid-test. Pearson Correlation Coefficients of .80 and .84, respectively, with the pre-test were found.

PROCEDURE

Group I was randomly assigned to the programming treatment and group II was randomly assigned to the classroom instruction treatment. A pre-test was given two days before the study began. When both groups completed fifteen one-hour sessions, a mid-test was given. Following the mid-test, group I received the instruction treatment and group II received the programming treatment. When both groups completed fifteen one-hour sessions, a post-test was given.

EXPERIMENTAL DESIGN

The independent variable is the sequence of instruction. Test scores (pre-, mid-, and post-) are the dependent variables.

The experimental design can be described as a repeated measures experiment and is represented using
the design notation of Campbell and Stanley (1963) shown in Figure 1 below.

\[
\begin{align*}
R1 & \quad 0(1) \quad XP(1) \quad 0(3) \quad XI(2) \quad 0(5) \\
R2 & \quad 0(2) \quad XI(1) \quad 0(4) \quad XP(2) \quad 0(6)
\end{align*}
\]

**Figure 1:** EXPERIMENTAL DESIGN

R1 and R2 represent random assignment of subjects to groups and random assignment of groups to treatments. Observations 0(1) and 0(2) represent the pre-test score for each subject. The treatments are represented by XP (programming) and XI (classroom instruction). Following intervention, observations 0(3) and 0(4) were taken. Observations 0(5) and 0(6) represent the post-test score for each subject after the second treatment.

An analysis of variance on pre-test scores was conducted to determine if both groups are equal. To determine if one treatment is more effective than another and to determine if sequence of treatment is a factor, a two-factor (one-between-one-within-subjects) design was used. The between-subjects factor was the instruction and the within-subjects factor was the scores on the pre-, mid-, and post-tests (Kennedy, 1978; Winer, 1971). Analysis of variance (ANOVA) for
repeated measures was performed on pre-test, mid-test, and post-test scores.

INTERNAL VALIDITY

The computers used were located in the school library. There were fifteen computers. Subjects worked in groups of two, changing partners every other day. Most subjects had used the computers in the library the previous year with some of the educational software provided by the library. All subjects used the computers for drill and practice exercises and other educational software, once a week, for ten weeks prior to the study. The subjects' only experience with computers had been with software. Six students had previous experience with programming and they were excluded from the study.

The study was conducted at the same time each day for both groups. The programming treatment was conducted in the library every day at 10:00 AM for both groups. The classroom instruction treatment was conducted daily at 12:15 PM for both groups. The subjects' lunch period, which includes time for outdoor recess, was from 11:20 AM to 12:00 PM.
HYPOTHESES

This study attempted to ascertain that (1) through computer programming experience in BASIC, students develop an understanding of variable, (2) computer programming experience enhances formal instruction on variable, and (3) one sequence of treatments is more effective in developing students' understanding of variable. The following null hypotheses were tested:

H1: There is no significant difference in mid-test scores between group I and group II.

H2: There is no significant difference from pre-test scores to post-test scores for group I and group II.

H3: There is no significant difference in post-test scores between group I and group II.

H4: There is no significant difference for programming instruction--from pre-test scores to mid-test for group I, and from mid-test scores to post-test scores for group II.
H5: There is no significant difference for formal instruction of variable--from mid-test scores to post-test scores for group I, and from pre-test scores to mid-test scores for group II.
CHAPTER 4

RESULTS

INTRODUCTION

This chapter reports and interprets the results of the pre-test, mid-test, and post-test for group I and group II as described in Chapter III. Descriptive statistics for the pre-test, mid-test, and post-test are presented and discussed separately. Item analysis statistics, comparing pre-, mid-, and post-test scores by group, are followed by statistics for analysis of variance for repeated measures. Additionally, post hoc comparisons are made between and within groups for pre-, mid-, and post-test scores.

Individual items from the pre-, mid-, and post-test were selected for comparison and analysis in order to understand which concepts of variable were learned through programming.

ANALYSIS OF PRE-TEST DATA

Data were collected for 52 seventh-grade students. A pre-test was given two days prior to the study. Twenty-six students were randomly assigned to group I
and twenty-six students were randomly assigned to group II.

The pre-test was used to determine students' initial understanding of concepts of variable. This test consisted of 25 items, each of which was graded right or wrong. The possible range of scores was from 0 to 25. The observed range of pre-test scores for 52 students was from 4 to 23. Analysis of pre-test data for the entire sample revealed an overall mean of 13.94 with a standard deviation of 4.74 and Chronbach's alpha reliability score of .82.

Descriptive statistics for pre-test scores for group I and group II are summarized in Table 1.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>PRE-TEST MEANS AND STANDARD DEVIATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>N</td>
</tr>
<tr>
<td>---------</td>
<td>---</td>
</tr>
<tr>
<td>I</td>
<td>26</td>
</tr>
<tr>
<td>II</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
</tr>
</tbody>
</table>
To determine if initial differences existed among treatment group means, a one-way analysis of variance (ANOVA) was performed on the pre-test data for the 52 subjects. An analysis of variance allows the comparison of means of two or more independent groups. Table 2 presents the results of a one-way ANOVA on pre-test data. The following hypothesis was tested:

**H0**: There will be no significant differences between treatment groups on the pre-test.

Results indicated no significant differences existed between treatment group means (\( F(1,50)=1.306, p < 0.258 \)). \( H1 \) cannot be rejected at the .01 level of significance. Thus, since the cell means did not differ significantly, the groups at pre-test can be considered similar in abilities.

**TABLE 2**

ANALYSIS OF VARIANCE SUMMARY TABLE FOR PRE-TEST MEANS

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>29.250</td>
<td>1.306</td>
<td>.258</td>
</tr>
<tr>
<td>Error</td>
<td>50</td>
<td>22.391</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ANALYSIS OF MID-TEST DATA

A mid-test was given after 15 one-hour programming treatments were given to group I and 15 one-hour classroom instruction treatments were given to group II. After the mid-test the treatments were reversed and group I received the classroom instruction and group II received the programming treatment. The mid-test consisted of 25 items which paralleled the 25 pre-test items. The Pearson Product Moment Correlation between pre-test data and mid-test data was .79 ($p < .001$).

