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A Study Of The Relationship Between Economic Education And Formal Reasoning In Ninth Grade Students

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A STUDY OF THE RELATIONSHIP BETWEEN ECONOMIC EDUCATION AND FORMAL REASONING IN NINTH GRADE STUDENTS

Abstract of Dissertation

PROBLEM: The purpose of this study was to investigate the relationship between the use of instructional materials of the economic education project at the University of the Pacific and movement into formal operations. Also examined was the percentage of ninth grade students who have achieved formal operations.

PROCEDURE: Data were collected in four secondary schools in Northern California which were involved in field-testing case studies from Our Economy: How It Works (Clawson, 1980). Eight social studies classes of ninth grade students (N = 186) receiving instruction in economics were the experimental group while eight social studies classes within the same schools (N = 201) not receiving instruction in economics served as the control group. Measurements used were the Piagetian Assessment of Formal Thinking (PAFT), compiled by the author, and the Junior High School Test of Economics (JHSTE), developed by the Joint Council for Economics Education. The Solomon Design was employed to control for pretest effect. Five experimental and five control classes were given the PAFT and all experimental classes were given the JHSTE as pretests. Treatment consisting of instruction in economics using concrete materials and activities was conducted over a nine-week period. The JHSTE was administered to the experimental classes and the PAFT was administered to all classes as the posttest.

The relationship between cognitive development as measured by the PAFT and economic understanding as measured by the JHSTE was determined by the use of Pearson Product Moment Correlation (Pearson r). Three Analyses of Covariance (ANCOVA) were employed to compare: a) scores of the posttest of the PAFT between experimental and control groups, b) difference between gender on posttest scores of the PAFT for experimental groups and, c) difference between gender on posttest scores of the JHSTE for experimental groups. In each case pretest scores constituted the covariate.

FINDINGS: The findings of this study did not provide definitive results regarding the efficacy of instruction on increasing the use of formal operations. The experimental group did make significant gains in cognitive development ($p < .01$). However, there was significant gains for the control group also ($p < .001$). Therefore, no effect of gains in cognitive development can be attributed to treatment. No pretest effect was measured on the PAFT posttest. Of the sample population 4% were determined to be formal operational

thinkers on the posttest of the PAFT. There was a significant relationship ($p < .001$) between cognitive development and economic understanding for both the pretest and posttest measures. No significant difference was determined between boys and girls in the experimental group for either the PAFT or the JHSTE. However, when gender for the entire sample population was compared a significant difference ($p < .05$) was determined between boys and girls on the PAFT.

CONCLUSIONS: Several factors may have accounted for the lack of support for the effectiveness of instructional method and materials on increasing formal reasoning. The length of time for treatment most likely did not allow for the internal process of self-regulation to occur to a significant extent. Also, due to restraints of time some activities designed for maximum student participation and involvement were utilized very little, if at all, and a major aspect of the experimental design was invalidated. Therefore, it should not be concluded that instruction using concrete methods and materials does not have an effect on increasing the ability to use formal operations.

RECOMMENDATIONS: Research in cognitive development indicates that few secondary students have fully attained formal operational reasoning ability. A continuation of research is needed into productive methods of encouraging the development of formal operations among adolescent students. The following recommendations were made. More experimental studies should be conducted in all areas of the curriculum to determine which teaching approaches relate to current cognitive abilities of students and which approaches result in increasing use of logical operations. Research should be concerned with cognition rather than mastery of subject matter. Reappraisal of current secondary school curriculum should be conducted to examine those areas requiring formal operations. Concrete activities and experiences should be included in all academic disciplines. Informal assessments of cognitive development that are easy for the classroom teacher to administer should be developed. Teachers should also have training in interpreting results and in implementing change within the curriculum.

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CHAPTER I

INTRODUCTION

Mastery of secondary curriculum requires use of a number of abstract skills. These include the ability to use hypotheses, to manipulate variables mentally, to understand second-order relationships and symbols, and to project thought in time and space. These skills are requisite to mastering all disciplines of the curriculum. However, according to the theory of Jean Piaget, these thinking skills are available only to those students who have attained the cognitive level of formal operations. The thinking ability of the less than formal thinker is qualitatively different. If any secondary students lack skill in abstract thinking, they are likely to have serious difficulty in meeting the demands of the regular curriculum.

