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A STUDY OF CREATIVITY, INTELLIGENCE AND DISCOVERY TEACHING AS RELATED TO PERFORMANCE IN ELEMENTARY SCHOOL MATHEMATICS

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CHAPTER I

INTRODUCTION

Overview

If there exists a societal concept common among the masses, then it would have to be that our society should be immune to decay; i.e., it should be an ever-renewing society (Gardner, 1963). An ever-renewing society is a free society that understands that the only stability possible today is stability in motion. Such a society fosters innovative, versatile, and self-renewing men and women and gives them room to breathe.

Implicitly permeating the idea of an ever-renewing society is the cognizance that the society's capacity for renewal depends upon the individuals who make it up. Is this not manifested by our society, which accepts "respect for the individual" as being the "basic American value"? The Educational Policies Commission (1961, p. 1) contends that this value, respect for the individual, has led to one of the major responsibilities which American education has had placed upon it by the people, the proposition being "to foster that development of individual capacities which will enable each human being to become the best person he is capable of becoming."

Human Variability

Clearly, then, education must concern itself with the concept of human variability--individual differences. In a comprehensive sense, human variability, as most other flexible or fluid phenomena, varies in a predictable manner. Namely, human variability is one of degree rather than of kind, human variability is usually representative of a continuum from one extreme to the other, and human variability is usually representative of the statistical concept--normal distribution.

Bloom (1964) in discussing human characteristics hypothesizes that we can determine the theoretical limits on the prediction of academic achievement with reference to time, age, and vertical status in school. This determination, however, is dependent upon identification of certain factors and conditions of human variability.

Although the array of individual differences is dramatic, education gives priority to differences most related to learning. Denemark (1961) lists six areas of human variability which have implications for learning. These are individual differences in perceptions, maturity levels, types of intelligence, rate of development, social context, and objectives for learning.

Creativity and Intelligence

One of the most controversial areas of human variability is types of intelligence. Prevalent in the controversy is the creativity vs. intelligence problem. Givens (1963) identifies "creative intelligence" as the important aspect of the human cognitive structure with which we <u>should</u> become better acquainted. This category of intellectual behavior is characterized by spontaneous expression resulting from synthesis, original, or divergent thinking.

On the other hand, "adaptive intelligence," representative of our notions of intelligence as measured by IQ tests, is characterized by analytical and critical thinking. This type of intelligence is considered to have been fostered in our educational practices and often at the expense of creative intelligence.

The controversy is further exemplified by Wallach and Kogan's (1965, p. 2) assertion that the possibility of a unified dimension of individual differences that discriminates cognitive behavior appropriately labeled as more or less creative, and the possible limitations of the concept of intelligence in understanding individual differences, have been the foci of creativity research projects, symposia, and reports. Therefore, Wallach and Kogan (1965, p. 25) claim that the goals of these creativity endeavors have been slanted toward establishment of the idea that "there exists a unified pervasive dimension of cognitive activity which is properly characterizable as creativity, standing relatively independent of another pervasive cognitive dimension which is properly characterizable as general intelligence."

Creativity and its possible significance for educational practice have been considered from the standpoint of philosophy, psychology, and sociology. Philosophically, Brameld (1965) maintains that education, to be a source of power in today's world, cannot afford to minimize or subordinate the role of creativity in the experience of learning. On a critical note, he claims the schools are in a state of imbalance away from creativity toward passivity--that is, toward standardization.

From psychology comes a similar note of disquietude. Paul Torrance

(1960) generalizes:

> In the main, current school curricula at all levels of education are designed to develop and make use of the kinds of thinking abilities reflected in traditional tests of intelligence. No one is suggesting that the development of these abilities be eliminated. It is only suggested that parallel treatment be given the creative thinking abilities.

In a sociological sense, Calvin Taylor (1963), a psychologist, states, "Creative talent may well be the human resource most needed today." He, too, deems it important for education to "concern itself not just with the kind of giftedness and high-level talent which has been singled out and favored to date, but also with the identification and cultivation of <u>all</u> high-level human resources."

Perhaps this concern for creativity recognition, as well as intelligence recognition, emanates from a change in educational objectives for the schools. This conjecture seems reasonable when one reflects on the Educational Policies Commission (1961, p. 12) proclamation that the central purpose of the schools is development of the ability to think, i.e., to use rational powers; that these rational powers are compatible with Guilford's (1959) three faces of intellect and Bloom's (1956) six categories of educational objectives (both contain aspects that have been identified in the dimension of creative cognition); and the concensus that intelligence tests--intelligence being accepted as that which intelligence tests measure--are used to estimate the capacity of the student for school learning.

This circumscribing thought, coupled with the previously cited charge to the schools by the American people, probably is indicative of a new era in the development of the concept of intelligence and its measurement. The hypothesis seems to be verified by McLeish (1963, p. 29), who offers this historical note:

> Mental testing crystallized out as a by-product of several unrelated lines of development in the history of psychology. In the historical order of their appearance these were: theological speculations and philosophical criticism of the "faculties of the soul"; the attempt to investigate the relations between mind and body by Fechner ("psycho-physics"); the anthropometric investigations of Sir Francis Galton, in which he attempted to measure the physical and mental differences between individuals over a very wide field; the study of backwardness in school children by Binet. These trends, the historical order corresponding to the increasing importance of each for the development of tests, represent the strands which have been woven together by historical circumstances to give rise to this highly sophisticated branch of applied psychology.

The present era is characterized by the treatment of intelligence as a developmental concept that is modified as the individual interacts with his environment. Recent studies manifesting this idea pertain to the child's acquisition of his native language and his development of thinking processes.

Hence, the concept of intelligence is being modified--the creativity strand being interwoven and accepted as developmental--so that it will accommodate the identified objectives of the school. In this transition period, educators and psychologists are systematically studying the intellectual development of children in language acquisition and the processes of thinking. Among the prevalent questions prompting particular studies are: How much and what do children understand at particular ages? How much more can they be taught at these same ages? In what ways can information best be presented to them? What is the significance of the creativity strand?

In response to the last question, Ausubel (1963, p. 98) captures the magnitude and potential of the concept, as well as implicating objectives and directions for research when he states that "creativity constitutes an intra-personal variable which affects individual differences in meaningful learning and retention, problem solving, and academic achievement."

School Mathematics

From the emphasis on recognizing individual differences in terms of intelligence, including creativity, educators are subsequently faced with students' achievement in most areas of the curriculum. No small amount of attention has been attracted by the recent experimental programs in school mathematics. The activity and changes in this segment of the curriculum have been labeled as the "revolution in school mathematics." Keppel's (1963, p. vii) statement testifies to the scope and influence of the revolution:

> If one were to look for the most significant development in education over the past decade, it would be reasonable to single out the wave of curriculum reform which has swept the school system and appears to be maintaining its vigor undiminished. Beginning with mathematics . . . it has spread in scope until almost every discipline represented in the primary /elementary/ and secondary school curriculum has been in some degree affected.

Experimental school mathematics projects have been striving for gains within the broad realm of mathematics education itself, but ultimately a higher level of mathematical literacy and competency for each individual has loomed as the major objective. That is, the new programs in mathematics have not abandoned the classic American goal of providing a general education for the masses. Indeed, they have been created for this very purpose, but tailored to fit modern life and modern educational needs. Characteristically, products of the experimental mathematics projects--and expectedly so--correspond to causes and reasons for the revolution.

One of the causes behind the revolution is the vast amount of mathematics that has been created within the past 60 years; hence, the new programs in school mathematics contain some new content. A second cause is the increasing need of our society for mathematical competence due to advances in scientific and technological knowledge. This need has been an influential force which the project programs have responded to by telescoping (teaching topics earlier) mathematical material. The interest of mathematicians in mathematics education has prompted the new programs to concentrate on precision of vocabulary, a third common characteristic of the experimental projects.

Thinking about more effective methods of teaching and developments in learning theory and educational psychology sets the stage for a fourth characteristic. In the new programs not only are meaning and understanding of primary importance but also emphasis on structure, generalization, reasoning, and discovery. This is clearly revealed by inspection of An Analysis of the New Mathematics Programs (NCTM, 1963). The presence of each idea is based on psychological beliefs about how students learn mathematics.

Clearly, the direction of the revolution has been from the polar position of mathematics in terms of social utility to a position of sound mathematics. This is not to say that the revolution is a move back to the content-centered school, since the contention among revolutionists is that mathematics is not enough. The California Mathematics Council (1963) exemplifies this when it recognizes, and emphasizes, that a sound curriculum is not sufficient. Sound and meaningful concepts can be just as poorly taught as unsound concepts. A reorientation of the mathematics program which emphasizes structural aspects will be unsuccessful unless the pedagogy is successful.

Discovery Teaching

Although variation in teacher effectiveness is ever present, the general instructional objective is to utilize the discovery approach in developing meaning and understanding of mathematical concepts. The assumption is that discovery teaching will enable the student to learn meaningfully in less time and also extend his retention time, as compared to the results attained by expository teaching.

In applying this teaching approach to mathematics, Bruner's (1962) statement is accepted that "every subject has a structure . . . . It is this structure that provides the underlying simplicity of things, and it is by learning its nature that we come to appreciate the intrinsic meaning of a subject." Thus, mathematics has a structure and learning of this structure makes it possible to gain an understanding of mathematics.

Any mathematical topic studied is a part of this structure. Hence, the concern with a given topic is its niche in the total structure of mathematics. How is this problem resolved? It is resolved by developing within the students an attitude of inquiry; that is, an attitude that leads to discoveries. Specifically, students are encouraged to ask questions like (Hardgrove, 1963):

How do these things relate?

What are the essential things I know?

What does it all mean?

If generalizations are made from the responses to these questions, then students should be encouraged to ask:

Is this generalization always true?

Can I prove it?

Where can I go from here?

The premise accepted is that this approach helps students to develop an awareness and appreciation of the structure of mathematics as a result of their own thinking. Not only does this approach aid students in discovering and understanding the principles of mathematics, but it also develops a way of working, a way of thinking, an approach to learning and problem solving.

Variables of Teaching and Learning Mathemtics

In perspective of time, the revolution in school mathematics has evolved from a stage in which mathematical content was the focal point, to its present stage in which the learning of mathematics is central. The revolutionists, then, recognizing that learning is individual, are confronted with human variability and its role in learning mathematics.

To determine the variables that affect mathematical learning, most of the revolutionists are observing practice and examining research conclusions. Observations yield rather startling and disquieting results. Foremost is that teachers' awareness of student variation is almost universal, but practice reveals that many of them seem to believe that all classes and students must be taught, and must learn, the same materials in the same way and at the same rate. Suppes (1964, p. 79) depicts the situation when he states, "In spite of the obeisance paid to this tenet [learning rates] in discussions of curriculum I consider it the most important principal of learning as yet unaccepted in the day-to-day practice of subject matter teaching in the classroom."

Examination of theory and research is producing some general principles of human variability with implications for the revolutionists in their concern with achievement and growth in mathematics. Some of the general principles are: individual differences are real, inevitable, ineradicable, desirable, and essential (Tyler and Brownell, 1962); one of the most firmly established psychological concepts is the existence of significant differences in individual rates of learning (Suppes, 1964, p. 79); and in seeking to provide intelligently for these, educational diagnosis of and prescription for the individual are essential (Goodlad, 1965, p. 57).

Pertinent and more specific in implications for the revolution is this statement by Torrance (1965d, p. 678):

> To me, by far the most exciting insight that has come from our research is that different kinds of children learn best when given opportunities to learn in ways best suited to their motivations and abilities. Whenever teachers change their ways of teaching in significant ways, a different group of learners become the stars or high achievers. This advance has far reaching implications for educating a larger number of people to a higher level of dignity and mental health in our society . . . . Curiosity and creative needs are strong enough and universal enough to make creative ways of learning useful for all individuals, but creative ways of learning should not be an exclusive way of learning for all children nor for any single child, even though he may prefer learning in creative ways and learn little when we insist that he learn exclusively by authority.

Among the inferences of Torrance's preceding comments detected by the revolutionists is the notion that one instructional approach is not sufficient. Bruner (1966, p. 71) reinforces this view when he declares, "The fact of individual differences argues for pluralism and for an enlightened opportunism in the materials and methods of instruction."

Explicitly, Torrance further suggests that an individual's motivational level and abilities are the variables which identify the instructional approach that will provide the most effective learning results. Admitting conjecture in part, Kagan (1965, p. 561) claims that the method of discovery is most appropriate for highly motivated older children and least appropriate for younger children who do not have high motivation to master intellectual tasks.

Torrance (1965b, p. 201), in answering the question, "Why measure the creative behavior in children?", isolates one of the abilities of which those persons concerned with the learning of mathematics should be cognizant. He responds, "Children who score high on measures of creative behavior . . . prefer to learn in creative ways rather than by authority, by spontaneous rather than deliberate ways, by discovery rather than by authoritarian identification."

Revolutionists are elated with Torrance's response since it is compatible with their position on discovery teaching as well as present educational objectives of the school. Logically, one can assume that the revolutionists would deduce that a creativity index might possibly be the measure of human variability that best correlates with success in the new mathematics.

However, if Torrance is adhered to, consideration of other abilities is imperative. Kramer (1966, p. 393), in pointing out the measure of human variability that has been heavily relied on for prediction of success in mathematics, cautiously concludes, "Though an intelligent child usually performs quite well in mathematics, the pupil's IQ does not appear to be an infallible basis for predicting his success in mathematical computation and problem solving."

Analysis of Torrance, Kagan, and Kramer's thoughts produces a domain for subsequent research for those revolutionists delving into the learning of mathematics. Research to date has endorsed discovery teaching for <u>some</u> students. The new mathematics has been, hopefully, designed for <u>all</u> students. Hence, the questions: Is discovery teaching the most effective for all student? If not, then what are the abilities of this group and what alternative teaching approaches should be used?

Presently, answers to these questions are nonexistent, but Jackson (1962, p. 86) generalizes a solution that generates a further question. He states,

> A . . . *step toward a more productive view of the teaching* process might be to abandon our univariate approach to inquiry in favor of a multivariate one . . . . Perhaps certain types of teachers using certain types of methods, work best with certain types of students given certain types of educational goals.

The extended question is, "What types?"

The Study

In this study, consideration was given to human variability in the areas of its measurement--creativity and intelligence; the curriculum in elementary school mathematics; and the teacher employing the discovery approach to teaching mathematics. The study includes five segments: introduction, review of literature, methodology, analysis of data, and summary. Generation of the study emanated from a synthesis of ideas just presented, together with the following questions:

1. What is the relationship of creativity to intelligence?
2. Is discovery teaching more effective with the more creative students than with less creative students, when all possess similar indices of intelligence?
3. Do the better achievers in elementary school mathematics have a higher creativity index or a higher intelligence index?
4. Should the discovery approach be the only approach used in the teaching of elementary school mathematics?

Statement of the Problem

How do a creativity index and performance compare with an intelligence index and performance in an elementary school mathematics program that is taught by teachers employing the discovery teaching approach?

Statement of the Purpose

The purpose of this study was to examine the possibility that a diagnosis of an individual's creativity and intelligence indices would indicate that the best educational prescription for the individual would include a teaching approach compatible with his more dominant index. This is an extremely sensitive educational problem which has not been resolved. Generally speaking, proponents of discovery teaching and learning seem to feel that it applies equally well to all learners; e.g., Bruner's discourse (1961) on discovery is nonexcluding. Conversely, other psychologists implicity and explicitly recommend diversified approaches depending upon the characteristics of the students; e.g., Ausubel (1964), acknowledging that discovery has a place among the repertoire of accepted techniques available to teachers, concludes that, "the issue is not whether it should or should not be used in the classroom, but rather for what purposes and under what conditions."

Hypotheses

For purposes of this study the following hypotheses will be tested:

H_o-1 When a subjective evaluation of performance in mathematics is made by teachers there is no significant relationship between intelligence and mathematical performance in:

a. reasoning

b. numeration

c. structural aspects of number systems

d. computation

e. general (composite evaluation)

H_o-2 When a subjective evaluation of performance in mathematics is made by teachers there is no significant relationship between creativity and mathematical performance in:

a. reasoning

b. numeration

c. structural aspects of number system

d. computation

e. general (composite evaluation)

H_o-3 When gain (growth) is determined by pre- and post-test measures of a standardized arithmetic achievement battery there is no significant relationship between intelligence and gain in:

a. mathematical concepts

b. mathematical problem solving

c. composite mathematical change

H_o-4 When gain (growth) is determined by pre- and post-test measures of a standardized arithmetic achievement battery there is no significant relationship between creativity and gain in:

a. mathematical concepts

b. mathematical problem solving

c. composite mathematical change

H_0-5 There is no significant relationship between a "combined index of 'creativity and intelligence' and composite performance in elementary school mathematics" when performance is determined by:

a. the teachers' subjective evaluation

b. growth as measured by a standardized arithmetic achievement battery

Subjects

University Elementary School is a laboratory school enrolling up to twenty-five students in each grade, kindergarten through Grade 6. The subjects of this study were the sixty-nine students in the intermediate division of the school. Hence, most of the subjects were in the nine-to-eleven age range, although a few were twelve years of age. The following data were obtained for each subject: an intelligence quotient, a creativity index, an objective and subjective measure of performance in mathematics.

Instruments and Procedure

The instruments used were the Lorge-Thorndike Intelligence Test (1962), the Torrance Tests of Creative Thinking (1966), the arithmetic section of the Iowa Test of Basic Skills (Lindquist, 1964), and a subjective rating of each subjects's success in mathematics as perceived by his mathematics teacher. The intelligence and achievement tests were administered as part of the school's regular testing program. Creativity tests were administered by the chairman (supervising teacher) of the intermediate division of the school in accordance with the suggested procedures outlined by Torrance and his staff. The subjective rating was categorized as moderately successful, successful, and very successful.

Statistics

To test the hypotheses raw data were converted to scores which were usable in employment of the chi square statistic for significant relationship. In particular, the median score of each index, creativity and intelligence, was used to check the relationship to performance in mathematics.

Indices of performance in mathematics were of two types. The first, teacher evaluation, was the frequency of each rank: moderately successful, successful, or very successful for five categories of mathematical performance. Mean gain in months for the sample in each of three performance categories was the index used for the second type as derived from a standardized achievement test.

Definitions

Instruction. One segment of professional education. For purposes of analysis (Gage, 1964), instruction is considered in terms of types of teacher activities, types of educational objectives, components of the learning process, and families of learning theory. When viewed comprehensively, it is said to be concerned with life, substance, and process; or in terms of knowledge, instruction is concerned with the nature of knowledge, the knower, and the knowledge-getting process.