The purpose of the mid-test was to assess students' use and understanding of variable. The possible range of scores was from 0 to 25. The observed range of mid-test scores for 52 students was from 8 to 24. The overall mean on the mid-test was 16.83 with a standard deviation of 3.23, and Chronbach's alpha reliability score of .66. Descriptive statistics for mid-test scores for group I and group II are summarized in Table 3.
TABLE 3

MID-TEST MEANS AND STANDARD DEVIATIONS

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>26</td>
<td>16.73</td>
<td>3.09</td>
</tr>
<tr>
<td>II</td>
<td>26</td>
<td>16.92</td>
<td>3.41</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>16.83</td>
<td>3.23</td>
</tr>
</tbody>
</table>

ANALYSIS OF POST-TEST DATA

A post-test was given after group I received 15 one-hour classroom instruction treatments and group II received 15 one-hour programming sessions. The post-test consisted of 25 items which paralleled the 25 pre-test and mid-test items. Pearson Product Moment Correlation between the pre-test and the post-test was .73 (p < .001). The Pearson Product Moment Correlation between mid-test data and post-test data was .71 (p < .001). The purpose of the post-test was to assess students' use and understanding of variable after both treatments. The possible range of scores was from 0 to 25. The observed range of post-test scores was from 4 to 25. The overall mean on the post-test was 19.28 with a standard deviation of 4.33, and Chronbach's alpha reliability score of .84.
Descriptive statistics for post-test scores for group I and group II are summarized in Table 4.

**TABLE 4**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>26</td>
<td>20.00</td>
<td>4.03</td>
</tr>
<tr>
<td>II</td>
<td>26</td>
<td>18.57</td>
<td>4.58</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>19.28</td>
<td>4.33</td>
</tr>
</tbody>
</table>

A frequency distribution of pre-, mid-, and post-test scores for groups I and II, and a comparison between groups can be found in Appendix D.

**ITEM ANALYSIS**

**PRE-, MID-, AND POST-TEST**

The Kuder-Richardson 20 statistic is an estimate of the internal consistency or reliability of a test and is a function of the number of items on the test, the variability of the scores, and the proportion of correct and incorrect answers for each item. Table 5
summarizes the KR-20 for the pre-, mid-, and post-test scores for group I and group II.

**TABLE 5**

**KUDER-RICHARDSON 20 ESTIMATES FOR PRE-, MID-, AND POST-TEST SCORES FOR GROUP I AND GROUP II**

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre</th>
<th>Mid</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>.82</td>
<td>.62</td>
<td>.82</td>
</tr>
<tr>
<td>II</td>
<td>.83</td>
<td>.69</td>
<td>.85</td>
</tr>
</tbody>
</table>

**ANALYSIS OF VARIANCE FOR REPEATED MEASURES**

An underlying assumption of ANOVA is homogeneity of variance. Bartlett’s test is often used and is extremely sensitive to non-normality (Kennedy, 1978). Box’s M, a multi-variate test for the homogeneity-of-dispersion matrices is especially useful in the analysis of repeated measures designs (Norusis, 1985). Bartlett’s F-test and Box’s M provided no evidence of failure to meet the assumption of homogeneity of variance.
Table 6 summarizes the results of the two-factor experiment with repeated measures. The results indicate there is a significant difference from pre-test to post-test for both groups. There is no interaction between groups.

Further post hoc comparisons will determine where the significance differences occur from pre-test to mid-test to post-test.

**TABLE 6**

ANALYSIS OF VARIANCE SUMMARY TABLE FOR REPEATED MEASURES DESIGN

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groups (A)</td>
<td>1</td>
<td>35.103</td>
<td>.992</td>
<td>.324</td>
</tr>
<tr>
<td>Subjects Within Group</td>
<td>50</td>
<td>35.387</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Mid-Post</td>
<td>2</td>
<td>364.160</td>
<td>45.517</td>
<td>.000*</td>
</tr>
<tr>
<td>A x B</td>
<td>2</td>
<td>12.814</td>
<td>1.602</td>
<td>.207</td>
</tr>
<tr>
<td>Error</td>
<td>100</td>
<td>8.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

p < .001
As a more visual means of examining pre-, mid-, and post-test data, Figure 2 displays these results in graphical form.

FIGURE 2: PRE-, MID-, AND POST-TEST SCORES
Since (1) analysis of variance for repeated measures showed a significant difference from pre-test to post-test, (2) n's are equal, and (3) multiple pairwise comparisons are of interest, Tukey's test of Honest Significant Difference (HSD) is an appropriate measure of significance (Winer, 1971). Table 7 summarizes the post hoc comparisons for the data.

TABLE 7

POST HOC MULTIPLE COMPARISONS FOR PRE-, MID-, AND POST-TEST

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Results</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre to Mid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid &gt; Pre</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Pre to Mid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid &gt; Pre</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Mid to Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post &gt; Mid</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Mid to Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post &gt; Mid</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Group I Mid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with Group II Mid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Difference</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Group I Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with Group II Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Difference</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Results of Tukey's HSD indicated a significant increase from pre-test to mid-test for group I at the .05 level of significance, and a significant increase from pre-test to mid-test for group II at the .01 level of significance.

Tukey's HSD also indicated a significant gain from mid-test to post-test for group I at the .01 level of significance and a significant gain for group II from mid-test to post-test at the .05 level of significance.

No significant difference exists between the groups at the mid-test or at the post-test.

**COMPARISONS BETWEEN SELECTED ITEMS ON THE MID-TEST**

Since there was a significant difference from pre-test to mid-test for group I and group II, both groups—programming and classroom instruction—learned about variables. Individual items from the pre-test and mid-test were analyzed to determine which questions students from each group answered correctly. This information can be used to make inferences about which concepts of variable were learned from programming or from classroom instruction or from both treatments.

Items that were chosen from the mid-test were items on which the number of correct responses
increased by five or more from pre-test to mid-test. This criterion was met by six items for group I.

These items include pre-test items number 7, 8, 15, 18, 21, and 25, and the parallel items on the mid-test numbered 12, 6, 1, 18, 8, and 21, respectively. (The pre-test and mid-test are included in Appendix C).

These six test items involve the concept of substituting a given number for a letter, or the concept of operating on a letter, or unknown, directly. The items from the mid-test which involve substitution are listed below:

Item 6    If h = 10, what does h + 7 = ?
A. 7h    B. 10h
C. 17    D. 10    E. 7

Item 8    If t = 15, then t - 5 = ?
A. 155    B. 10    C. 20
D. 15 - t    E. t - 15

Item 21   If p = 3, what does p + 2 = ?
A. 2p    B. 3p
C. 3    D. 2    E. 5
Items 1 and 12 require operating on an unknown.

These items from the mid-test follow:

**Item 1**
If 3 feet equal 1 yard, y yards equals how many feet?

A. \(3 \times y\)  
B. 3  
C. \(1 \times y\)  
D. \(3 + y\)  
E. \(3 + 1\)

**Item 12**
If \(n\) represents a number, what is 50 more than the number?

A. \(50n\)  
B. \(n + 50\)  
C. 50  
D. \(50 - n\)  
E. \(50n + 50\)

Table 8 summarizes the number of correct responses on the pre-test and mid-test for these items.

