A DESCRIPTIVE STUDY OF COGNITIVE AND AFFECTIVE VARIABLES ASSOCIATED WITH ACHIEVEMENT IN A COMPUTER - ASSISTED INSTRUCTION LEARNING SITUATION

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

THOMAS SCOTT NAGEL

1969

This is to certify that the

thesis entitled

A Descriptive Study of Cognitive and
Affective Variables Associated With Achievement
In A Computer-Assisted Instruction
Learning Situation

presented by

Thomas Scott Nagel

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Education

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Date July 30, 1969

O-169

ABSTRACT

A DESCRIPTIVE STUDY OF COGNITIVE AND AFFECTIVE VARIABLES ASSOCIATED WITH ACHIEVEMENT IN A COMPUTER-ASSISTED INSTRUCTION LEARNING SITUATION

By

Thomas Scott Nagel

The problem investigated in this study was to identify variables from the cognitive and affective domains which best relate to achievement as measured by concept block posttests on computer-assisted instruction drill and practice mathematics materials. Once identified, these variables would then be used to generate linear regression equations which, when validated, could be used to predict achievement for other children before they began the program.

The subjects used were second through sixth graders at Riverside Elementary School, Waterford Township, Michigan, where an RCA Instructional 70 CAI facility is installed. These children made daily use of the facility studying Mathematics by the Patrick Suppes' drill and practice mathematics program.

The experimentor used the following instruments to assess affective variables for each child: Children's Personality Questionnaire, Self-Concept and Motivation Inventory, and Thinking Creatively With Pictures. The

Individual Communication Project (INDICOM) had already administered the following instruments: Stanford Achievement Arithmetic Subtest, Quick Word Test, Iowa Test of Basic Skills, and the Warner Socio-Economic Scale.

The scores from all of these instruments formed a group of independent variables relating to both cognitive and affective domains for each child. The dependent variable was found by averaging the scores on posttests across several concept blocks studied by CAI.

Because predictive equations were desired, regression analysis employing stepwise addition of variables was used. Each grade was analyzed separately because different mathematical topics are studied at each grade level. This analysis produced the following equations:

Grade 2:

Posttest Score = 1.033 (Stanford Arithmetic)
+ 1.930 (CPQ-Teneness)
- 3.645 (CPQ-Neuroticism)
+ 0.405 (SCAMIN-Motivation)
+ 14.546

Grade 3:

Posttest Score = 0.748 (Vocabulary)
+ 1.201 (CPQ-Shrewdness)
+ 1.849 (CPQ-Excitableness)
+ 1.603 (CPQ-Warmheartedness)
+ 59.363

Grade 4:

Posttest Score = 0.353 (Vocabulary) + 0.149 (Language Skills) - 0.121 (SCAMIN-Motivation) + 0.440 (CPQ-Intelligence) + 0.109 (SCAMIN-Self-Concept) + 69.888

Grade 5:

Posttest Score = 3.420 (CPQ-Intelligence) + 1.114 (Arithmetic Problem Solving) - 0.126 (Creativity-Elaboration) + 54.917

Grade 6:

Posttest Score = 0.462 (Arithmetic Concepts) + 1.870 (CPQ-Emotional Stability) + 0.206 (Language Skills) + 3.799 (Sex) + 41.756

Each of these equations was generated using data on three-fourths of the children while one-fourth of the children had been randomly selected to validate the equation. Results of t tests on data supplied by the validation sample showed no significant difference at the $p < .05$ level between predicted and actual average concept block posttest achievement. The standard error of estimate also provided usable confidence intervals for prediction of individual scores.

Differences in achievement between males and females were investigated at each grade level. Results of t tests showed no significant differences for grades two through five; however, grade six showed a significant difference at the $p < .05$ level favoring the boys.

Contrary to expectations there was almost no correlation between CAI achievement and socio-economic status, an inconsistent pattern of correlations with academic motivation, and small but positive correlations with extraversion rather than introversion. Measures of creativity appeared to have little relation to achievement.

One of the broad generalizations which seems warranted from this study concerns the importance of the affective domain. While, as expected, cognitive variables assumed primary importance in all of the regression equations which were generated, a great deal of additional variance was explained by the addition of affective variables.

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A THESIS

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

DOCTOR OF PHILOSOPHY

Department of Counseling, Personnel
Services, and Educational Psychology

1969

ACKNOWLEDGMENTS

There are countless persons who made substantial efforts which facilitated the progress of this study. Sincere appreciation is expressed to all of these people.

Particular appreciation is expressed to Dr. Norman Bell for his counsel and direction throughout the project and for his guidance and encouragement in every step of the doctoral program.

Great assistance was offered at every turn by my wife, Anne Nagel, who performed the most menial to highly sophisticated tasks in the progress of the study and was always ready with advice and encouragement.

Gratitide is expressed to Dr. Robert Scrivens of the INDICOM Project staff for his efforts in arranging scheduling and data collection.

The assistance of Principal Charles Welch and the staff of Riverside School was invaluable in collecting the data for this study.

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CHAPTER I

THE PROBLEM

Introduction

Educational technology has made it increasingly possible to meet the individual needs of students. This is accomplished in the main by breaking subject matter down into small packages which students may work on at their own pace, if indeed they require such instruction at all. Various instructional methods may be employed in a variety of these packages aimed at satisfying the individual needs of children. Consequently it becomes more and more important to acquire the capability of being able to prescribe those instructional packages for each child which will account for his particular characteristics and have the greatest probability of helping him to maximize his achievement.

Cronbach (1957, p. 679) comments that, "The greatest social benefit will come from applied psychology if we can find for each individual the treatment to which he can most easily adapt." Later he goes on to say (p. 681) ". . . we do find that a person learns more easily from one <u>method</u> than another, that this best method differs from person to person, and that such between-treatments differences are correlated with tests of ability and personality." In this regard, Donaldson (1969, p. 6) states:

> The use of a single variable such as intelligence is not the most effective route to identifying student-types, or the most reliable usage of scores to categorize students effectively in terms of supplying alternate methods of instruction. To derive the most meaningful identification, combinations of basic ability and personality adjustment can be used in terms of alternate experimental treatments to identify groups of students likely to achieve 'better' (at a higher level) by each of the alternate methods.

Bloom (1968, p. 10) comments, "At present, we do not have firm evidence on the relations between student characteristics and instructional materials and procedures." He goes on to say, however, that knowledge of these characteristics is important in being able to devise instruction which will assist in maximizing a child's achievement. Additionally, both Bloom (1968) and Carroll (1963) express the idea that the same instructional materials are not equally good for all children.

The electronic computer is one technological innovation which has already demonstrated great effectiveness in the delivery and management of instructional packages. This process is called computer-assisted instruction, or CAI. Richard C. Atkinson (1968, pp. 225-226) has delineated three possible systems for the use of computers in an instructional capacity. He defines these systems as follows:

1. Drill and Practice: This system operates at the simplest interactional level and presents a fixed, linear sequence of problems. "Student errors may be corrected in a variety of ways, but no real-time decisions are made for modifying the flow of instructional material as a function of the student's response history."

2. Tutorial: "Tutorial programs have the capability for real-time decision making and instructional branching contingent on a single response or on some subset of the student's response history. Such programs allow students to follow separate and diverse paths through the curriculum based on their particular performance records."

3. Dialogue: This type of program has not as yet been successfully developed but its goal is ". . . to provide the richest possible student-system interaction where the student is free to construct natural-language responses, ask questions in an unrestricted mode, and in general, exercise almost a complete control over the sequence of learning events."

Particularly at a time when the cost of using computers is rather high, as it is now, and facilities and trained personnel are limited, it may be important to allow only the children achieving at the highest level to use such facilities. If this is to be accomplished, it will be necessary to identify student characteristics associated with the achievement which may be expected of a child when computer-assisted instruction is utilized.

A school in Michigan utilizing a CAI facility, Riverside Elementary School in Waterford Township, faces just such a problem. Soon it will be necessary for the school to go on a split shift, making it impossible for all children to use the CAI facilities. Teachers and school authorities alike desire to arrange scheduling in such a way that the children who use the facilities are the ones who have predictions of the greatest achievement.

In response to these needs, it was planned to conduct a testing program at Riverside School encompassing both cognitive and affective areas. Data from this program was used to look for relations to achievement resulting from the use of computer-assisted instruction drill and practice mathematics materials.

Objectives

The objectives of this study were: (1) to obtain a rather complete description of the population of students using the computer-assisted instruction RCA instructional 70 system and the Suppes' mathematics materials at Riverside School, and (2) to generate predictive regression equations for average concept block posttest achievement on the basis of the factors from the population description which explain the greatest portion of the variance.

System Description

The description of the population was obtained by using a variety of instruments covering the areas of personality, self-concept and motivation, creativity, achievement, intelligence, and socio-economic status.

The manuals for these tests claim that they are all standardized, reliable measures appropriate for this age group. A more detailed description of the specific instruments used is presented in Chapter III

The RCA Instructional 70 system is the CAI system installed at Riverside School. It consists of 32 teletype terminals linked by phone lines to a SPECTRA 70/45 computer in Palo Alto, California. The terminal is of a standard variety. It consists of a typewriter keyboard and prints on a roll of paper. The keyboard is locked while the computer is in control and is unlocked when the child is in control. It is necessary for children to use only the number keys for the mathematics program, so that even very young children have little difficulty in learning to use the equipment. This terminal provides what may be an added advantage by producing a typed copy of the lesson which the child takes with him at the end of each session. This copy contains all of the problems presented by the computer for that lesson, all of the child's responses, the average per cent corrent, and the time in seconds spent on the terminal. Teachers may scan each child's print-out as he leaves the CAI lab and offer appropriate comments.

The software used in the RCA Instructional 70 system is the drill and practice mathematics program prepared by Dr. Patrick Suppes. Mathematical topics studied during a school year are divided into 24 units, called concept blocks, at each grade level. Each concept block covers seven days of instruction. The first day consists of a pretest and the last day is a posttest. The level of difficulty of these tests is the same for all children. The five days of drill and practice problems between pretest and posttest, however, are also scaled on five levels of difficulty. The level of difficulty on the lesson started the second day is determined by the child's score on his pretest taken the first day. The level of difficulty of the lesson on the third day is determined by the child's score on the second day's lesson. This procedure continues in like manner for five lessons. The child moves up one level if he has a score between 85 and 100, he stays at the same level if his score is between 60 and 85, and he moves down one level if his score is below 60.