Individualized instruction. The steps taken to meet the needs of pupils, each being a unique individual. "These steps (Clymer and Kearney, 1962, p. 268) . . . involve the selection and organization of content . . . [and] the creation of situations in which pupils will work and be considered both as individuals and as members of groups."

The act of teaching. Characterized by certain activities and components of the learning process that a teacher utilizes in striving for an educational objective. Hence, teaching is one segment of instruction.

Discovery through inquiry. One approach to teaching. This approach (Bruner, 1961) provides activities that cause the learner to rearrange or transform evidence in such a way that one is enabled to go beyond the evidence so reassembled to new insights.

Reception via exposition. One approach to teaching, often identified as learning by authority. This approach (Ausubel, 1963, p. 16) is used when a teacher presents to the learner, in final form, the entire content of what is to be learned.

Intelligence. Thought of as the ability to work with ideas and the relationships among ideas (Lorge and Thorndike, 1962, p. 2).

Creative thinking--creativity. Takes place in the process of sensing difficulties, problems, gaps in information, missing elements, making guesses or formulating hypotheses about these deficiencies; testing these guesses and possibly revising and retesting them; and finally in communicating the results (Torrance, 1965c, p. 8).

Elementary school mathematics. A program characterized by new content as well as content from traditional programs in arithmetic, a teaching approach identified as discovery through inquiry, utilization of mathematically precise vocabulary; the telescoping (moving topics downward) of material; and thinking of the program as segments of different mathematical systems with emphasis on the structural aspects of the systems.

Assumptions

For the purposes of this study the following assumptions have been applied:

1. That the gains attained in the Iowa Test of Basic Skills (Lindquist, 1964) arithmetic section are an objective measure of the student's success in mathematics.
2. That the teacher's evaluation of each student is a subjective index of the student's performance in mathematics.
3. That the Lorge-Thorndike Intelligence Test (1962) measures intelligence according to the definition used in this study.
4. That the Torrance Tests of Creative Thinking (1966a) provides a creativity index compatible with the accepted definition of creativity.
5. That the teachers involved in this study are competent in elementary school mathematics as defined and are particularly oriented to discovery teaching.
6. That the content taught is representative of the content used in the experimental mathematics program.
7. That the subjects of the sample are well oriented in the study of the "new mathematics."

Justification

The results of this study may possibly suggest clues for increasing individualized instruction in the schools. That is, the factor of a teaching approach compatible with a student's creativity or intelligence has significance for the educational "diagnosis of and prescription for" the individual.

Recent inference that the "revolution in school mathematics" has progressed from a stage in which content received the priority to the current setting in which content is considered tantamount to and simultaneous with how students learn mathematics, is pertinent to the justification of this study. There is also possible illumination on the validity of the revolution's allegiance to discovery teaching, or the lack of validity since skeptics such as Ausubel (1963, p. 17) contend that "discovery technics hardly constitute an efficient primary means of transmitting the content of an academic discipline."

Further, the study may provide research information that shows a relationship among and between the phenomena of intelligence, creativity, achievement in mathematics, and discovery teaching. The value of such data is noted by Lumsdaine (1964, p. 393), who states:

> In view of the complexity of human learning and the diversity of human learning tasks, we can expect to find relatively few generalizations that hold for all classes of instructional objectives, all classes of learners, and all conditions of instruction. Rather, what is likely to be most needed is a series of contingent generalizations that take account of the interaction of variables. Experimentally, this position argues for factorial experiments in which two or more variables are studied in combination, so that qualifications on a generalization can be determined.

Finally, the data collected in this study may have implications for Bruner's (1966) work on instructional theory. Specifically, the results could show that the need is for theories, rather than a theory, of instruction compatible with the different theories of learning. On the other hand, by considering a theory of instruction from the unity viewpoint, the study may have suggestions for the ratio of discovery to reception teaching as Getzels and Jackson (1962, pp. 130-131) suggest:

> We need to distinguish . . . between using repetition or discovery as the instructional method . . . [The distinction is] merely to set extreme points along which individual characteristics and educational practices tend to be distributed. The issue is not "either/or" but "how far toward one/how far toward the other."

CHAPTER II

REVIEW OF LITERATURE

Introduction

This and the two following chapters contain ideas and information obtained from reviewing the literature--research and theoretical--relevant to the study. Specifically, the area of discovery and mathematics education is considered historically in terms of philosophical, psychological, and pedagogical views and practices. Further concern with discovery is reported by examination of research dealing with the phenomenon during this century.

Creativity and intelligence, the second segment, is couched in the concept of human variability. Piaget's views of developmental psychology were selected as a basis for the discussion of intelligence. The views of other psychologists could have as readily been utilized, but Piaget's seemed more relevant to this study. Emanating from this is a discussion of intellectual functioning in which Guilford is relied on for the theoretical structure that contains the domain of activity named creativity.

Finally, reports of "grass roots" research are presented in the third segment--Chapter 4. These reports are concerned with the variables of creativity, intelligence, and achievement--in general and in mathematics. Perhaps it should be noted that no evidence was found that creativity, intelligence, achievement, and discovery had ever been studied collectively.

Discovery and Mathematics Education

To the novice in education, discovery is a term that is used as readily to modify "learning" as to modify "teaching." He also tends to believe that the concept of discovery is a new and unique educational idea introduced by current curricular reform. Certainly, discovery is a common component of contemporary experimental programs, but it has a rather natural evolutionary history, rather than being a grand and insightful innovation.

In mathematics education (elementary school), the evolution is apparent by noting the shifts from one emphasis to another during the twentieth century. Philosophically, there was evidence, early in the century, that the justification of arithmetic in the curriculum was shifting from the theory of mental discipline to the theory of social utility (quite indicative of the emerging "Progressive Education Era" assumption). The former assumed that the central purpose of the school was to train and develop the mind, whereas the social utility theory identified the chief purpose of the school to be equipping the child for life (Wilson, 1948).

During World War I, Stone (1918, p. 12) described the prevailing notions in mathematics education:

> The emphasis in arithmetic is now placed upon the practical values of the subject. That does not mean that all the older aims, as discipline, pleasure, culture, and preparatory values, are now wholly ignored; but it does mean that the emphasis has shifted from these to the practical in the broad sense of that term. But in so doing, whatever claims of recognition any of the older values have, may be taken care of when teaching the subject from the practical standpoint.

Research findings in psychology and developments in learning theory accompanied the philosophical evolution from mental discipline to social utility. Seldom were philosophical and psychological positions correlated, although analysis reveals that corresponding extremes were compatible. In arithmetic the psychological limits were known as the drill theory and meaning theory, the drill theory emanating from the connectionist view of learning that paralleled the philosophic mental discipline theory.

Drill theory possessed these characteristics (NCTM, 1935): (1) Arithmetic was analyzed into many separately conceived units or elements of skill. (2) These elements were to be mastered by the student as relatively independent acts of skill which did not need to be understood. (3) The mastered content was in a form that could be used effectively and efficiently by the adult. (4) The primary means of mastery was formal repetition.

From field (or Gestalt) views emerged the notion of meaning theory. In arithmetic, meaning theory had these characteristics: (1) Arithmetic was viewed as a closely knit system of ideas, principles, and processes. (2) This system had an organized, logical structure which could be understood by the student. (3) Arithmetic learning consisted of understanding number relations and the mathematical significance of quantitative situations. (4) Repetition was valuable for developing skills after understanding had been achieved or generalizations made.

Natural corollaries to drill and meaning in learning theory were the respective inferences for instructional procedure. Connectionist principles applied to arithmetic instruction resulted in the use of three procedures: (1) analysis of arithmetic into its constituent elements, (2) presentation of each element to the learner as a specific situation, and (3) fixing response to each situation through acceptable drill.

Similarly the application of field theory to arithmetic provided three principles: (1) use of the number system as a system, (2) discovery of relations and formulation of generalizations concerning this system through experience with it, and (3) testing and fixing these generalizations through repeated application.

Since its conception, meaning theory in arithmetic has been a controversial issue. However, it has served as a catalyst for change and subsequent improvement in mathematics education. Controversially, it has been compared to the philosophical theories of mental discipline or social utility in arithmetic. Wilson (1948, p. 333) states:

> Obviously there is no "meaning theory." All good teaching, regardless of type of material, is based upon clear understanding. No good teacher drills or carries on any type of teaching when meaning is absent. Meaning is not a theory, but it is a condition for any effective teaching or learning.

Proponents of meaning theory were secondarily concerned with philosophical issues in school arithmetic, but meaning is probably responsible for the emergence of a dual purpose in elementary school arithmetic. Dawson and Ruddell (1955, p. 393) capture this idea when asserting that:

> It is now generally agreed that there are two major mutually related and interdependent purposes for arithmetic instruction: a social purpose and a mathematical purpose. The social aim has to do with the application of arithmetic to the practical affairs of daily life . . . . The mathematical aim gives arithmetic its principal content: ideas, concepts, relationships, principles, generalizations, and the like--all this, in addition to the computation skills which have always been taught.

Concurrently "meaning" notions were making inroads into the pedagogy of mathematics education as illustrated in the report of a Los Angeles study by Miller (1957):

> Although learning in arithmetic can be facilitated in many ways, two predominant methods are used currently. The first, <u>the rule method</u>, is a technique in which an instructor solves a problem and describes the specific rules to be learned to obtain the solution to the problem . . . . In the second, <u>the meaning method</u>, the instructor explains a problem by reference to concrete examples, making use of definitions and principles of arithmetic . . . the former places emphasis upon the rule, the latter upon meaning and understanding.

These comments and citations are indicative of the evolution and final stage of mathematics education in the twentieth century prior to Sputnik and the revolution in school mathematics. Today's elementary school mathematics programs are characterized (Hardgrove, 1963, p. 32) by a body of content which differs significantly from pre-revolution programs.

Basic topics are number systems, geometry, measurement, and problem solving which utilize other mathematical strands in their development. The other strands are labeled as sets, logic, functions, and mathematical sentences. Mathematics educators (California, 1963) contend these latter strands contribute to clarity, precision, and economy in learning and teaching mathematics.

Emphasis on structure (p. 7) is probably the most novel characteristic of the new programs. Such an emphasis creates an implied mandate for meaning and understanding. To attain this goal, revolutionists, after reviewing the shortcomings of mental discipline implications for teaching arithmetic and the apparent success of meaning notions in arithmetic teaching, have, with little or no reservation, adopted discovery (pp. 7, 8) as the appropriate teaching mode. Therefore, it is a significant program characteristic.

From a theoretical point discovery teaching has been advocated throughout the century (if indeed it cannot be traced to Socrates). Bagley (1905, p. 262) and Young (1906, p. 70) show this in their respective statements.

> The pupil is not to be told but led to see . . . . Whatever the pupil gains, whatever thought connections he works out, must be gained with the consciousness that he, the pupil, is the active agent--that he is, in a sense at least, the discoverer.
>
> The pupil is expected in a sense to rediscover the subject, though not without profit from the fact that the race had already discovered it . . . . It is the function of the teacher and the text so to present the things to be done, so to propose the problems to be solved that they require real discovery on the part of the pupil; that at the same time the steps are within his power, and that he attains in the end a good view of the whole subject.

If discovery has been theoretically sound, why has it not become more commonly practiced in the schools? Johnson (1966) conjectures that teachers (before the revolution) have not really been encouraged to use it and furthermore to get students to discover, inquire, and generalize is not easy. Too, research endorsing the approach is relatively sparse as Mayor (1966, p. 351) claims:

> A very great deal is heard these days about learning research in mathematics, but specific information is hard to come by, even though the term is used loosely. Part of the difficulty in communication results from the fact that studies in learning are usually couched in the technical vocabulary of the psychologist, which the mathematics teacher . . . is not prepared to interpret, let alone translate into classroom action.

Cronbach (1965b) after evaluating the research on discovery concludes that the data on inductive teaching has not begun to give the answers necessary for firm recommendations to the schools. From a more critical stance Ausubel (1961, p. 47) states that "actual examination of the research literature allegedly supportive of learning by discovery reveals that valid evidence of this nature is virtually nonexistent."

To document these views of research one must first be aware of what proponents of discovery purport the results of this teaching mode to be. Although variation exists most advocates have agreed that when a student learns by discovery he (1) understands what he learns, (2) has acquired a learning set, and (3) develops an interest in what he learned (Kersh, 1965, p. 414).

In his research design McConnell (1934) set up two equivalent groups, A and B. Group A was taught by the pedagogy of authority, of mechanical repetition, and of relatively discrete connection-forming. Group B was taught by a pedagogy of discovery and verification, of meaning, and of relational learning. Results indicated that the method of sheer repetition was superior when the teacher was interested in immediate and automatic response to the number facts. However, if the teacher desired to give the pupil whatever satisfaction might accrue to him through a knowledge of the meaning and truth of the number facts and to develop a deliberate and meditative attack upon them, then method B was superior. There was also some evidence that B resulted in greater transfer potential and facility in manipulation of number facts.

Anderson (1949), in attempting to determine the differential effect of two instructional procedures upon arithmetic achievement, compared results of ten classes taught by the drill method with eight taught by the meaning method, involving 575 fourth-year pupils. Teachers of the drill classes spent on the average about eleven minutes per day on instruction and twenty-four on drill, while the meaning classes received approximately twenty-seven minutes a day on instruction and eighteen minutes on drill.

The evidence is far from conclusive that the instructional procedures resulted in significant differences in the performance of pupils on tests that purported to measure computational skill. Differences found indicated the drill method tended to be superior for pupils who scored low on the ability test but high on the arithmetic pre-test. The meaning method tended to be superior for pupils high on the ability test but low on the arithmetic pre-test.

Differences were likewise insignificant between the two groups in understanding of social concepts in arithmetic and vocabulary. However, there was substantial evidence that the two methods resulted in a differential effect upon ability to think mathematically. Generally, students ranking below average in school ability and above average in arithmetic achievement were more successful with drill procedure, whereas meaning method was more profitable for students who ranked above average in school ability, especially if they were below average in arithmetic achievement.

Swenson (1949) investigated learning of the addition facts by second-year students taught by one of three instructional methods--generalization, drill, or drill-plus. She sought to answer (among others) the question, "Which of the three methods seems to be the most efficient in promoting learning of the addition facts?"

The results showed the generalization group to be significantly superior to both of the other groups on the net total achievement; i.e., the total net effect of instruction on the addition facts seemed to be significantly different under different methods of instruction, a significant advantage being associated with a method that stressed organization of number facts around pupil-discovered generalizations.

Kersh in two different experiments (1958 and 1962) on learning by discovery derives conclusions that he contends are complementary. The same two novel addition tasks under three different methods were taught to a college sample and to a high school sample. With the former his results implied a definite superiority of the discovery method, by developing a unique motivation rather than by increased meaning (understanding). The data of the latter suggested that under certain conditions of learning, highly formalized techniques produced better results than techniques which attempt to develop understanding.

His final conclusions from the experiment are twofold. First, learning by self-discovery is superior to learning with extended direction only insofar as it increases student motivation to pursue the learning task. Also, this motivation power ostensibly does not appear strongly unless the student is required to learn almost completely without help and expends intensive effort over a period of at least fifteen minutes. Second, if it is important only that the task be understood, the essential relationships may be learned most economically when taught by a process other than self-discovery.

Later (1964) Kersh suggests specific teaching objectives should regulate the teaching approach used. He continues by looking at techniques of discovery per se as an objective. The purpose of such a learning experience would be to exercise and reinforce the "searching behavior"--strategies of problem solving, divergent as opposed to convergent thinking, flexibility in thinking--in essence, the characteristics of a "creative individual." With such objectives, discovery techniques are most appropriate.

Suchman (1961) asserts that a chief objective of "Inquiry Training" is to shift the frame of reference for causality from the linear to the multidimensional form; i.e., the attempt should be made to explain the causality of a single instance in terms of broad universal principles and generalizations. This is the unification of concepts for which the scientist strives.

In his study of fifty highly intelligent fifth-year students to establish the need for inquiry training he found a marked lack of autonomy and productivity, stemming (conjecture!) from children's dependence upon authorities, teachers, parents, and books, to shape their concepts. Accustomed to having concepts explained to them in discussions, pictures, films, and textbooks, the subjects were unwilling or unable to plan and initiate action with the purpose of discovering new concepts for themselves.

To help subjects attain the accepted objectives, Suchman and his staff designed a schema consisting of three stages, each having its own goals. The child must adopt a sequence of goals such that grasp of the first provides foundation for the pursuit of the second, and so forth; i.e., the goal for each stage is discovery at a higher order of abstraction and generality.

Stage I, Episode Analysis, has as its goal verification of facts. Determination of Relevance, Stage II, is the isolation of the relevant variables and necessary conditions. Stage III, Induction of Relational Constructs, has the function of discovering why all these conditions are necessary.

In summary, Suchman believes that the ability to inquire and discover concepts autonomously is more basic than the attainment of concepts. Inquiry training is not proposed as a new way to teach, but as a way of teaching basic cognitive skills. He believes that it belongs in every curriculum area that requires the performance of empirical operations, inductive and deductive reasoning, and the formulation and testing of hypotheses. However, it is as unrealistic to teach inquiry separate from content as to teach reading apart from literature. "The autonomous attainment of new meaning and comprehension--the unification of diverse experiences through the discovery of principles and generalizations--this is what inquiry holds for those who learn to use it productively."

Ray (1961) designed a study which considered the efficacy of pupil discovery versus teacher dominated direct instruction with three levels of intelligence. An index was taken upon initial learning, one week later, and six weeks later. The subjects were randomly selected ninth-grade students who were placed in a forty-seven-minute teaching-learning session of micrometer principles and skills.

He concluded that (1) didactic and discovery methods of teaching are equally effective with regard to initial learning and retention after one week; (2) the discovery approach was more effective in retention after six weeks and in application of material learned; and (3) there is no interaction of teaching method and intellectual level.

An investigation (Anklam, 1962) of instructional differences which had as one of its hypotheses "that there would be more evidence of greater motivation in classrooms with democratic instructional methods than with autocratic methods" concluded that achievement and motivation were not affected by these dichotomous methods. Inferentially the study implied that differences in methodology should be respected and encouraged, and contriving a general mold of teacher acceptability into which all teachers must learn to squeeze themselves is a mistake.

Wolfe (1963), experimenting with an abrupt change from discovery to an expository teaching approach with secondary students, concluded that such a change did not seriously interfere with their learning of mathematics.

In a study of the relative effectiveness of three methods of teaching addition and subtraction of fractions, Shuster and Pigge (1965) found that fifth-year students learned the skills better by spending less time on drill and more time on developmental activities.

Pate (1966), in his study of differences of teacher-pupil interaction patterns in "modern" vs. "traditional" elementary school mathematics programs, found that although teachers using the modern program asked more recall and demonstration of skill questions than other question types, more modern teachers than traditional teachers utilized analysis and comprehension questions.

