AN ABSTRACT OF THE THESIS OF

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Title: AN ANALYSIS OF THE EFFECT OF MATHEMATICS READINESS EDUCATION AT THE KINDERGARTEN LEVEL ON THE GROWTH OF CONCEPTUAL ABILITY OF NUMBER AS MEASURED BY PIAGET'S STAGES OF THE DEVELOPMENT OF NUMBER

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The purpose of this study was to test two assumptions. They are that factors in a child's background correlate with the notion of conservation and that additional mathematical instruction will result in a higher level of maturity of the notion of conservation as well as increased achievement in mathematical skills.

To test these assumptions 45 kindergarten students attending the Campus Elementary School during the spring term of the 1969-1970 academic year at Oregon College of Education were studied. To test the assumption that increased mathematical instruction will result in a higher level of concept maturity of the notion of conservation and increased achievement in arithmetic, a pretest-posttest design was used. The independent variable measured for this

assumption was readiness information. It was measured in one instance by using Piaget's experiments to determine the understanding of conservation and in another instance by an arithmetic test to measure achievement in arithmetic. To test the assumption that factors in a child's background are related to the acquisition of conservation skills, chronological age, nursery school experience, IQ, and placement in the family constellation were measured.

The dependent variables in the assumption that readiness instruction implies increased achievement and a higher level of maturity of the concept of conservation were arithmetic performance as measured by an arithmetic test and change in status of the levels of concept maturity of the notion of conservation as measured by Piaget's experiments. To measure the relationship of background variables age, IQ, family constellation, and nursery school experience to the level of concept maturity of the notion of conservation a biserial correlation was determined. The level of concept maturity was the dependent variable measured in the second assumption.

The instruments used to collect the data for this study were an analysis of the level of maturity of the concept of conservation determined by the replication of Piaget's experiments; One to One Correspondence (Flowers), and Discontinuous Quantities (Beans); The American School Achievement Test: Arithmetic Readiness, to measure arithmetic achievement; and the Peabody Picture Vocabulary

Test, to measure IQ.

The assumption that increased readiness instruction in arithmetic would result in a higher level of conecpt maturity and increased achievement in arithmetic developed two hypotheses. They were tested in the null form at the .05 confidence level, using the Student's t-test and the chi-square test with one degree of freedom. These hypotheses were:

1) There are no significant changes between the control and experimental groups in the level of understanding of the concept of conservation.

2) There is no significant difference between the experimental and control groups in arithmetic achievement as measured by an arithmetic readiness test.

The results of the testing of these two hypotheses were not of statistical significance; therefore the null hypotheses were not rejected.

The assumption that background variables chronological age, IQ, nursery school experience, and place in the family constellation relate to the variable level of maturity of the notion of conservation was measured by biserial correlation. Hypotheses measured were:

1) There is no significant correlation between the IQ of a child and his ability to conserve.

2) There is no significant correlation between the chronological

age of the child and his ability to conserve.

3) There is no significant correlation between the place of a child in a family constellation and his ability to conserve.

4) There is no significant correlation between the fact that a child has nursery school experience and his ability to conserve.

The results did not culminate in a statistically significant correlation and the null nypotheses were not rejected.

The theory of cognitive development formulated by Jean Piaget provided the theoretical framework for this study. Specifically, Piaget's concepts about the development of number in young children were examined. Replication of Piaget's experiments is a fruitful experience for the educator to gain insight into cognitive growth in young children and to enable the educator to provide more meaningful kindergarten experiences.

An Analysis of the Effect of Mathematics Readiness Education at the Kindergarten Level on the Growth of Conceptual Ability of Number as Measured by Piaget's Stages of the Development of Number

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CHAPTER I

INTRODUCTION

Introduction

The resurgence of interest in cognitive development in recent years has resulted in increased attention by educators to the acquisition of contemplative skills in children. How do children learn? What should be taught and when should formal education begin? Educators have long been counseled to begin where the child is, but in the area of pre-primary education the child's level is sometimes difficult to determine. Considerable emphasis has been given to the early years of childhood, and educational communities are showing a new interest in the potential of young children.

Kindergarten programs offer learning opportunities that are helpful for the five year old child as well as offering education and language that will assist the child in the school years ahead. The area of readiness is a special area of concern to early childhood educators. Readiness is defined as the optimum time to present a child with new material. It is an enormous responsibility to determine what should be taught at a specified grade level and to decide the appropriate time to present a child with new material. Educators differ in opinions about what constitutes readiness, but evidence continues to accumulate about emotional problems that may be caused by improper evaluations of readiness and readiness training.

Many well known educators have spoken out in favor of the need for curriculum change, among them is Jerome Bruner. He says:

> Each generation gives new form to the aspirations that shape education in its time. What may be emerging as a mark of our own generation is a widespread renewal of concern for the quality and intellectual aims of education--but without abandonment of the ideal that education should serve as a means of training well balanced citizens for a democracy. Rather we have reached a level of public education in America where a considerable portion of our population has become interested in a question that until recently was the concern of specialists. 'What shall we teach our children and to what end?' (1966, p. 1).

The concern expressed in this passage has caused educational authorities to form committees to study curriculum offerings in present day schools and to plan for future curriculum programs that are relevant to student needs. The number of studies now under investigation indicates the intense interest in the learning processes of young children.

The concept of readiness is of particular interest to educators and is being studied by many groups. Bruner expresses the belief that our schools may be wasting precious years by postponing the teaching of many subjects. The importance of the structure of a subject and its role in enabling a child to become proficient in that subject is the theme of much of his work. He believes that an understanding of structure rather than the mastery of rote memorized facts and techniques is the center of real knowledge about subject matter. Children can begin to understand new concepts by early introduction to the subject. His hypothesis is "that any subject can be taught effectively in some honest form to any child at any stage of development" (1966, p. 19).

Kindergartens vary in the kinds of programs offered to children. Programs reflect differing values, purposes, financial arrangements, and the professional preparation of teachers. However, there are similar trends that are noticeable throughout the United States in all kindergarten offerings. In the survey made by the National Education Association in 1967-1968, about 40 percent of the schools surveyed across the nation maintained kindergarten programs. Most had a definite sequence and program arrangement. The school period was usually about two and one half hours long and occurred very week day of the school year. The kindergarten survey requested information about kinds of programs and importance of subjects stressed in these programs. Many schools gave various kinds of tests at the conclusion of the kindergarten year in order to help place children in first grade classes. These tests included reading readiness tests, intelligence and aptitude tests. Mathematics readiness was not tested, yet of the nine specific curriculum experiences included in the kindergarten programs, number relationships received the most emphasis. The curriculum experiences were reported as follows in descending order of frequency:

Number relationships	95.3 percent
Art	94.3 "
Health	89.5 "
Physical Education	88.2 "
Social Studies	84.7 "
Science	84.4 "
Reading	83.9 "
Music	83.5 "
Language Arts	83.2 "

(N. E. A., 1967-1968, p. 22)

From this information it is evident that the area of mathematics or number relationships is one that is currently being emphasized. Well known authorities such as Helen Heffernan are advocating an increase in mathematics in kindergarten. In an article in Today's Education, she gives the following goal for mathematics in kindergarten: that of increasing the child's ability to use mathematical concepts, symbols, and processes (1970). Children today are being exposed to mathematics teaching at an earlier level and are being taught more complicated procedures at earlier grade levels. Knowledge about a child's ability to learn new concepts becomes a primary concern.

Basic to the determination of suitable subject matter for specific grade levels is an understanding of a child's pattern of development. Developmental psychologists believe that all children pass through stages of maturation which finally culminate at a period in adolescence called maturity. Children remain in various stages for differing lengths of time, but each child passes from one stage to another and the subsequent stage is dependent on the previous stage. The psychologist Piaget has given educators a theory that gives insight into the intellectual development of children. This theory is explained in "The Psychological Background for the Study" section of Chapter II. A brief description of the theory and the effect that it has on young children follows.

Piaget believes that children from birth have certain sensory-motor coordination that he calls "schemata." Flavell defines schema as follows:

> A schema is a cognitive structure which has reference to a class of similar action sequences, these sequences of necessity being strong, bounded totalities in which the constituent behavioral elements are tightly interrelated (1963, p. 53).

Variation in stimulus situations cause changes in these schemata. These changes can be "assimilated" or stored. Assimilation is defined as:

> The process of changing elements in the milieu in such a way that they become incorporated into the structure of the organism (Flavell, 1963, p. 45).

Incongruities between the central schemata and receptor inputs can facilitate growth, but if they extend beyond a child's capacity for accommodation, anxiety and fear can result. Accommodation is defined as:

> . . .the organism must accommodate its functioning to the specific contours of the object it is trying to assimilate (Flavell, 1963, p. 45).

The child develops continuous schemata by accommodations and assimilations until a child's schemata corresponds so well with reality that no further accommodations are required (Hunt, 1968).

This research investigates Piaget's hypothesis of the child's development of number concepts. His hypothesis states that

> the construction of number goes hand in hand with the development of logic, and that a pre-numerical period corresponds to the pre-logical level (1964, p. 8).

Purpose of the Study

The main purpose of this research was to test two assumptions held by many early childhood educators. The first assumption to be tested concerns Piaget's theory of cognitive structure and the existence in the theory of the stages of concept maturity that lead to a child's capacity for reversibility and thus the notion of conservation.[1]

The psychologist, Jean Piaget, has produced a prolific offering of books and articles concerning cognitive structures. Piagetian theory takes a developmental approach to identify stages of growth and their ordinal sequence. Piaget has concentrated much of his work on

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[1] Piaget's theory and its implications for the concept of readiness are detailed in the second chapter of the thesis under the section called "Psychological Background for the Study."

pre-school children in an effort to determine the child's mental operations as the child attempts to understand the concept of number. Piaget has devised simple experiments that determine the level or stage of a child's understanding of procedures that lead to the concept of conservation in the mathematical areas of number, quantity, volume, time, and so forth. Conservation is defined as the ability of an individual to be aware of the invariant properties in the face of transformations. For Piaget, conservation is a central prerequisite for the acquisition and development of logical thought. The child's thought can be identified by levels in his stages of growth as his thinking proceeds to the period in his development that Piaget labels "concrete operations." The basic skill, according to Piaget, for all mathematical thinking is the capacity for reversibility, the ability of returning in thought to one's starting point. He further contends that conservation is a "necessary condition for all rational activity" (1964, p. 3). This study replicated two of Piaget's experiments; conservation of discontinuous quantities and provoked correspondence with a one for one exchange of pennies. Following Piaget's procedures of questioning the children for understanding of concepts, this researcher questioned two groups of kindergarten children to determine levels of concept maturity. Background characteristics of the children were examined to discover whether or not conservation correlated with nursery school experience, chronological age, IQ, and place in the family constellation.

A second assumption held by many educators is that additional readiness work will enhance a child's performance in a given field. This second assumption was also tested. Authorities differ on what constitutes readiness and therefore there are also differences about what constitutes readiness training. To many educators, readiness education is as much education as the child is capable of absorbing. In an article in Today's Education, James L. Hymes, Jr. gives his suggestions for an educational program for young children. He says:

> But if the program is worth its salt, it isn't teaching readiness. It is teaching as much reading as every child is ready for. It is teaching science, mathematics, art, and social studies (1970, p. 34).

Another view of readiness is that of Irving Adler. He states his position in an article in The Mathematic's Teacher:

> How do pupils learn? The art of teaching must be based on an adequate theory of learning. The child has growth directed by the teacher. It is true that we should not teach the child what he is not ready for, but we should not wait passively for him to become ready. We should actively help him to become ready (1966, p. 707).

The amount and kind of readiness education differs according to the views that the educators hold about development and potential interests and abilities of children. Most educators hold the view that some form of readiness training should be started in the pre-primary years. Men like Jerome Bruner advocate teaching some aspects of mathematics at each grade. In an article in The Arithmetic Teacher, George W. Schlinsog questions Bruner's statement about teaching "real" mathematics to kindergarten children. He examines kindergarten reforms and concludes that there are many concepts that a young child can learn (1967).

Some form of mathematics in kindergarten is advocated by most authors. Educators specify many goals for kindergarten, and mathematics education is usually one of them. Gilstrap and others see the curriculum in the kindergarten as a liberal arts curriculum that emphasizes science and the humanities, but also includes mathematics (1970). The educator Helen Heffernan also emphasizes mathematics in kindergarten. She sees the role of a kindergarten as one that increases a child's ability in the use of mathematical symbols and processes (1970).

Studies are being initiated to determine the number concepts held by children upon entry into kindergarten. Studies by Dutton (1963) and Heard (1970) indicate that there is a wide disparity in the number concepts held by young children. These authors suggest the need for curriculum reform so that an adequate foundation can be established in kindergarten.

The second assumption tested in this study pertains to whether or not increased mathematics information does, in fact, result in increased understanding and better performance of children in the area of arithmetic.

The manner in which these assumptions were tested is explained in Chapter III, Methodology and Research Design.

Statement of the Problem

The study was designed to examine the following general questions: to what extent, if any, does the acquisition of conservation affect mathematics performance in kindergarten; what effect does added mathematics instruction have on arithmetic achievement in kindergarten? The study also attempts to ascertain the characteristics in a child's background that may be related to the concept of conservation as described by Piaget. The characteristics utilized in this study are: IQ, chronological age, place in family constellation, and nursery school experience.

Significance of the Study

The significance of the study emerges from the testing of assumptions that are held by many educators in the field of early childhood education. By testing these assumptions new understanding may develop that would determine the kind of curriculum courses that are most suitable for kindergarten.

In recent years curriculum builders and educational innovators have attempted to design programs that instill relevance at all school levels. The structure of subject matter has been studied in order to present meaningful material at every level. Kindergarten has gained acceptance by many school systems as an integral part of the elementary school, with a resultant concern about curriculum needs for this level.

American curriculum development tends to push subject matter downward. At a conference to determine the relationship of cognitive studies and curriculum development which was held at Cornell University in 1964, Lee Cronbach presented a paper on learning research and curriculum development. In the paper he stated:

> Prominent in American curriculum development has been a stress on pushing topics downward. As Professor Piaget has said, whenever you tell Americans about some process of development, their first question is "How can you accelerate it?" It has been the spirit of many of the curriculum innovators to say "If this is worth teaching at the ninth grade level, why can't we teach it in kindergarten?" (1964, p. 74).

If the education of the "whole" child is the real goal of educators today, planning and research must lay a foundation for a meaningful kindergarten curriculum. Subject matter inappropriate for the young child must not be "pushed down," but thought must be given to the child's interests and capabilities.