Besides the regular drill lessons for days two through five in a concept block, each child is also given a review lesson which may be drawn from material covered in any previous concept block. The computer keeps a record of all the concept block posttest scores and uses this information to select which review lesson the child will receive. The lowest posttest score on any concept block covered determines that that material will be reviewed. On the sixth day of drill, instead of taking a review, the pupil takes a review test along with the regular drill. The score on this review test replaces the drill posttest score which was used for the initial selection of the review lesson.

Figure 1 illustrates the structure of a concept block and shows the interrelationship of drill and review lessons, the activities on each of the seven days, and the five levels of difficulty.

A sample drill and practice mathematics lesson is included in Appendix A showing what an actual lesson may look like when it is presented to a child.

While a child is working on a lesson at the terminal, he is given a fixed period of time in which he must respond or the computer will "time-out." When this happens, the terminal keyboard locks and the computer tells the child, "Time is up. Try again." The computer then types out the same problem and gives the child a second chance. If a third chance is necessary, the computer will also give the child the correct answer. If the child still times-out or responds incorrectly, the computer goes on to a new problem. Three chances are also given for incorrect responses as well as timing-out.

The CAI system incorporates a number of features which are aimed at meeting individual needs. It presents lessons at an appropriate level of difficulty. It is flexible in the amount of time a child may use, while not

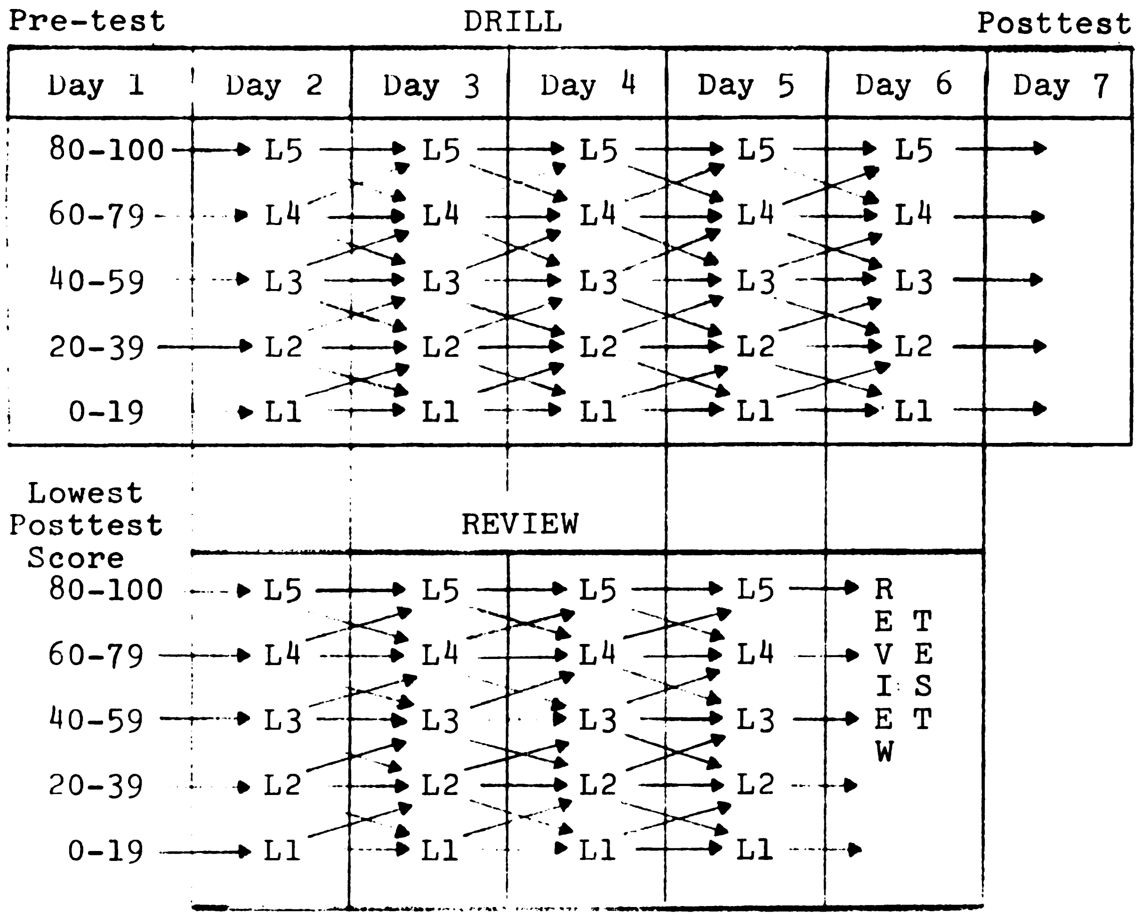

Figure 1. Structure of a concept block.

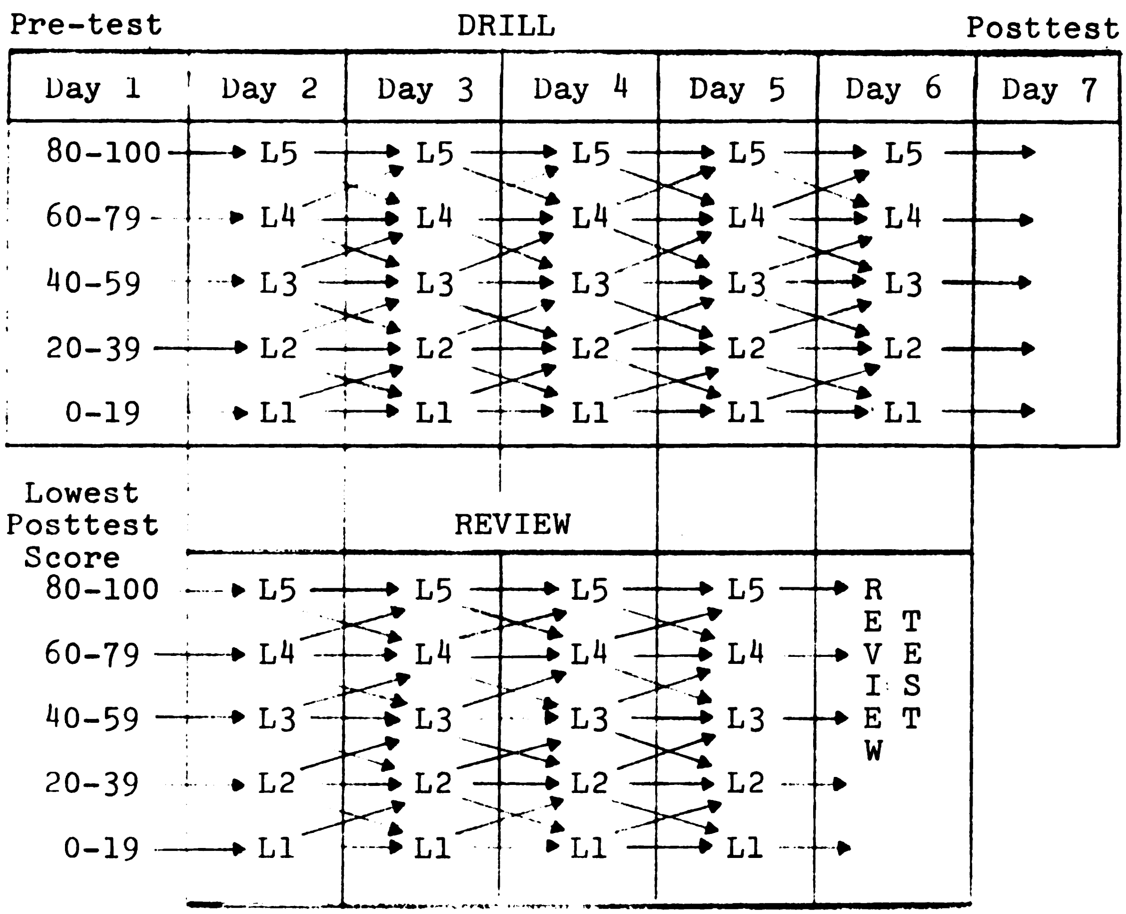

Figure 1. Structure of a concept block.

allowing his perserverance to lag greatly. It provides immediate reinforcement for the child's responses, and gives him a firm idea of how well he is doing after each day's work.

One thing this CAI program does not do, which is true of all drill and practice programs, is to accept the responsibility for the presentation and teaching of new material. The actual teaching process takes place in the classroom under the regular teacher. All that this CAI program provides is drill and practice over material the teacher has provided instruction on in the classroom.

Limitations of the Study

One limitation of this study is that it provides no built-in procedure for comparing the factors found to be important in predicting achievement using CAI with those important in other methods of instruction. Further, while a prediction of achievement for the CAI situation can be made, it is not possible to predict what achievememt would result if other methods were used. For example, it is possible to predict which children will demonstrate the greatest achievement with CAI, but there is no way of knowing whether these children would do better, or worse, or about the same with another method.

This limitation was necessarily imposed since all of the children at Riverside School used the CAI facilities for drill and practice in mathematics during the 1968-1969 school year. However, since there are a number of other studies reporting factors related to achievement with other methods of instruction, an effort will be made in Chapter V to compare the findings of this study on CAI achievement with other reports.

CHAPTER II

RELATED RESEARCH

Introduction

Most research involving computer-assisted instruction and its forerunner, programmed instruction has dealt with (a) effectiveness of the application of certain learning principles, modes of presentation, and feedback, and (b) a comparison of the effectiveness of such instruction with other means of presenting instructional material to students. Thus the programs have been treated independently of the individual characteristics of the student.

After considerable experience using and doing research with CAI, Patrick Suppes concludes that "The greatest improvement in . . . learning will result from an almost single-minded concentration on individual differences."

A real need therefore exists for more research devoted to the interaction between the special conditions of computer-assisted instruction and the nature of the learner. The present study is concerned with discovering both cognitive and affective variables which are associated with elementary school students' achievement in a computer-assisted mathematics drill and practice learning situation.

Computer-assisted drill and practice programs in mathematics were first introduced into an elementary school setting by Patrick Suppes in 1963. The project began with an intensive accelerated program for a group of gifted first graders. Over a seven week period it was observed that the fastest child was able to do about 3,400 problems while the slowest did about 2,200 problems and that rate was not strongly correlated with IQ. In a subsequent project Suppes collaborated with Richard C. Atkinson in the highly publicized Brentwood School project in Palo Alto, California. The initial results of this project have been widely publicized and a detailed review will not be given again here except to say that it was demonstrated that children learn as well using CAI as by traditional methods, but that there is wide variance in rate of learning, and that no differences in achievement were found on the basis of sex of the child.