Although teachers in the modern programs evidenced awareness of the processes of discovery through inquiry, they did not implement them, as shown by their limited use of synthesis and opinion questions, subsequently preventing the students from having the opportunity to develop inferences from available evidence.

Study of the foregoing research creates implications as well as questions. Seemingly an assumed activity of discovery is that of confronting the learner with a problematic situation in which he must devise a solution, discover a principle, or explain some phenomenon; i.e., discovery tasks are used to <u>train</u> children in some of the skills of scientific inquiry.

Emanating from such study is the question, "Is discovery the main goal of instruction in arithmetic?" Hartung (1959) concedes that if so, then considerable time can be spent in providing the experience. However, he maintains that discovery is only a means to more important ends. Hence, the places where discovery by the students is to be used must be carefully selected.

Mussen (1965) endorses Hartung's position by asserting that "one educational technique, or sequence of methods, may be most effective at certain points in the process of mathematical concepts and skills, while another technique may be more efficient under other circumstances."

Cronbach (1965a) hypothesizes that "a rich mixture of discovery-to-presentation is best to get the learner started, but that after he is well on the road, a leaner mixture will make for faster progress and greater economy."

On a note of individualizing education, Mussen (1965) sees that it is theoretically possible that the most efficient teaching methods are those congruent with the learners' cognitive styles. Thus personality factors known to influence learning might be taken into account in developing more highly individualized programs. Therefore, if the discovery were made that an integral part of the variance in rate or degree of learning is accounted for by personality or cognitive style variables, it might be concluded that different teaching techniques should be used with students of different personality, cognitive style, or motivational characteristics. That is, use might be made of such measures as the Guilford measures of creativity to determine who might best profit from one type of teaching and who might best profit from another type.

The following paragraph by McDonald (1964, p. 539) identifies the probable problems, status, and anxiety existent in current research on discovery.

> Discovery learning and creativity may be explored at a more pragmatic level. Only long work with a problem can assure that a representative range of potentially relevant variables has been sampled. The contribution of the many studies that represent the beginning of a course of investigation is difficult to evaluate.

Inquiry training is a case in point. The sample of tasks to which the method is relevant has hardly been tested. Similarly, the range of specific procedures is limited.

CHAPTER III

REVIEW OF LITERATURE

Intelligence and Creativity

To begin a discussion of these phenomena, one asks, "What are they?" and "How are they related to other similar phenomena?" That is, what are they in relation to man and other human characteristics?

One prolific experimenter in the field, Jean Piaget, contends that intelligence can be considered meaningfully only as an extension of certain fundamental biological characteristics, fundamental in the sense that they obtain wherever life obtains (Flavell, 1963). That is, intellectual functioning is a special form of biological activity and, as such, possesses important attributes in common with the parent activities from which it derives.

For Piaget, intelligence is allied to biology in the sense that inherited biological structures condition what we may directly perceive. However, our biological endowment consists of a second component, a mode of intellectual functioning (a specific manner in which we transact business with the environment) which permits transcendence of the perceptual structures. This modus operandi is always and everywhere the same. Therefore, the properties for it are referred to as functional invariants. Furthermore, Piaget (Flavell, 1963, p. 43) believes: "These invariant characteristics, which define the essence of intellectual functioning and hence the essence of intelligence, are also the very characteristics which hold for biological functioning in general."

Inferentially Piaget has assumed that all human beings are sentient organisms and therefore possess intelligence. His biological basis does not imply that heredity is the only relevant factor in intelligence. Indeed he believes that intelligence is developmental and has experimented mainly with subjects from birth to fifteen years.

The components of intelligence in Piaget's schema are (1) function--concernment with the process an organism employs in making cognitive progress, (2) content (product)--the external behavior which tells us that intellectual functioning has occurred, and (3) structure--the inferred organizational properties which explain why this content rather than some other content has emerged.

Developmentally Piaget establishes three periods from birth to maturity to designate the major epochs of intellectual performance. The period of sensory-motor intelligence (0-2 years) witnesses the infant move from a neonatal, reflex level of complete self-world indifferentiation <u>to</u> a relatively coherent organization of sensory-motor actions <u>vis-a-vis</u> his immediate environment. Note that the organization involves only simple perceptual and motor adjustments to things rather than symbolic manipulations of them.

The period of preparation for and organization of concrete operations (2-11 years) begins with the first crude symbolization late in the sensory-motor period and concludes with the beginning of formal thought in early adolescence. Preoperational representations (2-7 years) is a subperiod of the above in which the individual makes his first attempts to master the world of symbols. Concrete operations, a second subperiod, sees the individual establish a fairly stable and orderly conceptual framework which he systematically brings to bear on the world of objects around him.

The period of formal operations (11-15 years) observes the adolescent deal effectively not only with reality before him but also with the world of pure possibility.

Two factors in Piaget's work should be noted at this point. First, he has hypothesized and has experimentally satisfied himself that the functional invariants, organization and adaptation--with adaptation segmented into assimilation and accommodation--operate the same in each of the above periods, the differences being in content and structure rather than function.

Secondly, Piaget has concerned himself primarily with the theoretical and experimental investigation of the qualitative development of intellectual structures. More specifically his interest has been in the study of the structure of developing intelligence rather than the function and content of intelligence.

Piaget's influence on experimentation in the study of intelligence is apparent by an article on general mental ability in a recent issue of Review of Educational Research (Millman, 1965). Here is stated that an emerging concept of intelligence purports that the phenomenon is developmental in nature.

Incorporating the work of Bloom (1964) on the growth of intelligence and Wechsler (1944) on the decline of intelligence, Hicklin, Reitan, and Rahmlow (1965) have derived a theoretical curve for the growth and decline of intelligence. The curve is based on the assumption that a state of dynamic equilibrium exists between the individual and the environment.

This equilibrium state possesses shades of Piaget's functional invariant components--assimilation and accommodation as well as concurring that intelligence is developmental in nature. However, it goes an important step beyond in considering the development beyond adolescence.

Although the curve is flexible, it indicates there are four norms which are accepted as a basic structure of the system.

1. By age four 50 per cent of intellectual growth is attained.
2. Over 99 per cent of the growth has occurred by age twenty.
3. The maximum growth is reached by age twenty-five.
4. By age fifty-five the intellectual level has reverted to the level held at age thirteen.

Implications of the theoretical curve, however, would permit two individuals to reach the same peak level of intellectual development but at different chronological ages. Actually the only requirement of the theory is that sometimes the individual who remains in a standard environment will eventually reach a point where the rate of acquisition is just balanced by the rate of loss.

In a less global scope, that is, within the individual rather than the individual within his environment, Guilford has for more than a decade been concerned with the structure of intellect. He has systematically developed his hypotheses and then set about to establish their validity. Specifically, his unified theory of human intellect organizes the known, unique, or primary intellectual abilities into a single system called the "structure of intellect."

Guilford's structure of intellect (SI) was introduced in the fifties under the title "The Three Faces of Intellect" (Guilford, 1959).

The model used to depict this was a rectangular prism composed of one hundred twenty cells, each cell containing a known or hypothesized mental ability. The dimensions of the model were "four by five by six." One dimension, the content (material to be acted upon) of intellectual activity, possessed four components: figural, semantic, symbolic, and behavioral. Another dimension, the operations of mental functioning consisted of five components: cognition, memory, divergent production, convergent production, and evaluation. Finally, the third dimension, products (categorized results of intellectual functions) were six in number: units, classes, relations, systems, transformations, and implications. The model is depicted in Illustration 1 (Guilford, 1966, p. 21).

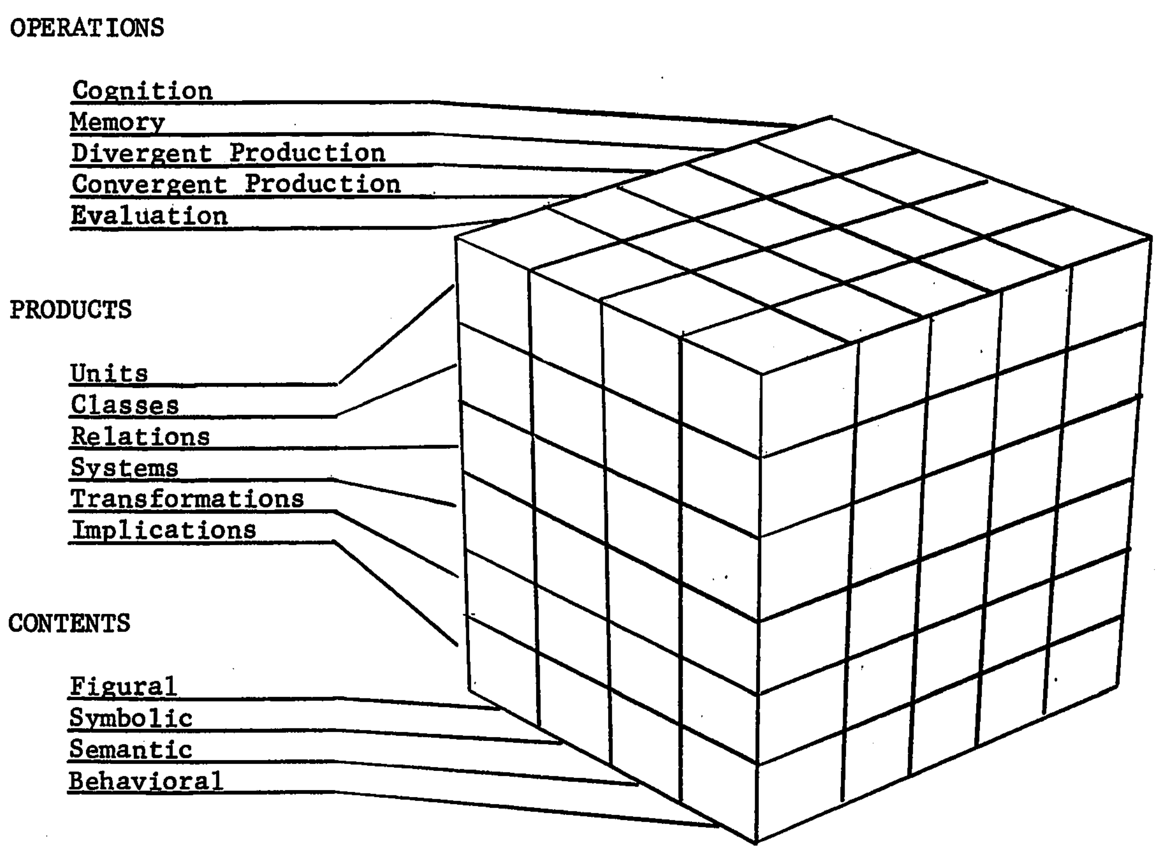

Illustration 1.--Model of the structure of intellect

To date seventy-five of the one hundred twenty hypothesized mental abilities have been identified and placed within the model. In summary, all twenty-four cognitive, twelve memory, sixteen divergent production, ten convergent production, and thirteen evaluation cells are occupied.

The structure-of-intellect model has generated numerous experimental studies and has produced substantial evidence that intelligence is developmental in nature. Divergent production has been an area receiving much interest, consideration, and activity. Although not synonymous with creativity, it is the "operation" from which many beliefs and concepts of creativity have been derived.

Educators and psychologists ultimately concerned with individual differences have used Guilford's model often as a point of departure in studying creativity. In this context tests were designed to measure divergent production. Concurrently it was hypothesized and generally accepted, for experimental purposes, that the more creative individual would be expected to think with greater fluency, with more flexibility. and with greater originality (Guilford, 1962). A fourth factor often considered was elaboration.

In the vein of individual differences, research has shown creativity to be important in mental health, educational achievement, and vocational success as well as other areas in life. This research has considered creativity as person, product, process, or press. Hence, one of the difficulties in such research is definition of creativity.

Torrance, for example, in his studies of creativity has utilized a process definition (p. 17). He states (1965c, p. 8), "If we define creativity as a process, we can then ask what kind of person one must be in order to engage most successfully in the process, what kinds of environment he needs in order to function most successfully, and what kinds of products result from the process."

Since 1958 Torrance, as director (through August, 1966) of the Bureau of Educational Research at the University of Minnesota, and his staff have been engaged in a continuing program of development and research related to the identification, development, and utilization of creative talent. They have been attempting the development of instruments for assessing the creative thinking abilities at all levels of education, kindergarten through graduate school; plotting of the developmental nature of the creative thinking abilities, including cross-cultural studies; and study of conditions affecting creative growth including both factors that can be manipulated in the classroom and laboratory and factors that originate in nature and society.

In answering the question, "Why measure the creative behavior in children?", Torrance's (1965b) comprehensive response implies his philosophical, psychological, sociological, and pedagogical positions on the significance of creativity in relation to the total of human activity. His reasons for wanting to measure the creative behavior of children are (1) that such measurement is a means for obtaining a more complete understanding of the human mind and personality and their functioning, (2) that it is a possible basis for individualizing instruction, (3) that such measurement is part of the process of guiding mental growth, an indicator of mental health status, and a source of clues for remedial or psychotherapeutic programs, (4) that it offers means of assessing the differential effects of various kinds of experimental programs, new curricular arrangements or materials, organizational arrangements, teaching procedures and the like, and (5) that it may be used as an indicator of growth potential and future guidance needs.

The Minnesota group, in developing the now copyrighted and commercially published instrument, Torrance Tests of Creative Thinking, has accumulated pertinent research data in regard to construction of such an instrument. These data include information concerning problems of task development, problems of test administration, scoring problems, and problems of test reliability and validity.

Interest in and study of the developmental nature of creativity in children has prompted this statement from Torrance (1965a, p. 274):

> One of the most persistent and recurrent findings in creativity research with children is that there are discontinuities in creative development in most societies, apparently accompanied by loss of interest in learning, increase in behavioral problems, and increase in emotional disturbance . . . in Anglo-American cultures these discontinuities seem to appear at about the kindergarten, fourth-grade, and seventh-grade levels.

On the basis of comparative studies in cultures outside the United States Torrance has concluded that these discontinuities in creative development are man-made and are primarily the result of discontinuities in our culture and in our educational program.

A direct implication of these results is that teachers, school cultures, and larger cultures play roles of varying importance in determining continuity of creative development. Experimentally Torrance and his associates have verified this by demonstrating that the concept of guided, planned experiences in creative thinking can eliminate for most children the fourth-grade slump in creativity (Torrance and Gupta, 1964).

Three beliefs are expressed by Torrance regarding the importance of the developmental nature of creativity in children. First, children can and will learn more if a higher degree of continuity in creative development is maintained. Second, continuity of creative development is healthy and normal. Third, continuity can be achieved by grafting onto the learning skills that a child brings with him when he first comes to school.

The third broad domain of creativity studies by the Torrance group, conditions affecting creative growth, is more diversified in scope than either the domain of measurement or continuity. "What can we do?" is the question which generated many of the studies in this domain.

Torrance (1965c, p. 75) answers this question with two sweeping generalizations: (1) by providing a curriculum that gives opportunities for creative ways, and (2) by rewarding creative behavior. Ostensibly these should occur simultaneously (at least contiguously), but the first is impossible without the second. Therefore, Torrance considers the problems, the knowns, and the accepted principles of rewarding creative behavior.

For Torrance the knowns are general and particular. The general known is based on repeated research conclusions that show that individuals tend to develop along whatever lines they find rewarding. In particular, experiments have shown that creative thinking rewarded is the creative thinking obtained; e.g., if originality is rewarded, responses will be more original; a larger number of ideas will be produced when fluency is rewarded; and if elaboration is rewarded, more detailed and more elaborate products will result.

The problems of valuing creative activities are: difficulty of recognizing and appreciating the student's creative production and our tendency to overrate the finished product--the completed poem, the masterpiece of music or art, the organized behavior of the championship team.

On the basis of early exploratory research and rational consideration by teachers and experimenters five principles for rewarding creative behavior have been widely accepted. These are:

1. Respect for student's unusual questions
2. Respect for student's imaginative and unusual ideas
3. Developing student's awareness that the teacher considers his ideas to be of value
4. Permitting students to do something occasionally without the threat of evaluation
5. Uniting evaluation with causes and consequences

Specific studies related to conditions fostering creative development have viewed the role of evaluation in terms of society's (or immediate environment) values of creative behavior; evaluative behavior of the student's teachers, parents, and peers; and a person's evaluation of his own creative behavior (Torrance, 1965c, p. 15).

In concluding the review of Torrance's work in creativity a description of creative individuals is imperative. Creative people are those who are able to produce a large number of ideas, exhibit a high degree of flexibility in their responses, produce ideas that are unusual or off the beaten track, or are able to develop these ideas in detail. That is, they possess the qualities of fluency, flexibility, originality, and elaboration.

Wallach and Kogan (1965) in reviewing the literature of creativity research developed a reservation regarding the tendency to consider creativity as somewhat dependent or closely related to intelligence. Precisely, they took issue with much of the work emanating from the Guilford-oriented studies.

Consequently, their work has been focused on establishment of the two dimensions relatively independent of each other. Using 151 fifth-grade students as subjects, they chose to define creativity as "the ability to generate or produce, within some criterion of relevance, many cognitive associates, and many that are unique." A corollary to the definition assumes that if creativity is to reveal itself most clearly, it requires a frame of reference which is relatively free from the coercion of time limits and the stress of knowing that one's behavior is under close evaluation.

Ten intelligence indices including three subtests of the Wechsler Intelligence Scale for Children (WISC), verbal and quantitative tests of the School and College Ability Tests (SCAT) and five tests from the Sequential Tests of Educational Progress (STEP), were obtained.

On ten constructed creativity subtests statistical reliability ranged from .51 to .93. The range of intercorrelations was from .08 to .74 on the creativity measures and from .12 to .80 on the intelligence measures. Finally the intercorrelations between the ten creativity and ten intelligence measures ranged from .13 to .23.

These results led the researchers to conclude that there is a unified dimension of creativity which exists apart from a unified dimension of intelligence. Since the average intercorrelation among creativity measures was .41 and among intelligence measures was .51 and between creativity and intelligence measures .09, the conclusion seems warranted.

Using the median as the point of discrimination, Wallach and Kogan defined four groups of children--creative and intelligent, creative but not intelligent, intelligent but not creative, and neither creative nor intelligent. A second objective, to advance understanding of the psychological differences among these four types of children, was pursued. The studies were concerned with the child's creativity-intelligence indices in relation to the domains of cognition, affectation, perception, and overt behavior.