Instruction at the secondary level is usually dependent on the figurative mode of teaching. This mode consists of transfer and recording of information as, for example, the memorization of dates, names, and locations in history, theorums in geometry, and definitions of terms in science. The figurative mode provides little interaction of the student with the content. For information to be transmitted meaningfully, however, there must be some previous knowledge with which to connect this information. For many students the material being presented figuratively is out of the realm of previous experience, and in these cases no assimilation will occur or, if it does, the result is an incorrect incorporation which creates misconception and mislearning.

The content area of economics was addressed in this study. Generally, instruction in economics is in abstract terms and presented through the figurative mode of teaching. Many students have difficulty with the study of economics because of the emphasis on abstract concepts and terminology. It may be that this difficulty stems from the fact that these students have not achieved the ability to think abstractly.

A curriculum development and research project in economic education currently in process at the University of the Pacific has as its rationale the application of the concept of operative learning. In contrast to the more commonly used figurative mode, operative teaching leads the student to discover concepts through active exploration and interaction with the content under study. It is neither all student-directed nor all teacher-directed, but represents a flexible interchange of leadership. It encompasses the acquisition of concepts by reasoning and inductive learning from actual experiences with objects or materials dealing with concrete referents. The teacher provides the content, opportunities, time, and materials. However, what the student learns is a product of experience that is itself conditioned by the level of cognitive development the student has attained.

Operative teaching provides the student with logical conflicts and cognitive dissonance which encourage him/her to develop greater understanding. It also requires the application of skills which permits horizontal elaboration. This mode of instruction provides learning experiences that enlarge and expand existing mental structures of the student (Elkind, 1976; Piaget, 1976).

The instructional materials developed at the University of the Pacific have been written for junior high school students. The distinguishing characteristics of these materials are; (1) The case study approach is used to provide content closely related to student life experiences. (2) Activities are provided which allow for maximum student interaction. (3) The text and activities are written with the objective of leading from concrete experiences to skill in abstract reasoning; the abstract subject of economics has been approached from a concrete perspective.

The Problem

The premise that abstract logic is an essential aspect of secondary education is generally accepted by educators. That many students do not demonstrate this ability is also supported. Secondary educational reform has been studied for many years. This reform has been more directed toward changes in structure than toward careful examination of curriculum content to determine whether there is a fit between the curriculum and the student. Until recently little attention has been given to the qualitatively different cognitive skills possessed by many high school students.

The Purpose of the Study

The study was designed to determine the percentage of ninth grade students who have not yet achieved the level of formal thinking as defined by Jean Piaget. The relationship between the use of instructional materials of the economic education project at the University of the Pacific and movement into formal operations was also addressed. The cognitive development of ninth grade students was measured and the economic materials examined to determine their effect on increasing movement into formal operations.

Statement of the Problem

The questions to be examined were whether teaching a course in economics based on concrete experiences and activities deliberately designed to lead from concrete to abstract thinking would result in more students who have attained formal operations, and if there was a differential effect of this teaching on boys and girls. Specifically, students who were taught using the Junior High Economics course developed at the University of the Pacific Center for the Development of Economic Education were assessed to determine if they, in fact, demonstrated attainment of formal operational thought to a greater extent than those students who did not receive such training.

This study also sheds light on the questions of when, to what extent, and under what conditions students achieve the ability to use formal operations. Although it is widely recognized that these thinking capabilities are developmental, there is the question of the extent to which cognitive development, particularly formal operations, responds to instructional techniques and materials. The efficacy of instruction toward increasing formal operations was addressed.

Significance of the Study

Piaget's theory of cognitive development, particularly the parts dealing with formal thinking, has been studied to determine the relationship between cognitive development and success in learning in secondary schools. The study in this area, however, has been limited almost entirely to science. This situation is due in a large measure to the methodology of Piagetian research. His clinical assessments of children's thinking have dealt with physical and mathematical phenomena. Recently, however, educators in curriculum areas other than science have begun to examine Piaget's theory of formal operational thought and the abstract reasoning skills which seem to be requisite for academic success in secondary education (Lovell, 1971; Elkind, 1976).