The remainder of this chapter will be devoted to reviewing appropriate literature in the areas of learner variables and computer-assisted instruction and differences in elementary school arithmetic achievement related to sex, socio-economic status, intelligence, reading ability, creativity, anxiety, self-concept, motivation, and personality factors.

Learner Variables and Computer-Assisted Instruction

The study of individual differences assumes great importance in CAI since individualized instruction is an important part of its justification. Even so, there are relatively few studies in this area.

O'Neil, Spielberger, and Hansen (1968) investigated the effects of anxiety on performance on a CAI learning program divided into difficult and easy sections. Subjects responded to difficult CAI materials with a greater increase in self-reported and physiological measures of anxiety than was the case for easy CAI materials. For tasks in which errors were high, high anxiety subjects did as well or better than low anxiety subjects.

Sears and Feldman (1968) reported a correlational analysis of the relations between behavior factor scores, measures of achievement, and IQ of first grade children in a mathematics CAI program. In the fall term, neither social nor academic behavior showed a consistent pattern of correlations with ability or achievement. By spring term, however, academic behavior correlated positively and significantly with achievement and IQ measures while social behavior correlated negatively with these measures. It was concluded:

> that within the CAI group there is a progressive strengthening over the year of the relation between behavior and achievement: those behaving

> in a task-oriented, achievement motivated fashion achieve increasingly better on tests and on computer progress, while those low in this behavior do not achieve as well.

In a study of learner variables and interpersonal conditions in CAI by Sutter and Reid (1969) it was hypothesized that any difference in student achievement or attitude was a result of an interaction between certain personality traits and the interpersonal (CAI with a partner) or noninterpersonal (CAI without a partner) nature of the learning situation. The personality traits used were test anxiety, sociability, and dominance. One experimental group took the CAI problem solving course with a partner, a second group took the same course without a partner, and a control group did not take the course at all. All groups received all pre and post measures. Results showed that subjects high in sociability, but low test anxious achieved better in pairs, while subjects who were low in sociability and high test anxious achieved better alone.

In summarizing the above studies, it appears that those achieving best in CAI would be more task-oriented, display more achievement motivation, and be less sociable. It appears that the sex of the child is not a differentiating factor, and that the effect of test anxiety is not altogether clear.

Sex Differences in Elementary School Arithmetic Achievement

A popularly held belief is that boys are better in arithmetic than girls (Lambert, 1960). Early evidence to support this belief was presented by Bonser in 1910. He reported that boys' performance on tests of arithmetic reasoning and computation was consistently superior to that of girls.

An extensive study based on over 50,000 pupils in approximately 300 schools was conducted by Stroud and Lindquist (1942). Sex comparisons were made on the basis of scores received on the Iowa Every Pupil Basic Skills Test. They found that girls maintained consistent superiority over boys in all subject tests, except arithmetic, where small usually insignificant gains favored the boys.

More recently, Jarvis (1964) surveyed 713 sixth graders to determine if boy-girl ability differences in elementary school arithmetic existed. The two sex groups were stratified on the basis of IQ--bright, average, and dull. Comparisons between groups were made on the basis of percentages only. All boys' groups excelled girls in the ability to perform arithmetic reasoning functions. All classifications of girls except the bright group were superior to boys in ability to execute arithmetic fundamental operations. Bright boys were found superior to girls of similar ability in both arithmetic reasoning and fundamentals. The author cautions that the percentage differences were not of sufficient magnitude to warrant jumping to any serious conclusions.

In another study involving sixth grade students and identical measures of arithmetic achievement, Cleveland and Bosworth (1967) found no significant differences between sexes in any aspect of arithmetic achievement.

Wozencraft (1963) compared scores obtained on the Stanford Achievement Tests by over 1,100 boys and girls at third and sixth grade levels. Each sex group was stratified by intelligence. The total group of girls scored significantly higher ($p < .01$) on both reasoning and computation subtests than the total group of boys. This same finding held true for the comparison between girls and boys in the "average intelligence" subgroup. However, groups with high or low intelligence ratings did not show significant sex differences.

As can be seen, conflicting evidence regarding the influence of sex differences on elementary school arithmetic achievement exists. Early studies such as those by Bonser (1910) and Stroud and Lindquist (1942) suggested the slight superiority of boys' achievement. However, more recent studies (Cleveland and Bosworth, 1967) found no difference, a difference only in certain arithmetic subskills and IQ ranges (Jarvis, 1964) or superior achievement by girls (Wozencraft, 1963). Atkinson (1968) found no differences in reading achievement between boys and girls when learning by CAI was utilized.

Studies Relating Socio-Economic Status and Elementary School Arithmetic Achievement

A survey of the relationship between sixth grade arithmetic achievement and socio-economic status was conducted by Erickson (1958). He found that students in the high socio-economic level made greater achievement in arithmetic than students in the low socio-economic group. However, when he controlled for IQ differences, no difference between the two socio-economic levels was found.

Three other studies produced conflicting findings. Passy (1964) evaluated the role of socio-economic status in third grade mathematics achievement. Samples at each of five socio-economic levels were equated on mental ability and reading ability. Results of the analyses indicated significant differences ($p < .05$) among the various levels of socio-economic status, with arithmetic achievement increasing with the level of education and skill of the bread-winning parent. Similar studies at varying grade levels by Unkel (1966) and Cleveland and Bosworth (1967) found a significant correlation between high socio-economic status and a high level of achievement in traditional arithmetic programs, even when differences in IQ were controlled.

Results of a majority of studies reviewed in this section then suggest that achievement in traditional elementary school arithmetic programs is positively related to socio-economic status.

Studies Relating Intelligence and Elementary School Arithmetic Achievement

Studies such as the following are typical of the relationship between intelligence and elementary school arithmetic achievement reported in the literature.

Erickson (1958) studied the relationship of intelligence and achievement in arithmetic for 269 sixth graders from several different socio-economic levels. He reported a correlation of .72 between IQ and arithmetic achievement in the total sample.

A somewhat different approach was taken by Holowinsky (1961), who studied the relationship between intelligence within a limited range (80-110 IQ) and arithmetic achievement. The 375 subjects were grouped in five groups as far as age level and three groups as far as IQ level is concerned. The Otis Quick Scoring Mental Ability Test and the arithmetic portion of the Wide Range Achievement Test were administered to all subjects. Pearson's coefficient of correlation was computed and showed an overall correlation between arithmetic and IQ of .30. The correlation was highest at the 12-13 age group and lowest in the 15-16 age group.

A study by Harootunian and Tate (1960) found that IQ as well as reading ability was significantly correlated with problem solving ability in seventh and eighth grade students.

In summary, one would expect to find a significant correlation between intelligence and arithmetic achievement in studies of achievement in traditional arithmetic programs. The size of the correlation increases as the range of intelligence considered expands.

Studies Relating Reading Ability and Elementary School Arithmetic Achievement

It is generally accepted that skill in reading is directly related to success in arithmetic reasoning or problem solving. This relationship is probably greatest at primary levels where reading of problems is almost purely a reading task (Harper, 1957). However, as arithmetic relationships and processes become more complex, good general reading comprehension becomes increasingly less significant in problem solving success (Fay, 1950).

More recently, Harootunian and Tate (1960) investigated the correlates of problem solving ability. To a sample of over 500 seventh and eighth grade students they administered several sets of problems. A criterion score was obtained by summing the weighted scores of the several individual tests. A number of predictor variables were correlated with the criterion variable. The highest correlation was found between the criterion score and students' reading ability.

In summary, a strong relationship between reading ability and arithmetic ability has consistently been shown to exist. While studies such as Harper's (1957) suggest that this relationship is probably greatest at the lower grade levels, research by Harootunian and Tate (1960) indicates that reading ability continues to correlate highly with arithmetic problem solving ability.

Studies Relating Creativity and Elementary School Arithmetic Achievement

The complexity of the interrelation of creativity, IQ, and academic achievement has been explored by several investigators. Torrance and Bowers (1960) compared the academic achievement of high IQ and high creative groups, and no reliable differences were found. However, the mean IQ for the high intelligence group was 152 and the high creative group, 127. Thus one should be extremely cautious in generalizing about the relationship of creativity, school achievement, and IQ from these results. This finding was essentially replicated in Getzels and Jackson's (1960) study of secondary school students.

More recently, Edwards and Tyler (1965) investigated the relationship of intelligence, creativity, and achievement in a nonselective public junior high school and obtained somewhat different results. The group which was in the upper third on performance on the SCAT but not on creativity was superior to the group which was upper third on creativity but not on SCAT performance in grade point average and STEP scores. Additionally, they compared a twice-talented group, high on SCAT and creativity, with a group high on SCAT performance and found that the groups did not differ in STEP tests, but that the twice-talented group was significantly lower than the high SCAT group on grade point average.

It is difficult to reach any definite conclusions about the role of creativity in elementary school performance from studies such as those reported above. It is highly possible that other factors such as learning atmosphere and teacher style would confound the relationship of creativity and achievement.

Studies Relating Anxiety and Elementary School Arithmetic Achievement

Studies such as those of Palermo and Castaneda (1956) and Sarason (1957) have shown that anxiety with moderate to high tension, whether artificially induced through experimentally controlled stress or present in the subjects from unspecified sources, has been shown to reduce learning efficiency.

Feldhusen and Klausmeier (1962) conducted a study designed to ascertain the relationship between anxiety as measured on a paper and pencil test, and school achievement in children of low, average, and high IQ. Significantly greater mean anxiety was found in the low IQ group than in average or high IQ groups. A significant negative correlation between anxiety and arithmetic achievement was found in the low IQ group. Similarly, Reese (1961) found a significant relationship between anxiety and performance on an arithmetic test by fourth and sixth grade students. High anxious students made significantly fewer correct responses than low anxious students. Partialing out IQ had little effect on the correlation between anxiety and achievement. Similar results were obtained by Phillips (1962).

The results of studies reviewed in this section generally agree that moderate to high levels of anxiety reduce achievement in arithmetic. However, limited findings concerning the influence of intelligence on this correlation between anxiety and arithmetic achievement are contradictory.

Studies Relating Self-Concept and Elementary School Arithmetic Achievement

Brookover, Paterson, and Thomas (1962) developed the Self-Concept of Ability Scale, a paper and pencil test, which was then administered to all seventh graders in a midwestern school system. They found that self-concept of ability was significantly correlated (.57) with school achievement. The significant relationship also held true when measured intelligence was controlled. The correlation, with measured intelligence partialled out was .42 for boys and .39 for girls. It was also found that a student's self-concept of ability in a specific school subject often differed from his self-concept in another subject as well as from his general self-concept of ability. The mean self-concept of ability in mathematics was significantly different from mean general self-concept of ability for girls but not for boys.