The psychologist Jean Piaget has devoted many years of study to the cognitive development of young children. In an interview with Elizabeth Hall reported in Psychology Today, Piaget expressed the belief that much time in school is spent teaching things that don't have to be taught. Piaget gave the following example about education:

> As for teaching children concepts that they have not attained in their spontaneous development, it is completely useless. A British mathematician attempted to teach his five-year-old daughter the rudiments of set theory and conservation. He did the typical experiments of conservation with numbers. Then he gave the child two collections and the five-year-old immediately said those are two sets. But she couldn't count and she had no idea of conservation (1970, p. 30).

Cronbach and Piaget have expressed the concerns about the education of children that are felt by many educators. Milton Schwebel, in the book Who Can Be Educated?, stresses the importance of reaching young children:

> Assessment and teaching should begin early in the life of the child, as early as the first year. Nobody who values life and health questions the desirability of regular medical examinations beginning in early infancy. . . . Now the time has come for infants and children to have careful attention given to their mental development on a regular schedule. Normal growth of the intellect is obviously as important as that of the body (1968, p. 238).

With modern statistical instruments for measuring learning concepts, educators no longer need to rely on subjective evaluation. Studies by Heard (1970), Williams (1965), as well as others have investigated the number concepts kindergarten entrants possess in order to provide a foundation on which to build a more meaningful curriculum. Educators such as Robert Rea and Robert Reys (1970) have constructed instruments to evaluate mathematical concepts in young children. Studies such as the ones mentioned above are aimed at providing information that will help educators secure better educational programs for school children. This study hopes to make a contribution to such programs by investigating the characteristics that affect cognitive development.

Summary

This study is concerned with testing two assumptions which are apparently held by many early childhood educators. The first assumption involves the concept of conservation as defined in Piaget's psychological theory that conservation is a necessary factor in the understanding and performance of mathematical functions. Characteristics such as chronological age, nursery school experience, IQ, and place in family constellation will be examined in an effort to relate these factors to a stage of concept maturity in the child.

The second assumption concerns whether or not acquisition of mathematical understanding and achievement in kindergarten children is related to the amount of mathematics information presented to the child. Some educators feel that increasing amounts of mathematics information should result in better arithmetic performance by the kindergarten child.

The need to test the two stated assumptions was demonstrated from statements found in literature about early childhood education and from educators who encourage the investigation of evaluative research.

CHAPTER II

RELATED LITERATURE

This chapter contains four sections. In the first section, the theoretical framework for the research is given. The second and third sections are concerned with a review of the literature that investigates conservation studies and training studies in the acquisition of conservation skills. The chapter concludes with a section about the implications that conservation studies have for the kindergarten curriculum.

Psychological Background for the Study

Research for this study is based on the theory of cognitive development formulated by Jean Piaget. Piaget is a developmental psychologist who believes that the study of ontogenetic change is valuable, and he has devoted much of his research to the area of the structure of developing intelligence. Flavell states Piaget's principal scientific aim as:

> . . . he is primarily interested in the theoretical and experimental investigation of the qualitative development of intellectual structures (1963, p. 15).

Piaget begins his discussion on the nature of intelligence by postulating that its origin is both biological and logical. He says:

> Every psychological explanation comes sooner or later to lean either on biology or logic. . . . Formal logic, or logistics, is

> simply the axiomatics of states of equilibrium or thought, and the positive science corresponding to this axiomatics is none other than the psychology of thought (1959, p. 3).

Piaget's developmental approach involves the careful description and theoretical analysis of successive ontogenetic states in a specified culture. Behavior change from stages that are simple to stages that are more complex are noted and compared. Underlying such changes is a theory of equilibrium.

An important feature of Piaget's theory is the study of the structure of developing intelligence as opposed to its content and function. Piaget calls raw behavioral data content. Function is concerned with the broad characteristics of intelligent activity that defines the core of intelligent behavior. Between function and content, cognitive structures that change with age exist. The study of these structures is the main aim of Piaget. In the book The Developmental Psychology of Jean Piaget, John Flavell defines these structures in the following way:

> . . . the organizational properties of intelligence, organizations created through functioning and inferrable from the behavioriable contents whose nature they determine (1963, p. 17).

Flavell gives a more concise definition of the terms function, content and structure. He explains that:

> . . . function is concerned with the manner in which any organism makes cognitive progress; content refers to the external behavior which tells us that functioning has occurred; and structure refers to the inferred organizational properties which explain why this content rather than some other has

emerged (1963, p. 18).

The factor of equilibration plays a major role in relating the constructs of the theory of Piaget. He defines structural characteristics in algebraic terms and explains them by a theory of equilibrium. Piaget says that intelligence is:

> . . . the form of equilibrium toward which all the structures arising out of perception, habit, and elementary sensori-motor mechanisms tend (1959, p. 6).

The role of equilibration is described as follows:

> This is what I call the factor of equilibration. Since there are already three factors they must somehow be equilibrated among themselves.[2] That is one reason for bringing in the factor of equilibration. There is a second reason, however, which seems to me fundamental. It is that in the act of knowing, the subject is active, and consequently, faced with an external disturbance, he will react in order to compensate and consequently he will tend towards equilibrium. Equilibrium, defined by active compensation, leads to reversibility. Operational reversibility is a model of an equilibrated system where a transformation in one direction is compensated by a transformation in the other direction. Equilibration, as I understand it, is thus an active process. It is a process of self-regulation (1964b, p. 13-14).

The experiments used in this study are based on Piaget's concept of conservation. A child goes through three stages of behavior in the development of his ability to arrive at the notion of conservation. The first stage shows a lack of conservation. In this stage a child thinks that the amount of a substance diminishes

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[2] Piaget is relating the factors of maturation, experience, social transmission, and equilibration to one another.

according to the size or the number of containers. In the second stage, that of intermediate behavior, a child understands that the total remains the same in spite of rearrangements of the parts in one situation but not in another. He is not sure and often changes his mind. In the third stage, that of conservation, the child is not fooled by changes. He has grasped the concept of conservation and has moved from the stage of pre-operational to the stage of concrete operations, and he knows that the whole remains the same irrespective of rearrangement of the parts. He has grasped the concept of reversibility, and he understands that the total remains the same regardless of how elements of the total are moved. Piaget lays the groundwork for the concept of the stages in conservation by the following statement:

> This process of equilibration takes the form of a succession of levels of equilibrium, of levels which have a certain probability which I shall call a sequential probability, that is the probabilities are not reached a priori. There is a sequence of levels. It is not possible to reach the second level unless equilibrium has been reached at the first level, and the equilibrium of the third level only becomes possible when the equilibrium of the second level has been reached, and so forth. That is, each level is determined as the most probable given that the preceding level has been reached. It is not the most probable at the beginning, but it is the most probable once the preceding level has been reached (1964b, p. 14).

Piaget sees each stage in the development of thought as blending into one another. Each stage encompasses the preceding one. He explains his concept of the term intelligence:

> Every structure is to be thought of as a particular form of equilibrium, more or less stable within its restricted field and losing its stability on reaching the limits of the field. But these structures, forming different levels, are to be regarded as succeeding one another according to a law of development, such that each one brings about a more inclusive and stable equilibrium for the processes that emerge from the preceding level. Intelligence is thus only a generic term to indicate the superior forms or organization or equilibrium of cognitive structurings (1959, p. 7).

Piaget, then, believes that intelligence does not consist of an isolated class of cognitive structurings. He sees intelligence as involving a radical functional continuity between thought and motor adaptation. The construct of adaptation in the development of the psychological theory of Piaget is explained in the book, Psychology of Intelligence. Piaget introduces the concept of adaptation and develops the role that it plays in the growth of intelligence:

> This view means, right from the start, an insistence on the central role of intelligence in mental life and in the life of the organism itself; intelligence, the most plastic and at the same time the most durable structural equilibrium of behavior, is essentially a system of living and acting operations. It is the most highly developed form of mental adaptation, that is to say, the indispensible instrument for interaction between the subject and the universe when the scope of this interaction goes beyond immediate and momentary contacts to achieve far-reaching and stable relations. But, on the other hand, this use of the term precludes our determining where intelligence starts; it is an ultimate goal, and its origins are indistinguishable from those of sensori-motor adaptation in general or even from those of biological adaptation itself (1959, p. 7).

The biological concept of adaptation on which Piaget builds his theory consists of two processes--assimilation and accommodation--which are called "functional invariants." These invariant characteristics define intellectual functioning and are the characteristics that hold for biological functioning in general (Flavell, 1963). Piaget describes adaptation as "an equilibrium between the action of the organism on the environment and vice versa" (1959, p. 7). Adaptation is the interplay between the process of "assimilation" and "accommodation." Assimilation describes the action of the organism on surrounding objects (Piaget, 1959). An example of assimilation is when a child acts on an object in relation to his previous experience. A child comes in contact with a ring suspended above his crib. He makes a series of exploratory accommodations such as touching or moving the ring. Piaget says that the ring is assimilated to the concepts of touching and moving and that these concepts are already part of the child's cognitive organization. The child's actions in touching and moving the ring are accommodations of these structures to the reality of the ring as well as assimilation of a new object to these concepts (Flavell, 1963). The child in turn learns new concepts as he interacts with the ring. Piaget believes that intellectual activity begins with physical-motor actions upon the environment. He makes the following statement:

> Mental assimilation is thus the incorporation of objects into patterns of behavior; these patterns being none other than the whole gamut of actions capable of active repetition (1959, p. 9).

He further postulates the converse action, that of the environment acting on the organism as accommodation so that adaptation is then defined as "an equilibrium between assimilation and accommodation" (1959, p. 8).

A further clarification of the term assimilation was made by Piaget at a conference held at Cornell University in March of 1964. Piaget stated:

> My second conclusion is that the fundamental relation involved in all development and all learning is not the relation of association. In the stimulus-response schema, the relation between the response and the stimulus is understood to be one of association. In contrast to this, I think the fundamental relation is one of assimilation. Assimilation is not the same as association. I shall define assimilation as the integration of any sort of reality into a structure, and it is this assimilation which seems to me fundamental in learning (1964b, p. 18).

The construct of "schema" is essential to building an understanding of the concepts of Piaget's theory. Flavell defines a schema as follows:

> . . . a cognitive structure which has reference to a class of similar action sequences, these sequences of necessity being strong, bounded totalities in which the constituent behavioral elements are tightly interrelated (1963, p. 53).

An example of an elementary schema is that of the grasping behavior of a child reaching for a rattle. There would be reaching, finger curling, and retracting. Such behavior makes up an interrelated unit of behavior that in turn leads to behavior that is more complex. The implication is that assimilatory functioning has generated a cognitive structure that will be disposed to grasp objects on repeated occasions. Behavioral sequences called schemas also exist in middle childhood and adolescence. An example of middle childhood schema is that of the intuitive qualitative correspondence behavior that a child uses to assess the numerical equivalence of two sets of elements (Flavell, 1963).

Piaget bases his theory about cognitive structures on the Bourbaki school that investigated the fundamental structures common to all the different branches of mathematics. In a lecture at a conference at Cornell University, Piaget explained the foundation for his thought about structures:

> Algebraic structures are one of three kinds distinguished by the Bourbaki [school]. The algebraic structures are based on operations whose prototype is in the group. The fundamental characteristic of these algebraic structures is the possibility of combining a direct operation with an inverse operation and thus to negate it. In other words, the form of reversibility characteristic of algebraic structures is what I call reversibility by inversion or negation. It negates and thus gives a null product when the direct operation and the inverse operation are performed jointly.
>
> The second type of basic mother structure includes all the ordering structures. The ordering structures are based on relations. The prototype is the lattice structure. The form of reversibility which characterizes lattices is not inversion in the sense of negation as is the case with algebraic subjects but rather is what we call in psychological language reciprocity . . . . The upper limit succeeds the lower limit.
>
> The third mother structure is a set of topological structures based on the concepts or proximity, continuity, continuous correspondence, limits, etc. (1964b, p. 34-35).

To Piaget, these operational structures are the basis of knowledge. He sees as the problem of development, the understanding of the formation, elaboration, organization, and function of these structures. He states the following belief: "Now I maintain that these structures correspond to something in natural intelligence and specifically in the thought of a child" (1964b, p. 35).

Essential to the understanding of the psychological theory of Piaget is his conceptualization about totalities and the equilibria that characterize such structures:

> . . . any structure consisting of parts and a whole containing these parts had three possible forms of equilibrium--predominance of the parts with consequent deformation of the whole, predominance of the whole, with consequent deformation of the parts, and reciprocal preservation of both whole and parts. Of the three, only the last is a good and stable equilibrium (Flavell, 1963, p. 2).

In the book, The Nature of Intelligence, Piaget discusses the "groupings" that make up the structures of thought. Intellectual activity starts with physical actions upon the environment. A mental structure is formed when the action is internalized. As the continuous assimilation of reality to intelligence develops, thought is in disequilibrium or in a state of unstable equilibrium. Adult structure can be described as a mobile equilibrium that can perform the following logical operations:

1. Combinativity: $x + x' = y$; Any two elements of a grouping can be combined and produce a new element of the same grouping

2. Reversibility: $y - x = x'$; $y - x' = x$ Each operation implies a converse operation; subtraction for addition, multiplication for division

3. Associativity: $(x + x') + y' = x + (x' + y') = (z)$; Thought

		remains free to make detours and a result obtained in two different ways remains the same in both cases
4. Identity:	$x - x = 0$; $y - y = 0$	An operation combined with its converse is annulled

(1959, p. 37-42).

According to Piaget, the development of mental structure can be partioned into stages of behavior. The stages must possess certain properties;

1. They must emerge in development in a constant, unchanging sequence.
2. They must be invariant.
3. They are hierarchial; each stage is incorporated into the following stage.
4. The structural properties which define a given stage must form an integrated whole (Flavell, 1963).

Piaget postulates that the operations of thought reach stable equilibrium when they are formed into groupings that are characterized by reversible combinativity.

According to Piaget, intellectual development proceeds through four main developmental stages from birth to maturity. These main stages are: sensori-motor, pre-operational, concrete operations, and formal operations. Each main period has several substages. Children pass from stage to stage but the amount of time a child remains at a specified level varies with each individual and is often influenced by specific cultures.

The first stage is the sensori-motor stage. This is a period from birth to about two years of age.[3] In this period a child moves from simple innate reflex actions to relatively organized sensori-motor actions. By the end of the period the child understands that an object continues to exist even though the object may be out of the child's immediate area of perception. The child is capable of reversibility and associativity in actions. He understands that a toy continues to exist even when he can no longer see it.

The second major stage is the pre-operational level. It has two subperiods. The first subperiod (from about two until four) has the development of symbolic function, symbolic play and imitation, and internalizing of language takes place. The second subperiod is the intuitive period; this is the beginning of real thought groupings. The child is between the ages of four and seven. At this period the child accepts the constancy of a relation in one set of objects but not in another. He may believe that pennies that are stretched wide apart are more in number than pennies that are grouped close together. He has a limited amount of conceptual activity and is still governed, sometimes, by perceptual appearances.

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[3] All ages are relative to the specified culture.