Wallach and Kogan concluded that knowledge of a child's creativity and intelligence status permits the making of a variety of probablistic statements in regard to that child's functioning in the domains studied. They (Wallach and Kogan, 1965, p. 317) state:

> In the cognitive domain, we have learned how the four types of children differ in their categorizations and conceptualizations of simple environmental stimuli. Information has also been obtained with regard to the child's awareness of the physiognomic, expressive aspects of his perceptual world. Turning to affect and motivation, the four types of children under consideration have been shown to vary in their pattern of psychodynamics as revealed by relative standing on dimensions of anxiety and defensiveness. Finally, the child's overt behavior in the classroom appears to vary as a function of his creativity and intelligence status.

Research in creativity has not been limited to education and creativity. This is directly reflected in the reports and presentations of the national invitational research conferences sponsored by the University of Utah under the direction of Calvin W. Taylor and his associates. There have been six of these conferences, each concentrating on the most recent creativity research findings in relation to industry, education, technology, science, art, and other areas.

The Institute of Personality Assessment and Research at the University of California under the directorship of Donald MacKinnon has concentrated on creativity research in higher education rather than elementary or secondary. With associates Frank Barron and Harrison Gough he has studied creativity in professional people who have been labeled as creative and effective in their work.

Creativity for this group (MacKinnon, 1962) is a process extended in time and characterized by originality, adaptiveness, and realization; that is, it involves a response or idea that is novel, a response adaptive to reality--serve to solve problems, and a sustaining of the original insight, an evaluation and elaboration of it.

Their findings suggest two significant generalizations with implications for education. First, the role of intelligence in creative achievement has been overestimated in our educational system. Second, nonintellective factors will determine whether an individual with sufficient ability to master a field of knowledge will perform creatively or banally in that field.

In higher education the University of Buffalo has experimented in creativity by the testing of principles of "brainstorming." This work has been conducted under the auspices of the Creative Education Foundation, founded and until recently directed by Alex F. Osborn. Helping education do more to develop creative ability is the circumscribing objective or purpose of the Foundation.

Activities of the Foundation include research, teaching, publication, and distribution of information regarding the nature and nurture of creativity. A currently reached milestone was the first issue of a quarterly publication, The Journal of Creative Behavior. The expressed purpose of the journal is to provide a focus for the rapidly increasing interest in literature in creativity, intelligence, and problem-solving.

In summary, research and theory provide several generalizations regarding creativity, intelligence, or creativity and intelligence. First, a still perplexing problem, "What is creativity?" Golann (1963) cites four views of creativity used for research and contends each view is justified if it makes a contribution. The views are: creativity as a normally distributed trait, creativity as the outcome of a complex of aptitude traits, creativity as a process culminating in a new thought or insight, and creativity as a style of life--the personality in action.

Second, theoretical explanations of creativity (Machler and Shontz, 1965) are found to be inconclusive and incomplete. There are associationistic, trait, and psychoanalytic theorists who see creativity as narrow in scope and mechanistically oriented or in general ignore the personal aspect of creating. Opposing this group is the group which is humanistically inclined but vague and poetic with little attention directed to scientific or operational problems. Among this group are the Gestaltists, Existentialists, and the Interpersonalists, that is, the group with a broad theoretical base rather than a more specific one.

Gaier and White (1965), in discussing trends in the measurement of personality rank predictors of creativity, which will be our third generalization, concluded that biographical items and measures of post-achievement appear to be the most valid and efficient predictors of creativity, followed by self-rating and direct expressions of goals and aspirations. Originality and personality inventories were third, and traditional aptitude and general intelligence measures ranked below these. The creative person, from inferences of current data, is simultaneously tough-minded and flexible enough to cope with environmental stimuli in a novel yet acceptable fashion.

The fourth generalization comes from Millman and Glock's (1965) review of trends in measurement of general mental ability. In summary, they cite emphasis on the nature and determinants of intelligence as being the focal point during the last several years. From this emphasis has emerged a concept that intelligence is composed of structures that are partially developmental and are characterized by general strategies for processing information. Hence, environment is a vital but not the sole factor of the intelligence phenomenon.

Yamamoto's (1965) work is representative of our fifth generalization. From his early work in creativity he accepted research conclusions that the correlation between creativity and intelligence ranged from .20 to .40 in the general population and was practically zero in selected populations. However, from a study of 1288 fifth-grade students using the Torrance Tests of Creative Thinking and the Lorge-Thorndike Intelligence Test, he found a linear correlation between intelligence and creativity scores to be beyond .50 using a positive corrected correlation.

He also found there was a consistent decrease in correlation size as the level of intelligence increased. This supports the idea that beyond a certain minimum level of intelligence, being more intelligent does not guarantee a corresponding increase in creativity. Hence, the results do not support the view that creativity is an entity independent of other facets of human intelligence. In conclusion, Yamamoto contends that creativity tests should be regarded as complementary components in new and more inclusive measures of human intellectual behavior, and not as a measure wholly independent and exclusive of the general factor of intelligence.

Our final generalization emanates from the question generated by Yamamoto's conclusion, "Why dichotomize creativity and intelligence?" Jackson and Messick's (1964) response is: "Although there are many ways to describe man's mental complexity--and particularly to depict his cognitive strengths--the two terms 'intelligence' and 'creativity' seem to have the greatest summary power. It is this concentration of meaning that explains the endurance of these two words in the layman's language and their continued use in professional discussions."

CHAPTER IV

REVIEW OF LITERATURE

Variables of the Study and Achivement

This section includes a collection of research results and conclusions on creativity and intelligence and the relation of each to educational achievement. An interesting observation to be made from examining this research is that the Getzels-Jackson study seems to set the stage for more than half of the other studies reported. The results of the studies (if correlations were derived) are presented in tabular form.

In a seven-year research project concerned with understanding the complex of factors associated with patterns of academic achievement in children, D'Heurle studied seventy-six students from Grades 3-9 at the University of Chicago Laboratory School. Among four broad questions asked was, "What personality characteristics are associated with a high level of general academic achievement and, more specifically, with achievement, reading, and spelling in young children?"

Comparatively it was found that (D'Heurle, 1959, pp. 12-15):

> The high arithmetic achievers tend to be more at peace with the world and with themselves. In their relations with their parents and other authority figures they show less strain than the high general achievers and the high reading achievers and greater independence than the spelling achievers. They show the greatest degree of ego integration as well as greater maturity in dealing with the outside world of people and things. They are

> dealing with the outside world of people and things. They are able to express their feelings freely but at the same time they are emotionally controlled and flexible. Their intellectual processes also tend to be spontaneous and creative, and they are the most skilled in the manipulation of abstract symbols.

Using subjects whose IQ index was equal to or greater than 95, Schmadel (1960) found that creative thinking ability contributed independently but meagerly to achievement. Specifically the creative thinking tasks calling for evaluation, whereas traditional factors of intelligence measures, achievement tests, and teacher ratings were also high on creativity. In particular he found a .66 correlation between creativity and arithmetic achievement and that students with a higher arithmetic achievement index tend to have a higher creativity index.

Gilbert (1961) found a .29 correlation between creativity and teacher marks in social studies, a .44 between creativity and standardized achievement index in social studies, a .88 between the School and College Aptitude Text (SCAT) and the Iowa Test of Educational Development (ITED), and .51 between the SCAT and creativity.

Through the use of specially designed measures of creativity and conventional intelligence tests Getzels and Jackson (1962) selected two experimental groups for their study.

One group, the high IQ group, was composed of those students who scored in the top 20 per cent of the 449 students on IQ measures but who were not in the top 20 per cent on measures of creativity. The other group included those who ranked in the top quintile in creativity but not in IQ. The two groups had a mean difference of 23 IQ points. Both groups were equally superior to the general population on standardized verbal and mathematical achievement tests.

Findings included differences in self-characteristics, teachers' preferences for teaching the high-IQ group, and the striking equality of academic success between the two groups. The authors suggest that unless conventional identification procedures are supplemented by measures of creativity, truly gifted students able to produce novel ideas as well as memory conservation of course content will be by-passed.

Torrance (1962) using eight groups replicated the Getzels-Jackson study. Of the eight, six returned results basically confirming the former study. More specifically, by use of partial correlation (IQ held constant) he found a .28 correlation between arithmetic achievement and creativity.

In a study of educational achievement Ahrens (1962) found the extent to which creative thinking abilities accounted for differences in achievement impossible to determine. Specifically she found achievement to be higher in high creativity groups; the influence of IQ on achievement lower in low creativity groups; a correlation range between creative thinking ability and achievement in reading, mathematics, science, and social studies from .10 to .38; a correlation range between IQ and achievement from .44 to .76; and a correlation between IQ and creativity indices from .11 to .43.

Flescher (1963) found that IQ made a significant difference in all areas of academic performance while creativity indices made no difference on any of them; neither was the interaction of IQ and creativity significant for achievement in any school subject.

Correlations derived included a .74 correlation between arithmetic computation and IQ and .04 between arithmetic computation and creativity, and .76 between problem solving and IQ and .09 between creativity and problem solving. Finally, a .04 correlation was found between the creativity and IQ indices.

Flescher (1963, p. 267) concludes by proposing that, "just as IQ is related to convergent achievement, an analogous relationship exists between CQ (creativity quotient) and divergent achievement."

DeBoer's (1964) study of the relationship of creativity to intelligence and achievement yielded these correlations: intelligence and creativity, .55; intelligence and achievement, .65; and creativity and achievment, .71.

Clark (1965) investigated the nature of divergent thinking as distinct from convergent thinking through the study of the relationships between measures of these two purportedly separate abilities and performance on verbal facility measures (word fluency and reading achievement). He found a .04 correlation between the two and concluded that divergent thinking ability is a dimension of cognitive activity separate and distinct from convergent thinking. Other findings showed subjects classified as high on the divergent thinking variable had significantly higher word fluency and reading scores than did subjects classified as low.

Cicirelli (1965) studied the nature of the relationship between IQ, creativity, and academic achievement. Only one of twelve combinations of these three variables possessed a significant interaction. The excepting combination was creativity (nonverbal fluency-flexibility-originality), IQ, and arithmetic achievement. He also failed to find thresholds for either IQ or creativity at which point each would respectively have the greater influence on achievement.

On four measures of creativity correlated with arithmetic achievement the following results were obtained:

1. creativity-verbal (fluency, flexibility, originality) and arithmetic achievement, .26

2. creativity-verbal (elaboration) and arithmetic achievement, .25
3. creativity-nonverbal (fluency, flexibility, originality) and arithmetic achievement, .11
4. creativity-nonverbal (elaboration) and arithmetic achievement, .16

Partial correlations--effect of IQ eliminated--between the measures of creativity and arithmetic achievement were .14, .14, .07, and .04 respectively.

Cicirelli concluded that while the relationship of creativity and achievement was a weak one, the form of the relationship was such that IQ and creativity were additive and linear in their effect on academic achievement. Failure to document the hypothesized threshold concept regarding academic achievement prompted Cicirelli to propose that the effect of teaching methods upon creativity and achievement might profitably be investigated.

From the Human Talent Project at the University of Texas, as reported by Goldberg (1965), new insights into the characteristics of high achievers were isolated. In a study of effective achievers three abilities which consistently appeared were convergent and divergent thinking and symbol aptitude. Seven other factors were also identified, three of which were conjectured to be the very characteristics which distinguish the high achiever, as measured by school grades, from the creatively gifted individual who may not make as good a showing but who produces novel ideas and unique patterns of performance. These were the factors of peer acceptance, an anti-academic attitude, and a quiet dependence.

Williams (1966) found evidence to support the conclusion that correlations between intelligence and creativity range from .20 to .40 in a general unselected population of students. He also found the following correlations between originality and grade average from mathematics, science, and social studies, .38; originality and grade average from language arts, music, and art, .38; and composite grade equivalent on an achievement battery and originality, .31.

In considering creativity in education he suspects that knowledge of subject matter is the key factor for creative behavior. The findings endorse the suspicion in terms of the creative child's characteristics: the creative child is likely to have higher than average grades, to be better informed, to display better citizenship, and to know how to study better than his less creative peer.

Owens (1966) used indices of intelligence, creativity, and achievment in studying under- and overachievement of seventy-two intermediate grade students. He found a .58 correlation between achievement and IQ. From these results he concluded that intelligence and creativity are separate intellectual components, creativity and achievement seem to be little more closely related than intelligence and creativity, and that neither high intelligence nor high creativity assures good achievement.

Bentley (1966) in a study undertaken to explore the relationship between creative ability and different kinds of academic achievement hypothesized that certain creative thinking abilities might contribute to certain kinds of achievement. From weekly tests administered to seventy-five subjects he accumulated data on each subjects' intellectual operations of cognition (multiple-choice), memory (fill-in-the blanks), divergent thinking (extension from given facts), and evaluation (decisionmaking situations).

The following correlations were then found between creativity and each operation and between the individual's Miller's Analogy index and each operation.

	Creativity	Miller's Analogy
Cognition	.03	.47
Memory	.11	.41
Divergent thinking	.53	.37
Evaluation	.38	.27
Total achievement	.34	.36

A correlation of .12 was derived between creativity and Miller's Analogy.

Klausmeier and Wiersma (1965) designed a study to determine the effect of IQ upon performance on divergent thinking tests. On all tests of divergent and convergent thinking administered, the low IQ group (71-95) performed less well than the average IQ group (96-114), and the average IQ group performed less well than the high IQ groups (115-141).

Scott (1963) in an experiment to determine the relationship between IQ scores and measures of gain in arithmetic reasoning, social studies, and science achievement, and between reading gains and these three areas, found that the highest correlation was between arithmetic reasoning and IQ. This correlation was .36.

Rose (1961) in studying the probable statistical association of intelligence to performance in arithmetic found a .67 correlation for upper-class socioeconomic subjects and a .53 for middle-class subjects. Each group, upper and middle, was segmented into three parts and each segment was examined for an IQ-arithmetic correlation. In all six cases the subsamples obtained a smaller correlation than the total sample. This for Rose indicated that factors other than intelligence are operative in arithmetic achievement.

Interesting results were obtained by Erickson (1958) in a study of the significance of intelligence to performance in arithmetic. He found a correlation of .72 between intelligence and arithmetic achievement with his total sample population, but only a .39 correlation for the upper 27 per cent of the sample on the two variables, a .46 for the middle 46 per cent, and a .40 for the lower 27 per cent.

Table 1 is a compilation of the correlations discussed in this chapter. The following abbreviations are used in the table: IQ-intelligence, CQ-creativity, Ach-achievement, and AA-arithmetic achievement.

TABLE 1

CORRELATIONS BETWEEN VARIABLES OF THE STUDY

Researcher	IQ-CQ	IQ-Ach	CQ-Ach	IQ-AA	CQ-AA
Ahrens	.11 to .43	.44 to .76	.10 to .38		
Bentley	.12				
Cicirelli	.24(VFFO)			.67	.26(VFFO)
	.23(VE)				.25(VE)
	.09(NFFO)				.11(NFFO)
	.20(NE)				.16(NE)
Clark	.04				
DeBoer	.55	.65	.71		
Erickson				.72(total sample)	
				.39(top 27%)	
				.46(middle 46%)	
				.40(low 27%)	
Flescher	.04			.74(compu)	.04
				.76(pros)	.09
Gilbert	.51	.88	.29(teacher marks)		
			.44(achievement battery)		
Owens	.12	.58	.20		
Rose				.67(upper soc-eco)	
				.53(middle)	
Scott				.36	
Spraker					.66
Torrance	.20 to .40				.28(partial)
Williams	.20 to .40		.31		.38

CHAPTER V

METHODOLOGY

Introduction

Included in this chapter are descriptions and explanations of the sample, instruments, and statistics used in the study. In particular, the background--social and educational--of the subjects is presented along with descriptions and characteristics of the instructional behavior of their teachers in mathematics.

Details of reliability, validity, and correlations relevant to the study are given for each of the standardized instruments used. A description is also given of the subjective evaluation of student performance in mathematics by teachers.

Each set of hypotheses is cited and the corresponding statistic to test each hypothesis explained. Accompanying the explanation of a given statistic is the rationale and documented justification for using the statistic.

Table 2 contains correlations between the Lorge-Thorndike Intelligence Test, Level 3, and three standardized achievement tests. The correlations are listed for composite achievement and arithmetic achievement. Also included are correlations between the intelligence test and teacher marks for Grades 4 and 5.

The Sample

Subjects of this study were primarily children of the University of Oklahoma faculty members. Others, up to one third of each class, were offspring of staff members of the Oklahoma Central State Hospital located in Norman, or children of local business or professional people. Each student had been admitted to the school on the basis of the following criteria: ability, past performance in school, possible individual benefit from being in an experimental school, siblings already in the school, and parental agreement to pay a token tuition fee--thirty dollars per semester--to supplement the regular state school membership appropriation.

In mathematics the students, with the exception of some transfers, had received instruction based on SMSG (School Mathematics Study Group) materials for at least three years. These materials were either in the preliminary or revised edition form. Some of the students also participated in the earlier pilot programs when the SMSG material was available only in unit form.

Of particular significance is the fact that all of the instruction received by the subjects was under the supervision of a member of the early SMSG writing teams who was also a participant in segments of the UICSM (University of Illinois Committee on School Mathematics) experimental and pilot programs. Teachers of subjects in this study received their content instruction from this supervisor.

These teachers, in addition to their proficiency with the content of modern elementary school mathematics, also took an important step beyond content mastery. That is, they acquired the skill of effectively using a hypothetical mode of teaching. Emphasis on discovery teaching in the "new" mathematics programs contributed to this acquisition, although a more significant factor was an intrinsic belief that learning can and should be meaningful to the student. Further, elementary school students are at a stage of development which is more compatible with hypothetical modes of teaching than with expository modes.

Instruments

Four general indices were obtained for each subject of the study. Three of these were standardized measures and the fourth was a subjective index. Specific indices were also recorded--each of which is described in subsequent paragraphs.

The Lorge-Thorndike Intelligence Tests

These are a series of tests of abstract intelligence based on the premise that most abstract ideas with which the school child deals are expressed in verbal symbols. However, deference is given to the fact that for some individuals such symbols may be an inadequate basis for appraising ability. Therefore, a parallel series of nonverbal tests is incorporated into the total battery (Lorge-Thorndike, 1962). Five levels of the tests, designed for kindergarteners to college freshmen, are available.

Level 3, recommended for Grades 4-6, was administered to subjects of this study during their fourth year. It consists of verbal and nonverbal batteries with a standardized index available for each battery. The correlation between the two batteries is .66, indicating that there is much in common between what is being measured in the two series.

Subtests of the verbal battery are word knowledge, sentence completion, verbal classification, verbal analogies, and arithmetic reasoning. The nonverbal battery subtests are figure analogies, figure classification, and number series. Intercorrelations of verbal subtests ranged from .47

to .70 and of nonverbal subtests from .51 to .55. The intercorrelations of the seven subtests ranged from .30 to .70.