Piers and Harris (1964) developed a self-concept instrument which could be used with children over a wide age range. The instrument was then administered to third, sixth, and tenth graders. A significant correlation of .32 was found between achievement and self-concept for third and sixth graders. This finding is similar to that of Coopersmith (1959) who found a correlation of .36 between adhievement and self-esteem of fifth and sixth grade students.

That self-concept is positively correlated with elementary school achievement is indicated by all of the above studies.

Motivation and Achievement in Elementary School Arithmetic Achievement

A majority of the studies relating achievement motivation and school performance have used secondary school and college students as subjects. Although there is a paucity of research in this area at the elementary school level, the following studies appear to have some applicability.

Schell, Veroff, and Schell (1967) investigated the relation of achievement motivation to performance on a school-like task at the second grade level. They found a significant but relatively low positive correlation between achievement motivation and performance for both boys and girls.

Twenty-six ninth grade students completed a program containing elements of both science and mathematics in a study by Woodruff, Faltz and Wagner (1966). Number of correct frame responses was correlated with subtest scores from the Edwards Personal Preference Schedule. "Need to achieve" was the only factor which correlated significantly with the achievement criterion.

Khan (1969) developed a 122 item instrument which purportedly measured attitudes, study habits, need achievement, and achievement anxiety. The instrument was administered to 1,038 junior high school students. Inter-item correlation matrices were factor analyzed and factor scores were used to predict subsequent scores on the Metropolitan Achievement Test subtests. The factor, need achievement, correlated significantly with scores on the Metropolitan Test. Further, affective predictors significantly increased the multiple correlations when they were used in conjunction with aptitude scores on the School and College Ability Test. The author concludes:

> The results of this study suggest a need for comprehensive and systematic research on affective variables in academic achievement. Such research may have potential significance in educational decision making, guidance, and placement of students, and identification of high and low achievers, for whom new educational environments ought to be devised so that their probable achievement can be heightened (Khan, 1969), p. 220).

Studies reviewed in this section have pointed out a consistent positive relationship between achievement motivation and actual achievement. Further, they have suggested that affective variables should be considered along with those in the cognitive domain when we are making predictions about academic performance.

Studies Relating Personality Factors and Elementary School Arithmetic Achievement

Traweek (1964) investigated the effectiveness of programed instruction in mathematics for individuals with certain personality characteristics. One hundred and eighty-six fourth graders were administered the California Test of Personality and then completed a program on fractions. Successful learners were found to be significantly more inclined toward tendencies of withdrawal and less self-reliant. Thus, those students whose personality test reports indicated poorer adjustment achieved beyond their expected performance in the programed instruction learning situation.

Cleveland and Bosworth (1967) designed a study to discover if statistically significant differences between top-quarter arithmetic achievers and bottom-quarter achievers at the sixth grade level in psychological characteristics existed. The California Test of Personality was used to assess these characteristics. They found a significant positive relationship between achievement and a psychologically healthy personality. High achievers of both sexes and both socio-economic levels attained higher scores in Personality Adjustment, Social Adjustment, and Total Adjustment.

In a study of 1,000 British elementary school boys, Astington (1960) found that boys with the best relative academic achievement received higher ratings on persistence, independence, were less extraverted and less sociable. Contrary to the Astington finding that high achievers tended to be less extraverted is a finding from a study by Ridding (1967). Students classified as over-achievers in arithmetic were significantly more extraverted than under-achieving students. Ridding also reported no significant relationship between over-all stability or adjustment and patterns of under or over achieving in arithmetic.

Woodruff, Faltz, and Wagner (1966) found that the following subtests on the Gordon Personal Inventory correlated significantly with achievement on a mathematics and science program: cautiousness, original thinking, personal relations, and vigor.

As can be seen, when studies relating personality factors and elementary school arithmetic achievement are considered, the results seem scattered and inconclusive. This may be due in part to the profusion of labels employed for various characteristics in the affective domain, and due to the fact that most studies look for a number of these characteristics across a broad spectrum. Such conditions make it extremely difficult to arrive at general conclusions.

Summary

In summary, as one attempts to draw some general conclusions from this body of literature it might be possible to build a description of the successful achiever in the traditional elementary arithmetic program as follows:

a) a boy or girl,

b) from high socio-economic level,

c) more intelligent,

d) possessing good reading skills,

e) having more achievement motivation,

f) a positive self-concept,

g) may be highly creative,

h) moderate to low anxiety,

i) probably more introverted than his lower achieving peers.

CHAPTER III

METHOD OF CONDUCTING THE STUDY

Introduction

This chapter will describe the tests used in the study and will enumerate the variables which they purport to assess. Some limitations associated with data collection are discussed.

Tests Used in the Study

The tests selected for use in this study were partly a result of decisions of the Individual Communications Project (INDICOM) satisfying other research needs, and partly a result of requirements of the experimentor. Tests selected and administered by the INDICOM Project included the following: Stanford Achievement Test (Arithmetic Subtest), Quick Word Test, Iowa Test of Basic Skills, and Warner Socio-Economic Scale. The experimentor had no control over selection or administration of these instruments since they were administered by INDICOM Project personnel in Fall, 1968, before the present study was initiated. It is reported that the tests were administered in accordance with procedures recommended by the publisher.

The Stanford Achievement Arithmetic subtest is a short, valid, and reliable test which was used as an index of math achievement for the second grade only. Children in grades three through six were given the complete Iowa Test of Basic Skills. For these children then there is a much more complete description of cognitive aspects of their development. A list of the scores available is presented later in this chapter.

The Quick Word Test consists of 50 words for which the proper synonym must be selected from among four choices. A maximum of 20 minutes is allowed. The publisher, Harcourt, Brace and World, claim a correlation with the California Short-Form Test of Mental Maturity of .73 and with the Lorge-Thorndike Intelligence Test (Verbal Battery) of .84. A test-retest reliability of .91 is claimed. In this study, scores from this test will be interpreted as an index of general intelligence.

The Warner Socio-Economic Scale consists of a rating form 1 to 8 depending on the occupation of the major bread winner in the family. The ratings in this scale are as follows:

1 - Unemployed

2 - Unskilled workers (including laborers and domestic servants)

3 - Semiskilled workers (including protective and service workers)

4 - Proprietors of small businesses (valued at less than $5,000)

5 - Skilled workers

6 - Clerks and kindred workers

7 - Semiprofessionals and smaller officials of large businesses

8 - Professionals and proprietors of large businesses (businesses valued at more than $5,000).

These ratings were made by INDICOM personnel in accordance with the U. S. Department of Labor Dictionary of Occupational Titles (1965).

Two hours of time were allowed by INDICOM for the experimentor and an assistant to collect additional data. The tests selected fitting this time requirement, the appropriate grade level, and exploring aspects of the affective domain and a portion of the nebulous area falling between the cognitive and affective domains were: Children's Personality Questionnaire (CPQ), Self-Concept and Motiviation Inventory (SCAMIN), and Thinking Creatively with Pictures.

The Children's Personality Questionnaire consists of 140 items which were administered in two separate sessions of 70 items each. Each session took about 40 minutes to administer. For grades 2 and 3 the experimentor read the test aloud, and for grades 4, 5, and 6 each child had his own test booklet and read the items himself. All children responded using the answer sheets published for this test. The results of the test are scores on 14 personality factors and three second order factors established by factor analytic procedures during the validation process. These factors are enumerated elsewhere in this chapter. Test-retest reliability ranges from .47 to .72 across the fourteen factors and averages .633.

The Self-Concept and Motivation Inventory (SCAMIN) consists of 24 items at the second grade level and 48 items at grades 3, 4, 5, and 6. The test was read to the children at all grade levels and required about 30 minutes. The children were instructed to shade in the nose on one of five faces on the answer sheet ranging from smiling to frowning which identified the face they would wear in the situation presented. Scores for academic self-concept and academic motivation are determined from the instrument. A reliability of .82 is claimed by the publishers.

The foregoing two tests (CPQ and SCAMIN) are scored objectively using a key. Before correcting it was determined that all children answered all questions. Many times this was found on the spot, but in some cases children were sought out again later to obtain missing responses. There are no children included in this study who do not have a complete set of responses on all tests, or who have not taken all tests.

The test Thinking Creatively With Pictures was constructed by E. Paul Torrance and contains three subtests. The first, Picture Construction, provides the child with a green, egg-shaped piece of paper about two inches long with glue on the back. He is told that he is to place this shape anywhere on a blank page in the test booklet which is provided for this purpose. He should place it in such a way that it is a part of a picture he has in mind. He is told to try to think of a picture no one else will think of and to add new ideas to his first idea to make the picture tell an interesting and exciting a story as he can. When the picture is complete he is told to give it a clever and unusual title. The second subtest, Picture Completion, presents the child with a set of ten curved lines and asks him to use each as a starting point for a drawing. As before, each drawing is given a title and the instructions emphasize using ideas no one else will think of. The last subtest, Lines, presents the child with 30 sets of straight parallel lines to use as a starting point for drawings. Instructions are the same as for the previous activity. A time limit of 10 minutes is allowed for each subtest, however, extra time is allowed for children to work on titles for drawings they have completed. Help with spelling was supplied if asked for.

The test was scored in accordance with procedures outlined in the scoring guide and scores for fluency, flexibility, originality, and elaboration were obtained. Since there are a limited number of subjective decisions that a grader must make in the scoring process, scoring was arranged so that the same grader scored all of the children on a particular subtest. Scoring reliability was thus insured.

In relating these tests to the variables reviewed in Chapter II, it was planned that the following instruments would be used to assess the indicated variables: Children's Personality Questionnaire (anxiety and personality factors); Self-Concept and Motivation Inventory (self-concept and motivation); Thinking Creatively with Pictures (creativity); Iowa Test of Basic Skills (reading ability); Quick Word Test (intelligence); and Warner Socio-Economic Scale (socio-economic status).