For group II, the number of correct responses on the mid-test increased by five or more for the same six items and for six additional items.
TABLE 8

NUMBER OF CORRECT RESPONSES FOR SELECTED ITEMS FOR GROUP I ON THE PRE-TEST AND MID-TEST

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Pre-test Responses</th>
<th>Mid-test Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-</td>
<td>Mid-</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>21</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>25</td>
<td>21</td>
<td>20</td>
</tr>
</tbody>
</table>

COMPARISON OF SELECTED ITEMS FOR BOTH GROUPS AFTER THE PROGRAMMING TREATMENT

Both group I and group II showed a significant gain after the programming treatment. There were six items for group I, on which the number of correct responses increased by five or more, and three items for group II. None of the three items that showed an increase of five or more correct responses for group II after programming were the same items that showed an increase of five or more for group I after programming (See Table 9).
Since group II had classroom instruction before programming and did not answer the questions correctly after the classroom instruction treatment, a closer look at these three items may indicate that some concepts are learned better through programming than through classroom instruction.

The mid-test items for the three problems are listed below. The parallel items are post-test items number 11, 4, and 10.

**Item 4** Karl brought a box of cupcakes to share at the scout meeting. There were 20 scouts at the meeting, and \( C \) cupcakes. How many cupcakes did each scout receive?

A. \( C - 20 \)  
B. \( 20 \div C \)  
C. 20  
D. \( C \div 20 \)  
D. \( 20C \)

**Item 15** What is the cost in cents of \( f \) folders at 28 cents a folder?

A. \( 28 \times f \)  
B. \( 28 + f \)  
C. \( 28c \times f \)  
D. \( 28c + f \)  
E. 56c

**Item 17** If \( A + B = 9 \), and \( A - B = 5 \), What is \( A \)?

A. 7  
B. 2  
C. \( 2AB \)  
D. 4  
E. Impossible to solve
TABLE 9
NUMBER OF CORRECT RESPONSES FOR SELECTED ITEMS FOR GROUP II FROM THE MID-TEST TO THE POST-TEST

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Mid-test Responses</th>
<th>Post-test Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>17</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>

Group I scores, after programming, did not indicate improvement on any of these three items. The scores for group I for the same items are presented in Table 10.

TABLE 10
NUMBER OF CORRECT RESPONSES FOR GROUP I FROM PRE-TEST TO MID-TEST FOR SELECTED ITEMS

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Pre-test Responses</th>
<th>Mid-test Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>17</td>
<td>17</td>
<td>8</td>
</tr>
</tbody>
</table>
In summary, items on which the number of correct responses increased by five or more from the pre-test to the mid-test, or from the mid-test to the post-test, were selected for analysis. At the mid-test, comparisons were made between group I and group II for items which met this criteria. Six items met this criteria for group I and 12 items for group II. The six items for group I were also among the 12 items for group II.

Comparisons were made between group I and group II after the programming treatment. Six items for group I and three items for group II met the criteria for selection for analysis. None of the three items for group II were among the six items for group I.

**SUMMARY**

The results of the statistical analysis are summarized as follows:

1. No significant difference in mid-test scores between group I and group II. H1 could not be rejected at the .05 level of significance.

2. A significant difference (p < .01) from pre-test to post-test scores for group I and
for group II. H2 was rejected at the .01 level of significance.

3. No significant difference in post-test scores between group I and group II. H3 could not be rejected at the .05 level of significance.

4. A significant difference ($p < .05$) from pre-test scores to mid-test scores for group I after the programming treatment, and a significant difference ($p < .05$) from mid-test scores to post-test scores for group II after the programming treatment. H4 was rejected at the .05 level of significance.

5. A significant difference ($p < .01$) from mid-test scores to post-test scores for group I after the classroom instruction treatment, and a significant difference ($p < .01$) from pre-test scores to mid-test scores for group II after the classroom instruction treatment. H5 was rejected at the .01 level of significance.
CHAPTER 5
SUMMARY AND DISCUSSION

The purpose was to investigate the effects of programming in BASIC on students' ability to use and understand variables. Although research is available in several areas of computer applications in mathematics, little research addresses the relationship between programming and understanding concepts of variable. Many educators question whether programming experiences, either before or after students are introduced to variables through classroom instruction, can affect and enhance the use and understanding of concepts of variable. Three primary research questions were examined:

1. Through programming in BASIC, is the computer an effective way to teach the concept of variable to seventh-grade students who have had no formal instruction of variable or concepts of variable?

2. Does computer programming experience in BASIC enhance an understanding of the concept of variable that seventh-grade students have previously learned through (formal) classroom instruction?
3. Does either sequence--computer programming experience preceding, or following, classroom instruction of variable--more effectively enhance the understanding of variable?

The sample consisted of 52 seventh-grade students from an alternative traditional school of a large city school system. Twenty-six students were randomly assigned to each of two treatment groups. Group I received 15 one-hour sessions of programming in BASIC, and group II received 15 one-hour sessions of classroom instruction. The experimenter was the instructor for both treatment groups. A mid-test was given to determine if there was a significant gain in use and understanding of variable for either group, and to determine if a significant difference between groups existed.

The increase in mean performance at the mid-test for group I ($p < .05$), and the increase in mean performance for group II ($p < .01$), showed a significant gain in use and understanding of variable for both groups. Additionally, no significant difference existed, at the mid-test, between group I,
after the programming treatment, and group II, after the classroom instruction treatment.

In order to determine if computer programming experience in BASIC enhances understanding of the concepts of variable that students have previously learned through classroom instruction, the treatments were reversed after the mid-test. Group I received 15 one-hour classroom instruction treatments and group II received 15 one-hour programming treatments. A post-test was given to both groups after treatments.

The post-test was also used to determine which sequence--computer programming experience preceding, or following, classroom instruction of variables--more effectively enhances the understanding of variable.

The increase in mean performance from the mid-test to the post-test for group I ($p < .01$), and the increase in mean performance from the mid-test to the post-test for group II ($p < .05$), shows a significant gain in use and understanding of variable for both groups. Additionally, no significant difference exists between group I and group II at the post-test.

Since there is a significant difference from mid-test to post-test for group II, there is evidence that programming in BASIC enhanced knowledge of
variable that students had previously learned through formal classroom instruction.

For this study, since there is no significant difference between groups at the post-test, neither sequence--computer programming experience preceding, or following, classroom instruction of variable--more effectively enhanced the understanding of variable.

DISCUSSION

PRE-TEST TO MID-TEST

The significant gain in performance at the mid-test for group I indicates that some concepts of variable are learned through programming experiences in BASIC. The results suggest that some concepts are learned, but do not indicate which concepts of variable are learned, nor how much can be learned.

An analysis of individual items on the mid-post suggests that the concepts of variable learned through programming were related to the direct manipulation of variables during programming.