This study examined the content area of economics to determine if formal thinking thinking was a necessary aspect of understanding economic concepts. Findings of this study have several theoretical and practical implications. First, the study yields information relating to whether the level of cognitive development can be increased through instruction; and second, whether secondary curriculum should be adjusted in content and approach to the developmental level of students. Third, this study offers teachers a means by which levels of thinking skills of students can be ascertained.

Research Hypotheses

This study analyzed the relationship between stages of cognitive development and the use of instructional materials designed to lead from concrete to formal thinking. The hypotheses were as follows;

1. Students who score high in cognitive ability on the pretest of the Piagetian Assessment of Formal Thinking (PAFT) also score high in economic understanding on the pretest of the Junior High School Test of Economics (JHSTE); those scoring low on the PAFT also score low on the JHSTE.

2. Students receiving specific instruction in economic education score significantly higher in cognitive ability on the posttest of the PAFT than students not receiving such instruction.

3. Students who score high in cognitive ability on the posttest of the PAFT also score high in economic understanding on the posttest of the JHSTE; students scoring low on the PAFT also score low on the JHSTE.

4. One sex scores significantly higher in cognitive ability than the other sex.

5. One sex scores significantly higher in economic understanding than the other sex.

Historical Background

The traditional high school curriculum was an outgrowth of the early Latin schools whose students were trained primarily for the professions. During the early nineteenth century the college preparatory schools gradually came to provide the precollege instruction for the intellectual elite. In 1869 Charles Eliot was appointed president of Harvard. His principal concern was the lack of educational skills evident in students entering Harvard. He set about to reform the secondary educational system. By setting requirements for college entrance he inaugurated the characteristics of secondary education which have remained the integral structure of the high school system since that time (Perkinson, 1976).

Eliot's structure has been essentially untouched since the turn of the century. Though curriculum reforms have been attempted on occasion, these have been short-lived. Present graduation requirements were established in 1905 as the 16 Carnegie Units through the direct influence of Eliot. Although an increasing number of high schools have begun to abandon the Carnegie Units to allow for greater curriculum flexibility, the systems most used for determining credits can easily be translated into these same units. Both the academic and administrative structures of secondary education are based, in fact, not on sound pedagogical theory, but on the established requirements of higher education as determined over a century ago by discipline specialists. These structures have remained essentially unchanged since they were implemented (Tanner & Tanner, 1976). The concept of separate departments of knowledge has been challenged however, through the research of Bärbel Inhelder and Jean Piaget.

As a result of over one-half century of studying children Piaget and Inhelder have delineated stages of thinking in children from birth to adolescence. Each stage of cognitive development represents a qualitatively different thinking process. The work of these two researchers has cut across subject areas in dealing with approaches rather than specific content. Their research is having increased impact on curriculum both elementary and secondary. An awareness among educators of the necessity of matching the subject content and degree of understanding to the student's level of cognitive development has emerged within the last two decades.

Theoretical Basis for the Study

This study is based on Jean Piaget's theory of the stages of mental development, particularly the stages of concrete and formal operations. Piaget describes knowledge as the internal processing of action. Rather than the reproduction of a static state, it is the active transformation between an initial and a final state; it is a fluid process through which change occurs or is understood. To know an object is to act upon it, to modify and transform the object, to understand the process of this transformation and to understand the way the object is constructed. This process of experience and interaction with physical objects is the essence of knowledge.

A stage theory of cognitive development comprises an important aspect of Piaget's work. There are two major characteristics requisite for stage theory, as delineated by Piaget. (1) The ordering of stages is invariate. This constancy has been found in all societies studied. Children neither skip a stage nor revert to a previous stage. Chronological age may vary considerably but order of acquisition is constant (Piaget, 1976). (2) There is an integrative quality to each stage. The structures constructed during one stage become an integral part of the structures of the following stage. A stage includes both a level of completion and a level of preparation for the next stage. Structures that are attained at each stage provide unity among characteristic behaviors of the next stage. Once a structure is achieved each characteristic it covers can be determined.