The third major stage is that of concrete operations. The child is between the ages of seven and eleven. The previous subperiod has its culmination in this period. The child's basic concepts are organized into stable structures. Using concrete materials, the child can perform the logical operations of conservation, reversibility, associativity, and identity on objects (Adler, 1964).

The period of formal operations encompasses the ages of 11 to 15. During this period there is a new and final reorganization based on the groups and lattices of algebra. The child can deal with reality as well as the abstract world of possibility. He has the ability to mentally conceptualize and formulate solutions to problems.

In the book The Psychology of Intelligence, Piaget summarizes the stages in the construction of operations:

> In order to arrive at the mechanism of this development, which finds its final form of equilibrium in the operational groupings, we will distinguish (simplifying and schematizing the matter) four principal periods, following that characterized by the formation of sensori-motor intelligence.
>
> After the appearance of language, or more precisely, the symbolic function that makes its acquisition possible (1-1/2 to 2 years) there begins a period which lasts until nearly 4 years and sees the development of a symbolic and preconceptual thought.
>
> From 4 to about 7 or 8 years, there is developed as a closely linked continuation of the previous stage, an intuitive thought whose progressive articulations lead to the threshold of the operation.
>
> From 7-8 to 11-12 years "concrete operations" are organized, i.e., operational groupings of thought concerning objects that

can be manipulated or known through the senses.

> Finally, from 11-21 years and during adolescence, formal thought is perfected, and its groupings characterize the completion of reflective intelligence (1950, p. 123).

In The Child's Conception of Number, Piaget sets two main goals; the demonstration of the stages in the development of certain concepts, and the demonstration of the development of a conceptualizing ability that lies beneath the formation of a concept. Piaget has as an hypothesis in this book that:

> . . . the construction of number goes hand in hand with the development of logic, and that a pre-numerical period corresponds to the pre-logical level (1964, p. 8).

When the child is at the pre-numerical level, he is at the pre-operational stage, where his understanding is influenced by manipulations and size of the objects that he sees. As he grasps the notion of conservation, he moves to the stage of concrete operations.

A foundation for the development of cognition is the ability of a child to understand the idea of conservation. Piaget states:

> Every notion, whether it be scientific or merely a matter of common sense, presupposes a set of principles of conservation, either explicit or implicit (1964, p. 3).

A child must understand that a collection will remain the same even when some of the elements within the collection are rearranged. Crucial to a discussion of conservation is Piaget's idea of an operation.

> . . . to understand the development of knowledge, we must

> start with an idea that seems central to me--the idea of an operation. Knowledge is not a copy of reality. To know an object, to know an event, is not simply to look at it and make a mental copy or image of it. To know an object is to act on it. To know is to modify, to transform the object, and to understand the process of this transformation, and as a consequence to understand the way the object is constructed. An operation is thus the essence of knowledge; it is an interiorized action which modifys the object of knowledge. For instance, an operation would consist of joining objects in a class, to construct a classification. Or an operation would consist of ordering, or of putting things in a series. Or an operation would consist of counting, or of measuring. In other words, it is a set of actions, modifying the object, and enabling the knower to get at the structure of the transformation.
>
> An operation is an interiorized action. But in addition, it is a reversible action; that is, it can take place in both directions, for instance, adding, or subtracting, joining or separating. So it is a particular type of action which makes up logical structures (1964b, p. 8).

A child must understand that a collection will remain the same even if the elements in a collection are rearranged. In one of the experiments for this study, a child is asked to put an equal number of beans in two jars. His ability to understand conservation is judged by whether or not he knows that the total number of beans remains constant when the beans are moved from container to container. Piaget calls this ability "conservation of discontinuous quantities." Piaget states:

> A set or collection is only conceivable if it remains unchanged irrespective of the change occurring in the relationship between the elements. For instance, the permutations of the elements in a given set do not change its value. A number is only intelligible if it remains identical with itself, whatever the distribution of the unit of which it is composed. A continuous quantity such as length or volume can only be used in reasoning if it is a permanent whole, irrespective of the possible

arrangements of the parts (1964, p. 3).

The ability of a child to understand conservation moves him from the stage of pre-operational representation, a stage characterized by the beginnings of language, of thought, when a child is still governed by actions, to the stage of concrete operations. Piaget defines the role of conservation in these two stages:

> In a second stage, we have pre-operational representation--the beginnings of language, of the symbolic function, and therefore of thought, or representation. But at the level of representational thought, there must now be a reconstruction of all that was developed on the sensory-motor level. That is, the sensory-motor actions are not immediately translated into operations. In fact, during all this second period of pre-operational representations, there are as yet no operations as I defined this term a moment ago. Specifically, there is as yet no conservation which is the psychological criterion of the presence of reversible operations. For example, if we pour liquid from one glass to another of a different shape, the pre-operational child will think there is more in one than another. In the absence of operational reversibility, there is no conservation of quantity (1964b, p. 9).

A second experiment used in this research was that of one to one correspondence. It was a replication of one of Piaget's experiments when children were asked to exchange flowers for pennies. The flowers were bunched together, or spread apart, and the child was asked to make judgements about the amount of flowers compared to the amount of pennies. Piaget maintains that children's ability to count has little relationship to his ability to judge equivalence. In Mathematical Epistemology and Psychology, co-authored by Evert Beth, this is explained:

> . . . we generally mean by this that the early part of this infinite series corresponds to a certain group of everyday concepts expressed in language by the numbers "one," "two," "three," etc. either in speech or writing. This is a superficial view, for a child may be able to count up to 10 or 20 without yet possessing the operations without which we could not talk of number (for example, the bi-univocal correspondence between two collections of six objects, with the preservation of equivalence when the objects are no longer opposite one another) (1966, p. 166).

The research for this study, therefore, was based on Piaget's concept of conservation and its importance in the development of thought. His experiments were replicated and note was made of the stage of conservation of each child. This in turn was related to mathematics readiness training in kindergarten and an attempt was made to draw conclusions about the efficacy of readiness arithmetic training in kindergarten.

Conservation Studies

Piaget has introduced a comprehensive, conceptual framework for studies about cognitive functioning. Specifically he has concerned himself with the developmental stages in the acquisition of concepts in the areas of mathematics, including studies of number, volume, time, and space. Because Piaget has focused his attention on the young child, his work has relevance and implications for elementary school curriculum. In addition to a theory specifying human behavior as it relates to cognitive processes, Piaget has developed techniques to study the growth and development of thought in children.

Basic to Piaget's theory is the ability of an individual "to conserve" number and quantity. This ability to conserve is apparent when a child grasps the mathematical idea that number is not changed when a set of objects is separated into subgroups or that a total mass or substance does not change when the shape or appearance of an object is transformed. The attainment of this ability, the understanding of the concept of conservation, according to Piaget's theory, marks a transition in thinking from intuitive, subjective thought to a more adult like kind of cognition. In Piaget's theory the ability to count is different from a true understanding of number. Piaget believes that the child's concept of number develops concurrently with the growth of logic. In order to determine the level of a child's concept of maturity of thought, Piaget has developed procedures or experiments that determine the stage of a child's thinking.

The experiments introduced by Piaget are relatively easy to perform and many studies have replicated his work and given support to his findings. The experiments are conducted in the following manner: the investigator interviews each child independently, asking the child to predict an outcome based on the child's manipulations of familiar objects, such as dolls, pennies, clay, or beads. An example of a commonly replicated experiment is one concerning a ball of clay. The clay is changed in shape to a long sausage-like object and the child is queried as to whether or not there has been a gain or loss of total material with the change of shape. A child that has not arrived at the state of conservation will answer that the long object is more or less than the original ball. A child in the intermediary state of conservation may believe that the sausage shape is the same total substance as the ball, but if the original ball is transformed into two balls, the child may now believe that somehow the first ball of clay has grown in quantity. A child that understands conservation (around the age of seven years) is not fooled by any change of shape. He understands that the original ball of clay retains the same total amount of substance regardless of any transformations.

Piaget has described experiments to discover concept maturity by using continuous quantities. In this experiment the child fills two equal sized containers with water or a colored liquid. The glasses are poured into containers that may be tall and thin or short and wide. The child is asked questions in order that the investigator can determine if the child believes that the total constancy of the substance has changed with the shape of the container. A young child (or a retarded person) has no conception of quantity. He believes that the total material has grown or diminished with the shape of the new container, because the level in the container is higher or lower. At about six years of age, the child reaches the intermediary stage. The child is undecided. Sometimes he is convinced that the total remains constant and then again he believes that the total changes with a new container. Sometimes the constancy of the quantity is apparent and sometimes the child's judgement is swayed by his perception of the levels in the glasses. When the child has arrived at the notion of conservation, levels of various heights in containers do not influence his judgement. He understands that the total amount of liquid remains constant in spite of transformations that occur.

Similar experiments are conducted with discontinuous quantities such as beads. The child counts out an equal number of beads into two similar glasses. The beads are poured into containers of various shapes. The child arrives at the various levels of understanding of conservation in spite of the fact that he has counted out an equal number of beads at the start of the experiment.

Educators often believe that if a child can count he has an understanding of what number means. In one of Piaget's experiments he investigates this hypothesis. The child is asked to match objects to establish a one to one correspondence. Provoked correspondence experiments match eggs with egg cups and flowers with vases. The child matches a row of objects to correspond with the row made by the investigator. If the objects in one row are spread wide apart or bunched close together, young children believe that the total has altered and that someone has more or less than before. Counting out loud does not help. The older child realizes that lengthening the space between objects does not alter the total amount of objects that exist. The child understands the concept of number and disregards the perceptual experience.

Piaget has other experiments using the concept of seriation or ordinal correspondence. Children are asked to match ten dolls of graduated sizes with ten rods of various lengths. The child inserts lengths of rods to continue the series. Piaget's conception of number involves the principles of classification and seriation. Number is the system of grouping involving classification based on similarity and seriation based on cumulative differences. For example, the number seven has two basic properties. Its cardinal (classificatory) property is its sevenness; it is a class of events between six and eight. The child must learn to coordinate these two concepts (Adler, 1964). In the child's growth of concept maturity he again proceeds through the stages of conservation as described by Piaget.

Many studies have investigated the concept of conservation--the ability of an individual to be aware of the invariant properties in face of transformation. In Piaget's theory, conservation is a central prerequisite for the development of logical thought. Various studies have replicated Piaget's experiments in order to validate his findings. With the exception of the study by Betsy Worth Estes, the studies are supportive of the sequence of conservation skills although researchers differ in conclusions about the ages necessary to obtain these skills.

Estes conducted a study on 52 four and five year olds, to determine whether Piaget's results about the formation of mathematical and logical skills could be confirmed. Her study did not support his findings as to the development of stages or age levels in the acquisition of mathematical and logical concepts (1956).

P. C. Dodwell (1960) tested 250 children between the ages of five and eight in a study to refute the investigation by Estes. The experiments carried out the familiar Piaget type articles of beakers and beads, eggs and egg cups, red and blue poker chips. The experiments tested the relation of perceived size to number, provoked correspondence, unprovoked correspondence, cardination, and seriation. The study confirmed Piaget's contention that young children do not fully understand the concept of number even though they may be able to count. His findings therefore differed from Estes', who stated that children are either able to count and can deal operationally with situations very similar to those used in the experiment or they cannot count and do not respond in terms of number. Dodwell's investigation related intelligence, as well as age, to the level of concept maturity. He also determined that the stages do not always follow in the sequence Piaget's theory requires. Dodwell stipulates that in order for a child to understand number, he must be able to manipulate and make judgements about perceived objects in such a way that (a) the order or perceived pattern of elements in a group of objects does not influence judgements about the number of objects present, and (b) the child should be able to arrange objects in series according to some obvious criterion such as size and he should be able to deal with ordinal correspondence between different series.

David Elkind developed a series of studies devoted to the systematic replication of Piaget's experiments. The first study in May of 1959, Elkind tested 80 school and pre-school children to determine the stage of concept maturity held by the children in experiments involving comparisons of quantity using different materials. He found that success in comparing quantities varied with age, type of quantity, and type of material. The results were in close agreement with Piaget's findings that success in comparing quantity developed in three age related, hierarchically ordered stages (1961a).

In the second study by Elkind in a series replicating Piaget's work, Elkind tested Piaget's hypothesis dealing with the ages that children discover the conservation of volume, mass, and weight (1961b). The sausage experiment with clay was used to determine the child's understanding of whether or not the quantity of the substance remained the same in spite of transformations in shape. Piaget has stated that conservation was related to age (1964); that conservation of mass is discovered about seven or eight; weight is discovered at nine or ten; and conservation of volume at about eleven or twelve. Piaget reported his findings by giving many examples of children in varying stages of conservation. Elkind replicated the work with 175 subjects, varying in ages from kindergarten to sixth grade, to provide statistical evidence for Piaget's concept of conservation. Elkind's study agreed with Piaget's findings regarding the ages at which children discover the conservation of mass, weight, and volume. In both of Elkind's studies, conservation of mass did not appear before seven or eight, weight before nine or ten, and volume by eleven or twelve.

The attainment of conservation of substance around the age of seven, weight around the age of nine, and volume around the age of eleven first described by Piaget and Inhelder has been confirmed by Carpenter (1955), Elkind (1961a, b), and Lovell and Ogilvie (1960). The studies of Carpenter (1955) and Lovell and Ogilvie (1960) have suggested that children who demonstrate conservation of a particular concept with material like the clay balls do not show conservation of the same concept when some other material is used. Ina C. Uzgiris (1964) initiated a study to investigate the effect of varying the materials used to test the conservation of substance, weight and volume on the observed sequential attainment of these concepts. One hundred and twenty children, from first through sixth grade, made up the sample. Four materials were used in the experiment: plasticine balls, metal nuts, wire coils and straight pieces of plastic covered wire. In general, the study supported Piaget's theory of sequential intellectual development of conservation of substance, weight, and volume.

Lovell and Ogilvie (1960) tested 116 children in order to validate Piaget's findings regarding the stages of conservation of substance. The researchers found strong evidence to support the three stages as proposed by Piaget but found that the stages were not "clear cut." Stages overlapped causing confusion. The investigators made some statements about verbal confusion that exists in the conservation studies that concern young children. The child's interpretation of words such as shorter, longer, the same, fatter often cause the researcher to assume a biased conclusion. In the book, The Underachieving School, John Holt criticizes the conservation studies based on Piaget's theory because of verbal confusion that arises over the children's language in response to questions from the investigator. Holt believes that Piaget misinterprets what the children are trying to say:

> When we try to predict reality, by manipulating verbal systems of reality, we may get truth; we are more likely to get nonsense (1969, p. 8).

Replications of Piaget's experiments have resulted in support for his ideas, but questions and criticism of techniques of questioning and reporting have been made by many investigators. Various researchers have attempted to develop new methods to improve the experiments.