Six items on the mid-test were items on which the number of correct responses increased by five or more after programming. The items involved substitution and operating on an unknown. The same concepts of
substitution and operating on an unknown are needed when programming in BASIC with INPUT statements and FOR-NEXT statements. The subjects learned the concepts through programming and applied that knowledge to correctly answer the problems on the test. For example, the following programs, which the subjects were assigned during the programming treatment, use these concepts:

Program 1.  
10 PRINT "HOW OLD ARE YOU"
20 INPUT A
30 PRINT "YOU ARE ABOUT "365 • A "DAYS OLD"

Program 2.  
10 For Y = 1 to 20
20 Print Y * 5
30 Next Y

With the first program, the student learns that a letter represents some number, but that number is unknown at the time the program is written. Whoever uses the program determines the value of the number A. The student is operating with an unknown (365 • A). The concept of substitution is used when the program is run and the value of A is determined. The program user’s age is substituted for A.

The second program involves several concepts. The concept of substitution is involved (Y = 1 to 20). The
student is also operating on an unknown \((Y \times 5)\). The value of \(Y\) varies and the student generalizes the value of \(Y\) in the statement \((Y \times 5)\). Therefore, the program also incorporates the concept that a letter can represent a set of numbers \((Y\) equals the set of numbers from 1 to 20).

Five students in group I correctly responded to item 18 on the pre-test, and 15 students in group I responded correctly to the parallel item on the mid-test. This increase of 10 correct responses for one item was the largest increase for any item from pre-test to mid-test for either group. The mid-test item follows:

Item 18 If \(R = (2 \text{ times } E)\), what is another way to write \(R + 3\) ?

A. \(2R + 3E\)   B. \(2E \times (R + 3)\)
C. \((2 \times E) + 3\)   D. \(2 + 3\)
E. \(2ER + 3\)

The concept of substitution is more abstract in this problem since substitution requires substituting one unknown with another unknown. Does the concrete manipulation of the unknown, as experienced in programming, result in understanding of the concept?
An example of the programming experience that used this type of substitution is a problem in simple interest. Students were asked to write a program to compute the balance after one year for any amount of money at 7% rate of interest.

```
10 INPUT M
20 I = M * .07
30 PRINT M + I
```

For group II, after classroom instruction on variables, the increase in number of correct responses from pre-test to mid-test is similar for each of these six items to the increase for group I, after the programming treatment. The similarities between group responses support the results of no significant differences between groups at the mid-test. After programming in BASIC, group I learned many of the concepts of variable that group II learned after classroom instruction of variable.
MID-TEST TO POST-TEST

For group II, after the programming treatment, there were only three test items on the post-test on which the number of correct responses increased by five or more from the mid-test to the post-test. None of these three items were the same items that showed an increase of five or more for group I after the programming treatment. Classroom instruction of variable preceding the programming treatment may account for the difference between groups. Since group II received the programming treatment after formal classroom instruction of variable, they may have scored better on these items because the concepts learned through classroom instruction of variable were further enhanced by the programming experience. There is evidence that previous knowledge of variable is enhanced by programming experiences, but which concepts and how much can be learned is unknown.

PRE-TEST TO POST-TEST

Although no significant difference between group I and group II at the post-test indicates that sequence--programming experience preceding, or following, classroom instruction of variable--has no
effect on use and understanding of variable, a look at individual items indicates sequence may affect learning.

Since the increase in correct responses from pre-test to mid-test for group I and from mid-test to post-test for group II (after each group received the programming treatment) occurred for different problems, it appears that sequence may have an effect on students' use and understanding of variable. More students with previous instruction on variable correctly responded to three test items than students with no previous instruction on variable. The students with previous instruction on variable responded to these items incorrectly after the instruction treatment. They responded correctly after the programming treatment. No conclusions about the efficiency of one sequence over another can be made from this research. Further research is needed to determine if sequencing affects students' knowledge of variable, which concepts of variable are affected by sequence, and the efficiency of one sequence over another.
RECOMMENDATIONS

Although there was a significant statistical gain in knowledge of variable for both groups after the programming treatment, the mean was higher for both groups with classroom instruction than for either group with programming experience. If the treatments were given over an extended period of time, would there still be a significant gain for both groups, or would the group with formal classroom instruction learn significantly more?

Since the gain for group II from the mid-test to the post-test (after the programming treatment) was significant at the .05 level of significance, and the gain for both instruction treatment groups was significant at the .001 level of significance, it is possible that the knowledge gained from programming can be learned more efficiently through formal instruction of variable. More research is needed to determine which concepts of variable can be learned from programming in BASIC, and if these concepts are more efficiently learned through programming or from formal classroom instruction.

This study should be extended to include two additional control groups. One control group should
program in BASIC for the entire duration of the study and one control group should have classroom instruction for the length of the study. A mid-test should be given to both control groups at the same time it is given to the treatment groups.

The treatments should be extended to include a more thorough presentation of the subject matter in the programming treatment and also on concepts of variable in the classroom instruction treatment. The subjects should be provided more time for individual experimentation and investigation of the topics as they are presented.

The control groups will provide a comparison at the mid-test between two programming and two classroom instruction groups. The additional groups will also allow for multiple comparisons at the post-test. The extended exposure of the control groups to the subject matter (from mid-test to post-test) may reveal information about which concepts of variable are learned through programming and if the concepts are learned more efficiently through programming or through classroom instruction. The control groups would also provide the opportunity to investigate several aspects of sequencing.
While no definite statements can be made about which concepts of variable are learned through programming experiences in BASIC, this study produces evidence that some concepts of variable are learned through programming. This study also provides evidence that further investigation into the relationship between programming and variables will be fruitful.
LIST OF REFERENCES


Weaver F. J. (1973). The symmetric property of the equality relation and young children's ability to solve open addition and subtraction sentences. *Journal for Research in Mathematics Education*, 4, 45-56.

APPENDIX A

Homework Assignments for
Computer Programming Treatment
HOMEWORK ASSIGNMENT
DIRECTIONS

YOU DO NOT NEED A COMPUTER TO DO YOUR HOMEWORK.

Predict the outcome you think the computer will give when the program is RUN, or write the program you think will produce the output.

When you come to class tomorrow, you will be given time to test your results on the computer before class begins. You may change your paper if you like.
HOMEWORK ASSIGNMENT 1

WHAT WOULD A COMPUTER PRINT FOR EACH OF THESE?

10 N = 5
20 PRINT N

10 N = 5
20 PRINT "N"

10 FOR N = 1 TO 3
20 PRINT N
30 NEXT N

10 FOR N = 1 TO 3
20 PRINT N, "N"
30 NEXT N

10 FOR N = 5
20 PRINT N - 1
30 NEXT N

10 FOR N = 1 TO 5
20 PRINT N, N - 1
30 NEXT N

10 FOR N = 1 TO 4
20 PRINT N * 10
30 NEXT N

10 FOR T = 1 TO 14
20 PRINT T, T * 5

(WATCH OUT !)
HOME ASSIGNMENT 2

WHAT WOULD A COMPUTER PRINT FOR EACH OF THESE?