Variables Included in the Study

With this brief background, the following is a list of the variables for which scores were obtained for each child in grades 2 through 6 at Riverside School:

A. Children's Personality Questionnaire (CPQ)

1. Reserved vs. Warmhearted (factor A)

2. Less intelligent vs. More intelligent (factor B)
3. Affected by Feelings vs. Emotionally Stable (factor C)
4. Phlegmatic vs. Excitable (factor D)
5. Obedient vs. Assertive (factor E)
6. Sober vs. Happy-go-lucky (factor F)
7. Expedient vs. Conscientious (factor G)
8. Shy vs. Venturesome (factor H)
9. Tough-minded vs. Tender-minded (factor I)
10. Vigorous vs. Circumspect (factor J)
11. Forthright vs. Shrewd (factor J)
12. Self-assured vs. Apprehensive (factor O)
13. Casual vs. Controlled (factor Q3)
14. Relaxed vs. Tense (factor Q4)
15. Anxiety (second order score)
16. Extraversion (second order score)
17. Neuroticism (second order score)

B. Self-Concept and Motivation Inventory (SCAMIN)

1. Academic Motivation
2. Academic Self-Concept

C. Thinking Creatively With Pictures

1. Fluency
2. Flexibility
3. Originality
4. Elaboration

D. Average Concept Block Posttest Score (dependent variable). This score was obtained by averaging the posttest scores over the following number of concept blocks at the indicated grade levels:

1. Second grade: 8 concept blocks (56 school days)
2. Third grade: 9 concept blocks (63 school days)
3. Fourth grade: 9 concept blocks (63 school days)
4. Fifth grade: 7 concept blocks (49 school days)
5. Sixth grade: 6 concept blocks (42 school days)

Additionally the following test data were available for all of the children in the particular grades indicated:

E. Stanford Achievement Arithmetic Subtest score (second grade only)

F. Quick Word Test (grades 4, 5, and 6 only)

G. Warner Socio-Economic Scale (grades 3 through 6 only)

H. Iowa Test of Basic Skills (grades 3 through 6 only)

1. Vocabulary
2. Reading Comprehension
3. Language Skills

4. Work Study Skills
5. Arithmetic Concepts
6. Arithmetic Problem Solving

Average concept block posttest score (item D above) was treated as the dependent variable and analyzed in relation to the other variables. As the above tabulation indicates, grade 2 had 24 independent variables. Grade 3 had 30 independent variables, and grades 4, 5, and 6 had 31 independent variables. Partitioning the data on the basis of sex of the child was not required, however, sex was included in the analysis as an additional independent variable to those listed above.

Data Collection

Collection of data from the Children's Personality Questionnaire, Self-Concept and Motivation Inventory, and Thinking Creatively with Pictures was done in a two week period in May, 1969 by the experimentor and an assistant. The assistant was trained in testing procedures and holds a Master's degree in educational psychology.

Collection of data from all other instruments was done by INDICOM personnel earlier in the year. The experimentor was furnished with summary sheets of this data.

In both instances the children were tested in their normal classrooms with the teacher present. There were thirteen classrooms and class size was usually about twenty-five. Administration of the tests seemed routine and there were no unusual difficulties in managing the groups.

For make-up testing, children were called out of their regular classes and were tested with children from other classes in a vacant room. Other than this, exactly the same procedures were followed for make-up testing as regular testing.

Data on the dependent variable was taken from computer Concept Block Reports prepared from performance records automatically stored by the computer in Palo Alto, California. The reports were mailed to INDICOM and then made available for use in this study. The scores were tabulated and averaged by the experimentor.

Limitations Associated with Data Collection

The majority of children attending Riverside School appear to come from typically middle class white families. The school is located in a suburban area of Waterford Township serving the city of Pontiac, Michigan. Parents were specifically informed of the type of testing which was done for this study and only positive comments were received. No child was deleted from the study due to parental objection.

Strenuous make-up procedures were followed for testing done by the experimentor so that no children were deleted due to missing data on these tests. Mortality was experienced for four other reasons, however. First, some children transferred in or out of the school during the 68-69 school year. Second, some children were absent the day of make-up testing done by INDICOM personnel. Both of these first two reasons had the result of providing an incomplete set of data on these children. Third, some children having particular difficulty in mathematics were assigned to special programs. For instance, a fifth grader might be assigned second grade CAI lessons. Because these children did not fit any particular group, they were deleted from the study. Fourth, some children were found who invalidated their test results. When answer sheets were found with all answers checked in one column or some other definite pattern, the results were considered invalid. At second and third grade some children were found who marked their answer sheet before questions were read.

A total of 367 children were enrolled in grades 2 through 6 in April, 1968. Deletions due to the above four reasons reduced the number of children used in the study to 304.

CHAPTER IV

ANALYSIS AND RESULTS

Introduction

This chapter will begin by briefly outlining the analytic procedures followed and will then present the results of pursuing these procedures in generating and validating predictive regression equations. The final section of the chapter will present the results of a study of differences in achievement based on the sex of the child.

The Analytic Procedure

Since the nature of the problem of this study is largely utilitarian, the most direct method of analysis of the data which offers a practical solution was selected. The ultimate product of this analysis was the generation of multiple linear regression equations for the prediction of the dependent variable (concept block posttest scores) from selected independent variables from the cognitive and affective domains.

Since different mathematical topics are included in the CAI drill and practice program studied at each grade level, it was necessary to analyze each grade separately and generate regression equations which were specific to that age of child and level of work. Additionally, it was anticipated that much of the test data might change significantly with sex, necessitating it being blocked on this variable as well. This assumption was checked by analyzing the data at each grade level without blocking on sex and comparing those results to results obtained when blocking on sex was included. Because blocking failed to produce great differences in the kinds of variables selected for the equations, the analysis was conducted by combining data on boys and girls at each grade level. However, sex was still included as an independent variable available to be selected for the regression equation.

The first step in carrying out the analysis was to plot all the raw data for each grade against each of the dependent variables to check for linearity.

The second step was to obtain means and standard deviations for all variables in the study and construct a correlation matrix. This matrix contains all possible correlations among independent variables and the dependent variable, average concept block posttest score.

The third step was to build regression equations using the stepwise additive method. In this method, the particular independent variable was selected which explained the greatest part of the variation in the dependent variable. Following this a second independent variable is selected that made the greatest additional contribution to explained variance in combination with the first variable. The process was continued until an acceptable or practical level of explained variance was achieved. At the same time that this procedure was followed, observations were also made of the standard error of the regression coefficient as a check for colinearity.

Because blocking on the sex variable was not required, there was a sufficiently large group of subjects available at each grade level so that direct validation of the regression equations could be performed as a fourth step. Before generation of the regression equations commenced, one-fourth of each class was randomly selected and their data set aside from participation in generation of the equations, in order to be able to use this data in checking the accuracy of prediction which each equation produced. The check used was a t test for correlated data with a significance level of $p < .05$. The test was made between the mean of the scores predicted by the regression equation and the mean of the actual scores obtained. No significant differences resulted and all equations were found to be valid by this procedure (see Table 5).

Generation of Regression Equations

The plots of all raw data were either obviously linear or gave no indications causing suspicion that they might be non-linear. In each case the plot for the first variable selected for an equation formed a tightly knit and obviously linear scatter diagram.

The means and standard deviations of all variables included in the study are presented for each grade level in Table 1. An asterisk is used to designate the values for variables which were selected for inclusion in the regression equation at that grade level.

Following, in Table 2, the correlations of each independent variable with the dependent variable are presented. Again an asterisk is used to designate the values for those variables included in the regression equations. It may be noted that the first variable selected for each regression equation was the one having the highest correlation with the dependent variable. From that point on, however, correlation does not provide a guide since variables are selected on the basis of the greatest additional contribution to explained variance in combination with variables already selected.

The stepwise addition of variables into the equation was continued, one at a time, until the significance probability of the F statistics which would be obtained if another variable were to be entered, was greater than .10.

TABLE 1.--Means and standard deviations of all variables at each grade level.

Variable	Grade 2		Grade 3		Grade 4		Grade 5		Grade 6	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sex	0.57	0.50	0.42	0.50	0.42	0.50	0.48	0.51	0.51	0.50
A (Warmheartedness)	6.07	1.82	6.55*	2.11*	6.81	1.78	6.15	2.32	7.03	1.70
B (Intelligence)	4.07	1.59	5.23	1.83	6.92*	1.82*	7.13*	2.16*	7.60	1.85
C (Emotional Stability)	6.28	1.77	5.91	1.56	6.19	1.92	5.83	2.15	6.45*	1.75*
D (Excitableness)	3.36	1.84	4.31*	2.10*	4.21	1.83	4.17	2.23	4.45	2.46
E (Assertiveness)	3.69	1.98	4.67	1.91	4.35	2.06	4.76	2.01	5.03	2.11
F (Enthusiasm)	3.81	2.09	3.41	2.42	3.56	2.44	3.80	2.07	4.31	2.23
G (Conscientiousness)	6.49	1.65	6.72	1.90	7.44	1.85	7.07	1.95	6.88	2.37
H (Venturesomeness)	5.07	1.84	5.09	1.97	5.48	2.31	4.98	2.14	5.38	2.16
I (Tender-mindedness)	4.82	2.58	5.06	2.88	5.17	2.93	4.63	2.47	4.75	2.46
J (Individualism)	4.19	1.53	4.36	1.67	4.06	1.74	4.09	1.76	3.75	1.60
N (Shrewdness)	3.94	1.76	3.91*	1.97*	3.62	2.09	3.87	2.28	3.55	1.80
O (Apprehensiveness)	3.90	2.01	4.50	2.46	3.83	2.22	4.52	2.50	4.14	2.26
Q3 (Emotional Control)	6.85	2.11	6.56	2.35	6.54	2.52	6.15	2.43	6.62	2.04
Q4 (Tenseness)	3.61*	2.44*	4.36	2.50	4.19	2.29	4.39	2.21	4.60	2.07
Anxiety	4.07	1.50	4.62	1.59	4.37	1.60	4.71	1.73	4.53	1.48

Extraversion	4.99	1.20	5.03	1.34	5.29	1.48	4.99	1.40	5.58	1.49
Neuroticism	5.13*	1.03*	5.39	1.11	5.20	1.31	5.27	1.10	5.03	1.40
Motivation	47.78*	4.50*	97.05	10.44	99.08*	9.15*	98.48	7.51	97.25	10.04
Self-Concept	47.99	5.89	94.72	11.88	90.85*	11.73*	89.70	12.79	87.52	12.78
Fluency	22.29	6.48	22.63	6.06	22.31	7.51	21.65	5.73	22.35	6.00
Flexibility	18.00	4.88	18.11	5.59	18.87	5.03	16.91	4.37	17.62	4.45
Originality	31.54	12.58	31.48	11.38	31.85	13.07	30.74	10.60	31.74	11.13
Elaboration	75.60	24.53	82.66	21.54	86.54	22.07	87.41*	26.02	84.98	22.60
Arith. Achievement	45.08*	8.97*	N.O.	N.O.	N.O.	N.O.	N.O.	N.O.	N.O.	N.O.
Vocabulary	N.O.	N.O.	14.39*	7.01*	17.63*	7.30*	18.09	7.81	19.20	7.18
Reading Comp.	N.O.	N.O.	19.80	6.78	29.06	12.40	29.83	12.48	32.80	11.10
Language Skills	N.O.	N.O.	45.03	16.29	69.52*	23.06*	69.59	26.60	67.62*	21.78*
Work Study Skills	N.O.	N.O.	31.78	9.30	46.02	15.20	46.50	17.83	53.49	17.91
Arithmetic Concepts	N.O.	N.O.	12.92	5.92	18.35	7.21	19.11	7.88	20.35*	7.76*
Arith. Prob. Slvg.	N.O.	N.O.	7.52	3.69	11.79	5.73	11.78*	3.85*	13.15	5.40
Quick Word Test	N.O.	N.O.	N.O.	N.O.	30.19	9.08	29.41	10.85	36.60	8.49
Socio-Economic Sc.	N.O.	N.O.	4.47	2.13	5.04	2.06	4.17	2.22	4.98	2.43
Concept Block Posttests	68.29	14.91	84.44	10.48	86.79	8.79	82.11	12.06	78.43	11.52

*Variable was selected by the LSADD routine for inclusion in the regression equation at that grade level.