Griffiths (1967) developed a study to determine the ability of pre-school children to use the terms "more," "same," and "less" often used by children in responding to conservation tasks. She found that the children had the most difficulty in using the term "same" correctly. Her conclusions were that a child's failure at conservation tasks may result because he does not understand the relational terms and because the structure of a question may elicit a specific response.

Smedslund (1963) criticized an experiment in conservation tasks performed by children in a study developed by Martin Braine (1964). The words "longer than" were the real point of controversy. Braine was studying the development in children of a grasp of the transitivity of the relation "longer than"; that is the child's ability to infer from observation that A is longer than B. Braine answers Smedslund by stating what he considers the real issue, that is the specification of the process with which Piaget's theory deals. Braine feels that a consensus about the kinds of experimental procedures needed to elicit responses from the children must be reached by examiners of Piaget's theory.

Figenbaum (1963) criticizes the procedures used by Piaget in reporting his studies:

> Nowhere does he [Piaget] tell his reader exactly what he said to all his subjects, how many children he employed in the sample, how many succeeded or failed to comprehend the conservation principle at each level or what the IQ of the subjects were. Nor does he give any idea as to the standard of the material used (i. e., how many beads were employed, their sizes, the dimensions of the glasses used). These variables are relevant if they influence the empirical data upon which Piaget's theory is based (1963, p. 424).

Figenbaum developed a study to test whether Piaget's explanation emphasizing logical operations occurring in the invariable age-stage system was sufficient to account for success or failure in understanding the principle of conservation. In his study, he sampled 90 children in nursery school and elementary school on the conservation tasks. He found an overlapping in the stages of development in the acquisition of the conservation principle and he found that the factor of IQ had a positive relation to the concept of conservation.

Other writers have also commented on techniques that may influence the results in the conservation experiments. Duckworth (1964) comments on variations in question phrasing that influence significantly performance in certain number tasks.

Differences in procedures that have been employed to study conservation is a concern of Gruen (1966). He suggests that efforts should be made to reach a general consensus on the definition of conservation to lessen some of the confusion that has resulted in experiments to determine levels of concept ability about conservation. Goldschmid (1968a) is also concerned over the lack of consistency in conservation tasks and test procedure. He feels that the lack of uniformity in procedures makes the comparison of research studies a particulary difficult task. In a study that he initiated he evaluated tasks proposed to measure conservation and from the evaluations he constructed a conservation scale with sound statistical properties.

Pratoomraj (1966) investigated the influence of a kind of question concerning conservation and the effect it might have on the level of concept maturity obtained by performing a conservation task. He tested 32 children, from four to seven years of age. The proportion of children's conservation responses were not significantly influenced by the kind of questions asked by the researchers. On the other hand, opposite conclusions were found by Barbara Rothenberg (1969). She performed a study on 210 pre-school and kindergarten children to investigate methodological issues in the conservation of number. She tried to determine the effect on conservation status by the focus and number of questions asked. The results showed important differences in the number of conservers identified depending on the conservation questions asked and the number of transformations presented.

Dodwell (1962) initiated a study to investigate the extent to which children, in developing concepts of number and conservation, also develop the concept of class of objects and the operations and linguistic skill which allowed them to deal with number classification. He sampled 60 children, from five to eight years of age. Dodwell concludes that unfamiliarity and verbal confusion may be important determinants of a child's responses. He makes a suggestion that researchers provide a situation that is familiar to the child to ensure a minimum of confusion over language.

Braine and Shanks (1965) are also concerned about procedural variables. They believe a child shows conservation in a particular experiment because of procedural techniques that influence his understanding of instructions.

In addition to procedural differences, writers have been concerned with other environmental variables that have an influence on the child's acquisition of conservation skills. Tajfel and Winter (1963) investigated Piaget's suggestion that children three to five years old have not yet become operationally distinct about the concepts of number and size. The researchers undertook a study on two groups of pre-school children to test the hypothesis that estimated magnitudes and values of stimuli. They matched the size of the counters before the counters had been associated with rewards and again after this association was established. The rewards were disrupted and then reinstated. One group had a one to one correspondence between the number of counters and the rewards. The other group did not. The amount of the reward influenced the children's concept of size and number.

Murray (1970) attempted to test conservation acquisition in relation to concreteness of materials. His hypothesis was that if the conservation stimuli were of differing degrees of abstractness, one might expect that the acquisition of conservation behavior would be facilitated when the stimuli were more concrete rather than abstract. Although he presented stimuli with varying degrees of concreteness, no significant difference in responses was found.

The influence of characteristics in the child's personality as it relates to the concept of conservation has been studied by Goldschmid (1968b). He studied the factors of anxiety, self description, peer and teacher rating, and parent attitude and the relation these aspects have to conservation. He believes that specific aspects of the child's personality co-exist with conservation and possibly foster its development.

Cultural influences have also been a source of study in the conservation literature. The man made part of the environment that creates differences in modes of thinking has been studied by Goodnow (1966), Greenfield (1966) and others. Goodnow and Bethon (1966) compared a group of Chinese boys with no schooling to a group of European schoolchildren. The conservation tasks involving weight, volume, and surface were used by the children. The findings indicated that the unschooled Chinese boys did as well as the European schoolchildren on the assigned tasks.

Egon Mermelstein and Lee Schulman (1967) conducted a study of Negro six and nine year old children from Prince Edward County, Virginia. This community had been without public schools for four years at the time of the study. These children were given the Piagetian conservation tasks to perform and the results were compared to results in a Negro community that had a regular school. The findings indicated that there were no significant differences attributable to effects of non-schooling.

Duckworth (1964) and Hood (1962) report findings that suggest a wide range of experiences in play and school facilitate the acquisition of conservation by children. Almy, Chittenden and Miller (1966) report the importance of socio-economic level on conservation. Their study showed that lower class children show conservation of quantity and number later than middle class children.

Studies continue to accumulate evidence about the social and environmental influences that affect the child's development of understanding of number. The mental age of the child or the IQ and its relation to concept maturity of conservation has been studied by Goldschmid (1967) who found that conservation was positively correlated with IQ, MA, and verbal ability. Carpenter (1955) and Dodwell (1960) as well as Figenbaum (1963) also support this hypothesis.

H. Blair Hood, an educational psychologist in England, designed a study to repeat some of Piaget's experiments on number. He was concerned by the criticism that had been made about Piaget's studies which do not relate the conservation tasks to variables such as MA considered important by many investigators. His study's purpose was:

> . . . to determine whether (a) a group of normal English-speaking children and (b) a sample of mentally retarded children and adults would show the same general trends in development of pre number concepts as Piaget's subjects. The factors of mental and chronological age were also

> considered, as well as the relation of stage of development to ability in arithmetic (1962, p. 273).

The sample of normal children contained 61 boys and 65 girls from four to eight years of age. The sample of retarded subjects was boys from 10 to 15 years of age with IQ's below 75 and subjects between 9 and 41 years of age who were mentally defective. The subnormal sample totaled 40 subjects.

The results for the normal sample showed that the pre number concepts develop as the child gains years, but mental stature is primarily important. In the study of the mentally defective subjects, the relation between mental age and stages of development of the conservation concept was apparent.

Education and language development play a role in the acquisition of conservation. Lunzer (1960) investigated questions relating to a child's understanding of volume conservation. He followed procedures used by Piaget to conduct studies to determine the level of maturity a child had about the conservation of volume. Most of his findings supported Piaget's psychological theory, but he found evidence that suggested that education is an important factor in the development of a child's understanding of conservation of volume. Language also interacts in the conservation studies to determine effects. Jerome Bruner reviewed various studies in which culture and language have an impact. In an article in the American Psychologist, he comments on the course of cognitive growth:

> I shall take the view in what follows that the development of human intellectual functioning from infancy to such perfection as it may reach, is shaped by a series of technological advances in the use of the mind. Growth depends upon the mastery of techniques and cannot be understood without reference to such mastery. These techniques are not, in the main, inventions of the individuals who are "growing up"; they are rather, skills transmitted with varying efficiency and success by the culture, language being a prime example. Cognitive growth, then, is a major way from the outside in as well as from the inside out (1964, p. 1).

Bruner cites various studies about conservation and the role played in these studies by language. He suggests that improvement in language skills might help a child in the experiments in which different shaped glasses cause perceptual problems.

The studies cited represent some of the research based on Piaget's experiments to investigate the concept of conservation. Information about the variables that influence conservation may provide a foundation for the development of more effective methods of instruction for young children in mathematical studies. The results of the investigations can give educators insight into cognitive growth in children. How these studies can influence curriculum development in American schools is a matter yet to be determined.

Training Studies in Acquisition of Conservation Skills

In Piaget's theory the environment plays a facilitating role through provisions for necessary stimulation. Flavell (1963) describes the individual and the active role he plays in response to the environment. The individual interacts with reality, takes in information through the process of assimilation, and adjusts to the new knowledge by accommodation. Many researchers have concerned themselves with the learning conditions necessary for the acquisition of conservation skills.

Smedslund, in a series of experiments, investigates the acquisition of conservation through repeated exposure to conflict situations. In an experiment in 1961, he gave subjects who showed no traces of conservation,two training sessions in operations designed to induce conservation. He then attempted to cause extinction to the conservation principles in the two groups of subjects; one had acquired conservation naturally and the other group had acquired conservation through training. He found that the children who had acquired conservation by means of controls had learned only an arbitrary empirical law but the children who had acquired the notion of conservation in a natural way resisted extinction (1961a). In further research Smedslund (1961b, c) devised several studies to determine the learning situations which foster the acquisition of conservation.

Gruen (1965) investigated number conservation using training procedures derived from Smedslund's experiments. The training procedures were designed to induce internal cognitive conflict that would bring about conservation of number in the young child. Ninety nursery school and kindergarten children were used for the experiment. The children were tested on acquisition of conservation before and after training. Subjects in the conflict plus verbal pre training group out performed the group without verbal pre training, but there was very little transfer of training from number conservation to other kinds of conservation. The researcher suggests that the process for conserving each concept is acquired separately and independently.

Winner (1968) devised a study on the acquisition of conservation based on Smedslund's conflict resolution experiments. Kindergarten children who could respond to addition and subtraction changes but were lacking in conservation were divided into three groups: addition and subtraction set training, perceptual set training, and a no training control group. The effect of these training conditions was measured on conflict trials. Only a slight, nonsignificant difference in favor of the groups receiving the conflict trials was noted. The results cast doubt on conflict resolution interpretations of the acquisition of conservation such as those used in Smedslund's experiments.

Wallach and Sprote (1964) also studied the attainment of conservation by young children. Sixty-six first grade children were induced to conservation of number by demonstrations giving the children practice in reversibility of rearrangements. For example, dolls were placed in doll beds to impress upon children the fact that the total quantity remained constant. The study concluded by finding that the training period was effective in inducing conservation.

Wallach, Wall and Anderson (1967) designed an experiment to answer questions that arose from the previous study by Wallach and Sprote (1964). In the earlier experiment by Wallach and Sprote, the researchers indicated that conservation could be induced through experiences with reversibility in certain specified operations. Smedslund (1962) and Wholwill and Lowe (1962) suggest that experiences with addition and subtraction may be critical for conservation. Wallach, Wall and Anderson devised a study to test reversibility experience and experience with addition and subtraction to determine the influence of these factors in the acquisition of conservation. The authors tested a group of young children and concluded that recognizing reversibility and not using misleading perceptual cues are both necessary for conservation. In view of the interpretations suggested by this study, the study by Wallach and Sprote using the dolls and doll beds, reversibility training procedure can no longer be regarded as providing evidence for the recognition of reversibility in conservation. Wallach, Wall and Anderson suggest that the procedures used in the earlier experiment probably provided misleading cues.

Harper, Steffe and Van Engen (1968) also had success in lessons that would enhance a child's ability to conserve numerousness. They define numerousness as:

1. Irrespective of how a set of objects is rearranged the number of objects remain the same.
2. If two sets are in one to one correspondence then the number of objects in each is the same regardless of the arrangement of the objects (1968, p. 13).

The study tested the effect of a sequence of 12 lessons designed to enhance the ability of kindergarten and first grade children to recognize and conserve numerousness. The sample included 754 children in lessons involving one to one correspondence, perceptual rearrangement, as many as, more than, fewer than, additions, and subtractions. The investigators found that for kindergartners, the lessons enhanced the children's ability to conserve numerousness.

Rothenberg (1969) also concluded that conservation of number can be taught to kindergarten age children. In a study including 130 kindergarten children, training in conservation of number through logical sequences of concept was given. The experimental group showed significant growth in conservation. The author found that the training was effective and lasted as long as three months. The children had a significant increase of understanding of the related problem of conservation of quantity.

Wohlwill and Lowe (1962) attempted to determine the process at work in the development of the notion of conservation of number. Seventy-two kindergarten children received four conditions of training on reinforced practice on conservation skills. The results indicated an overall increase in non verbal conservation responses but no significant differences attributable to the conditions of training. Wohlwill (1960) conducted an investigation of the developmental processes by which a young child arrives at an abstract concept of number. He found that success on tasks involving a simple addition and subtraction preceded success on a task embodying the principle of conservation and in some subjects led to the emergence of conservation responses.

Mathematical concepts other than conservation of number have been investigated by researchers attempting to discover environmental influences that enhance the ability to conserve. Beilen and Franklin (1962) attempted to induce conservation of area in school children in New York City. One group of children underwent a training procedure that instructed the children about measurement concepts; the other group of children did not receive such instruction. From the study, the authors conclude that first graders profit from task training and a little from group instruction. Third graders profit more from measurement concept instruction. In spite of training in the task as well as measurement instruction, no child was able to achieve operational area measurement in the first grade. This study supports Piaget's developmental theory.

Shantz and Sigel (1967) conducted a study to determine whether conservation of number, quantity and area could be induced by training procedures. The researchers tried to assess the relationship between conservation and the logical operations of classification, seriation, and reversibility. The authors concluded after the study that conservation ability did not relate to any of the logical operations, with the exception of low order significant relationship between reversibility and number conservation and classification and area conservation. They suggested that further research is needed to determine what aspects of training are crucial to conservation.

Sigel, Roeper and Hooper (1966) undertook a study to train 20 nursery school children in the operations necessary for the acquisition of conservation of quantity. The children were pretested on the conservation tasks of continuous quantity for substance, weight, and volume. The training group received education in operations necessary for the acquisition of conservation. The results showed that training increased the children's ability to conserve correctly. The authors replicated the experiment with similar results.

Support for the maturational aspects of Piaget's theory was given by a study by Susan M. Ervin (1960). She investigated the patterns of logical maturation in Piaget's hypothesis. Sixteen children, one half boys and one half girls, from the third and fourth grades were tested. The purpose of the study was to explore a procedure for testing the logical relationship between two tasks. It was found that success on the various transfer tasks, once training on relevant experience had been given, was related to spatial and verbal ability. The researcher concluded that evidence from the study supported the maturational aspects in the test problem as contended by Piaget.