Structures are the constantly enlarging understandings which are composed of interrelated skills and abilities. They are a system of connections that the individual uses but whose contents are not within conscious thought. A major aspect of structures is that they build on and incorporate previous structures. They are the mental processing abilities by which later knowledge is constructed. The central problem of development is to understand the formation, elaboration, organization, and functioning of these structures.

The attainment of new structures is the means by which stage progression is accomplished. Four conditions must be present for this to occur. First is maturation, a necessary but insufficient factor because it never occurs in a pure or isolated state. The variation in chronological ages at which stages appear substantiates this fact. The second factor is experience with the physical environment and its role in changing mental structures. The importance of experience cannot be underestimated but this also is insufficient to explain change. Child logic is not drawn from experiences with objects themselves but from the mental actions of the child affecting the objects (Piaget, 1964).

The third condition for stage progression is social transmission, the educative factor. The child can receive valuable information through language or education, but this can occur only if s/he has reached the developmental stage where the information can be understood. To understand the information the child must have a structure which enables him/her to assimilate this information.

The fourth factor, equilibration, is considered by Piaget to be fundamental in cognitive development. The existence of equilibration brings balance among the other three factors. Equilibration is the internal process by which all learning is accomplished. When the child is faced with external disturbance or cognitive dissonance, this disturbance necessitates compensation which tends toward equilibrium. The process by which equilibration occurs involves assimilation and accommodation, discussed below.

The acquisition of knowledge is a total developmental process involving the biological, neural, and mental functions. It results from continuous construction; in each act of understanding some degree of invention is involved. Each element of learning occurs as a function of total development rather than being the sum of discrete learning experiences. Knowledge is not provoked by isolated situations or problems, nor is it the result of separately considered actions. It is the scheme of these actions, the generalization of actions, that can be transposed from one situation to another. The development of knowledge is the spontaneous, internal process of integration of new reality into an existing mental structure through assimilation and accommodation.

Assimilation is a self-regulating process of internalizing any new experience. Acquisition is accomplished by incorporating an object or a situation into a previously organized mental structure and thus enlarging it. Assimilation involves an individual's reorganization of mental schemes or structures when the individual recognizes that something unique in the environment also relates to previous experiences. When faced with a novel experience the learner must incorporate this new observation into the mental structure containing the most logical "fit." The human mind constantly attempts to achieve equilibrium through this incorporating of new learning with previous knowledge.

The accommodation of new learning changes the learner's mental structures. This process is comparable to the ingestion of food by an organism; the change in cell structure is a result of the incorporation of the food. Accommodation is an internal process, unique to each learner. As new learning is incorporated mental structures expand. Existing structures become substructures for newly acquired concepts incorporated into larger structures. This individual interiorization process by which the learner strives for equilibrium between what is known and what is new is a major premise of Piaget's theory.

In the process of learning the child gains knowledge through two types of actions or experiences. The first, physical experience, consists of actions with objects which result in the child's drawing some knowledge about the objects. Physical experience occurs when a child determines that a sponge is lighter in weight than a rock through the process of holding the objects and comparing their weights. The second, logico-mathematical experience, involves interaction between actions which modify objects and which have as their result the deduction of knowledge. Learning results from the experience of the child in rearranging and counting objects, for example, rather than merely observing or handling the objects. This awareness leads to the discovery that changing the positions of objects does not alter their number. It is not the actions themselves but the mental processing resulting from the actions which develops knowledge. This mental processing of experiences with objects enables the child to construct mental representations (Piaget, 1964).

The development of mental representations can be traced through the progression of cognitive stages. Each stage makes its unique contribution to the mental development of the individual and incorporates the accomplishments of the previous stage. Therefore, each stage is a level of completion and a level of preparation for the next stage.