Reliability of the Level 3 test has been considered from the concept of alternate forms (A and B), odd-even, and test-retest situations. A .81 correlation was found between Forms A and B of the nonverbal battery and a .90 on the verbal battery. On each battery the odd-even reliability index was a .94 coefficient of correlation. Using different grade levels and different periods of time, a range of correlations from .58 to .79 was found as test-retest measures of reliability.

Lorge and Thorndike (1962, p. 14) based the validity of their tests upon the premise, "The validity of psychological measures may be evaluated in some cases by how well they 'represent' a certain area of performance, in some cases by how well they 'predict' specific criteria of social importance, in some cases by how meaningfully they 'signify' some attribute or psychological construct." The authors believe the following statements about tasks of the tests are representative of intelligent behavior and therefore contribute to the tests' validity:

1. The tasks deal with abstract and general concepts.
2. In most cases, the tasks require the interpretation and use of symbols.
3. In large part, it is the relationship among concepts and symbols with which the examinee must deal.
4. The tasks require the examinee to be flexible in his basis for organizing concepts and symbols.
5. Experience must be used in new patterns.
6. 'Power' in working with abstract materials is emphasized, rather than speed.

One common prediction criterion is the relationship of intelligence as measured by a test to success in school. The Lorge-Thorndike tests are correlated with school success as measured by achievement tests or teachers' marks. The correlations presented in Table 2 were computed for the Level 3 test. Those correlations between the tests and the Iowa Tests of Basic Skills are of particular significance to this study, as are the correlations between the tests and teachers' marks. Therefore, if an intelligence test possesses sufficient validity, it is expected to show a substantial correlation with academic success.

TABLE 2

CORRELATIONS OF LORGE-THORNDIKE INTELLIGENCE TEST LEVEL THREE WITH ACHIEVEMENT TESTS AND TEACHERS' MARKS

	ITBS		Stanford	California		Teachers' Marks	
Lorge-Thorndike	Comp	Arith	Arith	Comp	Arith	Grade 4	Grade 5
Verbal	.84	.74	.81	.87	.72	.66	.76
Nonverbal	.68	.66	.75	.75	.69	.52	.54

Finally, if a measure of intelligence is signifying of intelligent behavior, the measure should also show a high correlation with other accepted measures of intelligence. The verbal battery of the Lorge-Thondike test, Level 3, shows a .80 correlation with the Stanford-Binet intelligence test; a .69 correlation was obtained between the Stanford-Binet and the nonverbal battery of the Lorge-Thorndike test Level 3.

Torrance Tests of Creative Thinking

Four batteries, figural and verbal--each with alternate Forms A and B--of test activities are included in these tests. Both the figural and verbal batteries may be used from kindergarten through graduate school

(Torrance, 1966b). The figural batteries may be administered as group tests at all levels; the verbal batteries, however, should be administered orally and individually below Grade 4.

Test tasks are those selected from a number of experimental tasks which can be most easily and economically administered and scored. The verbal tests consist of seven parallel tasks, believed to bring into play somewhat different mental processes, yet each requiring the subject to think in divergent directions in terms of "possibilities." Activities of the verbal batteries are classified under four categories. The "ask and guess" category has three activities--asking questions about a drawing, making guesses about the causes of the event pictured, and making guesses about the possible consequence of the event. "Product improvement" is the second category and the activity requires production of ideas for improving a toy so that it will be more fun for children to play with. The third category, "unusual uses and questions," is composed of two activities--thinking of unusual uses for cardboard boxes and unusual and provocative questions about cardboard boxes. The final category, "consequences," is a single activity titled "just suppose" which asks the subject to think of the varied possible ramifications of an improbable event.

The figural tests include three activities: The first, "picture construction," is designed to stimulate originality and elaboration. The second and third tasks, "incomplete figures" and "repeated figures," elicit increasingly greater variability in fluency, flexibility, originality, and elaboration. Required to perform well on the "repeated figures" task is the ability to return to the same stimulus again and again, perceiving it in different ways. The "incomplete figures" task calls into play the tendency to finding a purpose for something that has no definite purpose and to elaborate on it in such a way that the purpose is achieved.

Correlations between the figural and verbal batteries have not been determined nor have intercorrelations among the ten tasks. Although criticized for this omission, Torrance contends the criticism is based on the assumption that creative thinking ability is a pervasive, unitary function--an assumption he does not believe true.

However, intercorrelations of figural and verbal batteries--Form A--on measures for 608 students enrolled in Grade 6 were found to range from .74 to .80 on the verbal measures of fluency, flexibility, and originality. Figural measures of fluency, flexibility, originality, and elaboration had an intercorrelation range from .18 to .77. Finally, intercorrelations among the figural and verbal measures ranged from .23 to .52.

Correlations were also determined between each category of a battery and the battery total for seventy-three students enrolled in Grade 5 who were administered Form A of the verbal and figural batteries. Total score on the verbal had a .90 correlation with ask and guess, a .77 with product improvement, a .87 with unusual uses and questions, and a .78 with consequences. Task correlations with total score on figural battery were .36 for picture construction, .72 for figure completion, and .85 for repeated figures.

Reliability factors for measures of creative thinking are presumed to be more numerous and complex than those used for other measures of intellectual functioning. Specifically, emotion, educational experiences, motivation, and mental health are factors to which creativity measuring instruments tend to be sensitive. Torrance, rather than being disturbed by the effect these factors have on test-retest reliability, is encouraged, since this sensitivity can be extremely useful in different kinds of situations.

The test-retest data most relevant to this study was gleaned from a study involving 118 students enrolled in Grades 4, 5, and 6. On three verbal and four figural measures the test-retest correlations ranged from .93 to .71. Numerous other segments of the tests have been studied for reliability with correlation results ranging from .34 to .97, with most of them falling between .60 and .80.

Of particular significance in reference to the Torrance Tests of Creative Thinking is reliability of scoring. In a study in which teachers and secretaries were each instructed to score a set of the tests after perusing the scoring manual, the inter- and intrascorer correlations were significantly high. The lowest correlation was .66 and the highest .99, with the majority being above .90.

In discussing validity of his creativity tests, Torrance (1966c, p. 23) prefaces his comments by ascertaining that it is presently impossible to specify the number and range of test tasks necessary to give a complete or even an adequate assessment of a person's potentialities of creative behavior. Hence he admits that the test tasks do not sample the universe of creative abilities, but is confident they sample a rather wide range of abilities in such a universe.

Content validity of the tests has been insured by basing test elements on research concerning the lives and personalities of eminent creative people, the nature of creative performances, and the functioning of the human mind. Further effort to insure content validity has been made by keeping the tasks free of technical or subject matter content.

Construct validity studies to increase understanding of the qualities being measured by the tests have involved the comparison of personality characteristics of persons scoring either high or low on the tests and correlations between the creativity test scores and other measures. Studies involving children, adolescents, and adults, studies of growth resulting from experiences in creative thinking, and studies of preferred ways of learning are representative of research concerned with construct validity of the Torrance tests.

To date no generally acceptable criteria of concurrent validity have been found. However, Torrance and his staff have experimented with several. Some of the more acceptable ones are peer nominations, teacher nominations, and educational achievement.

Since it is necessary that a considerable period of time elapse in order to complete long-range predictive validity studies, no data of this nature are available on the Torrance Tests of Creative Thinking. There are presently studies underway, with some information that indicates a probable significant level of predictive validity for the tests.

The tests, figural and verbal, Form A, were administered to subjects of this study during April, 1966. Administration and scoring of each battery adhered to the suggestions and instructions as presented in the research edition of the "Directions Manual and Scoring Guide" (Torrance, 1966b).

Iowa Tests of Basic Skills

This battery provides for the measurement, at the levels of Grades 3-9, of certain skills involved in reading, work-study, language, and arithmetic. Major purposes of the tests are to provide for students, parents, teachers, counselors, and school officials information regarding the educational accomplishments and abilities of each student, which are needed for effective educational guidance, and information of an objective and dependable nature for the evaluation of school and class achievement. For all these purposes, measures of "growth" as well as of "status" are highly desirable (Lindquist and Hieronymus, 1964). A unique characteristic of these tests when compared with other achievement batteries is the concern only with "generalized" intellectual skills and abilities, rather than measures of achievement in content subjects.

Each of the forms (1-4) of the battery contains five tests, and three of the tests have two or more subtests. The total number of items in each form is 1232, but no one grade takes more than 507 of these items.

For each of Grades 4, 5, and 6, the standardization sample was near 18,000 students and the reliability sample in each grade was approximately 2700 students. The split-halves method of establishing reliability was used with each of these samples by employing the Spearman-Brown formula. For each grade level the reliability coefficient found was .98. Equivalent forms reliability analysis for Forms 3 and 4 with Grades 4, 5, and 6, produced coefficients for each of the five tests ranging from .83 to .94.

Although not designed as predictors of future academic success, the Iowa Tests of Basic Skills results in the various grades have been correlated with scores on achievement tests taken at a later date and with grade point averages in high school and as a college freshmen. The range of these correlations is from .42 to .76.

In this study the tests were used to indicate growth in arithmetic from October, 1965, to May, 1966. Forms 3 and 4 were used--this fact being significant since these two forms were designed with the transition from "traditional" to "new" elementary school mathematics in mind.

The arithmetic test contains two subtests, "arithmetic concepts" and "problem solving." Heavy emphasis is placed upon understanding, discovery, and quantitative thinking. Computational skill as such is not measured in a separate test.

In the "arithmetic concepts" test the emphasis is on understanding of the number system; of terms, processes, and operations; of geometric concepts; and of units of measurement. Namely, the skills represented are concepts involving currency, decimals, equations, fractions, geometry, measurement, numerals and number systems, per cents, ratio and proportion, and whole numbers.

Examined on the "problem solving" test is competence in a functional setting with problems which have been chosen to be challenging and practical. In addition to the skills on the concepts test is the arithmetic process or sequence of processes involved in solving each problem.

Subjective Index of Students' Performance in Mathematics

Each subject in the study was rated by his teacher during the final two weeks of school in accordance with the form in Illustration 2.

	Moderately Successful	Successful	Very Successful
Reasoning	______	______	______
Computation	______	______	______
Structure	______	______	______
Numeration	______	______	______
COMPOSITE	______	______	______

Illustration 2.--Form used for teachers' rating of student's performance in elementary school mathematics

The subjective evaluation by teachers of each student's performance in mathematics during the 1965-66 school year was determined by considering the student's understanding and application of reasoning, structure, computation, and numeration in computational and other problem-solving situations.

Performance level in "reasoning" was decided by evaluating the student's understanding and use of:

1. relations such as "greater than," "equal to," "less than," and "not equal"
2. logic concepts including quantifiers, "all" and "some," and connectives, "and," "or," "if-then," and "not"
3. structural properties of the mathematical system under consideration to justify steps taken in solving a problem
4. the numeration system to facilitate computation and justify steps

Each student's performance rating in "structure" was determined by his understanding and use of the properties of the whole and fractional numbers, and the distributive property of multiplication over addition.

In "computation" the student's facility with and understanding of the operations and their respective algorithms determined his rating. The operations of addition and multiplication and their inverses as defined on the whole and fractional numbers were considered. The fractional numbers operated upon were expressed as fractions or decimals.

The individual's rating in "numeration" was derived by considering his understanding and use of the Hindu-Arabic numeration system. This includes his awareness of the characteristics of the system itself, i.e., awareness that the system was conceived by man and adapated to his needs whether mathematical or social. Particular attention was directed toward the student's utilization of place value and expanded notation in computational problems and in the development of the algorithms for the operations. Consideration was also given to his understanding of the principle of grouping and the relationship of grouping to positional numeration systems with different bases.

Clearly each of the areas cited above intersects and interrelates with one or more of the remaining areas. This is desirable, yet difficult when one's purpose is analization. However, the consideration is each area was unique in its inferred objectives.

Statistics

The hypotheses of this study were tested by means of the chi square statistic. In particular, contingency tables were constructed according to the particular hypothesis for "performance in mathematics" and either "intelligence" or "creativity." The H_o-5 set of hypotheses (p. 15) varied in that "performance in mathematics" and the "combination" of creativity and intelligence were the variables considered.

McNemar's (1955, p. 223) discussion was accepted as a basis for utilizing chi square tests in this situation. He indicates that chi square may be applied when the variables classified are based on continuous or ordered discrete data for subjects of the sample. This is a means for testing the significance of the correlation or association as a chance departure from zero or no relationship between the variables. Further, the significance test can be used without knowledge of the degree of correlation. Finally, he states that, "If we have evidence for correlation . . . from the chi square technique, we can proceed to calculate an appropriate coefficient for measuring the degree of correlation."

"Performance in mathematics" was classified into three categories--very successful (V), successful (S), and moderately successful (M)--for the teacher's subjective evaluation of performance and into two categories--high gain (HG) or low gain (LG)--for the pre- and post-test measures based on the mean gain. In all cases save those in set H_o-5, intelligence and creativity were each categorized into high and low based on the median score of the sample. For the H_o-5 set, creativity and intelligence were combined to form four categories--high intelligence, high creativity (HIHC); high intelligence, low creativity (HILC); low intelligence, high creativity (LIHC); and low intelligence, low creativity (LILC).

In the H_o-1 and H_o-2 sets (p. 13) 3x2 contingency tables were constructed for each of the hypotheses. Results were significant for the tests of relationship between performance in mathematics and intelligence but nonsignificant for those of creativity and performance in mathematics. However, a correlation was computed for the "composite" performance in mathematics and creativity as well as for each of the performance measures and intelligence by using the "triserial" technique.

Wert (1954, p. 271) endorses use of the triserial statistic and states that in some situations the linear relationship is desired between a continuous variable and a variable classified into three or more broad groups. He uses as an example teachers who graduated from a college who were rated regarding teaching success on a scale of high, medium, and low.

Contingency tables for the H_o-3 and H_o-4 sets of hypotheses (p. 14) were 2x2 and six in number. Chi squares were nonsignificant in each case, but zero-order correlations were computed for creativity and the three indices of performance in mathematics and also intelligence and the three indices. Then partial correlations were computed for each of the six situations with creativity or intelligence being partialed out respectively. This technique eliminates the tendency of the remaining independent variable to obscure the relation. Guilford (1965, p. 339) uses the correlation between height and weight with age ruled (partialed) out as an example.

The partial correlation computations were followed by a combining of the indices of intelligence and creativity. This combined index, creativity-intelligence, was then correlated, by multiple correlation, to each of the three indices of performance in mathematics. As Guilford (1965, p. 394) explains, a multiple correlation indicates the strength of relationship between one variable and two others taken together. It should be noted that the correlations derived in this study are relevant only to conditions and subjects involved.

Two contingency tables were constructed for the chi square tests of the H_o-5 hypotheses. The first, concerned with the relationship of "performance" in mathematics as determined by teachers and the "combination" of intelligence and creativity, was a 3x4 table and the second, concerned with "performance" as measured by the Iowa Tests of Basic Skills and the "combination," was a 2x4 table.

CHAPTER VI

ANALYSIS OF DATA

Introduction

This chapter contains in word form and in many cases tabular form the results of this study. The section on raw data describes and illustrates the instruments used and the collective results. These results are in terms of frequencies, measures of variance, and measures of central tendency.

In the statistics section the data used to test the null hypotheses of the study are presented and discussed. The statistic employed for this purpose was the chi square. Data acquired from subsequent computations of a series of correlations are then reported. Various correlations techniques were used in deriving the resulting coefficients.

The final section of the chapter is a theoretical discussion of possible implications and inferences that were generated by the study. The discussion contains ideas that emanate directly from the data and also notions that are of a divergent nature but closely associated with the central theme of the study.

Raw Data

An intelligence score (IQ) was obtained from the Lorge-Thorndike Tests for each subject, as was a creativity score (CQ) from the Torrance

Tests of Creative Thinking. Each IQ score was a weighted average of verbal and nonverbal scores, which were sums of three or more tests in each category. Creativity scores were determined by a summation of figural and verbal scores, which were sums of fluency, flexibility, originality, and elaboration on the tasks of the respective categories. Data used in this study relevant to intelligence and creativity are presented in Table 3.

TABLE 3

VARIANCE AND CENTRAL TENDENCY MEASURES OF CREATIVITY AND INTELLIGENCE OBTAINED FROM SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

	Central Tendency		Variance	
	Mean	Median	Standard Deviation	Range
Intelligence	123	124	11.8	94-158
Creativity	265	270	68.3	109-441

Information pertaining to performance in mathematics as determined by teachers of the subjects is summarized in Table 4. These are the data used to establish a significant or nonsignificant relationship between performance in mathematics and creativity and/or intelligence.

A second measure of performance in mathematics was derived from pre- and post-tests of the arithmetic section of a standardized achievement battery. These data appear in Table 5.

Statistical Tests

Each null hypothesis of the study was tested by the chi square technique. In determining the degree of relationship for hypotheses that were rejected and others that were conjectured to be relevant if one of the independent variables were ruled out, or if the independent variables were combined, and appropriate correlation technique was employed.

TABLE 4

NUMBER OF STUDENTS PLACED IN EACH OF THREE PRESCRIBED PERFORMANCE LEVELS ON FIVE CATEGORIES OF ELEMENTARY SCHOOL MATHEMATICS AS RATED BY TEACHERS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

	Moderately Successful	Successful	Very Successful
Reasoning	23	23	23
Computation	20	27	22
Structure	27	26	16
Numeration	26	24	19
Composite	24	23	22

TABLE 5

DATA ON THREE CATEGORIES OF MATHEMATICAL PERFORMANCE AS ASSAYED BY THE IOWA TESTS OF BASIC SKILLS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

	Grade Equivalent		Difference in Months	
	October	May	Range	Mean
Concepts	5.9	6.6	-11 to 23	6.8
Problem Solving	5.7	6.3	-19 to 31	6.8
Composite	5.7	6.4	-8 to 18	6.7

Chi Square

In testing the hypotheses in set H_0-1, 3x2 contingency tables were used to determine the existence of a significant relationship between intelligence and performance in mathematics. The chi square obtained in each was significant at the .01 level of confidence. Hence the null hypotheses, "When a subjective evaluation of performance in mathematics is made by teachers, there is no significant relationship between intelligence and mathematical performance in (a) reasoning, (b) computation, (c) structure, (d) numeration, and (e) general," were all rejected. Table 6 contains information relevant to the results of hypotheses in set H_o-1.

Chi square scores were computed for each hypothesis in set H_o-2 in a manner like that used for the H_o-1 hypotheses. Excepting the hypothesis concerned with structural aspects of number systems, all obtained chi squares were nonsignificant at the .05 level. Therefore the null hypothesis, "When a subjective evaluation of performance in mathematics is made by teachers, there is no significant relationship between creativity and mathematical performance in structure," was rejected. The summary of this information is presented in Table 7.