Zimiles (1963) commented on much of the training research that has been edited in this paper. In an article in the Child Development magazine he said:

> . . . according to the present analysis of the development of conservation of quantity, it is not to be expected that short training periods of the type employed by Wohlwill and Lowe will be effective in changing the child's approach to conservation. The move from the first to the second stage of conservational thinking requires the assimilation of counting and other number skills, abilities which cannot be cultivated in a short training period (p. 695).

According to this author, much of the training research is ineffective in obtaining permanent conservation skills.

Ellen Kofsky (1966) has been involved in an intensive effort to uncover Piagetian stages by developing a scalogram. She has constructed a series of tasks designed to tap the developmental sequence of the child's concept of classes and classification skills. She hypothesized that there are 11 steps by which children learn to build upon simple equivalence groupings to attain the concept of class inclusion. The scalogram that she developed determines the difficulty of tasks. These tasks were administered to 122 children who were between the ages of four and nine. She found:

a) there was a significant correlation between the S's age and the number of tasks mastered.

b) the order of difficulty of the tasks corresponded to the predicted order.
c) there was no set order of mastery such that passage of a more difficult item invariably implied passage of all the easier items.
d) for each task there were no age differences among the S's who made different kinds of errors (p. 191).

An instrument of this kind should help to clarify the operations that lead to the acquisition of conservation skills. Educators should benefit from having an instrument to measure the status of conservation maturity.

This section has presented some of the training research that has been developed to determine the processes that aid in the acquisition of conservation skills. That environmental and cultural forces can facilitate conservation is apparent, but the determination of the kinds of training that aid in the acquisition of conservation is not yet clear. An understanding of conservation and how its acquisition affects the cognitive development of children should be of importance to educators who are interested in building a kindergarten curriculum that would provide beneficial procedures for learning.

The following section is devoted to examining the mathematical concepts held by young children and to making a determination about how these concepts can be influenced by the psychological theory of Piaget.

Implications for a Kindergarten Curriculum

In the two preceding sections of this chapter, the related literature has described studies that investigate conservation and training studies that attempt to induce conservation skills. This section will investigate studies that have assessed the mathematical concepts held by young children and will try to relate the information in these studies to the implications of cognitive growth found in Piaget's theory.

Educators generally assume that mathematical concepts can and should be taught at the kindergarten level. Studies by Bjonerud (1960), Heard (1970), and others have investigated the mathematical skills possessed by kindergarten entrants. Bjonerud (1960) investigated the arithmetic concepts held by 100 children who were beginning kindergarten. At the conclusion of this study, the researcher gave the following suggestions for a program for kindergartens:

1) There should be a planned arithmetic readiness program presented on the kindergarten level.
2) The first grade program should reflect the readiness period of kindergarten.
3) An inventory of the child's number concepts should be made at the beginning of school so that a program could be developed to build on this foundation.

Davis (1959) emphasized the need to develop a foundation of learned skills. He studied young children to determine their familiarity with measurement concepts. He found that young children have some understanding of this concept and suggested that this information be included in building a kindergarten curriculum.

Williams (1965) examined 595 kindergarten entrants to determine the mathematical concepts held by these children. At the conclusion of the study he made the following suggestions:

1) Math is part of the pre-school child's experience.
2) Appropriate mathematical instruction based on a child's experience would be beneficial and satisfying for a kindergartner's needs.
3) Topics such as measurement, number, and geometry should be used for instruction of mathematical concepts in kindergarten programs.

The fact that kindergarten children are interested in mathematical concepts was supported by a study developed by Dutton (1963). He interviewed 236 children as they were about to enter kindergarten to determine the number concepts held by these children. On the basis of this survey, Dutton determined that about one-third of each class is ready for systematical number work. This conclusion supports the findings of many conservation studies which also indicate that about one-third of most groups tested, understand conservation and are ready to assume work with mathematical operations.

The need to compile records for the kindergarten that was expressed by Davis and Bonjerud was also of concern to Rea and Reys (1970). They compiled a comprehensive mathematical inventory to aid teachers in determining the mathematical abilities of young children. These authors indicated the problems in curriculum construction in the kindergarten level because of the difficulty of obtaining records that show the child's cumulative skills. The measurement tool, the CMI, was devised by studying 30 kindergarten children and assessing their math skills and then compiling the information so that it could be used as a foundation for the new math programs.

Other studies investigated variables that might influence mathematical readiness in young children. The influence of nursery school on mathematical skills was investigated in a study by Rea and Reys (1970). Their study determined that nursery school was a factor in mathematical readiness in young children. A contrary view was expressed by Heard (1970) as a result of a longitudinal study that she conducted. She found that nursery school experience had no significant effect on children's mathematical ability in later school years.

David O. Montague (1964) investigated the effect of the variable of socio-economic background to mathematical readiness in kindergarten. He studied four kindergarten classes to determine the effect differences in socio-economic background had on mathematics concepts held by the children. His findings indicated a relationship between mathematic concepts held by kindergarten children and socio-economic areas from which the children come. Children that were deprived of the background of educational experience that helped build mathematic concepts entered school in need of specialized help.

The variable, age, was investigated by Joseph Ilka (1968). He studied the influence of age differences in the first grade and the effect on arithmetic achievement. His study resulted in suggestions that American grade school children can learn earlier than presently thought. He suggested that children can learn a much more complex kind of arithmetic. Carter (1956) also investigated the variable age. He investigated the hypothesis that first grade children who lack maturity are unable to achieve satisfactory progress in first grade. The findings in the study supported the advantage held by the chronologically older child in school.

Methods used in kindergarten were investigated by William K. Reece (1966). He investigated training in number names and the alphabet, common procedures in kindergarten. He found that this type of formalized training was of questionable value.

These studies indicate some of the confusion that exists in kindergarten education. Eleanor Duckworth (1964), speaking at a conference on cognition development and curriculum, sums up the confusion:

> As far as education is concerned, the chief outcome of this theory of intellectual development is a plea that children be allowed to do their own learning. Piaget is not saying that intellectual development proceeds at its own pace no matter what you try to do. He is saying that what schools usually try to do is ineffectual (p. 2).

Piaget's theory of cognitive growth in children has significance for educators who would build a stimulating environment for learning. Piaget sees the mental development of children developing in stages. These stages result because of maturation, physical and mental experience, and social interaction and transmission. Factors such as visual maturation influence a child's perception and intelligence. The age when visual maturation begins to influence the operations important for learning needed mathematical concepts is set by Piaget at about seven. In the book, The Psychology of the Child, Piaget and Inhelder (1969) discuss the relation of perception to their concept of intelligence:

> It is of some interest to note that learning does not make its appearance until around seven. At that time syncretism[4] declines sharply and eye movements are better controlled. Above all, the first logico-mathematical operations appear: perceptual activity can be directed by an intelligence that has a better grasp of the problems (p. 41).

Piaget stresses the importance of experience and environment in building understandings that are essential in cognition and constitute what is commonly called intelligence.

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[4]Syncretism refers to a stage of perception when a child perceives only a total impression.

> Generally speaking, it is therefore impossible to maintain that the concepts of intelligent thought are simply derived from the perceptions through abstraction and generalization. In addition to perceptual data, concepts incorporate specific constructions of a more or less complex nature. Logico-mathematical concepts presuppose a set of operations that are abstracted not from the objects perceived but from the actions performed on these objects which is by no means the same (1969, p. 49).

He believes that a child learns by internalizing concepts that he experiences as he manipulates materials and interacts with an environment that stimulates physical and mental operations. To Piaget, formal educational procedures can sometimes be a waste of time. He believes that teachers sometimes force concepts upon children who lack an adequate foundation for understanding these ideas. He believes that children need experience in manipulation of materials provided by a stimulating environment. Piaget has some comments about educational methods for young children. In the Foreward for a study of young children's thinking by Almy, Chittenden and Miller (1966) Piaget writes:

> In the realm of education, this equilibration through self regulation means that school children and students should be allowed a maximum of activity of their own, directed by means of materials which permit their activities to be cognitively useful. In the area of logico-mathematical structures, children have real understanding only of that which they invent themselves, and each time we try to teach them something too quickly, we keep them from reinventing it themselves. Thus there is no good reason to try to accelerate this development too much; the time which seems to be wasted in personal investigation is really gained in the construction of methods (p. vi).

Almy, Chittenden and Miller comment in this study about how children seem to learn from the manipulations that take place in the conservation experiments. This prompts a reply from Piaget where he again stresses how children learn by interacting with materials. In the same text he says:

> . . . which will help us to see that a child learns very little indeed when experiments are performed for him, and that he must do them himself rather than sit and watch them done (1966, p. 3-4).

The importance of the educational environment and the social interaction that must result for learning to take place was emphasized by the educational leader, John Dewey. In an article on the child and the curriculum, Dewey discusses the place of methods and environment on the growth of understanding of specific concepts. He emphasizes the child's operations in the process of education:

> The only significant method is the method of the mind as it reaches out and assimilates. Subject matter is but spiritual food, possible nutritive material (1964, p. 343).

He also saw education as a process of living that resulted as a child interacted with an environment to build new concepts and new understandings. He states:

> . . . the only true education comes through the stimulation of the child's powers by the demands of the social situations in which he finds himself (1964, p. 427).

Dewey, like Piaget, was distressed by educational procedures which caused problems by too early subject matter exposure. In <u>My</u>

Pedagogic Creed, he voiced this concern:

> . . . we violate the child's nature and render difficult the best ethical results by introducing the child too abruptly to a number of special studies, of reading, writing, geography, etc., out of relation to this social life (1964, p. 432).

Present day educators in the field of mathematics have developed the mathematics laboratory to assist children in learning concepts by investigation of puzzles, rods, and measurement materials. In *Today's Education*, Edwina Deans (1971) describes a laboratory for effective learning of mathematics by young children. The description of this laboratory resembles the kindergarten of 100 years ago as pictured by Kristina Leeb-Lundberg in an article in the *Arithmetic Teacher* (1970). She described Frederich Froebel's sequence of learning program based on mathematical uses of geometric forms. The early kindergarten had programs that emphasized understandings obtained from manipulations of geometric materials. The programs gave way to a curriculum that emphasized pictures and books with demonstrations rather than a child's self-involvement. The laboratory of Froebel's time disappeared from education in America only to reoccur in present day schools as mathematical laboratories. Perhaps the work of Piaget can assist in strengthening the growth of mathematics laboratories.

Adler (1966) summarizes the concepts of Piaget's work that can influence methods of teaching:

1. The basis of all learning is the child's own activity as he interacts with his environment.
2. Mental activity is a process of adaptation to the environment. The child fits new experiences into pre existing mental structures through assimilation. Accommodation is the tendency of mental structures to change because of environmental influence.
3. The child interacts with society. As he interacts he changes behavior patterns and understandings.

Summary

In section one, a psychological background for the study is given. Selective constructs from Piaget's theory of the development of cognition are related to mathematical operations. The concept of conservation is defined and the relationship of levels of conservation status to mathematical operations is shown. Acquisition of conservation is seen to be an underlying understanding for mathematical procedures used in educational processes.

Replications of conservation studies are reviewed in section two. An explanation of the procedures used in these experiments is given and studies relative to Piaget's work are reported. Although researchers comment on procedural problems and aspects of conservation that may influence conservation, they generally validate Piaget's theory.

Training studies in which researchers attempt to structure situations in order to induce conservation are presented in section three. Although some success has been achieved in training procedures to induce conservation, there is still a question about the lasting effects of this kind of short term training. Research to determine effective training procedures is yet to be accomplished.

Section four relates studies that attempt to assess the mathematical qualifications possessed by kindergarten children to the structure of the kindergarten curriculum. Concepts in Piaget's theory are evaluated for implications for strengthening curriculum offerings in kindergarten.

CHAPTER III

METHODOLOGY AND DESIGN

The purpose of this study was to test two assumptions held by many educators in early childhood education. These two assumptions are that factors in a child's background are related to the acquisition of the notion of conservation and that additional mathematical instruction will result in a higher level of maturity of the notion of conservation as well as increased achievement in arithmetic skills.

Hypotheses that were developed from these two assumptions were tested by using two classes of kindergarten children during the spring term of the 1969-1970 academic year at the Campus Elementary School at Oregon College of Education. A master teacher, assisted by two student teachers, conducted both morning and afternoon sections of the kindergarten.

To test the assumption that additional instruction will result in a higher level of understanding of conservation and increased achievement in arithmetic skills, the morning class was designated the control group, and the afternoon class was designated the experimental group. Each child in the control and experimental group was pretested and posttested to determine each child's level of understanding of the notion of conservation. The experimental group spent almost twice as much time on mathematical activities as did the control group. At the end of the spring term, the control and experimental groups were tested to determine arithmetic achievement, by using the American School Achievement Test; Arithmetic Readiness.

Data about background characteristics were combined from both classes to test the assumption that factors in a child's background relate to the acquisition of conservation. The following variables were measured to determine their relationships to the notion of conservation: IQ, chronological age, nursery experience, and place in the family constellation.

This chapter describes the design, sample, instruments, and statistics employed to test the six hypotheses that were developed from the two assumptions that originated the study. These hypotheses appear before the Data Analysis section in this chapter.

Design

This study used a pretest-posttest control group design. Carter V. Good, in Essentials of Educational Research, describes this pretest-posttest control group design:

> The pretest-posttest control group design (the most widely used) was formed by adding a control group to the one group pretest-posttest design. This experimental design seeks to control the main effects of history, maturation, testing, instrument decay, regression, selection, and mortality (1966, p. 360).

The control and experimental groups were pretested the first week of spring term 1970. The pretest determined the level of maturity of the notion of conservation as explained by Piaget in the book, A Child's Conception of Number (1964). Description of these experimental tests is included in the section Instruments. Using the same experiments, the control and experimental groups were posttested during the last week of the same term.

A second part of the study investigated the relationship of variables in the background of a child's experience and the level of concept maturity of conservation in the child. Good has this comment to make on investigations between variables:

> Some investigators differentiate between experimental research and psychometric research (studies in which psychometric techniques are used to investigate relations between variables, but excluding such procedures in assessing individuals for clinical or other applied psychological work). Since experimental and psychometric techniques are basically similar in purpose, they can be combined in areas traditionally restricted to one or the other (1966, p. 375).

Data about background characteristics that could relate to an understanding of the notion of conservation were combined from both classes to discover the relationship of the variables chronological age, IQ, nursery school experience, and place in the family constellation on the level of concept maturity of conservation.

Sample

The subjects of this study were 45 kindergarten students attending the Campus Elementary School during the spring term of the 1969-1970 academic year at Oregon College of Education. Preference for enrollment at the kindergarten is given to students whose parents are affiliated with the college. In this study some of the children were from non-college families in the town of Monmouth, but a majority of the children had parents who were associated with the college. Tables 1 and 2 show some of the background characteristics of both the control and experimental groups.