Sensori-Motor Stage

Representational thought has its origins in the sensori-motor period of a child's life, from birth to approximately age two. Intelligence develops in the young child through the expansion of mental structures, or schemes. It is not the sensations or perceptions a child experiences but the child's actions incorporating these phenomena that cause learning to occur. The mental structures constantly expand through the interaction of the infant with his/her environment.

Representational thought is seen first in deferred imitation. During the second half of the first year the copying of a model's behavior by the infant begins to occur without the model's presence. This deferred imitation leads to internalized imitation, which in turn leads to mental imagery. This progression of mental ability in the infant is the basis of symbolism and the development of language (Piaget, 1964, 1976).

The sensori-motor stage provides the milieu for establishing the roots of logic. The actions of this period allow for the development of practical knowledge which becomes the substructure of later representational thought. Object permanence, or the knowledge that things continue to exist when out of sight, is the foundation for operational logic of conservation. This concept emerges from the infant's coordination of actions (Piaget, 1964).

The assimilation process, or the incorporation of new experiences with objects from the infant's universe, predominates during the sensori-motor stage. Incorporation occurs through the senses as the child becomes more and more capable of controlling his/her behavior. S/he assimilates the surrounding world first through sucking, then looking, listening, and gradually through manipulating objects. These actions are repeated and generalized to new situations. They become "action schema" in that the child coordinates them into purposive behavior. An example of behavior which is coordinated with a pre-established goal is the child's pulling a blanket close to him/herself in order to get the object on the blanket. This sensori-motor intelligence occurs toward the end of the first year (Piaget, 1976).

The actions of the infant lead to discriminations, first of the self from the universe, then of certain objects and persons as distinct from others. As s/he acquires sufficient behavioral facility s/he begins to notice the results of these actions. Rather than merely reproducing movements, the child intentionally varies these movements in order to study the results. This allows the infant to explore and to experiment. As these experimental behaviors become capable of coordinating with one another the process becomes analogous to what will later occur in the ideas or concepts of thought itself (Piaget, 1968).

The mental activity of the infant involves the organization of perceptions and sensations rather than the mere recording of these experiences. This organization allows for the construction of categories of objects, space, causality, and time. Therefore, knowledge cannot result from the mere impression made by an object on the sensory organs but is due to the active assimilation of the infant, who incorporates the object with pre-existing sensori-motor schemes. This incorporation of sensations and elaboration of perceptions through the purposive actions of the infant is the fundamental process of the practical intelligence of the sensori-motor stage (Piaget, 1964).

Pre-Operational Stage

Pre-operational thought emerges with the beginnings of language. Internalization of schemes of action in representations are now possible. Language allows the child to describe his/her actions. It also provides the tools needed to reconstruct the past and to anticipate the future. In both these processes actions are replaced by words and therefore, not actually performed. This is the point of departure for thought. However, there must now be a reconstruction on the level of representational thought of all learning that was developed through sensori-motor activity.

The process of restructuring practical intelligence based on actions into representational thought is the major task of the pre-operational period. An example of this process is the time lag between a child's ability to move from one place to another and his/her ability to represent the actions needed to accomplish this. When a child is asked to show a path from one point to another by drawing, telling, or simply arranging models, s/he cannot successfully execute the task until the age of 7 or 8 (Piaget, 1964, 1976).

As a result of increased motor skills, knowledge gained from actions expands during the pre-operational stage. The child's own actions are purposive and the actions of others can be imitated. However, these actions cannot be represented symbolically through thought. Actions and configurations are not yet interrelated. These separate actions and configurations are called intuitions (Piaget, 1968).

Representational thought at this stage is fixed on static configurations. Static configurations of pre-operational thought can be compared to viewing individual frames of a motion picture separately which results in the elimination of any relationships or sense of motion among the separate pictures. This perception of static states produces non-conservation, or the notion that quantity is altered when shape or spatial arrangements are altered.

~~As connections or relationships begin to emerge, separate~~ intuitions based on perceptual illusions of the moment give way to operations.

> Intuitions become transformed into operations as soon as they constitute groupings which are both composable and reversible . . . actions become operational when two actions of the same kind can be composed into a third action of the same kind . . . when these various actions can be compensated or annulled . . . the action . . . is an operation (Piaget, 1968, p. 49).