10 FOR H = 1 TO 24
20 PRINT H/2
30 NEXT H

10 FOR N = 1 TO 7
20 PRINT N, N*3, "N"
30 NEXT N

(WHAT'S WRONG?)

10 FOR A = 1 TO 15
20 PRINT A, A + 2, A * 2
30 NEXT A

10 FOR N = 1 TO 10
20 PRINT "N", N * 10
30 NEXT N

10 FOR N = 0 TO 4
20 PRINT N, N + 2, N * 2
30 PRINT "NEXT NUMBER"
40 PRINT "PLEASE"
50 NEXT N

10 FOR N = 0 TO 4
20 PRINT N, N+2, N*2
30 NEXT N

40 PRINT "NEXT"
50 PRINT "NUMBER"
60 PRINT "PLEASE !"
HOME ASSIGNMENT 3

WHAT WOULD A COMPUTER PRINT FOR EACH OF THESE?

10 N = 5
20 PRINT N
30 PRINT "N"
40 PRINT N "+" N
50 PRINT N - N
60 PRINT "N - N"

WRITE A PROGRAM TO PRINT EACH OF THESE:

1 10 1 3
2 20 2 6
3 30 3 9
4 40 4 12
5 50 • •
6 60 •
7 70 •
8 80 12 36
9 90
10 100
HOMEWORK ASSIGNMENT 4

WRITE A PROGRAM TO PRINT EACH OF THESE:

1 1
2 4
3 9
4 16
5 25
6 36
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
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59
60

WRITE A PROGRAM TO PRINT THIS:

1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16
17 18 19 20

(HINT: " ")
HOMEWORK ASSIGNMENT 5

WHAT NUMBER WOULD A COMPUTER PRINT FOR EACH OF THESE?

1.  $7^3 - 1$
2.  $3^3 - 5^2$
3.  $(9/3) \times 10$
4.  $21/7 + 100/10$
5.  $13^5/13 - 13$
6.  $(8 + 5)/22 - 9$
7.  $95 - (70 - 30)$
8.  $(4 \times 5) + 6$
9.  $4 \times 5 + 6/2$
10.  $7 \times 2 - (12/4)$
HOMEWORK ASSIGNMENT 6

TELL IN YOUR OWN WORDS WHAT WILL HAPPEN WHEN THIS PROGRAM IS RUN:

10   G = 1
20   PRINT G
30   G = G + G
40   GO TO 20

WHAT DO YOU THINK THE LAST NUMBER WILL BE?

WRITE A PROGRAM TO ASK:

   "HOW HIGH DO YOU WANT TO COUNT?"

THEN MAKE THE PROGRAM COUNT THAT HIGH.
HOMEWORK ASSIGNMENT 6

WRITE A PROGRAM TO COUNT BACKWARDS FROM 16 TO 1

16
15
14
13
12
11
10 etc.

WRITE A PROGRAM TO COUNT BACKWARDS BY 5

100
95
90
85
80 etc.
HOMEWORK ASSIGNMENT 7

WRITE A PROGRAM TO LET YOU GUESS A NUMBER BETWEEN 1 AND 100. HAVE THE COMPUTER TELL YOU IF YOU ARE TOO HIGH OR TOO LOW, OR IF YOU ARE A WINNER.

EXTRA CREDIT: Can you make the computer tell you how many guesses it took to win?
HOMEWORK ASSIGNMENT 8

WRITE AN ADDITION PRACTICE PROGRAM FOR A FIRST GRADER.

Have the computer randomly select numbers for the problems and tell the user if the answer is correct or incorrect.

EXTRA CREDIT: Choose one or more:

- If the answer is incorrect, give the user a second chance to get the correct answer.

- If the answer is incorrect, tell the user the correct answer.

- Program the computer to stop after ten problems.

- Ask the user if he or she wants to do another set.
HOMEWORK ASSIGNMENT 9

Mr. Sanders' boy scout troupe made 600 pieces of fudge to sell. They plan to sell the fudge for $1.00 per box. Their total expenses for the project were $10. They want to make a profit of $50. How many pieces should they put in each box?

Write a program so you can input any amount for the number of pieces of fudge, the profit, and the total expense. Try different numbers and keep a record of your results.
HOMEWORK ASSIGNMENT 10

SUPPOSE YOU DON'T KNOW HOW TO DIVIDE!

The problem below would take a while to solve if you couldn't divide. The computer could do it quickly, however. Write a program to solve the problem without division.

Mr. Ray borrowed money from a (rich) friend. He borrowed $2241. He promised to pay him $124.50 each month until the debt was paid. How many months will it take Mr. Ray to pay his friend?
HOMEWORK ASSIGNMENT 11

WRITE A PROGRAM TO SOLVE THIS PROBLEM:

The Community Center has a capacity of 5000. You are sponsoring a special event for children (and their parents, if they want) next week. You want to know whether you will break even.
- you must gross $20,000 in ticket sales to break even
- an adult ticket cost $\_\_\_.00
- a child's ticket cost $2.00
- a capacity crowd is expected

What is the least amount of adult and children’s tickets you must sell to break even?
WRITE A PROGRAM TO HELP YOU SOLVE THIS PROBLEM:

You have a fixed amount of fencing material—300m. You want to build a rectangular pasture to have the largest area possible. With this fencing you try different shaped (still rectangular) pastures. What dimensions will give you the pasture with the largest area?

EXTRA CREDIT: Write the program to draw the different rectangles for you to see how they look.
APPENDIX B

Summary of Results of Statistical Analysis of Pre-test
DESCRIPTIVE STATISTICS

TABLE 11

MEANS AND STANDARD DEVIATIONS FOR GRADE 5, 6, AND 7

<table>
<thead>
<tr>
<th>Grade</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>46</td>
<td>10.15</td>
<td>3.59</td>
</tr>
<tr>
<td>6</td>
<td>46</td>
<td>11.63</td>
<td>3.79</td>
</tr>
<tr>
<td>7</td>
<td>46</td>
<td>15.15</td>
<td>5.67</td>
</tr>
<tr>
<td>Total</td>
<td>138</td>
<td>12.31</td>
<td>4.89</td>
</tr>
</tbody>
</table>

FACTOR ANALYSIS

FACTOR ONE

A factor analysis showed that two factors accounted for 25.6% of the variance. Eleven test items loaded significantly on one factor and six items loaded significantly on the second factor with a cut-off point of .375 for both factors.