Before testing the hypotheses in sets H_o-3 and H_o-4, the mean change in each of the three categories of mathematics performance was checked by the t-test to determine that the change was significant. The t-score obtained for the concept category was 8.2914. In the problem solving category, the t-score was 6.5201. The composite category produced a t-score of 9.9057. In each instance the t-score indicated the change to be significantly different from zero.

The hypotheses in sets H_o-3 and H_o-4 were then tested for significant relationships by the chi square statistic. A 2x2 contingency table was constructed for each of the hypotheses and the resulting chi square checked for significance at the .05 level of confidence. Results of these tests appear in Tables 8 and 9. From the table of chi square (Wert, 1954, p. 423) not one of the hypotheses could be rejected at the prescribed level.

TABLE 6

CHI SQUARE DATA FOR SIX CLASSIFICATIONS OF INTELLIGENCE AND MATHEMATICAL PERFORMANCE AS RATED BY TEACHERS IN FIVE CATEGORIES OF PERFORMANCE FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

	Reasoning		Computation		Structure		Numeration		Composite	
	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected
High intelligence and very successful performance	21	11.7	20	11.2	14	8.1	16	9.6	21	11.2
High intelligence and successful performance	9	11.7	8	13.7	16	13.2	12	12.1	9	11.7
High intelligence and moderately successful performance	5	11.6	7	10.1	5	13.7	7	13.3	5	12.1
Low intelligence and very successful performance	2	11.3	2	10.8	2	7.9	3	9.4	1	10.8
Low intelligence and successful performance	14	11.3	19	13.3	10	12.8	12	11.9	14	11.3
Low intelligence and moderately successful performance	18	11.4	13	9.9	22	13.3	19	12.7	19	11.9
CHI SQUARES	23.8916*		20.8213*		21.1261*		14.7352*		27,1380*	

*Significant at the 1 per cent level of confidence with 2 degrees of freedom.

TABLE 7

CHI SQUARE DATA FOR SIX CLASSIFICATIONS OF CREATIVITY AND MATHEMATICAL PERFORMANCE AS RATED BY TEACHERS IN FIVE CATEGORIES OF PERFORMANCE FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

	Reasoning		Computation		Structure		Numeration		Composite	
	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected
High creativity and very successful performance	12	11.7	8	11.2	9	8.1	9	9.6	12	11.2
High creativity and successful performance	9	11.7	16	13.7	8	13.2	10	12.1	9	11.7
High creativity and moderately successful performance	14	11.6	11	10.1	18	13.7	16	13.3	14	12.1
Low creativity and very successful performance	11	11.3	14	10.8	7	7.9	10	9.4	10	10.8
Low creativity and successful performance	14	11.3	11	13.3	18	12.8	14	11.9	14	11.3
Low creativity and moderately successful performance	9	11.4	9	9.9	9	13.3	10	12.7	10	11.9
CHI SQUARES	2.2857		2.8083		7.1034*		1.9329		1.9863	

*Significant at the 5 per cent level of confidence with 2 degrees of freedom.

Therefore the null hypotheses, "When gain (growth) is determined by pre- and post-tests measures of a standardized arithmetic achievement battery there is no significant relationship between intelligence [or creativity] and gain in (a) mathematical concepts, (b) mathematical problem solving, and (c) composite mathematical change," were not rejected.

TABLE 8

CHI SQUARE DATA FOR FOUR CLASSIFICATIONS OF INTELLIGENCE AND MATHEMATICAL PERFORMANCE AS ASSAYED BY THE IOWA TESTS OF BASIC SKILLS IN THREE CATEGORIES OF PERFORMANCE FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

	Concepts		Problem Solving		Composite	
	Actual	Expected	Actual	Expected	Actual	Expected
High intelligence and high performance	13	15.7	18	17.2	16	16.7
High intelligence and low performance	22	19.3	17	17.8	19	18.3
Low intelligence and high performance	18	15.3	16	16.8	17	16.3
Low intelligence and low performance	16	18.7	18	17.2	17	17.7
CHI SQUARES*	1.70836		0.14848		0.11385	

*At the 5 per cent level of confidence with 1 degree of freedom all chi squares were insignificant.

A 3x4 contingency table was constructed to determine the existence of a relationship between a combined index, "creativity-intelligence," and performance in mathematics according to the teachers' estimation of performance. The table represented three levels of performance and four "creativity-intelligence" classifications. A chi square of 30.48098 was obtained and found to be significant at the .01 level with six degrees of freedom. Hence, null hypothesis H_o-5a, "There is no significant relationship between a combined index, 'creativity-intelligence' and composite performance in elementary school mathematics when performance is determined by the teachers' subjective evaluation," was rejected.

TABLE 9

CHI SQUARE DATA FOR FOUR CLASSIFICATIONS OF CREATIVITY AND MATHEMATICAL PERFORMANCE AS ASSAYED BY THE IOWA TESTS OF BASIC SKILLS IN THREE CATEGORIES OF PERFORMANCE FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

	Concepts		Problem Solving		Composite	
	Actual	Expected	Actual	Expected	Actual	Expected
High creativity and high performance	15	15.7	19	17.2	18	16.7
High creativity and low performance	20	19.3	16	17.8	17	18.3
Low creativity and high performance	16	15.3	15	16.8	15	16.3
Low creativity and low performance	18	18.7	19	17.2	19	17.7
CHI SQUARES*	0.11431		0.75161		0.39269	

*None of the chi squares was significant at the 5 per cent level with 1 degree of freedom.

To determine the existence of relationships between the combined index (creativity-intelligence) and performance in mathematics as determined by pre- and post-tests of a standardized test, a 2x4 contingency table--two levels of performance and four classifications of creativity-intelligence--was constructed. The obtained chi square, .62971, was not significant at the 5 per cent level of confidence with 3 degrees of freedom. Therefore, hypothesis H_o-5b, "There is no significant relationship between a combined index of 'creativity-intelligence' and composite performance in elementary school mathematics when performance is determined by growth as measured by a standardized arithmetic achievement battery," was accepted.

Correlations

A product moment correlation of .25 was found between the intelligence and creativity indices of subjects. This was significant at the .05 level. It was also well within the range of correlations found by many researchers studying the two phenomena (Table 1).

The triserial correlation technique was employed to determine the degree of relationship between intelligence and performance in mathematics as determined by teachers. To provide estimated moment correlations each triserial coefficient was multiplied by a "correction factor for coarse grouping" (Wert, 1954, p. 429). The results, estimated r's for intelligence and mathematical performance, for the five performance categories were as follows: (1) reasoning, .65; (2) computation, .50; (3) structure, .62; (4) numeration, .56; and (5) composite, .68. All correlations were significant at the .01 level.

A triserial correlation was also derived for the degree of relationship between creativity and performance in mathematical structure as determined by teachers. Although the chi square obtained to reject the corresponding null hypothesis was significant at the .05 level, the resulting estimated r, .04, was not significant since such a correlation requires a sample population of over one thousand to be significant.

Zero-order moment correlations were computed for each of the mathematical performance categories--concepts, problem solving, composite--and intelligence. These performance categories, obtained from the pre- and post-tests of the Iowa Tests of Basic Skills, were also correlated with creativity. With the exception of the correlation between problem solving and creativity, all other zero-order correlations were insignificant. The significant coefficient, .27, was acceptable at the 5 per cent level of confidence for a sample of 69. The moment correlations, presented in Table 10, were then used in deriving partial correlation coefficients.

TABLE 10

CORRELATIONS BETWEEN INTELLIGENCE AND/OR CREATIVITY AND THREE CATEGORIES OF PERFORMANCE IN MATHEMATICS AS ASSAYED BY THE IOWA TESTS OF BASIC SKILLS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

	Moment		Partial		Multiple
	IQ	CQ	IQ(CQ ruled out)	CQ(IQ ruled out)	IQ & CQ
Concepts	-.10	-.09	-.18	-.07	.12
Problem Solving	-.10	.27***	-.18	.30**	.41*
Composite	-.16	.16	-.21	.20	.26

***Significant at the .05 level
**Significant at the .02 level
*Significant at the .01 level

First-order partial correlations are the result of ruling out one variable and determining the degree of relationship between the other two. In this part of the study either intelligence or creativity was ruled out and the correlation found between the remaining variable and respective performance categories of mathematics. Of the six coefficients computed only the partial r for creativity and problem solving with intelligence ruled out was significant. The correlation was .30 and significant at the .02 level. Table 10 contains all the results of the partial correlation technique.

Using the moment coefficients of intelligence and creativity, creativity and mathematics performance, and intelligence and mathematics performance, multiple correlations were computed for the changes recorded on the arithmetic section of the Iowa Tests of Basic Skills in the composite, concepts, and problem solving categories. The results, shown in Table 10, contain one significant relationship. By combining intelligence and creativity into a single index and then correlating it with mathematical performance in problem solving, a .41 coefficient was obtained. This multiple correlation, R, was significant at the .01 level.

The findings produced by each correlation technique were checked for significance, i.e., to see whether the correlation was significantly different from zero, by an appropriate means. Moment and multiple coefficients were tested for significance by examination of a correlation table (Guilford, 1965, p. 581). Correlations obtained by the partial method were tested for significance by the t-test (Wert, 1954, p. 248).

Theoretical Discussion

At the outset of this study considerable attention was given to human variability in general and in particular. The latter centered around the human variables of intelligence and creativity and their importance in school learning. The area of school learning discussed specifically was mathematics.

Clearly the variance in performance is not totally accounted for by these two variables, since there is evidently a set of variables which have a greater effect on performance than either or both of the intelligence and creativity variables. To be sure, a number of the variables exist outside the learner himself--a fact which focuses attention on the constant variable of this study, discovery teaching. Other possible intervening variables causing variance of performance are content studied and media used to develop concepts.

Variation of performance was noticeable in almost every category under consideration and furthermore this variation was not the same for both of the independent variables. Worthy of note is the relationship found between creativity and the problem solving category and the category of structure. Both are areas which receive emphasis in the "new" mathematics programs.

Probably the most influential external variable is the teacher. She has some voice in what is taught and almost complete control of teaching approach and media--other than textbook--utilized in teaching. The teacher then, would undoubtedly cause students to strive to perform in accordance with her accepted principles. Naturally this process would be followed by a compatible evaluation procedure.

On these premises one might deduce from the results of this study that intelligent behavior in mathematics is more acceptable than creative behavior. Immediately there is a conflict, a hypothetical teaching mode used with an exacting evaluation system. Theoretically one would assume that a more permissive system of evaluation would accompany the practice of discovery teaching.

The look at evaluation leads to scrutiny of the results of the standardized arithmetic battery. Evidently a different set of variables is operating here because there is significant growth, but neither intelligence nor creativity--save in one category--seems to be responsible for the change.

Apparently, performance in school learning, if mathematics is representative of school learning, cannot be chiefly attributed to the human variables of intelligence and creativity. However, in terms of the learner, each of these variables seems to make some contribution to learning.

From all indications of this study, not only does each variable, intelligence and creativity, contribute to school learning, but combined they contribute even more. This observation definitely supports the conjecture that the scope of the intellectual or cognitive dimension of man includes both intelligence and creativity.

The preceding conjectures are supported in part by the statistical discussion of correlation by Guilford (1965, p. 105), who theoretically contends that a significant relationship is in reality a perfect relationship if all other intervening variables are partialed out. On the other hand, he sees a relationship not significantly different from zero as being representative of no correlation. Precisely he states that "a correlation is always relative to the situation under which it is obtained, and its size does not represent an absolute natural fact."

CHAPTER VII

SUMMARY

Overview

In this final chapter the findings of the study are stated in general terms; i.e., not in terms of the hypotheses. From the findings conclusions have been made relevant to achievement in elementary school mathematics, creativity and intelligence, teaching elementary school mathematics, and evaluation in elementary school mathematics.

These findings and conclusions are then compared with some of the findings and conclusions of other studies concerned with one or more of the variables of this study, which have been cited in the review of literature. After a comparative analysis the studies are listed and briefly annotated either in a category relatively agreeing with or in a dichotomous category relatively conflicting with the findings and conclusions of this study.

Finally, recommendations for elementary school mathematics are presented which suggest how teaching and learning experiences might be made more conducive to individualizing instruction. A second set of recommendations consists of those ideas for related research that have been generated by this study.

Findings

In this study the following findings seemed to be most significant:

1. When the performance level in mathematics was determined by teachers, there was a high degree of relationship between the human variable of intelligence and performance in the categories of: (1) reasoning--the teachers looked at the students' use and understanding of order relations, logical quantifiers, structural properties of a number system, and the numeration system to solve mathematical problems; (2) structure--the students' utilization of insight into the significance of the properties of closure, commutativity, associativity, identity, and distributivity for the operations of addition and multiplication was examined by the teachers; (3) computation--consideration was given to the students' facility and understanding of the addition and multiplication operations, their respective algorithms and their respective inverse operations; (4) numeration--the teachers evaluated in terms of the students' awareness of the characteristics of the system; and (5) composite--this was the teachers' overall evaluation of the students' performance in mathematics.

2. When the performance level in mathematics was determined by teachers, a significant relationship was found between the human variable of creativity and this performance in the category of structure (see Item 2 in Finding 1). In the other categories--reasoning, computation, numeration, composite--no relationship discovered.

3. When performance in mathematics was established by change on pre- and post-tests of the Iowa Tests of Basic Skills arithmetic battery, no statistical relationship was found between this performance and the human variable of intelligence in the categories of: (1) concepts--the students' were tested on the understanding of terms and operations of numbers,

geometric concepts, and concepts of measurement; (2) problem solving--test items were generally composed of social situations requiring organization of thought and competence in numerical computation for solution; and (3) composite--this was a weighted average of concepts and problem solving performances.

4. When performance in mathematics was established by change on pre- and post-tests of the Iowa Tests of Basic Skills arithmetic battery, a significant statistical relationship was found between the human variable of creativity and problem solving (see Item 2 in Finding 3), but no relationship was found between creativity and concepts or creativity and composite performance in mathematics.

5. Using the statistical technique of partial correlation, a significant coefficient was derived between performance in problem solving, as determined by the standardized arithmetic tests, and creativity. The technique did not yield significant results for the other five combinations considered in Finding 3 and Finding 4.

6. A finding similar to Finding 5 was found by multiple correlation; that is, a combined index of creativity-intelligence was significantly correlated to the problem solving category of mathematics performance, but not to the categories of concepts or composite performance.

Conclusions

Based on the findings of this study the following seemed to be logical conclusions:

1. If, as Torrance (1965c) contends, students' classroom behavior is representative of that which is rewarded by teachers, then the high relationship between intelligence and the teachers' evaluation of performance

in mathematics would seem to indicate an ultimate acceptance of intelligent behavior as more worthy than creative behavior. Although the teachers had exhibited to students, other teachers, and administrators their acceptance and practice of a hypothetical mode of teaching, the evaluation would seem to be representative of evaluation accompanying an expository mode of teaching.

2. Although no general statement could be made, the findings would tend to support the premise that certain topics in mathematics can be grasped more readily by students who are more creatively endowed than those who are more intelligent, e.g., the finding pertaining to "creativity and problem solving."

3. In terms of the mean performance on the Iowa Tests of Basic Skills, the students of this sample had made acceptable progress. This indicated that the students were achieving satisfactorily and the variable responsible might well have been the teaching approach, since either intelligence or creativity was significantly related in only one of six instances.

4. The findings further document the relevance and pertinence of the "revolution's" concern with the learning and teaching of mathematics. This is most apparent when neither intelligence nor creativity can be identified as the variable responsible for change in mathematical performance.

5. The evidence apparently signifies that the set of objectives seemed important by teachers of elementary school mathematics is not the same set as examined for proficiency by the Iowa Tests of Basic Skills.

Supportive Findings and Conclusions from Other Studies

From the following sentence summaries, the stated findings and conclusions appear to be compatible with those of:

McConnell (1934). Teaching elementary school mathematics by discovery resulted in greater transfer potential and facility in manipulation of number facts than teaching by a didactic method.

D'Heurle (1959). The intellectual processes of high achievers in elementary school mathematics tended to be spontaneous and creative.

Schmadel (1960). Creative thinking ability contributed independently, but meagerly, to achievement and the contribution was most significant with tasks requiring synthesis.

Rose (1961). Factors other than intelligence were operative in arithmetic achievement.

Ahrens (1962). The extent to which creative thinking abilities accounted for differences in educational achievement was impossible to determine.

Getzels and Jackson (1962). A striking equality in academic success existed between the high creativity group and the high intelligence group. Teachers showed an expressed preference to work with the high IQ group.

Torrance (1962). The partial correlation derived between creativity and achievement in elementary school mathematics with intelligence ruled out was .28.

Flescher (1963). A .74 correlation was found between arithmetic computation and intelligence and a .04 correlation was found between computation and creativity.

Kersh (1964). Discovery teaching exercised and reinforced searching behavior.

Cicirelli (1965). The relationship between creativity and arithmetic achievement was weak, but the form of the relationship was such that intelligence and creativity were additive and linear in their effect on academic achievement.

Torrance (1965b). Creativity was a significant factor in attempting to individualize instruction.

Yamamoto (1965). Creativity tests should be regarded as complementary components in new and more inclusive measures of human intellectual behavior.

Owens (1966). Creativity and achievement were no more closely related than intelligence and creativity, and neither high creativity nor high intelligence assured good achievement.

Nonsupportive Findings and Conclusions from Other Studies

Findings and conclusions of other studies that tend to be in conflict with those of this study are those of:

Anderson (1949). The meaning method was more profitable for students who ranked above average in school ability, especially if they were below average in arithmetic achievement.

Erickson (1958). Sample stratification yielded corresponding correlations each of which was lower than the composite correlation of the sample between intelligence and arithmetic achievement.

Spraker (1960). Students who ranked high on intelligence, achievement, and teacher ratings also ranked high on creativity.

Klausmeier (1965). On tests of divergent and convergent thinking the average IQ group performed less well than did the high IQ group.

Wallach and Kogan (1965). There was a unified dimension of creativity that existed apart from a unified dimension of intelligence.

Owens (1966). Creativity and intelligence were separate intellectual components.

Recommendations

On the basis of the findings of this study the subsequent recommendations are proposed. The first set of recommendations relates to classroom practice in elementary school mathematics, while the second set represents suggested research areas related to the theme of this study.

Recommendations for Teaching

1. From the finding of a high relationship between IQ and teacher evaluation in elementary school mathematics and a relatively nonexistent relationship between CQ and teacher evaluation, emanates the recommendation that when teachers are studying and contemplating teaching via the discovery approach they also consider the accepted principles of rewarding creative behavior.