The experimental group was an afternoon kindergarten class and consisted of 22 children. The group designated as the control group was a morning kindergarten class of 23 children. The problem of using given classrooms as samples for research studies is discussed by Eli S. Marks in an article on Some Sampling Problems in Educational Research:

> It should be noted that a valid sample and statistically sound conclusions can be drawn from the school system to which our obliging friend, the superintendent, gives us access. A research finding does not have to apply to the whole population of the United States or the whole human race in order to be scientifically valuable (1969, p. 253).

Independent Variables

Fred N. Kerlinger, in Foundations of Behavioral Research, defines the terms independent and dependent variables:

> An independent variable is the presumed cause of the dependent variable, the presumed effect. The independent variable is the antecedent; the dependent variable is the consequent. Whenever we say "If A, then B," whenever we have an implication, A implies B, we have an independent variable (A) and a depeddent variable (B) (1967, p. 39).

Table 1. Background characteristics of the experimental group (n=22).

Sex	IQ	Age	Nursery school experience	Place in family constellation	Occupation	
					Father	Mother
B	112	6-9	No	5 of 6	Teacher	Housewife
B	97	6-5	No	3 of 3	Fireman	Student
G	143	6-6	Yes	1 of 2	Professor	Housewife
B	145	6-6	No	1 of 2	Teacher	Housewife
B	107	5-10	Yes	2 of 2	Mgr. farm equipment	Housewife
G	101	6-4	Yes	1 of 2	Professor	Teacher
G	93	6-8	No	6 of 6	Teacher	Housewife
B	113	6-6	No	4 of 4	Instructor	Housewife
G	117	5-10	Yes	1	Educator	Educator
G	105	5-9	Yes	2 of 2	School supt.	Student
B	123	5-11	No	2 of 6	Professor	Housewife
G	101	6-0	Yes	1	Teacher	Housewife
B	103	5-8	No	3 of 4	Teacher	Housewife
B	111	6-6	No	8 of 8	Instructor	Housewife
G	113	6-5	No	2 of 2	Mechanic	Housewife
B	125	6-6	Yes	1	Forester	Housewife
B	141	6-0	No	4 of 4	Professor	Housewife
G	106	5-6	No	3 of 3	Counselor	Housewife
G	123	6-6	No	1 of 2	Student	Secretary
B	107	6-7	No	1 of 2	Purchasing agent	Housewife
G	111	6-3	No	1	Professor	Housewife
B	139	6-2	Yes	2 of 2	Professor	Housewife

Table 2. Background characteristics of the control group (n=23).

Sex	IQ	Age	Nursery school experience	Place in family constellation	Occupation: Father	Occupation: Mother
B	109	6-5	Yes	2 of 2	Sales manager	Housewife
G	135	6-5	Yes	1 of 2	College admin.	Housewife
G	120	5-7	No	1	Plywood worker	Housewife
G	141	6-5	Yes	2 of 2	Professor	Housewife
G	119	5-11	No	2 of 2	Paper mill	Student
G	101	6-6	No	4 of 4	Instructor	Housewife
G	131	6-6	Yes	1 of 2	Professor	Housewife
G	111	5-9	Yes	3 of 3	Professor	Housewife
G	137	5-11	No	2 of 3	Teacher	Housewife
G	129	6-7	Yes	7 of 9	Professor	Housewife
B	113	6-1	Yes	2 of 3	Professor	Instructor
B	113	6-1	No	2 of 2	Insurance	Student
B	109	6-3	No	2 of 3	Student	Housewife
G	133	6-5	No	4 of 4	School principal	Housewife
G	114	5-7	Yes	3 of 4	Professor	Housewife
G	123	6-3	Yes	2 of 2	Professor	Housewife
G	111	6-0	Yes	2 of 2	Farmer	Housewife
G	93	5-9	No	3 of 3	Oil distributor	Housewife
G	111	6-2	Yes	2 of 3	Teacher	Housewife
G	125	6-2	Yes	2 of 2	Farmer	Housewife
B	111	6-2	Yes	3 of 3	Manager paper co.	Housewife
G	107	6-0	Yes	2 of 2	Mgr. prod.	Housewife
G	113	6-0	Yes	2 of 3	Physician	Housewife

In the assumption that mathematical information used for readiness instruction increases readiness behavior, readiness information is the independent variable or the cause of behavior that is measured by testing arithmetic achievement. This behavior is measured in one instance, utilizing a pretest and posttest design, by Piaget's experiments to determine the understanding of conservation and in another instance by arithmetic tests to measure achievement in arithmetic.

In the assumption that factors in a child's background are related to the acquisition of conservation skills, age, IQ, nursery school experience and placement in family constellation are independent variables.

Dependent Variables

According to Kerlinger (1967), the dependent variables are the effects caused by the independent variables. In the assumption that readiness instruction implies increased achievement, arithmetic performance as measured by an arithmetic readiness test is the dependent variable. In this assumption, change in status of the levels of concept maturity are also measured and these levels of understanding of the notion of conservation are dependent variables.

The assumption that investigated the relationship of background characteristics, age, IQ, nursery school experience, family constellation placement was measured by the relationship to the concept level of maturity of the understanding of conservation. The levels of concept maturity of conservation are the dependent variables. The instruments used to determine the measurements are described in the section Instruments.

Instruments

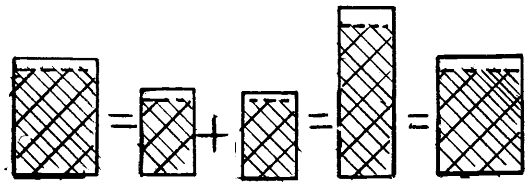
Instruments used to collect the data for this research were replications of two of Piaget's experiments, One to One Correspondence (Flowers) and Discontinuous Quantities (Beans), the American School Achievement Test: Arithmetic Readiness, and the Peabody Picture Vocabulary Test, Form A. These instruments ~~are~~ discussed in terms of their purpose, reliability, and validity.

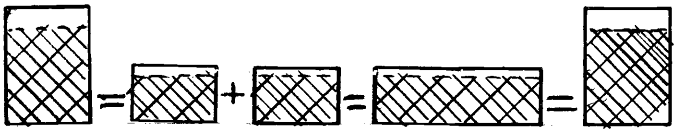
Conservation Experiments: Discontinuous Quantities (beans in glasses)

The purpose of the two experiments, Discontinuous Quantities and One to One Correspondence, was to judge the level of maturity held by the child in his understanding of the notion of conservation. According to Piaget, understanding of conservation is a necessary prerequisite for mathematical operations. In the first experiment, the child fills two glasses of similar shape and size with an equal amount of beans. He is questioned about the equivalence of the sets of beans in the two similar sized glasses. One of the glasses of beans is poured into two smaller glasses. The child is questioned again about the equivalence of the sets; one set, in a tall container, one set now divided into two smaller containers. The beans are returned to the original container and the beans from the second container are now poured into a tall narrow glass. The child is questioned to see if he believes that the amount of beans is more, less, or the same when rearranged in different sized glasses. The child who cannot conserve believes that the total amount of material grows or becomes less by being poured into a different sized container even though he had equivalent amounts of beans in the two original glasses. The child who is in the intermediate stage is not sure; sometimes he believes transformation can occur and another time he is sure that an equal amount remains in spite of rearrangements of the beans. The child who can conserve is not fooled by the size or shapes of the containers. He knows that the amounts were equal in the beginning and must remain equal in spite of any rearrangements of the contents caused by different containers. Figure 1 illustrates the conservation experiments.

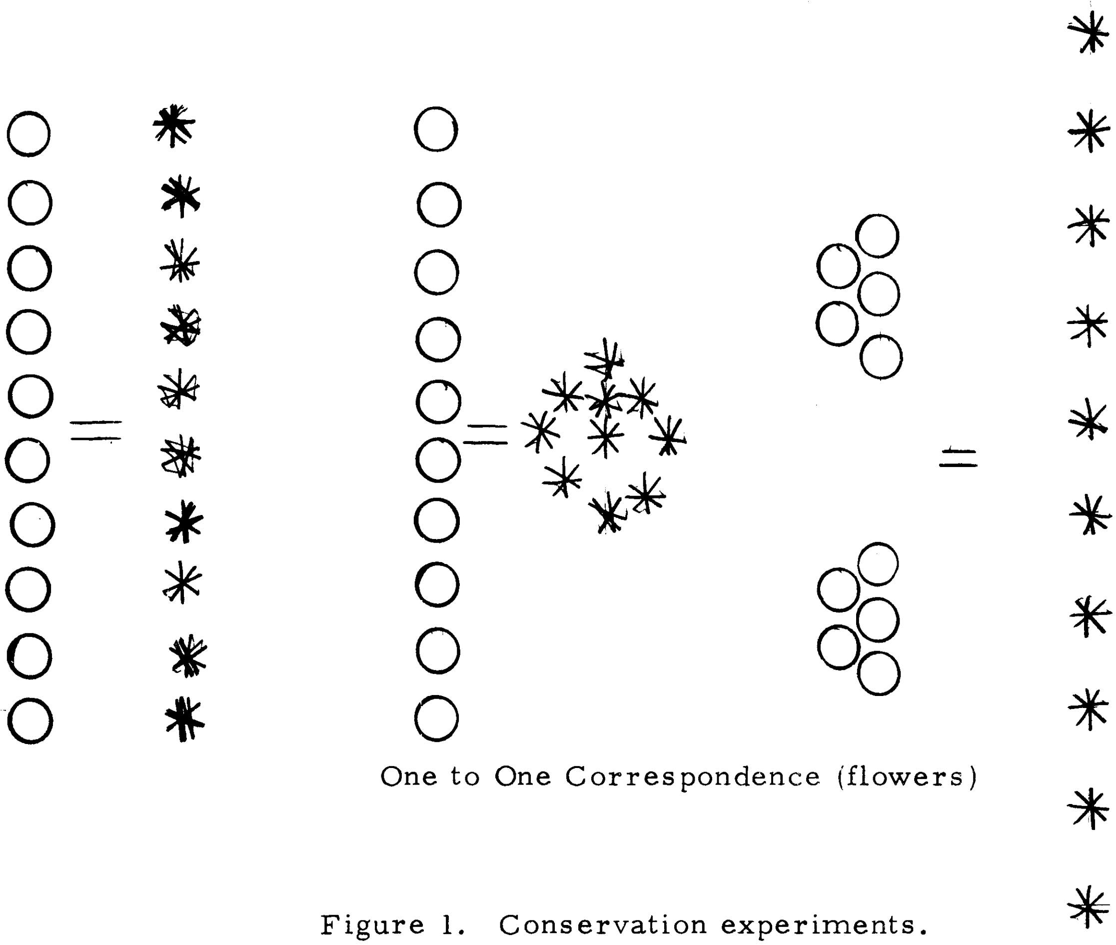
Conservation Experiment: One to One Correspondence (pennies for flowers)

The child exchanges ten pennies for ten artificial flowers, one at a time. The pennies are lined up on one side of the table, the flowers are lined in a similar fashion on the opposite side of the table.





Discontinuous Quantities (beans)



One to One Correspondence (flowers)

Figure 1. Conservation experiments.

After the exchange, the child is questioned to determine his understanding of the notion of conservation. The flowers and pennies are exchange but the researcher rearranges the flowers in a bunch and again questions the child about the equivalence of the two sets. Again an equal exchange is performed between the researcher and child. This time the flowers or money are spread further apart. The child again is questioned as to equivalence of the sets. The child who does not understand conservation will believe there are more pennies or flowers if one line is spread out to give the impression of greater length or if the pennies are bunched to look like a small stack while the equivalent number of flowers is spread apart to look like a lot of flowers. The child in the intermediary stage will be convinced of equivalence in some instances but not in others. The child who understands conservation will maintain the equivalence between the two sets in spite of any rearrangements of the objects.

American School Achievement: Arithmetic Readiness

The purpose of this test is to measure the achievement of concepts in mathematics that are commonly emphasized in the first grade. The test was used to measure achievement in this study. The concepts measured include the following: length as determined by understanding of the words like smaller, longer; recognition of number symbols, geometric forms, fractional parts, time, Roman numerals, mathematical operations of addition and subtraction. These concepts were part of the instructional program for the control and experimental groups used in this study. A more detailed explanation of mathematical activities is included in the section Readiness Instruction Activities.

Reliability for the tests is high, ranging from .71 to .96 with a median of .86. Reliability of the tests has been established experimentally and both grade and age norms are furnished on the basis of median scores of pupils in schools ranging from rural to urban districts.

Harold E. Moser reviewed the test in The Fifth Mental Measurements Yearbook. His main criticism stems from confusion over the purpose of the test. The tests were originally designed as achievement tests and yet one of the purposes stated is to diagnose readiness. Moser states his objection:

> Knowing that a pupil has not attained a mathematical objective is not equivalent to knowing that he is ready for formal training in that area (1959, p. 582).

The American School Achievement Test: Arithmetic Readiness was used for its original purpose, that is to determine achievement.

Peabody Picture Vocabulary Test

The PPVT is designed to measure an estimate of the child's verbal intelligence by measuring his hearing vocabulary. Children are not required to read in the test so that nonreaders are not penalized. Since responses are non-oral, children with speech defects and other problems caused by emotional tensions are not inhibited by the testing procedure.

The PPVT was standardized on 4,012 cases composing a sample drawn from elementary and high school students in the United States. Alternate reliability coefficients were obtained by calculating Pearson product-moment correlations on the raw scores of the standardization subjects for both forms A and B at each level. Standard errors of measurement for IQ's were then calculated from the parallel forms reliability coefficient. The manual (1965) includes a page that states research findings on the reliability of the PPVT.

> The PPVT was re-administered to 29 crippled children after one year in a hospital; r = 0.88 (stability of IQ scores after one year). Here is evidence on the temporal stability of PPVT scores for children in a rather restricted, standardized environment (1965, p. 31).

The coefficients of equivalence and temporal stability appear to be satisfactory for averages as well as children with a number of disabilities.

Content validity was built into the test by a search of Webster's New Collegiate Dictionary (1953) for words that could be depicted by a picture. The PPVT scores were compared with other vocabulary and intelligence tests. PPVT correlated with Binet mental age scores over the range 0.60 to 0.87 with a median of 0.71. PPVT was also compared to the Wechsler with a correlation from 0.30 to 0.84 with a median of 0.61. Research findings on the validity of the PPVT are given in tables on pages 34 to 40. PPVT was also correlated with achievement scores on the California Achievement and Metropolitan Achievement Tests as well as others.

The test is reviewed in the Sixth Mental Measurements Yearbook by Howard B. Lyman in a favorable light: "In summary the PPVT is a highly usable test, of moderate reliability, and largely unestablished validity" (1965, p. 821).