All the items that loaded on factor one fit into one of Kuchemann’s first three categories of letter usage. All of the problems could be solved by hints from key words, recalling a familiar bond, substituting numbers for letters, or using the letter as an object. None of the solutions involved manipulating or
operating on an unknown). The following problems are examples of problems that loaded on factor one:

1. How old will Joe be in 10 years if he is Y years old now?
   A. 10 x Y  B. Y + 10  C. 10 - Y
   D. Y - 10  E. 10 -- Y
   (letter as object--years + 10, or familiar bond--add 10 to find out how old in ten years)

2. What is 10 less than 3 times w?
   A. 7  B. 30  C. w - 7
   D. 10 - w  E. (3 x w) - 10
   (key word--10 less means subtract 10)

3. The perimeter or distance around this figure is?
   A. fg + 5  B. f+g+5  C. f5g
   D. 18  E. 5fg
   (familiar bond--perimeter is sum of the sides of figure)

4. If t = 3, what does t + 2 =?
   A. 2t  B. 3t  C. 5
   D. 3  E. 2
   (substitution)

5. The cost for a ride at the fair was c cents for each adult and d cents for each child. What is the cost for 3 adults and 2 children?
   A. 3c + 2d  B. 5cd  C. 5 x c x d
   D. 6cents  E. c + d cents
   (letter as object--3 adults and 2 children.)
FACTOR TWO

All of the items that loaded on factor two fit into category four, five, or six. The solutions to the six problems that loaded on factor two required the ability to do at least one of the following:

1. to see the relationship between two specified values and to find those values.
2. to see relationships between two unspecified values
3. to manipulate and operate on an unknown,
4. to regard the letter as a generalized number.

The following problems are examples of problems that loaded on factor two:

1. The mother is 20 years older than her daughter. The sum of their ages is 40. Which of the following is not true about their ages?
   A. M = D + 20  
   B. D - M = 20  
   C. M + D = 40  
   D. D = M - 20  
   E. M - D = 20  

   (relationship between two specified values)

2. If \( n \) nickels and \( 2 \times n \) dimes equal 50 cents, how much does \( n \) equal?
   A. 10  
   B. 4  
   C. 3  
   D. 2  
   E. 5  

   (specific unknown)
3. Which statement is always true about these two numbers: 2 x n and n + 2?
   A. 2 x n > n + 2   B. 2 x n = n + 2
   C. n + 2 > 2 x n   D. 2 x n > n + 2 when n > 2
   E. n + 2 > 2 x n when n > 2

(Kuchemann's example of a relationship between unspecified values)

REGRESSION ANALYSIS

Results of regression analysis found that grade level was a significant predictor of total test score, \( p < .0001 \). Eighteen percent of the variance in grade can be explained by the total test score.

A stepwise multiple regression performed on factor 1 and factor 2 with grade as the dependent variable found that the combination of factor 1 and factor 2 explained 20% of the variance in grade. Factor 2 alone accounted for 16% of the variance. Factor 2 is significantly related to grade level, \( p < .0001 \), and factors 1 and 2 combined are also significantly related to grade, \( p < .0001 \).
ITEM ANALYSIS

TABLE 12
SUMMARY RESULTS OF ITEM ANALYSIS

<table>
<thead>
<tr>
<th></th>
<th>Average Item difficulty</th>
<th>Phi</th>
<th>Cronbach’s Alpha</th>
<th>Number of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>.52</td>
<td>.69</td>
<td>.81</td>
<td>26</td>
</tr>
<tr>
<td>Factor 1</td>
<td>.42</td>
<td>.74</td>
<td>.79</td>
<td>11</td>
</tr>
<tr>
<td>Factor 2</td>
<td>.71</td>
<td>.71</td>
<td>.63</td>
<td>6</td>
</tr>
</tbody>
</table>

Item analysis showed that item difficulty for factor one ranged from .23 to .54, and item difficulty for factor two ranged from .59 to .83. The range for the total was .13 to .83.

Phi coefficients for the items in factor one ranged from .62 to .84 with significance ranging from $p < .0004$ to $p < .00001$. Phi coefficients for factor two ranged from $.60$ to $.82$ with significance ranging from $p < .001$ to $p < .00001$. 
CORRELATION WITH MATHEMATICS GRADE

Pearson correlation coefficients were calculated to determine the relationship of the student's total test score with his or her final grade in mathematics for the school year. The grading scale was A, B, C, D, or E. (Table 19).

TABLE 13

PEARSON PRODUCT MOMENT CORRELATION TOTAL TEST SCORE AND FINAL GRADE IN MATHEMATICS

<table>
<thead>
<tr>
<th>Grade</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>.59</td>
</tr>
<tr>
<td>6</td>
<td>.75</td>
</tr>
<tr>
<td>7</td>
<td>.65</td>
</tr>
<tr>
<td>total *</td>
<td>.65</td>
</tr>
</tbody>
</table>

p < .001
APPENDIX C

Pre-test, Mid-test, and Post-test
CIRCLE THE LETTER NEXT TO THE CORRECT ANSWER.

1. Add 4 to n + 5
   A. 9
   B. 4n + 5
   C. n + 9
   D. 36
   E. 13

2. How old will Joe be in 10 years if he is Y years old now?
   A. 10 x Y
   B. Y + 10
   C. 10 - Y
   D. Y - 10
   E. 10 ÷ Y

3. Mary brought a bag of candy to school to share with the class. There are 16 students in her class and C pieces of candy. How many pieces does each student receive?
   A. C - 16
   B. 16 + C
   C. 16
   D. C ÷ 16
   E. 16C

4. How many dolls do Janet and Kate have altogether if Janet has J dolls and Kate has K dolls.
   A. 5J + 4K
   B. JK
   C. 9
   D. J + KD
   E. J + K
5. If \( w + y = 32 \), then \( w + y + 2 = ? \)
   A. 34
   B. 32
   C. \( w + y \)
   D. \( 2(w + y) \)
   E. \( 2wy \)

9. What is the sum of twice the number \( n \), and 4 times the same number ?
   A. \( 2n + 4 \)
   B. \( 4 + 2n \)
   C. \( 8n \)
   D. \( 6n \)
   E. \( 2(n + 4) \)

6. What is \( (7 + 3) \) multiplied by \( h \) ?
   A. \( 7h + 3 \)
   B. \( 10 \times h \)
   C. \( 7 + 3h \)
   D. \( 10 \)
   E. \( 73h \)

10. What is the cost in cents of \( p \) pencils at 8 cents a pencil ?
    A. \( 8 \times p \)
    B. \( 8 + p \)
    C. \( 8c \times p \)
    D. \( 8c + p \)
    E. \( 16c \)

7. If \( n \) represents a number, what is 20 less than the number ?
   A. \( 20n \)
   B. \( 20 - n \)
   C. \( 20 \)
   D. \( 20 + n \)
   E. \( n - 20 \)

11. The cost for a ride at the fair was \( c \) cents for each adult and \( d \) cents for each child. What is the cost for 3 adults and 2 children ?
    A. \( 3c + 2d \) cents
    B. \( 5cd \) cents
    C. \( 5c \times c \times d \) cents
    D. \( 6 \) cents
    E. \( c + d \) cents

8. What is the sum of \( n \) and 6, if \( n = 2 \) ?
   A. \( 2n \)
   B. \( n + 6 \)
   C. \( 2 \times n = 6 \)
   D. \( 6 \)
   E. \( 8 \)

12. What is 5 more than \( n \) ?
    A. \( 5n \)
    B. \( 10 \)
    C. \( 7 \)
    D. \( n + 5 \)
    E. \( 5 \)
13. The mother is 20 years older than her daughter. The sum of their ages is 40. Let $M$ be the mother's age and $D$ be the daughter's age. Which of the following is not true about their ages?