TABLE 2.--Correlations of independent variables with posttest achievement at each grade level.

Variable	Grade				
	2	3	4	5	6
Sex	0.207	-0.125	-0.171	-0.061	0.307*[2]
A (Warmheartedness)	0.148	0.248*[2]	0.173	0.071	0.339[1]
B (Intelligence)	0.168	0.356[1]	0.447*[1]	0.636*[1]	0.336[1]
C (Emotional Stability)	0.115	0.107	0.347[2]	0.231	0.460*[1]
D (Excitableness)	-0.064	0.083*	-0.024	-0.012	0.104
E (Assertiveness)	0.095	-0.096	0.130	0.138	0.183
F (Enthusiasm)	0.216	-0.229	0.017	-0.009	0.183
G (Conscientiousness)	-0.141	0.062	0.268	0.006	0.101
H (Venturesomeness)	0.111	0.164	0.013	0.082	0.317[2]
I (Tender-mindedness)	-0.353[1]	0.173	0.102	-0.223	-0.315[2]
J (Individualism)	0.076	-0.177	-0.004	-0.150	-0.240
N (Shrewdness)	-0.101	-0.297*[2]	-0.243	-0.141	0.151
O (Apprehensiveness)	-0.244[2]	-0.160	-0.194	-0.262	-0.284
Q3 (Emotional Control)	-0.109	0.178	0.296[2]	0.066	-0.049
Q4 (Tenseness)	0.202*	-0.187	-0.013	0.023	-0.020
Anxiety	-0.012	-0.171	-0.200	-0.130	-0.145
Extraversion	0.255[2]	0.072	0.084	0.076	0.369[1]
Neuroticism	-0.248*[2]	-0.021	-0.119	-0.265	-0.354[1]
Motivation	0.204*	0.119	-0.184*	0.149	-0.120
Self-Concept	0.001	0.099	0.340*[2]	0.224	0.185
Fluency	0.140	0.048	0.025	-0.108	0.045
Flexibility	0.197	0.127	0.002	0.089	0.073
Originality	0.178	0.177	0.211	0.030	0.170
Elaboration	0.008	0.110	0.142	-0.068*	-0.015
Arithmetic Achievement	0.697*[1]	N.O.	N.O.	N.O.	N.O.
Vocabulary	N.O.	0.558*[1]	0.677*[1]	0.362[2]	0.456[1]
Reading Comprehension	N.O.	0.480[1]	0.633[1]	0.310[2]	0.486[1]
Language Skills	N.O.	0.481[1]	0.675*[1]	0.521[1]	0.543*[1]
Work Study Skills	N.O.	0.431[1]	0.656[1]	0.524[1]	0.622[1]
Arithmetic Concepts	N.O.	0.485[1]	0.652[1]	0.598[1]	0.645*[1]
Arith. Problem Solving	N.O.	0.378[1]	0.641[1]	0.604*[1]	0.445[1]
Quick Word Test	N.O.	N.O.	0.578[1]	0.479[1]	0.476[1]
Socio-Economic Scale	N.O.	-0.037	0.014	0.028	-0.004

*Variable was selected by the LSADD routine for inclusion in the regression equation at that grade level.

[1]Significant at $p < .01$

[2]Significant at $p < .05$

This procedure resulted in the selection of from three to five variables, and multiple correlation coefficients of about .75. Both the number of variables and the value of the multiple correlation coefficient are believed to be at a practical level for easy and reliable use in the school.

The regression equations generated by this stepwise addition of variables are presented in the following paragraphs. The equation is presented in raw score form and is written using abbreviations. Immediately following the equation are the full descriptions of the variables these abbreviations represent.

Predictive Regression Equation for Grade Two:

$$POST = 1.033(ARI) + 1.930(Q4) - 3.645(NEUROT) + 0.405(MOT) + 14.546$$

Abbreviations:

POST	Predicted average concept block posttest scores
ARI	Stanford Achievement Arithmetic Subtest score
Q4	Relaxed (low score) vs. Tense (high score)
NEUROT	Neuroticism (high score indicates more neurotic)
MOT	Motivation

Predictive Regression Equation for Grade Three:

$$POST = 0.748(V) - 1.201(N) + 1.849(D) + 1.603(A) + 59.363$$

Abbreviations:

POST	Predicted average concept block posttest score
V	Vocabulary
N	Forthright (low score) vs. Shrewd (high score
D	Phlegmatic (low score) vs. Excitable (high score)
A	Reserved (low score) vs. Warmhearted (high score)

Predictive Regression Equation for Grade Four:

$$POST = 0.353(V) + 0.149(L) - 0.121(MOT) + 0.440(B) + 0.109(SC) + 69.888$$

Abbreviations:

POST	Predicted average concept block posttest score
V	Vocabulary
L	Language Skills
MOT	Motivation
B	Less Intelligent (low score) vs. More Intelligent (high score)
SC	Self-Concept

Predictive Regression Equation for Grade Five:

$$POST = 3.420(B) + 1.114(A2) - 0.126(ELAB) + 54.917$$

Abbreviations:

POST	Predicted average concept block posttest score
B	Less Intelligent (low score) vs. More Intelligent (high score)
A2	Arithmetic Problem Solving
ELAB	Elaboration (high score indicates more elaboration)

Predictive Regression Equation for Grade Six:

$$POST = 0.462(A1) + 1.870(C) + 0.206(L) + 3.799(SEX) + 41.756$$

Abbreviations:

POST	Predicted average concept block posttest score
A1	Arithmetic Concepts
C	Affected by Feelings (low score) vs. Emotionally Stable (high score)
L	Language Skills
SEX	Sex of the child (girls equal zero and boys equal one)

Table 3 presents the multiple correlation coefficient and the standard error of estimate for each equation. The standard error of estimate can be interpreted as an indicator of the amount of variation one can expect in the predicted score. Normally one would expect that the actual score would be between plus or minus one standard error of estimate from the predicted score two-thirds of the time.

TABLE 3.--Multiple correlation coefficients and standard errors of estimate for the regression equation at each grade level.

Grade	R	SE
2	0.7897	9.560
3	0.6600	8.548
4	0.7916	5.253
5	0.7774	8.834
6	0.7795	8.002

TABLE 4 presents the value of the multiple correlation coefficient as each variable is added to the equation.

TABLE 4.--Values of the multiple correlation coefficient for the addition of each variable into the equation.

Grade	Item	Variables				
		1	2	3	4	5
2	Variable R	ARI .6967	Q4 .7239	NEUROT .7559	MOT .7897	none
3	Variable R	V .5582	N .5887	D .6349	A .6600	none
4	Variable R	V .6767	L .7199	MOT .7456	B .7669	SC .7916
5	Variable R	B .6364	A2 .7173	ELAB .7774	none	none
6	Variable R	A1 .6449	C .6969	L .7290	SEX .7795	none

Validation of Regression Equations

As mentioned earlier, each equation was validated by using the scores of one-fourth of the available children at each grade level. The values are presented in Table 5 for the number of children used in the validation of the equation, the total number of children at each grade level, the value of the t statistic for correlated data, the degrees of freedom, and the standard deviation of the difference between predicted and actual scores. Because none of the t tests were significant at the $p < .05$ level with the appropriate degrees of freedom, it is concluded that the average concept block posttest scores predicted by each regression equation are not significantly different from the ones actually obtained by the children in the validation sample. It is believed therefore that these equations may be considered to be reasonably accurate predictors of average concept block posttest scores at their appropriate grade levels.

TABLE 5.--Numbers of children involved in generation and validation of equations and t test, mean difference, and standard deviation results of the validation process.

Item	Grade				
	2	3	4	5	6
n (generation)	54	48	39	34	49
n (validation)	18	16	13	12	16
N total	72	64	52	46	65
t	0.534[1]	1.148[1]	1.110[1]	1.535[1]	1.160[1]
df	17	15	12	11	15
$\bar{D}$	-1.34	2.01	-2.26	2.75	2.55
S_D	10.34	6.77	7.02	5.95	8.50

[1]Not significant at $p < .05$.

The standard deviation of the difference between predicted and actual scores provides a good indication of what sort of variation was experienced in using each equation. Normally one would expect that two-thirds of the time a child's actual score would range between plus or minus one standard deviation of his predicted score. The standard error of estimate of the regression equation also gives a similar indication of the confidence that can be placed in a predicted score. It will be noticed that the standard error of estimate presented in Table 3 does not differ greatly from the standard deviation of the difference presented in Table 5. Either of these figures provides an indication of the sort of fluctuation which may occur in predicting a child's score. It is believed that the size of these expected variations is partly due to the size of the sample used to generate the equation.

Sex Differences in Achievement

Because differences in math achievement on the basis of sex of the child have been of interest in the literature and have produced conflicting results, a series of additional tests were conducted. Table 6 presents average posttest scores, standard deviations, and the number of children for males and females at each grade level.

TABLE 6.--Average posttest scores, standard deviations, and number of children for each grade level and sex.

Grade	Sex	Mean	SD	N
Grade 2	Male	70.96	11.71	41
	Female	64.76	17.91	31
Grade 3	Male	82.92	10.30	27
	Female	85.55	10.62	37
Grade 4	Male	85.05	8.91	22
	Female	88.07	8.63	30
Grade 5	Male	81.35	12.99	22
	Female	82.80	11.39	24
Grade 6	Male	81.88	10.34	33
	Female	74.86	11.74	32

Using this data, a series of t tests for uncorrelated data were conducted to determine whether or not any of the differences in scores between males and females were significant. Results of these tests are summarized in Table 7.