2. The recommendation that teachers experiment with the ratio of discovery teaching to authoritarian approaches stems from the conclusion that certain areas of mathematics, problem solving for example, are more compatible with discovery than are other approaches.

3. In evaluation of elementary school mathematics there was an apparent chasm between that which teachers took into consideration and that which was measured by the standardized test. From this observation the recommendation is made to use multiple criteria in evaluating performance in elementary school mathematics. These criteria would be such things as self evaluation, teacher evaluation, and test evaluation.

Recommendations for Research

The following are general descriptions of suggested studies which might lead to greater insight into effective teaching or better learning of elementary school mathematics:

1. A series of studies conducted with either discovery teaching or authoritarian teaching as a constant, creativity and intelligence as independent variables, and student performance on finely delineated mathematical concepts and topics as the dependent variable.

2. A set of studies with prescribed levels of mathematical thinking corresponding to Gagne's (1965) levels of learning and the correlation between each of the indices, creativity and intelligence.

3. A set of studies to see whether creative students or intelligent students are more strongly influenced by different educational media in learning elementary school mathematics.

4. A set of studies designed to observe whether a difference exists in the effects of small group instruction on highly creative students as compared to highly intelligent students.

5. A study designed to look at the interaction patterns of students and teachers in modern mathematics as studied by Pate (1966) and the relationship to creativity and to intelligence.

REFERENCES

Ahrens, Delores F. A Study of Educational Achievement in Relation to Creative Thinking Abilities and Intellectual Abilities. Unpublished doctoral dissertation, University of Illinois, 1962.

Anderson, G. L. Quanitative Thinking as Developed under Connectionist and Field Theories of Learning. Learning Theory in School Situations, University of Minnesota Studies in Education No. 2, Minneapolis: 1949, pp. 40-73.

Anklam, Phoebe A. A Study of the Relationship Between Two Divergent Instructional Methods and Achievement Motivation of Elementary School Children. Unpublished doctoral dissertation, University of Southern California, 1962.

Ausubel, D. P. Learning by Discovery: Rationale and Mystique. Bulletin of the National Association of Secondary School Administration, 1961, 45, 18-58.

Ausubel, D. P. The Psychology of Meaningful Verbal Learning. New York: Grune & Stratton, 1963.

Ausubel, D. P. Some Psychological and Educational Limitations of Learning by Discovery. The Arithmetic Teacher, 1964, 11, 290.

Bagley, W. C. The Educative Process. New York: Macmillan, 1905.

Bentley, J. C. Creativity and Academic Achievement. Journal of Educational Research, 1966, 59, 269-272.

Bloom, B. S. (Ed.) Taxonomy of Educational Objectives, Handbook I: Cognitive Domain. New York: David McKay, 1956.

Bloom, B. S. Stability and Change in Human Characteristics. New York: Wiley, 1964.

Brameld, T. Education as Power. New York: Holt, Rinehart and Winston, 1965, pp. 56-59.

Bruner, J. S. The Act of Discovery. Harvard Educational Review, 1961, 31, 21-32.

Bruner, J. S. Structures in Learning. The National Education Association Journal, 1962 (March), 26-27.

Bruner, J. S. Toward a Theory of Instruction. Cambridge: Harvard University Press, 1966.

California Mathematics Council. Strands of Mathematical Concepts. Sacramento: California State Department of Education, 1963.

Cicirelli, V. G. Form of the Relationship Between Creativity, IQ, and Academic Achievement. Journal of Educational Psychology, 1965, 56, 303-308.

Clark, C. M., Veldman, D. J., and Thorpe, J. S. Convergent and Divergent Thinking Abilities of Talented Adolescents. Journal of Educational Psychology, 1965, 56, 157-163.

Clymer, T. & Kearney, N. C. Curricular and Instructional Provisions for Individual Differences. In N. B. Henry (Ed.), Individualizing Instruction. The sixty-first yearbook of the National Society for the Study of Education, Part I, Chicago: University of Chicago Press, 1962, pp. 265-282.

Cronbach, L. J. Issues Current in Educational Psychology. Monographs of the Society for Research in Child Development, 1965a, 30-serial No. 99, 109-126.

Cronbach, L. J. The Logic of Experiments on Discovery. A paper prepared for a conference arranged by the Social Science Research Council, Committee on Learning and the Educational Process, New York City, January 28-29, 1965b.

Dawson, D. T. and Ruddell, A. K. The Case for Meaning Theory in Teaching Arithmetic. The Elementary School Journal, 1955, 55, 393-399.

DeBoer, Dorothy L. A Study of the Relationship of Creativity to Intelligence and Achievement. Unpublished doctoral dissertation, Northwestern University, 1964.

Denemark, G. W. Human Variability and Learning: Implications for Education. In W. B. Waetjen (Ed.), Human Variability and Learning. Washington, D. C.: Association for Supervision and Curriculum Development, 1961.

D'Heurle, Adma, Mellinger, Jeanne C., and Haggard, E. A. Personality, Intellectual, and Achievement Patterns in Gifted Children. Psychological Monographs, 1959, 73 No. 13 (Whole No. 483). 23 p.

Educational Policies Commission. The Central Purpose of American Education. Washington, D. C.: National Education Association and American Association of School Administrators, 1961.

Erickson, L. H. Certain Ability Factors and Their Effect on Arithmetic Achievement. The Arithmetic Teacher, 1958, 5, 287-293.

Flavell, J. H. The Developmental Psychology of Jean Piaget. Princeton: D. Van Nostrand, 1963.

Flescher, I. Anxiety and Achievement of Intellectually Gifted and Creatively Gifted Children. The Journal of Psychology, 1963, 56, 251-268.

Gage, N. L. Theories of Teaching. In E. R. Hilgard (Ed.), Theories of Learning and Instruction. The sixty-third yearbook of the National Society for the Study of Education, Part I, Chicago: University of Chicago Press, 1964, pp. 268-285.

Gagne, R. M. The Conditions of Learning. New York: Holt, Rinehart, and Winston, 1965.

Gaier, E. L. and White, W. F. Trends in the Measurement of Personality, Review of Educational Research, 1965, 35, 63-81.

Gardner, J. W. The Ever-Renewing Society. Saturday Review, 1963, 46 (January 5).

Getzels, J. W. and Jackson, P. W. Creativity and Intelligence. New York: Wiley, 1962.

Gilbert, Janet M. Creativity, Critical Thinking, and Performance in Social Studies. Unpublished doctoral dissertation, University of Buffalo, 1961.

Givens, P. R. Creativity and the Gifted Child. Educational Theory, 1963, 13, 128-131.

Golann, S. E. Psychological Study of Creativity, Psychological Bulletin, 1963, 60, 548-565.

Goldberg, M. L. Research on the Talented. New York: Bureau of Publications, Teachers College, Columbia University, 1965.

Goodlad, J. I. Nongraded Schools: Meeting Children Where They Are. Saturday Review, 1965, 58 (March 20).

Guilford, J. P. Three Faces of Intellect. American Psychologist, 1959, 14, 469-479.

Guilford, J. P. Factors That Aid and Hinder Creativity. Teachers College Record, 1962, 63, 380-392.

Guilford, J. P. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill, 1965.

Guilford, J. P. Intelligence: 1965 Model. American Psychologist, 1966, 21, 20-26.

Hardgrove, Clarence. National Problems and Trends in the Mathematical Training of Elementary School Teachers. CUPM Report: Number Nine. Berkeley: Mathematical Association of America, 1963 (April), 29-36.

Hartung, M. L. Distinguishing Between Basic and Superficial Ideas in Arithmetic Instruction. The Arithmetic Teacher. 1959, 6, 65-70

Hicklin, W. J., Reitan, H. M., and Rahmlow, H. F. Growth and Decline of Intellectual Ability in Terms of a Theory Based on Dynamic Equilibrium. The School Review, 1965, 73, 301-314.

Jackson, P. W. The Teacher and Individual Differences. In N. B. Henry (Ed.), Individualizing Instruction. The sixty-first yearbook of the National Society for the Study of Education, Part I, Chicago: University of Chicago Press, 1962, pp. 75-90.

Jackson, P. W. and Messick, S. The Person, the Product, and the Response: Conceptual Problems in the Assessment of Creativity. Princeton, N. J.: Educational Testing Service, 1964.

Johnson, M. Who Discovered Discovery? Phi Delta Kappan, 1966, 48, 120-123.

Kagan, J. Personality and the Learning Process. In S. R. Graubard (Ed.) Daedalus: Creativity and Learning. Boston: American Academy of Arts and Sciences, 1965, pp. 553-563.

Keppel, F. In the Foreword of Goals for School Mathematics. The Report of the Cambridge Conference on School Mathematics. Boston: Houghton, 1963.

Kersh, B. Y. The Adequacy of "Meaning" as an Explanation for the Superiority of Learning by Independent Discovery. Journal of Educational Psychology, 1958, 49, 282-292.

Kersh, B. Y. The Motivating Effect of Learning by Directed Discovery. Journal of Educational Psychology, 1962, 53, 65-71.

Kersh, B. Y. Learning by Discovery, What is Learned. The Arithmetic Teacher, 1964, 11, 226-232.

Kersh, B. Y. Learning by Discovery: Instructional Strategies. The Arithmetic Teacher, 1965, 12, 414-417.

Klausmeier, H. J. and Wiersma, W. The Effects of IQ Level and Sex on Divergent Thinking of Seventh Grade Pupils of Low, Average, and High IQ. Journal of Educational Research, 1965, 58, 300-302.

Kramer, K. The Teaching of Elementary School Mathematics. Boston: Allyn & Bacon, 1966.

Lindquist, E. F. and Hieronymus, A. N. Iowa Tests of Basic Skills: Manual for Administrators, Supervisors, and Counselors. New York: Houghton, 1964.

Lorge, I. and Thorndike, R. L. The Lorge-Thorndike Intelligence Tests: Technical Manual. New York: Houghton, 1962.

Lumsdaine, A. A. Educational Technology, Programed Learning and Instructional Science. In E. R. Hilgard (Ed.), Theories of Learning and Instruction. The sixty-third yearbook of the National Society for the Study of Education, Part I, Chicago: University of Chicago Press, 1964, pp. 371-401.

MacKinnon, D. W. The Nature and Nurture of Creativity. American Psychologist, 1962, 17, 484-495.

Machler, B. and Shontz, F. C. Creativity: Theoretical and Methodological Consideration. The Psychological Record, 1965, 15, 217-238.

Mayor, J. R. Issues and Directions. The Arithmetic Teacher, 1966, 13, 349-354.

McConnell, T. R. Discovery vs. Authoritative Identification in the Learning of Children. Studies in the Psychology of Learning II, Iowa City: University of Iowa, 1934, pp. 13-62.

McDonald, F. J. Meaningful Learning and Retention: Task and Method Variables. Review of Educational Research, 1964, 34, 530-544.

McLeish, J. The Science of Behaviour. London: Barrie Books Ltd., 1963.

McNemar, Q. Psychological Statistics. New York: Wiley, 1955.

Miller, G. H. How Effective is the Meaning Method?. The Arithmetic Teacher, 1957, 4, 45-49.

Millman, J. and Glock, M. D. Trends in the Measurement of General Mental Ability. Review of Educational Research, 1965, 35, 17-24.

Mussen, P. H. Issues Current in Educational Psychology. Monographs of the Society for Research in Child Development, 1965, 30-serial No. 99, 126-130.

National Council of Teachers of Mathematics. The Teaching of Arithmetic. Tenth Yearbook, New York: Bureau of Publication, Teachers College, Columbia University, 1935.

National Council of Teachers of Mathematics. An Analysis of New Mathematics Programs. Washington, D. C.: National Education Association, 1963.

Owens, R. E. The Relationship of Creative Thinking Ability to Extreme Over- and Underachievement. Paper presented in the Problem Solving and Creativity Session of the American Educational Research Association. Chicago, 1966 (mimeographed).

Pate, R. T. Transactional Pattern Differences Between School Mathematics Programs. The Arithmetic Teacher, 1966, 13, 21-25.

Ray, W. E. Pupil Discovery vs. Direct Instruction. Journal of Experimental Education, 1961, 29, 271-280.

Rose, A. W. and Helan, C. Intelligence, Sibling Position, and Sociocultural Background as Factors in Arithmetic Performance. The Arithmetic Teacher, 1961, 8, 50-59.

Schmadel, Elnora, Merrifield, P. R., and Bonsall, Marcella R. A Comparison of Performances of Gifted and Non-gifted Children on Selected Measures of Creativity. Paper presented to California State Psychological Association, Los Angeles, 1960 (mimeographed).

Scott, Carrie M. The Relationship Between IQ and Gain in Reading Achievement with Arithmetic Reasoning, Social Studies and Science. Journal of Educational Research, 1963, 56, 322-326.

Shuster, A. H. and Pigge, F. L. Retention Efficiency of Meaningful Teaching. The Arithmetic Teacher, 1965, 12, 24-31.

Spraker, H. S. A Study of the Comparative Emergency of Creative Intellectual Behavior During the Process of Group and Individual Study of Mathematics. Unpublished doctoral dissertation, University of Virginia, 1960.

Stone, J. C. The Teaching of Arithmetic. Chicago: Sanborn, 1918.

Suchman, J. R. Inquiry Training: Building Skills for Autonomous Discovery. Merrill-Palmer Quarterly, 1961, 7, 147-169.

Suppes, P. Modern Learning Theory and the Elementary-School Curriculum American Educational Research Journal. 1964, 1, 79-93.

Swenson, Esther J. Organization and Generalization as Factors in Learning, Transfer, and Retroactive Inhibition. Learning Theory in School Situations, University of Minnesota Studies in Education No. 2, Minneapolis: 1949, pp. 9-39.

Taylor, C. W. Bridges from Creativity Research to Teaching. The Instructor, 1963, 73 (September), 5.

Torrance, E. P. Gifted Children. Recent Research and Developments and Their Implications for Teacher Education. The thirteenth yearbook of the American Association of Colleges for Teacher Education, Washington, D. C.: National Education Association, 1960, p. 69.

Torrance, E. P. Guiding Creative Talent. Englewood Cliffs: Prentice-Hall, 1962.

Torrance, E. P. Continuity in the Creative Development of Young Children. In E. P. Torrance and R. D. Strom (Eds.) Mental Health and Achievement. New York: Wiley, 1965a, pp. 274-285.

Torrance, E. P. The Measurement of Creative Behavior in Children. In Mary J. Aschner and C. E. Bish (Eds.) Productive Thinking in Education. Washington, D. C.: National Education Association, 1965b, pp. 199-226.

Torrance, E. P. Rewarding Creative Behavior. Englewood Cliffs: Prentice-Hall, 1965c.

Torrance, E. P. Scientific Views of Creativity and Factors Affecting Its Growth. In S. R. Graubard (Ed.), Daedalus: Creativity and Learning. Boston: American Academy of Arts and Sciences, 1965d, pp. 663-681.

Torrance, E. P. Torrance Tests of Creative Thinking. Princeton: Personnel Press, 1966a.

Torrance, E. P. Torrance Tests of Creative Thinking: Directions Manual and Scoring Guide. Princeton: Personnel Press, 1966b.

Torrance, E. P. Torrance Tests of Creative Thinking: Norms-Technical Manual. Princeton: Personnel Press, 1966c.

Torrance, E. P. and Gupta, R. Development and Evaluation of Recorded Programmed Experiences in Creative Thinking in the Fourth Grade. Minneapolis: Bureau of Educational Research, University of Minnesota, 1964.

Tyler, F. T. and Brownell, W. A. Facts and Issues: A Concluding Statement. In N. B. Henry (Ed.), Individualizing Instruction. The sixty-first yearbook of the National Society for the Study of Education, Part I, Chicago: University of Chicago Press, 1962, pp. 316-327.

Wallach, M. A. and Kogan, N. Modes of Thinking in Young Children. New York: Holt, Rinehart and Winston, 1965.

Wechsler, D. The Measurement of Adult Intelligence. Baltimore: Williams and Wilkins Co., 1944.

Wert, J. E., Neidt, C. O., and Ahmann, J. S. Statistical Methods in Educational and Psychological Research. New York: Appleton, 1954.

Williams, F. E. Training Children To Be Creative May Have Little Effect on Classroom Performance. California Journal of Educational Research, 1966, 17, 73-79.

Wilson, G. M. The Social Utility Theory as Applied to Arithmetic, Its Research Basis, and Some of Its Implications. The Journal of Educational Research, 1948, 41, 321-337.

Wolfe, M. S. Effects of Expository Instruction in Mathematics on Students Accustomed to Discovery Methods. Unpublished doctoral dissertation, University of Illinois, Urbana, 1963.

Yamamoto, K. Effects of Restriction of Range and Test Unreliability on Correlation Between Measures of Intelligence and Creative Thinking. The British Journal of Educational Psychology, 1965, 35, 300-305.

Young, J. W. A. The Teaching of Mathematics. New York: Longmans, Green, 1906.