A. $M = D + 20$
B. $D - M = 20$
C. $M + D = 40$
D. $D = M - 20$
E. $M - D = 20$

14. If $n$ nickels and $2 \times n$ dimes equal 50 cents, how much does $n$ equal?

A. 10
B. 4
C. 3
D. 2
E. 5

15. If 12 in. equal 1 foot, $f$ feet equals how many inches?

A. $12 \times f$
B. 12
C. $1f$
D. $12 + f$
E. $12 + 1$

16. What is the sum of (3 times 6) and 4?

A. 19
B. 18
C. 22
D. 10
E. 9

17. What does $S$ equal if $M - S = 10$ and $M + S = 2$?

A. 8
B. 4
C. 2
D. 6
E. impossible to solve

18. If $R = 2$ times $E$, what is another way to write $R + 3$?

A. $2R + 3E$
B. $2E \times (R + 3)$
C. $(2 \times E) + 3$
D. $2 + 3$
E. $2ER + 3$

19. What is 10 less than 3 times $w$?

A. 7
B. 30
C. $w - 7$
D. $10 - w$
E. $(3 \times w) - 10$

20. Jill has 50 cents, and has twice as many dimes as nickels. How many nickels does she have?

A. 10
B. 4
C. 3
D. 2
E. 5
21. If $n = 3$, then $4 \times n =$
A. 43
B. 12
C. 7
D. 3n
E. 12n

22. If $R = S + 5$, and $S = 2$, which expression is true?
A. $R = 7$
B. $R = 5$
C. $R + S = 5$
D. $R = S = 2$
E. $R = 3$

23. The perimeter or distance around this figure is:
A. $fg + 5$
B. $f + g + 5$
C. $5fg$
D. 18
E. $5fg$

24. Choose the expression that represents the perimeter (distance around) of this figure.
A. $2A + 2C + B + D + E$
B. ABCDE
C. AABCCDE
D. $A + B + C + D + E$
E. 19
CIRCLE THE LETTER NEXT TO THE CORRECT ANSWER.

1. If 3 feet equal 1 yard, y yards equals how many feet?
   A. 3 \times y
   B. 3
   C. 1 \times y
   D. 3 \times y
   E. 3 \times 1

2. What is 2 times K, increased by 3?
   A. 6K
   B. K + 3
   C. 2 \times K
   D. 2 \times 3K
   E. 2K + 3

3. How many transformers do Bill and Joe have altogether if Bill has B transformers and Joe has J transformers?
   A. 5B + 4J
   B. BJ
   C. 9
   D. B + JT
   E. B + J

4. Karl brought a box of cupcakes to share at the scout meeting. There were 20 scouts at the meeting, and C cupcakes. How many cupcakes did each scout receive?
   A. C - 20
   B. 20 + C
   C. 20
   D. C \div 20
   E. 20C
5. If Q quarters and 2 x Q dimes equal $1.35, how much does Q equal?
   A. 5
   B. 4
   C. 3
   D. 6
   E. none of the above

6. If \( h = 10 \), what does \( h + 7 = ? \)
   A. 7h
   B. 10h
   C. 17
   D. 10
   E. 7

7. If \( N = C + 3 \), and \( C = 5 \), which expression is true?
   A. \( N = 8 \)
   B. \( N = 3 \)
   C. \( N + C = 3 \)
   D. \( N + C = 5 \)
   E. \( N = C + 5 \)

8. If \( t = 15 \), then \( t - 5 = ? \)
   A. 155
   B. 10
   C. 20
   D. 15 - t
   E. \( t - 15 \)

9. If \( a - b = 8 \), then \( a - b + 3 = ? \)
   A. 5
   B. 8
   C. 11
   D. 3ab
   E. 8ab

10. If \( t = 30 \), what is the sum of \( t \) and 6?
    A. 36
    B. \( t + 30 \)
    C. 30t
    D. \( t + 6 \)
    E. 30

11. The cost for a doughnut at the bakery was \( p \) cents for each plain doughnut and \( f \) cents for each filled doughnut. What is the cost for 3 plain and 2 filled doughnuts?
    A. \( 5 \times p \times f \) cents
    B. \( 5pf \) cents
    C. 6 cents
    D. \( 3p + 2f \) cents
    E. \( p + f \) cents

12. If \( n \) represents a number, what is 50 more than the number?
    A. 50n
    B. \( n + 50 \)
    C. 50
    D. 50 - n
    E. \( 50n + 50 \)
13. What is $12 - 7$ multiplied by $b$?
   A. $12b - 7$
   B. $5 \times b$
   C. $12 - 7b$
   D. $19b$
   E. $5$

14. What is 10 more than $G$?
   A. $10G$
   B. 20
   C. $10 + 10$
   D. $G + 10$
   E. 10

15. What is the coat in cents of $f$ folders at 28 cents a folder?
   A. $28 \times f$
   B. $28 \times f$
   C. $28c \times f$
   D. $28c \times f$
   E. $56c$

16. What is twice a number $n$, plus three times the same number?
   A. $2n + 3$
   B. $3 + 2n$
   C. $6n$
   D. $5n$
   E. $2(n + 3)$

17. IF $A + B = 9$, and $A - B = 5$, what is $A$?
   A. $7$
   B. $2$
   C. $2AB$
   D. $4$
   E. impossible to solve

18. If $N = (2 \times C)$, what is another way to write $N + 4$?
   A. $2N + 4C$
   B. $2C \times (N + 4)$
   C. $(2 \times C) + 4$
   D. $2 + 4$
   E. $2CN + 4$

19. What is 5 more than $(4 \times t)$?
   A. 9
   B. 20
   C. $t + 9$
   D. $t + 4$
   E. $(4 \times t) + 5$

20. Bob has $61.35$, and has twice as many dimes as quarters. How many quarters does he have?
   A. 5
   B. 4
   C. 3
   D. 6
   E. none of the above
21. If \( p = 3 \), what does \( p + 2 = ? \)
   
   A. \( 2p \)
   B. \( 3p \)
   C. \( 3 \)
   D. \( 2 \)
   E. \( 5 \)

25. What is 8 more than \( a + 4 \)?
   
   A. \( 12 \)
   B. \( 8a + 4 \)
   C. \( a + 12 \)
   D. \( 32 \)
   E. \( a + 8 \)

22. Pete’s dog, Spot, is 7 years older than Cory’s dog, Rusty. The sum of their ages is 15. Let \( S \) = Spot’s age and \( R \) = Rusty’s age. Which of the following is not true about their ages?
   