TABLE 7.--Values of t statistic and degrees of freedom for a comparison of male and female average concept block posttest achievement at each grade level.

Item	Grade				
	2	3	4	5	6
t	1.767	0.992	1.215	0.356	2.504*
df	70	62	50	44	63

*Significant at $p < .05$.

In all cases except the second grade an F test allowed the pooling of variances in computation of the t statistic, however, at the second grade an $F = 2.338$ (significant at $p < .01$ with 30 and 40 df) required the computation of a special value of t which was used to judge the significance of the t computed in the problem. The Cochran and Cox (1950) formula was used for this purpose and resulted in $t_{.05} = 2.035$. Because the t value of 1.767 is well below this value, a significant t was not found. This pattern continued up to the sixth grade where a significant difference was found at the .05 level. It is interesting to note that sex of the child was one of the variables included in the predictive regression equation for that grade level, but was not selected at other grade levels. The equation gives 3.799 more points to boys than girls, and the difference in means reported in Table 6 is 7.02 points favoring the boys.

Summary

This chapter has outlined the analytic procedure followed and presented a validated regression equation appropriate for predicting average concept block posttest achievement in CAI drill and practice mathematics at each grade level studied. Differences in achievement based on sex of the child were studied and it was found that the only significant difference occurred at the sixth grade.

CHAPTER V

SUMMARY AND DISCUSSION

Summary

The problem posed for investigation in this study was to attempt to identify variables from the cognitive and affective domains which best relate to achievement as measured by concept block posttests on CAI drill and practice mathematics materials. Once identified, these variables would then be used to generate linear regression equations which, when validated, could be used to predict achievement for other children before they began the program.

The subjects used to investigate this problem were second through sixth graders at Riverside Elementary School, Waterford Township, Michigan, where an RCA Instructional 70 computer-assisted instruction facility is installed. During the 1968-1969 school year these children made daily use of the facility studying mathematics by the Patrick Suppes' drill and practice mathematics program.

Cognitive and affective variables were assessed for each child using a variety of instruments. The Individual

Communication Project (INDICOM) had already administered the following instruments: Stanford Achievement Arithmetic Subtest (second grade only), Quick Word Test (grades 4, 5, and 6), Iowa Test of Basic Skills (grades 3, 4, 5, and 6), and Warner Socio-Economic Scale (grades 3, 4, 5, and 6). Two hours of time were allowed this experimentor by the INDICOM project for the collection of all additional data. As a result, the following instruments were used: Children's Personality Questionnaire, Self-Concept and Motivation Inventory, and Thinking Creatively With Pictures. These tests were given to all children in grades two through six.

The results of the instruments administered by INDICOM Project personnel and by the experimentor formed a group of independent variables relating to both cognitive and affective domains for each child. The dependent variable was found by averaging the scores on posttests across several concept blocks studied by computer-assisted instruction. The number of concept blocks used ranged from six to nine depending on the grade level. This is the equivalent of from 42 to 63 instructional days.

Because predictive equations were desired, regression analysis employing stepwise addition of variables was used. Each grade was analyzed separately because different mathematical topics are studied at each grade level. This analysis produced the following equations (see pages 47-49 for abbreviations):

Grade 2:

$$POST = 1.033\ (ARI) + 1.930\ (Q4) - 3.645\ (NEUROT) + 0.405\ (MOT) + 14.546$$

Grade 3:

$$POST = 0.748\ (V) - 1.201\ (N) + 1.849\ (D) + 1.603\ (A) + 59.363$$

Grade 4:

$$POST = 0.353\ (V) + 0.149\ (L) - 0.121\ (MOT) + 0.440\ (B) + 0.109\ (SC) + 69.888$$

Grade 5:

$$POST = 3.420\ (B) + 1.114\ (A2) - 0.126\ (ELAB) + 54.917$$

Grade 6:

$$POST = 0.462\ (A1) + 1.870\ (C) + 0.206\ (L) + 3.799\ (SEX) + 41.756$$

Each of these equations was generated using data on three-fourths of the children at each grade level. One-fourth of the children had previously been randomly selected to validate the equation. The results of t tests on data supplied by the validation sample showed no significant differences at the $p < .05$ level between predicted and actual average concept block posttest achievement. The standard error of estimate also provides usable confidence intervals for prediction of individual scores.

An additional aspect of the study investigated the differences in achievement between males and females at each grade level. Results of t tests showed no significant differences for grades two through five; however, grade six showed a significant difference at the $p < .05$ level favoring the boys.

Discussion

In this section the findings of the study will be reviewed in an effort to compare them with those reported by other experimentors. Variables will be discussed more or less in the order of their appearance in the equations, starting with all the first variables selected.

The first variable selected for each regression equation generated by the process of stepwise addition is also the variable having the largest correlation with the dependent variable and explains the greatest portion of its variance. As a result, the first variable is the most significant one in the equation. Additional variables increase the amount of explained variance in the dependent variable either directly by the strength of their relationship or indirectly by acting as a suppressor variable which absorbs error variance in the previous variables.

The first variable in the second grade equation is the arithmetic subtest of the Stanford Achievement Test. It has a correlation of 0.697 with the dependent variable and accounts for 49% of the variance. Similarly the first variable in the sixth grade equation is Arithmetic Concepts, from the Iowa Test of Basic Skills, which correlated 0.645 with the dependent variable and accounted for 42% of the variance. These results are not surprising since it would appear that students who achieve well in traditional mathematics programs also achieve well in mathematics under computer-assisted instruction drill and practice. Another variable falling in the category of arithmetic achievement is Arithmetic Problem Solving from the Iowa Test of Basic Skills, which was selected as the second variable in the fifth grade equation. It has a correlation with the dependent variable of 0.604.

The first variable in the fifth grade equation is factor B of the Children's Personality Questionnaire, which is described as Less Intelligent (low score) vs. More Intelligent (high score). This factor had a correlation with the dependent variable of 0.636 and accounts for 40% of the variance. Again, most studies such as those by Erickson (1958), Holowinsky (1961), and Harootunian and Tate (1960) report similar findings and this result is not surprising. The factor was also the fourth variable selected in the fourth grade equation and had a correlation of 0.447 with the dependent variable.

It should be noted that factor B was not the primary measure of intelligence selected for this study. It was anticipated that the Quick Word Test would fulfill this function, and it did have correlations of 0.578, 0.479 and 0.476 at the fourth, fifth, and sixth grades. It may be that since the Quick Word Test is strictly a verbal instrument, whereas factor B of the CPQ contains number series and other mathematical-type problems it is better related to mathematical ability.

The first factor of the equations for both the third and fourth grades is the Vocabulary score from the Iowa Test of Basic Skills. This factor accounts for 31% of the variance at grade 3 and 46% at grade 4. The correlations were 0.558 and 0.677 at the respective grade levels. Since it has been shown consistently that a strong relationship exists between reading ability (of which vocabulary is a component) and arithmetic achievement, this result is not unexpected. Harper's (1957) suggestion that this relationship is probably greatest at the lower grade levels seems to be borne out in this case; however, Harootunian and Tate (1960) obtained similar results with eighth grade students.

A variable similar to Vocabulary, Language Skills, was also selected as the second variable at grade four and the third variable at grade six. This variable had correlations of 0.675 and 0.543 respectively with posttest achievement. Since many of the language skills are similar to components of reading ability, just as is vocabulary, its strong relationship with arithmetic achievement was also anticipated.

Reading ability may be an important ability in computer-assisted instruction. Directions must be read and followed at the beginning of each lesson and many arithmetic problems are presented as word problems. Since a child is largely on his own while he is working at a terminal, differences in reading ability could account for differences in mathematics achievement.

It should be noted at this point that all of the first variables and two of the second variables in the equations are from the cognitive domain. However, in all but one case (Language Skills at the sixth grade), further variables are exclusively from the affective domain. This is taken as additional strong support for the contribution of affective variables in accounting for individual differences in learning.

Variable Q4, Relaxed vs. Tense, is the second variable in the second grade equation. This factor had a correlation of 0.202 with the dependent variable. The more tenseness a child admits to on this factor, the higher his score. Porter, Cattell, and Ford (1968, p. 5) state that, "In older groups, Factor Q4 seems to relate to a variety of symptomatic behaviors that might generally be explained in terms of 'nervous tension' or undischarged drive." It may well be that computer-assisted instruction provides a very suitable environment for the tense child by allowing him ample opportunity for drive reduction and introducing minimal frustration.

Factor N of the CPQ was selected as the second variable at grade three. It is described as Forthright vs. Shrewd, and higher scores are given at the shrewd end of the scale. Its correlation with the dependent variable was -0.297. Porter, Cattell, and Ford (1968, p. 5) comment on this factor that, "The high scorer, however, does seem more 'wise' to the ways of adults and peers and, therefore, better able to advance his own interests than the lower scorer." This factor carries a minus sign in the equation, however, so that the more shrewd a child reports himself to be, the less well he achieves. Such a result would be expected in this case since even though a child may be able to use his "wiseness" to advance his interests in working with adults and peers, these same techniques are irrelevant to his performance when dealing with a computer.

Factor C of the CPQ, Affected by Feelings vs. Emotionally Stable, was selected as the second variable in the sixth grade equation. It correlated 0.460 with the dependent variable, and higher scores are made by those indicating emotional stability. Porter, Cattell, and Ford (1968, p. 4) state that, "The higher scorer appears relatively calm, stable, and socially mature for his age, and is better prepared to cope effectively with others than is the low scorer, who is relatively lacking in frustration tolerance and more subject to a loss of emotional control." This result seems consistent with the results reported by Cleveland and Bosworth (1967) and Woodruff, Faltz, and Wagner (1966) when they respectively report significant correlations of psychologically healthy personality and personal relations with achievement.

These same studies would also seem to be adequate explanations for the selection of Neuroticism as the third variable in the second grade equation. The more neurotic a child, as measured by the CPQ, the lower his achievement, since this variable is subtracted in the equation. Also its correlation with the dependent variable is -0.248.

In like manner, factor A of the CPQ, Reserved vs. Warmhearted, may related to healthy personality and good personal relations. This is the fourth variable in the third grade equation. Its correlation with the dependent variable was 0.248 and higher scores are given for warmheartedness. Porter, Cattell, and Ford (1968, p. 3) comment that:

> The high scorer is generally characterized as warm and sociable, the low scorer, as more cool and aloof. At the childhood level, the difference between the high and low scorers is particularly evident in the extent to which the child responds favorably to teachers and to the school situation generally.