APPENDIX

RAW DATA

FLUENCY, FLEXIBILITY, ORIGINALITY, AND ELABORATION SCORES OF STUDENTS ON TORRANCE TESTS OF CREATIVE THINKING

	Verbal			Nonverbal			
	Fluency	Flexibility	Originality	Fluency	Flexibility	Originality	Elaboration
BRM	30	21	17	14	14	20	87
DRJ	32	21	11	17	15	23	38
HRL	29	25	24	14	11	20	55
NRJ	45	27	22	20	19	33	75
PRJ	44	25	17	11	8	7	38
RRJ	49	23	13	15	13	17	54
BRV	44	27	20	18	12	18	85
CRC	72	34	29	22	18	30	77
CRH	35	25	26	8	8	6	70
CRE	84	43	36	21	16	23	60
DRP	29	18	2	19	16	14	73
DRS	44	30	27	14	9	14	86
DRP	69	34	27	23	18	25	55

RAW DATA

FLUENCY, FLEXIBILITY, ORIGINALITY, AND ELABORATION SCORES OF STUDENTS ON TORRANCE TESTS OF CREATIVE THINKING (Continued)

	Verbal			Nonverbal			
	Fluency	Flexibility	Originality	Fluency	Flexibility	Originality	Elaboration
GRS	107	36	44	27	21	33	122
HRK	67	40	34	34	25	37	57
IRN	71	37	39	19	16	26	93
LRC	33	21	22	24	20	24	87
MRD	78	39	36	29	22	32	62
RRN	117	49	53	20	10	26	82
SRM	27	19	13	5	12	2	31
CET	75	30	23	24	17	25	117
EEK	71	30	14	9	4	10	44
FER	73	42	35	25	23	17	63
HED	49	29	21	25	21	23	15
HEB	47	32	30	8	8	17	98
HET	55	30	26	7	7	12	70

RAW DATA

FLUENCY, FLEXIBILITY, ORIGINALITY, AND ELABORATION SCORES OF STUDENTS ON TORRANCE TESTS OF CREATIVE THINKING (Continued)

	Verbal			Nonverbal			
	Fluency	Flexibility	Originality	Fluency	Flexibility	Originality	Elaboration
JEG	45	26	9	18	15	26	123
KED	30	22	12	8	8	14	61
LES	21	14	10	11	9	15	92
LED	51	34	21	22	16	18	104
PEJ	57	36	28	15	13	23	61
REG	81	43	39	13	10	14	130
RED	99	37	22	18	13	28	141
RET	26	18	15	14	12	19	74
WEP	52	24	26	14	10	14	65
BEC	122	38	19	27	18	32	64
FES	71	38	48	14	11	28	111
HEJ	58	35	19	17	13	22	100
HEK	59	39	17	8	6	13	64

RAW DATA

FLUENCY, FLEXIBILITY, ORIGINALITY, AND ELABORATION SCORES OF STUDENTS ON TORRANCE TESTS OF CREATIVE THINKING (Continued)

	Verbal			Nonverbal			
	Fluency	Flexibility	Originality	Fluency	Flexibility	Originality	Elaboration
LEC	48	23	18	23	20	14	51
MEP	97	44	24	20	16	25	51
PEM	67	42	22	18	14	11	44
PEL	102	48	43	18	17	24	62
SEH	49	28	30	19	14	31	84
TEP	57	39	45	20	26	42	79
BXR	88	34	22	31	23	30	74
BXC	170	44	31	27	22	26	121
CXM	136	54	27	26	18	22	123
EXJ	76	35	20	22	20	35	90
GXD	30	19	8	19	18	25	71
HXB	161	43	16	39	27	35	93
LXJ	105	35	23	22	19	21	61

RAW DATA

FLUENCY, FLEXIBILITY, ORIGINALITY, AND ELABORATION SCORES OF STUDENTS ON TORRANCE TESTS OF CREATIVE THINKING (Continued)

	Verbal			Nonverbal			
	Fluency	Flexibility	Originality	Fluency	Flexibility	Originality	Elaboration
MXG	56	30	24	17	14	25	71
OXG	32	20	12	16	15	20	43
PXR	88	29	2	17	14	10	56
PXL	61	31	27	24	16	25	101
ZXP	144	42	18	15	10	26	64
AXE	112	43	26	22	19	35	90
AXM	103	29	8	12	11	17	77
CXE	121	49	24	24	21	42	58
DXM	105	48	22	26	21	22	75
GXP	86	45	28	17	15	19	76
HXM	85	40	20	33	22	30	87
HXA	105	48	25	30	26	39	96
HXN	102	43	19	21	19	15	78

RAW DATA

FLUENCY, FLEXIBILITY, ORIGINALITY, AND ELABORATION SCORES OF STUDENTS ON TORRANCE TESTS OF CREATIVE THINKING (Continued)

	Verbal			Nonverbal			
	Fluency	Flexibility	Originality	Fluency	Flexibility	Originality	Elaboration
KXM	94	35	17	34	26	26	94
MXL	61	33	26	25	18	31	73
RXM	74	38	21	22	19	28	61
TXC	63	33	14	14	13	24	52

RAW DATA

VERBAL, NONVERBAL, AND COMPOSITE INTELLIGENCE AND CREATIVITY SCORES FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

Student	Intelligence			Creativity		
	Verbal	Nonverbal	Composite	Verbal	Nonverbal	Composite
BRM	108	113	111	68	135	203
DRJ	135	122	129	64	103	167
HRL	127	128	128	78	100	178
NRJ	117	127	122	94	147	241
PRJ	106	119	113	86	64	150
RRJ	114	104	109	95	99	194
BRV	128	122	125	91	133	224
CRC	116	120	118	135	147	282
CRH	138	136	137	86	184	270
CRE	122	126	124	163	120	283
DRP	146	129	137	49	122	171
DRS	138	129	134	101	123	224
DRP	120	131	126	130	121	251
GRS	131	96	114	187	203	390
HRK	124	127	126	141	153	294
IRN	149	143	146	147	154	301
LRC	118	129	124	76	155	231
MRD	121	108	115	153	145	298
RRN	143	139	141	219	138	357
SRM	116	114	115	59	50	109
CET	120	122	121	128	193	321

RAW DATA

VERBAL, NONVERBAL, AND COMPOSITE INTELLIGENCE AND CREATIVITY SCORES FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Intelligence			Creativity		
	Verbal	Nonverbal	Composite	Verbal	Nonverbal	Composite
EEK	146	135	141	115	67	182
FER	130	121	126	150	128	278
HED	111	109	110	99	174	273
HEB	130	130	130	109	131	240
HET	133	134	134	111	96	207
JEG	148	110	129	80	182	262
KED	114	110	112	64	91	155
LES	130	115	123	45	127	172
LED	86	102	94	111	160	271
PEJ	118	122	120	121	112	233
REG	150	143	147	163	167	330
RED	133	143	138	158	200	358
RET	140	123	132	59	119	178
WEP	118	124	121	102	103	205
BEC	129	127	128	179	131	310
FES	129	126	128	157	164	321
HEJ	133	130	132	112	152	264
HEK	117	120	119	115	91	206
LEC	120	117	119	89	108	197
MEP	104	106	105	165	112	277
PEM	119	127	123	131	87	218

RAW DATA

VERBAL, NONVERBAL, AND COMPOSITE INTELLIGENCE AND CREATIVITY SCORES FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Intelligence			Creativity		
	Verbal	Nonverbal	Composite	Verbal	Nonverbal	Composite
PEL	118	130	124	193	121	314
SEH	123	127	125	107	148	255
TEP	127	131	129	141	167	308
BXR	106	124	115	144	158	302
BXC	120	122	121	245	196	441
CXM	133	124	129	217	189	406
EXJ	139	145	142	131	167	298
GXD	118	123	121	57	133	190
HXR	118	110	114	220	194	414
HXJ	110	100	105	165	123	288
MXG	135	106	123	110	126	237
OXG	93	110	102	64	94	158
PXL	140	132	136	119	166	285
PXR	100	117	109	119	97	216
ZXP	133	139	136	204	115	319
AXE	156	160	158	181	166	347
AXM	132	121	127	140	117	257
CXE	139	137	138	194	145	339
DXM	128	119	124	175	144	319
GXP	119	107	113	159	127	286
HXM	111	105	108	145	172	317

RAW DATA

VERBAL, NONVERBAL, AND COMPOSITE INTELLIGENCE AND CREATIVITY SCORES FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Intelligence			Creativity		
	Verbal	Nonverbal	Composite	Verbal	Nonverbal	Composite
HXN	124	114	119	164	133	297
HXA	109	99	104	178	191	369
KXM	104	105	105	146	180	326
MXL	120	122	121	120	147	267
RXM	122	126	124	133	130	263
TXC	128	114	121	110	103	213

RAW DATA

TEACHER RATINGS--MODERATELY SUCCESSFUL (M), SUCCESSFUL (S), VERY SUCCESSFUL (V)--OF PERFORMANCE IN MATHEMATICS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

Student	Performance Category				
	Reasoning	Computation	Structure	Numeration	Composite
BRM	M	S	S	S	S
DRJ	S	S	S	M	S
HRL	V	V	S	V	V
NRJ	S	S	V	V	S
PRJ	M	M	S	S	M
RRJ	M	S	S	M	M
BRV	S	V	S	S	S
CRC	S	S	M	M	S
CRH	V	V	S	V	V
CRE	M	M	M	M	M
DRP	V	V	S	S	V
DRS	V	V	S	S	V
DRP	V	V	S	S	V
GRS	M	S	M	M	M
HRK	V	V	V	S	V
IRN	V	S	S	S	S
LRC	V	V	V	V	V
MRD	S	S	M	S	S
RRN	V	V	V	V	V
SRM	S	S	M	S	S

RAW DATA

TEACHER RATINGS--MODERATELY SUCCESSFUL (M), SUCCESSFUL (S), VERY SUCCESSFUL (V)--OF PERFORMANCE IN MATHEMATICS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Performance Category				
	Reasoning	Computation	Structure	Numeration	Composite
CET	S	M	M	M	M
EEK	V	V	V	V	V
FER	M	M	M	M	M
HED	M	M	M	M	M
HEB	V	V	S	V	V
HET	V	V	V	V	V
JEG	M	S	S	S	S
KED	S	S	S	S	S
LES	M	M	M	M	M
LED	M	M	M	M	M
PEJ	V	V	V	V	V
REG	V	S	V	V	V
RED	V	V	V	V	V
RET	S	V	S	S	S
WEP	S	M	M	S	M
BEC	M	S	M	M	M
FES	V	V	S	V	V
HEJ	S	M	S	M	S
HEK	M	S	S	S	S
LEC	M	M	M	M	M

RAW DATA

TEACHER RATINGS--MODERATELY SUCCESSFUL (M), SUCCESSFUL (S), VERY SUCCESSFUL (V)--OF PERFORMANCE IN MATHEMATICS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Performance Category				
	Reasoning	Computation	Structure	Numeration	Composite
MEP	M	M	S	M	M
PEM	M	M	M	M	M
PEL	S	M	S	S	S
SEH	V	V	V	V	V
TEP	M	M	M	M	M
BXR	S	S	S	S	S
BXC	M	S	M	S	S
CXM	S	M	S	S	S
EXJ	S	V	V	S	V
GXD	M	M	M	M	M
HXR	S	S	M	M	S
LXJ	M	M	M	M	M
MSG	S	V	S	S	S
OXG	V	M	S	M	M
PXL	V	S	V	V	V
PXR	S	S	S	V	S
ZCP	V	S	V	V	V
AXE	V	V	V	V	V
AXM	S	M	M	M	M
CXE	V	V	V	V	V

RAW DATA

TEACHER RATING--MODERATELY SUCCESSFUL (M), SUCCESSFUL (S), VERY SUCCESSFUL (V)--OF PERFORMANCE IN MATHEMATICS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Performance Category				
	Reasoning	Computation	Structure	Numeration	Composite
DXM	V	V	S	V	V
GXP	M	S	M	M	M
HXM	M	S	M	M	M
HXN	S	S	M	S	S
HXA	M	S	M	M	M
KXM	M	S	M	M	S
MXL	S	S	M	M	S
RXM	S	S	V	V	S
TXC	S	M	M	S	M

RAW DATA

GRADE EQUIVALENTS ON PRE- AND POST-TESTS IN ELEMENTARY SCHOOL MATHEMATICS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX

Student	Concepts			Problem Solving			Composite		
	Pre-	Post-	Change	Pre-	Post-	Change	Pre-	Post-	Change
BRM	4.7	5.1	.4	4.5	4.7	.2	4.6	4.9	.3
DRJ	5.4	6.6	1.2	5.4	5.6	.3	5.4	6.1	.7
HRL	6.0	6.1	.1	4.8	7.1	2.3	5.4	6.6	1.2
NRJ	5.2	6.6	1.4	5.3	5.6	.3	5.3	6.1	.8
PRJ	4.4	5.3	.9	4.0	4.1	.1	5.2	4.7	.5
RRJ	4.8	5.2	.4	4.6	5.0	.4	4.7	5.1	.4
BRV	5.8	6.3	.5	7.0	5.3	-1.7	6.4	5.8	-.6
CRC	4.8	6.3	1.5	4.8	6.6	1.8	4.8	6.4	1.6
CRH	5.8	6.3	.5	4.9	5.3	.4	5.4	5.8	.4
CRE	3.6	4.9	1.3	3.9	4.6	.7	3.8	4.8	1.0
DRP	5.4	5.3	-.1	4.7	5.1	.4	5.1	5.2	.1
DRS	6.2	6.3	.1	5.6	6.6	1.0	5.9	6.4	.5
DRP	5.6	5.6	.0	4.8	5.3	.5	5.2	5.4	.2

RAW DATA

GRADE EQUIVALENTS IN PRE- AND POST-TESTS IN ELEMENTARY SCHOOL MATHEMATICS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Concepts			Problem Solving			Composite		
	Pre-	Post-	Change	Pre-	Post-	Change	Pre-	Post-	Change
GRS	5.1	5.0	-.1	4.6	5.6	1.0	4.9	5.3	.4
HRK	6.0	6.3	.3	4.6	6.1	1.5	5.3	6.2	.9
IRN	5.8	6.1	.3	5.9	5.6	-.3	5.9	5.8	-.1
LRC	5.8	6.1	.3	6.2	6.3	.1	6.0	6.2	.2
MRD	4.8	4.7	-.1	4.8	4.8	.0	4.8	4.8	.4
RRN	6.4	6.3	-.1	6.2	7.1	.9	6.3	6.7	.4
SRM	4.8	5.2	.4	4.7	5.1	.4	4.8	5.2	.4
CET	4.8	6.6	1.8	5.5	5.1	-.4	5.2	5.8	.6
EEK	6.3	7.1	.8	5.8	5.9	.1	6.0	6.5	.5
FER	6.5	6.6	.1	4.9	4.8	-.1	5.7	5.7	.0
HED	5.2	5.6	.4	4.0	5.3	1.3	4.6	5.4	.8
HEB	6.7	6.4	-.3	5.8	6.1	.3	6.2	6.2	.0
HET	6.0	8.0	2.0	5.1	5.6	.5	5.6	6.8	1.2

RAW DATA

GRADE EQUIVALENTS ON PRE- AND POST-TESTS IN ELEMENTARY SCHOOL MATHEMATICS
FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Concepts			Problem Solving			Composite		
	Pre-	Post-	Change	Pre-	Post-	Change	Pre-	Post-	Change
JEG	6.0	6.2	.2	5.6	6.6	1.0	5.8	6.4	.6
KED	4.6	5.4	.8	3.3	5.0	1.7	4.0	5.2	1.2
LES	5.3	5.6	.3	6.9	5.9	-1.9	6.1	5.3	-.8
LED	3.4	5.2	1.7	4.0	4.2	.2	3.7	4.7	1.0
PEJ	6.3	7.3	1.0	5.3	6.8	1.5	5.8	7.0	1.2
REG	7.4	8.0	.6	7.6	7.9	.3	7.5	8.0	.5
RED	5.9	7.5	1.6	6.1	6.1	.0	6.0	6.8	.8
RET	5.5	6.9	1.4	5.1	5.8	.7	5.3	6.4	1.1
WEP	6.4	6.4	.0	6.6	6.1	-.5	6.5	6.2	-.3
BEC	5.4	6.1	.7	4.9	5.9	1.0	5.2	6.0	.8
FES	7.0	7.1	.1	7.2	7.7	.5	7.1	7.4	.3
HEJ	6.0	6.5	.5	4.6	5.8	1.2	5.3	6.2	.9
HEK	5.5	6.0	.5	4.3	3.6	-.7	4.9	4.8	-.1

RAW DATA

GRADE EQUIVALENTS ON PRE- AND POST-TESTS IN ELEMENTARY SCHOOL MATHEMATICS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Concepts			Problem Solving			Composite		
	Pre-	Post-	Change	Pre-	Post-	Change	Pre-	Post-	Change
LEC	5.5	6.3	.8	4.6	5.8	1.2	5.0	6.0	1.0
MEP	5.4	4.3	-1.1	2.7	2.6	-.1	4.0	3.4	-.6
PEM	5.7	6.7	1.0	5.1	4.5	-.6	5.4	5.6	.2
PEL	6.1	6.2	.1	4.6	5.3	.7	5.4	5.8	.4
SEH	6.5	7.1	.6	5.8	6.6	.8	6.2	6.8	.6
TEP	5.5	6.7	1.2	5.8	6.1	.3	5.6	6.4	.8
BXR	7.4	6.8	-.6	6.0	7.6	1.6	6.7	7.2	.5
BXC	7.8	7.6	-.2	6.3	9.4	3.1	7.0	8.5	1.5
CXM	7.0	7.7	.7	6.6	7.9	1.3	6.8	7.8	1.0
EXJ	7.4	7.7	.3	8.6	9.2	.6	8.0	8.4	.4
GXD	6.1	6.8	.7	5.5	5.3	-.2	5.8	6.0	.2
HXR	6.3	6.8	.5	6.6	7.2	.6	6.4	7.0	.6
LXJ	5.4	6.6	1.2	6.6	6.2	-.4	6.0	6.4	.4

RAW DATA

GRADE EQUIVALENTS ON PRE- AND POST-TESTS IN ELEMENTARY SCHOOL MATHEMATICS FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Concepts			Problem Solving			Composite		
	Pre-	Post-	Change	Pre-	Post-	Change	Pre-	Post-	Change
MXG	7.8	9.4	1.6	7.0	8.3	1.3	7.4	8.8	1.4
OXG	5.0	6.3	1.3	4.1	5.9	1.8	4.6	6.1	1.5
PXL	7.9	8.4	.5	8.0	9.7	1.7	8.0	9.0	1.0
PXR	6.7	6.8	.1	5.5	6.6	1.1	6.1	6.7	.6
ZXP	7.4	8.2	.8	7.4	8.7	1.3	7.4	8.4	1.0
AXE	8.4	8.8	.5	8.4	8.9	.5	8.4	8.8	.4
AXM	5.6	7.6	2.0	6.6	7.6	1.0	6.1	7.6	1.5
CXE	7.8	8.2	.4	9.3	10.0	.7	8.6	9.1	.5
DXM	6.2	7.2	1.0	6.5	8.3	1.8	6.4	7.8	1.4
GXP	6.5	6.4	-.1	6.0	7.4	1.4	6.2	6.9	.7
HXM	5.4	6.8	1.4	6.5	8.9	2.4	6.0	7.8	1.8
HXN	6.0	7.8	1.8	7.6	7.6	.0	6.8	7.7	.9
HXA	5.8	6.6	.8	5.8	7.4	1.6	5.8	7.0	1.2

RAW DATA

GRADE EQUIVALENTS ON PRE- AND POST-TESTS IN ELEMENTARY SCHOOL MATHEMATICS
FOR SIXTY-NINE STUDENTS IN GRADES FOUR, FIVE, AND SIX (Continued)

Student	Concepts			Problem Solving			Composite		
	Pre-	Post-	Change	Pre-	Post-	Change	Pre-	Post-	Change
KXM	4.4	6.4	2.0	4.5	5.3	.8	4.4	5.8	1.4
MXL	6.0	7.1	1.1	6.8	8.1	1.3	6.4	7.6	1.2
RSM	6.8	7.7	.9	6.5	7.6	1.1	6.6	7.6	1.0
TXC	4.8	7.1	2.3	4.9	6.2	1.3	4.8	6.6	1.8