   A. \( S = R + 7 \)
   B. \( R - S = 7 \)
   C. \( R + S = 15 \)
   D. \( R = S - 7 \)
   E. \( S - R = 7 \)

23. The area of this square is:
   
   A. \( 4 \times J \)
   B. \( 4 + J \)
   C. \( 4 \times 4 \)
   D. \( J \times J \)
   E. \( J + J + J + J \)

24. How old was Mr. Best 7 years ago if he is \( Y \) years old now?
   
   A. \( Y + 7 \)
   B. \( Y - 7 \)
   C. \( 7 - Y \)
   D. \( 7 \times Y \)
   E. \( 7Y \)
CIRCLE THE LETTER NEXT TO THE CORRECT ANSWER.

1. Multiply \((9 + 3)\) by \(z\).
   - A. \(9 + z\)
   - B. \(9 + 3 + z\)
   - C. \(12z\)
   - D. \(12\)
   - E. \(9z + 3\)

2. What is thirteen less than \(r\)?
   - A. \(13r\)
   - B. \(26\)
   - C. \(13\)
   - D. \(13 - r\)
   - E. \(r - 13\)

3. What is three times the number \(n\), minus twice the same number?
   - A. \(3n - 2\)
   - B. \(n - 3n\)
   - C. \(6n\)
   - D. \(3 - 2n\)
   - E. \(n\)

4. How much are \(G\) pieces of gum at the cost of 5 cents each?
   - A. \(5 \times G\)
   - B. \(5 + G\)
   - C. \(5c + G\)
   - D. \(5c \times G\)
   - E. \(10c\)
5. P pennies and 5 x P nickels equal 78 cents. What does P equal?
   A. 10  
   B. 5   
   C. 75  
   D. 3   
   E. 4

9. Y = (3 + W), What is another way to write Y times 2?
   A. 6W  
   B. 2(3 + W) 
   C. 6 + W 
   D. 2Y + W 
   E. 6Y

6. Bob is 9 years younger than his sister. How old is his sister?
   A. B + 9 
   B. B - 9 
   C. 9B  
   D. B + 5 
   E. 9 - B

10. If F + J = 6, and F x J = 8, Which of the following could be F?
    A. 4   
    B. 6 + 8 
    C. 6 - F 
    D. 14  
    E. 5

7. What is 4 less than (8 divided by h)?
   A. 2h  
   B. h/2 
   C. (8/h) - 4 
   D. h - 4 
   E. 8/4h

11. Mike had a bag of marbles to share equally with his friends. He had 5 friends and M marbles. How many marbles could each friend have?
    A. 5 x M 
    B. 5 ÷ M 
    C. M + 5 
    D. 5 
    E. M - 5

8. Sarah has 78 cents. She has 5 times as many nickels as pennies. How many pennies does she have?
   A. 10  
   B. 5   
   C. 75  
   D. 3   
   E. 4

12. Deb has D blouses and Meg has M blouses. How many blouses do they have together?
    A. D + MB 
    B. DB + MB 
    C. (D + M) x B 
    D. DM 
    E. D + M
13. Julie earned twelve more dollars than Dan. Their total earnings were $32. Let J = the amount of dollars Julie earned and D = the amount of dollars Dan earned. Which of the following is false?
   A. J = D + 12
   B. D - J = 12
   C. D - J = 32
   D. D = J - 12
   E. J - D = 12

14. What is 10 less than W, if W = 100?
   A. 10W
   B. 100 - W
   C. 1000W
   D. 90W
   E. 90

15. Add 7 to V.
   A. 7V
   B. 7
   C. V
   D. V + 7
   E. 7 + 7

16. What is twice a number n, plus three times the same number?
   A. 2n + 3
   B. 3 + 2n
   C. 6n
   D. 5n
   E. 2(n + 3)

17. If 5280 feet equal 1 mile, M miles equals how many feet?
   A. 5280 x M
   B. 5280
   C. 1 x 5280
   D. 5280 + M
   E. 5280 + 1

18. What is three times four, decreased by H?
   A. 12H
   B. 12 - H
   C. 3H x 4H
   D. 1H
   E. 7 - H

19. If n = 50, what does n - 30 =?
   A. 30n
   B. 30
   C. 20
   D. 20 - n
   E. 50

20. If K = M x 5, and M = 50, which of the following is true?
   A. K = 50 x 5
   B. M = 250
   C. K x M = 250
   D. K = 50 + 5
   E. K = 50
21. If $ab = 10$, then $a + b + 5 = ?$
   A. 50  
   B. 15  
   C. 5ab  
   D. $5a + b$  
   E. $5a + b$

22. What is the cost of 2 single-dip cones and one double-dip cone if a single-dip cone cost S cents and a double-dip cone cost D cents ?
   A. $2 \times S \times D$ cents  
   B. $2 + S + D$ cents  
   C. $(2 \times S) + D$ cents  
   D. $S + D$ cents  
   E. $3 \times S \times D$ cents

23. The perimeter of this figure is:
   A. $7 + h$  
   B. $7 \times h$  
   C. $7 \times 7$  
   D. $h \times h$  
   E. $7 \times 7$

24. If $t = 45$, what is $t$ divided by 5?
   A. $45t$  
   B. $45 \div t$  
   C. 9t  
   D. 5t  
   E. 9

25. If $E$ represents a number, what is 20 less than the number ?
   A. 20E  
   B. 20 + E  
   C. $E - 20$  
   D. 20  
   E. $20E - 20$
APPENDIX D

Frequency Distributions for Pre-Test, Mid-Test, and Post-Test Data
TABLE 14
FREQUENCY DISTRIBUTION OF PRE-, MID-, AND POST-TEST SCORES FOR GROUP I

<table>
<thead>
<tr>
<th>Score</th>
<th>Pre-test frequency</th>
<th>Mid-test frequency</th>
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<tr>
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<td>1</td>
<td>1</td>
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<td>20 - 22</td>
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Total 26  26  26
TABLE 15

FREQUENCY DISTRIBUTION OF PRE-, MID-, AND POST-TEST
SCORES FOR GROUP II

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| Total | 26               | 26                 | 26                 |
TABLE 16

MEAN SCORE AND NUMBER OF STUDENTS SCORING IN THE UPPER 27.5% AND LOWER 27.5% OF TOTAL TEST SCORE

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