Arithmetic Readiness Instruction

Because of scheduling of special classes at the Campus Elementary School, as well as the result of teacher interest in the area of mathematics, the experimental class received almost twice as much time in activities, classified as arithmetic readiness instruction, than the control class. A time schedule for both classes is listed below:

	Control class	Experimental class
April 1-April 23	425 min	840 min
April 24-May 7	150	210
May 8-June 5	60	180
Total time	635 min	1230 min

Both classes received instruction and participated in similar types of activities calculated to bring about mathematical understanding.

Children in both classes completed The Greater Cleveland Math Workbooks for kindergarten. Instructional activities included work with Cuisenaire rods, the abacus, counting, recognition of symbols for numbers and number names, calendar work, use of geometric shapes, time concepts, fractional parts, as well as other activities classified in the sphere of mathematics.

Hypotheses

Six hypotheses were developed to test specific aspects of the two original assumptions upon which this study was based. These assumptions were:

1) Factors in a child's background such as age, IQ, nursery school experience, and placement in family constellation are related to the level of maturity of the concept of conservation held by the child.
2) Increased amounts of mathematical instruction will result in improved arithmetic achievement and a better understanding of the concept of conservation.

In order to test these two assumptions the following variables were measured to detect changes. They were:

1) Change in conservation status was measured by an analysis of Piaget's experiments.
2) Achievement in arithmetic performance was measured by

the American School Achievement Test: Arithmetic Readiness.

An analysis of the relationship of the variables age, IQ, nursery school experience, place in the family constellation on the level of concept maturity of conservation was analyzed for correlation. The hypotheses are stated in the null form for testing.

1) There are no significant changes between the control and experimental groups in the level of understanding of the concept of conservation.

2) There is no significant difference between the experimental group and the control groups in arithmetic achievement as measured by the American School Achievement Test: Arithmetic Readiness.

3) There is no significant correlation between chronological age of the child and his ability to conserve.

4) There is no significant correlation between the IQ of the child and his ability to conserve.

5) There is no significant correlation between the place of the child in a family constellation and his ability to conserve.

6) There is no significant correlation between the fact that a child has nursery school experience and his ability to conserve.

Data Analysis

Two statistical tests were used to compute the data for this research. The chi square test was used to measure the difference observed and expected in the status of the level of concept maturity of the notion of conservation in the control group and the experimental group. Kerlinger (1964) gives the purpose of statistical tests as that of comparing results with expectations based on chance. In order to compute chi square the following steps should be followed:

1) To compute chi square, let f_e equal the frequency expected and f_o equal the frequency observed.
2) The formula for chi-square is

$$\Sigma\left[\frac{(f_o - f_e)^2}{f_e}\right]$$

3) Subtract each f_e from the comparable f_o.
4) Square the difference.
5) Divide the difference squared by the expected f_e and add the quotients (1964).

In the data computed at the .05 level, one degree of fredom is used. Kerlinger defines degree of freedom as "the latitude of variance a statistical problem has" (p. 152).

A second test used was Student's t-test. Downie and Heath define this statistic as measuring the difference between the group means, which is then divided by the standard error of the difference between means. A value larger than that expected by chance may be considered significant (1959, p. 125). The formula for the t-test is:

$$t = \frac{\bar{x} - \bar{x}_2}{s_{\bar{x}_1 - \bar{x}_2}}$$

To determine an estimate of the degree of correlation of dichotomized variables, two methods of biserial correlation were used. The method used for point biserial and tetrachoric correlation is detailed in Chapter 12 of the book Psychological Tests (McNemar, 1955). The formula that is used to estimate correlation of variables if the dichotomous trait being tested is truly discrete is:

$$r_{pb} = \frac{(M_2 - M_1)\sqrt{P_1 P_2}}{\sigma y}$$

When both variables being tested yield only dichotomized information an estimate of correlation can be determined by using a formula to determine the tetrachoric correlation coefficient. The equation used for this purpose is as follows:

$$\frac{c - qq^1}{z_x z_y} = r + xy\frac{r^2}{2} + x^2 - 1y^2 - 1\frac{r^3}{6} + (x^3 - 3x)(y_3 - 3y)\frac{r^4}{24} + \ldots$$

Computations were done by a programmed computer at the Computer Center at Oregon State University.

Summary

This chapter presented the methodology and design used to compute the research data in this study. The six hypotheses tested were developed from the two assumptions that were the basis for the research.

A pretest-posttest experimental design was used with one control and one experimental group. The dependent variables measured were concept level of maturity of the notion of conservation as well as arithmetic achievement. Independent variables measured were readiness instruction in arithmetic, chronological age, IQ, nursery school experience, and place in family constellation.

Two statistical tests were used to compute the statistics in this study. They were Student's t-test and chi-square. To determine correlation among background variables, the biserial correlation was used.

CHAPTER IV

ANALYSIS CF DATA

The purpose of this chapter is to provide an analysis of the data used to test the six hypotheses. Statistical tests to determine significance at the .05 level were the Student's t-test and chi-square with one degree of freedom. To determine an estimate of correlation between the variables chronological age, IQ, nursery school experience, and place in the family constellation to the variable level of maturity of the notion of conservation, the biserial correlation was used.

Hypothesis One

Hypothesis one states: There are no significant changes between the control group and the experimental group in the level of understanding of the concept of conservation.

To test this hypothesis, the Oregon State Computer System was used. The chi-square test, with one degree of freedom, was computed. The chi-square value was 3.105319 on the bean test and 3.246125 on the flower test. Table value for chi-square was $>$ 3.84. The chi-square values on the tests were not sufficient to have statistical significance at the .05 level, therefore the null hypothesis was not rejected.

Although the chi-square value was not statistically significant, it should be noted that in the Bean test, 11 children in the experimental class showed improvement by a move to a higher level of understanding of the notion of conservation as compared to three children in the control class. Tables 3, 4 and 5 show the responses of the children during the experiment.

The problem of regression in the responses of the children is stated in the literature by Almy (1966) and Fedon (1966). Piaget responds to this problem in the Foreward for the study by Almy, Chittenden and Miller (1966). Piaget says:

> It is surprising to me, however, that half of her subjects showed a regression in one or another of the areas she was examining. By contrast, B. Inhelder, with the collaboration of G. Noelting and others, studied 30 children of different ages over four or five years, questioning them every few months on problems of conservation, ordering, etc. and found not a single regression. It is possible that a difference in method is responsible for the difference between these two sets of results. Sometimes a child will react over-cautiously to a standardized procedure and give an intermediary response, while a more flexible line of questioning would reveal that these responses did not entirely satisy him, and that he is capable of going a little further (1966, p. 3-4).

Piaget's "clinical method" of questioning a child presents difficulties for the researcher. Several children in this study showed regression in conservation answers. Such behavior may have resulted from the inexperience of the researcher in the use of clinical techniques.

The difficulties in standardizing the techniques used in

Table 3. Conservation status of the control group (n = 23).

Subject	Experiment I		Experiment II	
	Pretest	Posttest	Pretest	Posttest
B	C	I	C	C
G	I	I	C	C
G	NC	NC	I	C
G	C	C	C	C
G	NC	NC	I	I
G	I	I	C	C
G	I	I	I	C
G	NC	NC	C	C
G	C	C	C	C
G	C	I	C	C
B	C	C	C	C
B	NC	NC	NC	NC
B	NC	I	NC	C
G	I	NC	NC	I
G	NC	NC	NC	I
G	I	I	C	C
G	NC	NC	I	C
G	I	I	C	C
G	I	C	I	C
G	C	I	C	C
B	NC	NC	C	C
G	NC	NC	NC	C
G	NC	C	C	C

NC = Non conserve
I = Intermediate
C = Conserve

Table 4. Conservation status of the experimental group (n = 22).

Subject	Experiment I		Experiment II	
	Pretest	Posttest	Pretest	Posttest
B	I	C	C	C
B	C	I	C	C
G	NC	C	C	C
B	NC	C	C	C
B	NC	NC	C	C
G	NC	NC	NC	C
G	NC	NC	C	C
B	NC	I	C	C
G	NC	NC	C	C
G	NC	I	C	C
B	NC	C	C	C
G	NC	I	C	C
B	C	C	C	C
B	NC	I	I	C
G	NC	C	C	C
B	NC	NC	C	C
B	NC	I	I	C
G	I	NC	C	C
G	I	NC	NC	C
B	C	C	C	C
G	C	C	C	C
B	NC	NC	NC	NC

NC = Non conserve
I = Intermediate
C = Conserve

Table 5. Conservation experiment I - Discontinuous quantities: beans in glasses.

	Control (n = 23)			Experimental (n = 22)		
	C	NC	I	C	NC	I
Pretest	6	10	7	4	15	3
Posttest	5	9	9	8	8	6
Regression	4			3		
Improvement	3			10		

Table 6. Conservation experiment II - One to one correspondence: flowers and pennies.

	Control (n = 23)			Experimental (n = 22)		
	C	NC	I	C	NC	I
Pretest	14	4	5	17	3	2
Posttest	19	1	3	21	1	0
Regression	0			0		
Improvement	8			5		

measuring a child's understanding of conservation have been stated in the section on conservation studies in the related literature. That three levels of the understanding of conservation are discernible by questioning is apparent. Errors in procedures used in conducting the experiments can cause misunderstanding in the conclusions drawn from the answers of the children. Tables 3, 4, 5 and 6 show the results of the pretest and posttest experiments in conservation.

Hypothesis Two

Hypothesis two states: There is no significant difference between the experimental group and the control group in arithmetic achievement as measured by an arithmetic readiness test.

The statistical test used to measure the difference in the means between the experimental and the control groups was the Student's t-test. Table 7 shows the computed data. The t-value was not of statistical significance at the .05 level, therefore the null hypothesis was not rejected.

The two groups were tested using the arithmetic readiness test at the end of the experiment, after they had been subjected to differing amounts of instruction in mathematical activities. Although the experimental class had spent almost twice as much time in activities that were designed to induce mathematical competence, they did not show a statistically significant improvement in their performance when

Table 7. Hypothesis two sample t-test.

Sample	Mean	Variance	Standard deviation
23	1.6261	.0738339922	.271724
21	1.6762	.0759047619	.275508

Table value (5) = 2.0182000

Table value (1) = 2.6984000

T-value = -0.60688499

tested using an arithmetic readiness test.

This hypothesis and its testing raised the problem of efficient testing instruments. A copy of the test questions is included in Appendix A. The amount and kind of questions asked of the children secured only a minimum amount of information about the children's knowledge of mathematical information. Instruments to test kindergarten children's knowledge of school subjects are limited. Accurate assessment becomes almost impossible.

Hypothesis Three

Hypothesis three states: There is no significant correlation between chronological age of the child and his ability to conserve.

To test this hypothesis the method of biserial correlation was used. A correlation between two variables does not necessarily indicate a causal relationship between them; the two variables may vary together perfectly, r = 1.00; or vary in perfect opposition, r = -1.00. If a coefficient of 0 is obtained, it may be considered as no relationship between the two variables.

The coefficient of correlation for the variable chronological age and the level of maturity of the notion of conservation was .379 for the Bean test and .0435 for the Flower test. Although there was a positive correlation between the two variables the amount was not statistically significant, therefore the null hypothesis was not rejected. The fact that correlation was higher in the Bean test than in the Flower test supports Piaget's statement of a hierarchial difficulty of conservation tasks. Tables 8 and 9 show the correlation coefficients for both tasks.

Hypothesis Four

Hypothesis four states: There is no significant correlation between the IQ of the child and his ability to conserve.

To test this hypothesis biserial correlation was used. The correlation coefficient for the variable intelligence quotient and the variable level of maturity of the notion of conservation was .04396 on the Bean test and .0637 on the Flower test. Although there was slight positive correlation it was not sufficient to be statistically significant; therefore the null hypothesis was not rejected.

Carpenter (1955) and Hood (1962) state that in their studies intelligence was a factor in the acquisition of conservation skills. This study does not support that belief. Children in this sample had average or about IQ's and most of the studies that indicated that intelligence was a factor in conservation skills dealt with children below normal in intelligence. Although intelligence may be a factor in learning when one is dealing with retarded subjects it is possible that it may assume no importance in the acquisition of conservation skills when the subjects are above average in intelligence.

Hypothesis Five

Hypothesis five states: there is no significant correlation between the place of a child in a family constellation and his ability to conserve.

To test this hypothesis, the biserial correlation was used. The correlation coefficient expressing the relationship of the variable family constellation and the variable level of maturity of the notion of conservation was -.253 on the Bean test and .240 on the Flower test. The correlation coefficient was not sufficient to be statistically significant; therefore the null hypothesis was not rejected.

Questionnaires were sent to the parents of the kindergarten classes that were being tested. A copy of this questionnaire is in Appendix B. Parents were asked to state any special experiences that may have helped to prepare their child for kindergarten. Table

Table 8. Correlation coefficients for variables using discontinuous quantities (beans).

Variable	Correlation coefficient
Chronological age	r = .379
Mental age (IQ)	r = .04396
Family constellation	r = .115
Nursery school experience	r = -.253

Table 9. Correlation coefficients for variables using one to one correspondence (flowers).

Chronological age	r = .0435
Mental age (IQ)	r = .0637
Family constellation	r = .013
Nursery school experience	r = .240

Table 10. Factors that relate to a child's ability in educational activities.

Factor	Number of respondents*
Nursery school	11
Other siblings	6
Home activities	2
Television	2
Travel	1
Sunday school	1
Library story hour	1

*Questionnaires sent: 23 AM class; 22 PM class
Questionnaires returned: 23 AM class; 22 PM class

10 shows the results of this questionnaire. Parents listed older brothers and sisters as being an important factor in preparing a young child for school. This belief is not supported by this study. Perhaps a young child with older siblings may have a better vocabulary so that he can express himself but he may not have the understanding needed to deal with the question concerning conservation.

Piaget (Hall, 1970) in Psychology Today comments on the fact that vocabulary does not mean that a young child has understanding needed for mathematical concepts. Much instruction in kindergarten is given to provide children with vocabulary as well as understanding of the concepts upon which the vocabulary is based. Perhaps teachers need to examine their instructional methods to determine if understanding as well as vocabulary is being learned by the child.

Hypothesis Six

Hypothesis six states: There is no significant correlation between the fact that a child has nursery school experience and his ability to conserve.

A biserial correlation was used to determine an estimate of correlation between the variable family constellation and the level of maturity of the notion of conservation. A correlation coefficient of .115 was obtained on the Bean test and a correlation of .013 was obtained on the Flower test. The correlation coefficient was not statistically significant; therefore the null hypothesis was not rejected.

Table 11 indicates the number of children in the sample who had nursery school experience. In the questionnaire, parents indicated that they felt that nursery school experience was an important factor in preparing a child for kindergarten. Although this study found no significant correlation between nursery school experience and conservation, it did not measure other behavioral experiences necessary for school success that might be related to nursery school experience.