The variable of Motivation, from the Self-Concept and Motivation Inventory, was selected for two equations. It is variable four in the second grade equation and variable three in the fourth grade equation. The correlations with the dependent variable are 0.204 and -0.184, respectively. It should be noted that it carries a plus sign in the second grade equation and a minus sign in the fourth grade. Studies such as Schell, Veroff, and Schell (1967); Khan (1969); and Woodruff, Faltz, and Wagner (1966) have consistently pointed out a positive relationship between achievement motivation and actual achievement. While the motivation variable in the second grade equation is consistent with these findings it is not consistent at the fourth grade. It may be that computers are unable to reward students who evidence high achievement motivation but do not necessarily perform well, while teachers may reward a child who is trying even though he is performing below the standard. Also it may be that things such as doing well in school and giving evidence of achievement motivation is not a popular thing among fourth graders who may be more concerned with peer approval or group conformity. Naturally it is also possible that is is acting as a suppressor variable in the equation and was selected for its ability to absorb error variance in the previous two variables.

Self-Concept, from the SCAMIN, was selected as a fifth variable in the fourth grade equation. Its correlation with the dependent variable was 0.340. In studies by Brookover, Paterson, and Thomas (1962) and Piers and Harris (1964) self-concept was shown to be positively related to elementary school achievement.

Factor D of the CPQ, Phlegmatic vs. Excitable, and Elaboration from Thinking Creatively With Pictures, were selected as the third variable in the third grade equation and the third variable in the fifth grade equation, respectively. They correlated -0.064 and -0.068, respectively, with the dependent variable. Factor D was added in its equation while Elaboration was subtracted. Since in both cases the correlations with the dependent variable are so small, it is believed that they must be acting as suppressor variables and are not explaining variance due to the strength of their relationship.

Sex of the child was the fourth variable selected in the equation for grade six. Its correlation was 0.307 with the dependent variable. It is also interesting to note that the sixth grade was the only grade to show a significant difference ($p < .05$) on a t test between boys and girls in CAI drill and practice math achievement. The literature on differences in mathematics achievement based on sex of the child show conflicting results. While early studies such as Bonser (1910) and Stroud and

Lindquist (1942) show a slight superiority for boys, more recent studies by Cleveland and Bosworth (1967) and Jarvis (1964) and Wozencraft (1963) show no differences, differences only in certain arithmetic subskills and IQ ranges, or superior achievement by girls. In his CAI reading project Atkinson (1968) found no significant difference in reading achievement between boys and girls, while traditional reading teaching methods had consistently shown girls to be superior. Thus in explaining the results of this aspect of the study it may be that there is a sex difference in math achievement which is minimized by CAI until it emerges at the sixth grade or that there is a difference which becomes apparent only in certain arithmetic subskills which happen to be studied at the sixth grade.

There are almost no reports in the literature over the last fifteen years of studies generating predictive equations for elementary school mathematics achievement. In fact the only example which could be located (Pierson, 1964), p. 3) predicted school achievement for ninth grade boys. The equation was generated from factor scores from the High School Personality Questionnaire (HSPQ). The HSPQ is a test measuring the same kinds of factors as the Children's Personality Questionnaire used in this study. The equation predicts SRA total percentile scores as a criterion of school achievement. The equation in sten score form is as follows:

$$\text{Prediction of school achievement} = 0.28\,(A) + 0.61\,(B) + 0.22\,(D) + 0.32\,(G) + 0.39\,(I) + 0.19\,(O) + 0.16\,(Q2) + 0.34\,(Q3) + 0.24\,(Q4) - 9.79$$

Pierson comments that:

> Aside from their superior intelligence, the more highly-achieving students in this population are defined factorily by the HSPQ as friendly, sensitive youngsters (A+, I+) with good character development (G+, Q3+), who are somewhat anxiously motivated (D+, O+, Q4+).

These findings are not greatly unlike those found in this study. It will be noticed that the first three factors reported in this equation were also included in equations for grades 3, 4, and 5 of this study. Pierson's conclusion that anxiety is a factor in achievement, however, was not found in this study. None of the correlations of anxiety with achievement were significant and all were negative.

In comparing the results of this study with the factors which one would expect to find judging by a review of the literature, there are a couple of surprises. One of these is that in a majority of studies reviewed it was suggested that achievement in traditional elementary school arithmetic programs is positively related to socioeconomic status. This study found correlations of -0.037, 0.014, 0.028, and -0.004 between ratings on the Warner Socio-Economic Scale and the dependent variable for grades three through six. There was a wide range of socio-economic levels found in Riverside School using this scale, and it would seem that there is tentative justification for the hypothesis that CAI may be successful enough at meeting individual differences that the effects of socio-economic status on achievement are "washed out."

Another surprise is the inconsistent pattern of correlations of Motivation with the dependent variable. These correlations were 0.204, 0.119, -0.184, 0.149, and -0.120. Studies reviewed in the literature pointed out a consistent positive relationship between motivation and achivement. While these correlations are none too large it is surprising to find two which are actually negative. Along with the possibilities suggested earlier in this chapter it may be that the instrument used to assess motivation in this case may be unreliable; however, its published reliability is 0.82.

It is interesting to note that the four factors assessing creativity appeared to have little relation to achievement. The correlations were nearly all positive but small in size. Since the literature shows no consistent pattern of results, these findings do not seem unusual.

A final unexpected finding results from the fact that the literature would lead one to believe that a successful student in CAI would probably be more introverted than his lower achieving peers. Correlations between the extraversion scale from the CPQ and the dependent variable of 0.255, 0.072, 0.084, 0.076, and 0.369 were obtained for grades two through six. While correlations for grades three, four, and five are quite small, those for grades two and six favor the child who is extraverted rather than introverted.

Validation of the regression equations by means of t tests provides assurance of prediction of group scores. In order to make this more meaningful for the prediction of individual scores, the standard error of estimate of the regression equation may be utilized. When a score is predicted for an individual, it may be assumed that two-thirds of the time the actual score will be within plus or minus one standard error of estimate of the predicted score. If greater confidence is desired, it may be assumed that the actual score will be within plus or minus two standard errors of estimate from the predicted score 95% of the time.

Implications

The results of this study have several implications which pertain to future educational programs and research.

Since predictive linear regression equations have been developed, it would be informative to do a follow-up study to see if accurate results can be obtained using new groups of children at another time. Naturally this is a logical undertaking for the INDICOM Project, which is also concerned with dividing the children at Riverside School for a split shift for the 1969-1970 school year. Only the morning shift of children will be able to use the CAI facilities, making it possible to do a comparative type of experiment in which factors important in predicting achievement in CAI mathematics could be compared with those associated with achievement in traditional programs. Such a comparative experiment would also be a good opportunity to check into some of the results which were not found in this study, such as a consistent pattern of relation of achievement motivation, an almost total lack of correlation of socio-economic status, the lack of relation of creativity, and the finding that extraversion correlates positively with achievement. Additionally, it would seem important to investigate the differences in achievement found to be based on sex of the child. Does a difference arise at this age and grade level, or is it simply a function of the kind of mathematical subskills employed?

Another interesting project would be to assess why second graders had an average of only 68.29 on concept block posttests while remaining grades averaged 84.44, 86.79, 82.11, and 78.43, respectively. Reading scores were not available on second graders, but because they appeared to have such a strong relationship at third and fourth grades, it might be that this score would be a good predictor of second grade mathematical achievement. It would be interesting as well to see if improvement in reading ability would result in improvement in mathematical achievement at this level.

One of the broad generalizations which seems warranted from this study concerns the importance of the affective domain. While, as expected, cognitive variables assumed primary importance in all of the regression equations which were generated, a great deal of additional variance was explained by the addition of affective variables. In grades two through six, respectively, the following amounts of variance were explained by affective variables: 13%, 13%, 7%, 9%, and 8%. As technology provides increasing capabilities for catering to individual differences, it seems important to continue the effort of assessing the relationship of the affective domain to the learning process in order that these variables may be incorporated into future systems which may maximize the outcomes a child derives from his studies.

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APPENDIX A

A SAMPLE FIFTH GRADE CAI DRILL AND PRACTICE LESSON IN FRACTIONS

APPENDIX A

A SAMPLE FIFTH GRADE CAI DRILL AND PRACTICE LESSON IN FRACTIONS

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D
PLEASE TYPE YOUR NUMBER.  7
NOW YOUR FIRST NAME.  JOAN ANYLESSON
TYPE 8-DIGIT LESSON OR REVIEW NUMBER  13502001


THIS IS A LESSON ON FRACTIONS.


1 / 9 + 4 / 9 = 5 / 9

3 / 4 - 4 / 20 = __ / 20 - 4 / 20
TIME IS UP.  TRY AGAIN.

3 / 4 - 3 / 20 = 11 / 20 - 4 / 20
NO, THE ANSWER IS 15.  TRY AGAIN.

3 / 4 - 4 / 20 = 16 / 20 - 4 / 20
NO, THE ANSWER IS 15.

3 / 4 - 4 / 20 = 15 / 20 - 4 / 20

               = 11/20

5 1/4 + 2 3/10 = (5 + 2) + (1 / 4 + _ / 10)
TIME IS UP.  TRY AGAIN.

5 1/4 + 2 3/10 = (5 + 2) + (1 / 4 + _ / 10)
TIME IS UP.  THE ANSWER IS 3.  TRY AGAIN.

5 1/4 + 2 3/10 = (5 + 2) + (1 / 4 + 3 / 10)

               =  7  + ( 5/20 +  6/20)

               = 7 +  11/20

               = 7  11/20
```

12 DIVIDED BY 2/3 = 12 X 8/ _
NO, TRY AGAIN.

12 DIVIDED BY 2/3 = 12 x 3/ 2

= 36/ 2

= 18

3 / 7 X 14 = __/ _
TIME IS UP. TRY AGAIN.

3 / 7 X 14 = 6/ _
NO, THE ANSWER IS 42. TRY AGAIN.

3 / 7 X 14 = 42 / 7

= 6

2 / 3 X 3 / 5 = 6 / 15

= 3/ __

NO, TRY AGAIN.

= 2/ 5

END OF LESSON 03/22/69
9 PROBLEMS CORRECT, 64 PERCENT, IN 307 SECONDS.

GOOD-BY JOAN
PLEASE TEAR OFF AT THE DOTTED LINE.

....