Summary of Findings

The assumption that additional mathematical instruction will result in a higher level of understanding of the notion of conservation as well as increased mathematical performance as measured by an arithmetic readiness test was tested by the first two hypotheses. Results, after testing the two hypotheses, were not significant at the .05 level; therefore the null hypotheses were not rejected.

The second assumption that acquisition of conservation skills is related to characteristics in a child's background, specifically chronological age, IQ, nursery school experience, and place in the family constellation, was tested by hypotheses three, four, five, and six. Results after determining correlation coefficients for the four variables and the level of maturity of the notion of conservation were not statistically significant; therefore the null hypotheses were not

Table 11. Number of weeks of nursery school experience per year.

Sessions attended					
1/2 day/ week	1 day/ week	2 days/ week	3 days/ week	4 days/ week	5 days/ week
	14	39	36	36	12
		12	36	12	36
			6	36	36
				36	36
				28	16
				28	36
				35	36
				36	36
				4	
				32	
				36	
				36	
Total number of children	1	2	3	12	8

rejected in all four cases. The variables chronological age, IQ, nursery school experience, and place in the family constellation did not correlate significantly with the variable concept level of maturity of the notion of conservation in this study.

CHAPTER V

SUMMARY AND CONCLUSIONS

Findings

The assumption that increased readiness instruction in mathematical activities would result in increased arithmetic achievement evolved two hypotheses: The hypotheses were tested in the null form. They were:

1) There is no significant difference between the control and experimental groups in the level of understanding of the concept of conservation.

2) There is no significant difference between the experimental group and the control groups in arithmetic achievement as measured by an arithmetic readiness test.

These hypotheses were tested using the Student's t-test and the chi-square test with one degree of freedom. The results were not statistically significant at the .05 level; therefore the null hypotheses were not rejected.

The assumption that characteristics in the background of a child relate to the acquisition of conservation evolved four hypotheses. Biserial correlation was used to determine an estimate of correlation between traits. The results were not statistically significant; therefore the null hypotheses were not rejected for the following four hypotheses.

1) There is no significant correlation between chronological age of the child and his ability to conserve.

2) There is no significant correlation between the IQ of a child and his ability to conserve.

3) There is no significant correlation between the place of a child in a family constellation and his ability to conserve.

4) There is no significant correlation between the fact that a child has nursery school experience and his ability to conserve.

Independent variables tested were arithmetic instruction, chronological age, IQ, nursery school experience, and place in the family constellation. Dependent variables measured were the levels of concept maturity of the notion of conservation and arithmetic achievement.

Theoretical Framework for the Study

The theory of cognitive development formulated by Jean Piaget provided the theoretical framework for this study. Specifically, Piaget's work in the development of number concepts in young children was examined in this study. Piaget believes that the construction of number co-exists with the development of logic. He has developed simple experiments to determine the level of a child's understanding of procedures that lead to the notion of conservation. Understanding of conservation is seen by Piaget as a basic skill necessary for mathematical operations.

Conservation studies as related in the review of literature establish the existence of levels of understanding of conservation in definite stages in young children's thinking. The literature also stated various background influences that related to the levels of understanding of conservation.

Discussion

This study replicated Piaget's experiments on the development of number concepts to determine the effect of readiness education on the understanding of the notion of conservation and the achievement in arithmetic in kindergarten children. The study supported Piaget's contention that three definite stages in the understanding of conservation exist. Although the stages are readily determined, difficulties ensue because of "clinical techniques." Misinterpretations can result from answers given by the children. Uniformity of questioning techniques as well as standardization of procedures used in the experiments could result in more accurate results.

Regression was experienced by children in this study as well as studies by Almy (1966) and Fedon (1966). Piaget and his co-workers have not experienced this problem in their work. This researcher feels that problems in regression occur because of inexperience in questioning techniques. Early answers are accepted when more detailed questioning might result in more accurate assessment.

Although the background characteristics examined in this study did not show a statistically significant correlation to the level of maturity of the notion of conservation a slight relationship did exist. Perhaps a larger, more varied sample might show the existence of such relationships.

Kindergarten research is scarce. The problem of what to teach young children needs more study. Instruments to determine knowledge held by young children should be developed. The entire area of learning in young children merits study and research. The determination of the status of concept maturity of the notion of conservation in order to determine ability and readiness for mathematical instruction would seem an essential step for meaningful programs in kindergarten education.

Limitation of the Research Design

Difficulties in educational research caused by sample size and definition result in questionable findings in educational studies. The sample in this study was small in size and composed of subjects who could not be considered average in ability or in environmental influences that affect educational performance. The children for the most part came from educationally enriched families.

A second difficulty in the study was control of the teacher variable. The class was conducted by a female master teacher who was assisted by a male student teacher in the morning class and by a female student teacher in the afternoon class. Educational research is at the mercy of school administrations and control of variables that could influence results becomes very difficult.

The instruments used to measure the dependent variables had strengths as well as weaknesses. The arithmetic test included in Appendix B did in fact measure the concepts stressed by the teacher in readiness instruction in arithmetic. The PPVT is an IQ test that stresses verbal ability and the children in the sample excelled in language ability. Piaget's experiments are interesting to young children and children are motivated by the testing situation. The experiments are designed to determine the levels of concept maturity and this they do.

Difficulties in interpretation have already been mentioned. The main problem in testing young children is the difficulty of finding accurate instruments to measure learning. The kindergarten level has not received the attention of test makers and few instruments are available to the investigator. As a result studies are conducted with inferior instruments.

Future Research

Comparatively few studies investigate cognitive growth in young children, or study the individual's potential for future educational success. Few instruments exist to accurately measure learning in young children. The importance of the early years of childhood and the relationship of early success to later success needs to be understood by educators. The conservation studies can contribute understanding and insight into the area of mathematics.

Relevance to Early Childhood Education

The findings in this study indicate that young children have some mathematical competencies. Factors that relate to these competencies were not determined by this study. It would seem that investigation into the levels of conservation held by a child might help to establish a more meaningful framework for mathematical activities at the kindergarten level.

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APPENDICES

APPENDIX A

AMERICAN SCHOOL ACHIEVEMENT TESTS: ARITHMETIC READINESS

AMERICAN SCHOOL ACHIEVEMENT TESTS

ARITHMETIC READINESS

TEST A

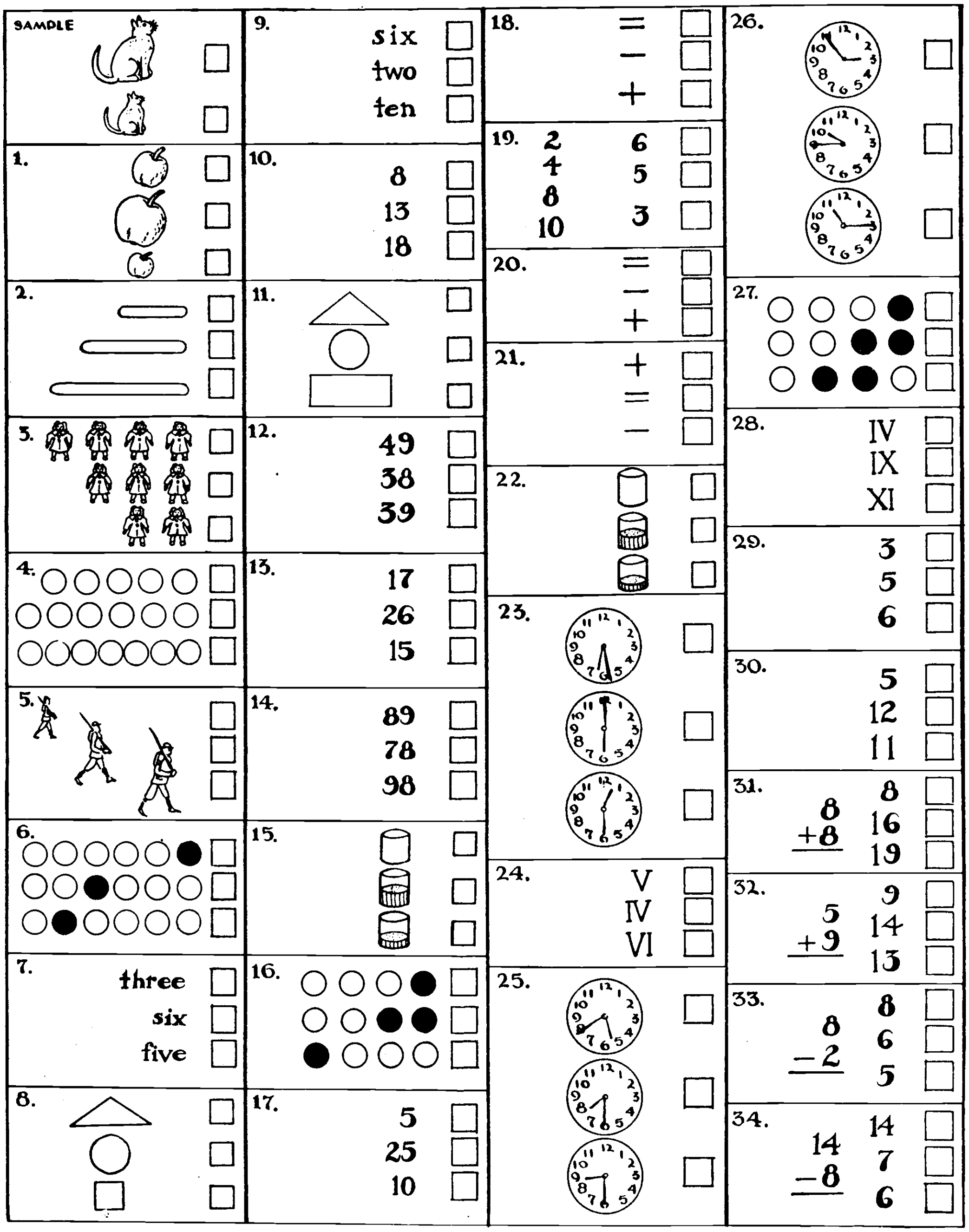
Test	Test Score	Grade Equiv.	Age Equiv.
A			
B			
Average			

by

WILLIS E. PRATT, ROBERT V. YOUNG, and GILBERT L. BETTS

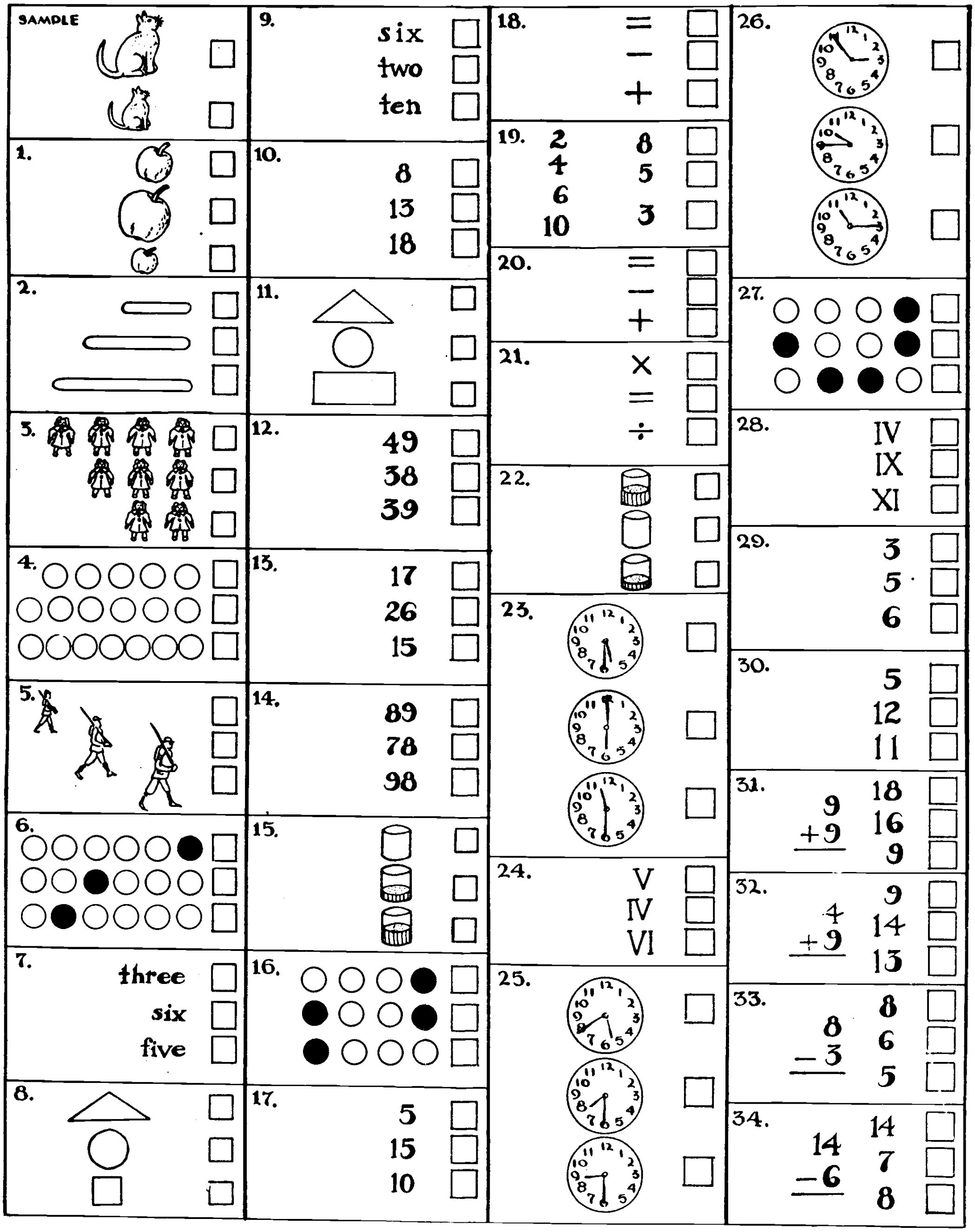
Name .... Grade ...... Age: .... Years ...... Months

School .... Teacher .... Date ....



ARITHMETIC READINESS

Test B



APPENDIX B

PARENT QUESTIONNAIRE

APPENDIX B

Parent Questionnaire

May 25, 1970
Oregon State University
Kindergarten Research
D. Anderson

Child's Name ______________________________

A study is underway to determine the effect of pre-school experience on specific areas in which the kindergarten child is involved. We would appreciate your help in furthering this research by answering the following questions:

Has your child had nursery school experience before kindergarten?

Yes No

Indicate the length of this experience

1/2 day five day week ________ number of weeks ____________

1/2 day three day week ________ number of weeks ____________

other ____________________ please explain ____________

Please describe any special experiences that may have prepared your child for kindergarten.