Thus operations have two characteristics lacking in intuitions. They are reversible and they are coordinated with other operations.

Concrete Operational Stage

Operations first appear at the concrete stage. They are called concrete operations because they are limited to physical objects or mental representations of objects. Concrete thinkers use logical reasoning about concrete objects and situations. They think in relationships of the first order, perceiving relationships between items, but not among items; that is, they can understand cause and effect in a one-to-one relationship but cannot think about multiple causes or effects having different degrees of importance (Piaget, 1976).

Concrete thinkers have the ability to examine two judgments simultaneously and arrive at reconciliation of opposing judgments. However, they are unable to construct systems and theories (Lunzer, 1970). They deal with each problem in isolation and do not integrate solutions from which they can abstract a common principle. They can draw conclusions from observations but not from hypotheses; they can make inference but do not comprehend implications (Piaget, 1968).

Concrete operations can be illustrated by again using the analogy of the motion picture. As the mind assimilated the pictures accommodation occurs within the mental structures. The separate static elements become dynamic and interrelated. This change allows for the interaction of states and transformations to construct a novelty, or learning, which is unique to each child. This novelty can be compared to the illusion of motion observed in motion pictures.

This phenomenon of motion cannot be explained however, by perception alone. Perception is limited to the present while cognition is the mechanism for past and future symbolic representations. Symbolic meaning is constructed, not copied. It emerges from the interaction between perception and conceptualization or cognition; therefore, images are not meaningful until they are structured by conceptualization. The assimilation process coordinates specific perceptions into general systems of relationships, concepts, and rules (Cowan, 1978).

The construction of representational thought is dependent on a series of structures or schemes developed from actions which become more and more capable of being carried out in thought. "To think is to classify, to arrange, to place in correspondence, to collect, to dissociate . . . (These) . . . must be carried out materially in actions in order to be capable afterward of being constructed in thought" (Piaget, 1976, p. 13). Representational thought is the system of internalized actions which provide the foundation of operations. To be operations these actions must be reversible; that is they must be capable of developing conceptually in both directions without distortion. They must include the possibility of a reverse action which cancels the result of the first action. This means that operations can be undone without disrupting structures. Reversible actions can be illustrated by the thinking involved in solving the following problems: (1) 6 + /_7 = 10; (2) 6 * 8 = 48 ÷ 8 = /_7; (3) Start with mammals and add all other types of animals to make the class "animals", then take away all other animals and only __________ remain; and (4) Given two rectangles of equal area, one rectangle having dimensions of 8" * 3" the second rectangle would be 6" * /_7".

Operations consist of a set of actions modifying the object. This process enables the learner to get at the structures of transformation. Operations are never isolated but are always linked to other operations as part of a total structure. For example, a logical class or number cannot exist in isolation but only in relation to the total structure of classification or series of numbers. The mental structures of operational thought consist of order/seriation, number, relations, classification, and conservation.

Concrete operations differ from the later stage of formal operational thought in that knowledge for the concrete thinker is limited to experience with real objects or concrete representations rather than abstract concepts. Formal operations, in contrast, can involve representation of possible actions (Piaget, 1964, 1968).

Formal Operational Stage

Formal thinking is much more abstract in both principle and practice. The attainment of this stage produces, "a great many transformations which are relatively rapid at the time of their appearance and extremely varied" (Piaget, 1976, p. 59). Thinking becomes more equilibrated through the ability to build combinations of relations among propositions. Patterns of actual and possible outcomes are developed with the number of combinations equaling _n_ variables multiplied by _n_ values of each variable (n * n). Hypotheses are created, tested, and conclusions are derived from the results. This skill is referred to as hypothetico-deductive reasoning. Also included in this level of cognition are the formal schemes of proportion, probability, equilibrium, volume, and relations between distance, time, and speed. Formal operational thought produces the greatest regulating balance between assimilation and accommodation processes (Cowan, 1978).

Formal reasoning ability is not an all or nothing development, but is more likely to be evidenced in areas of familiarity and interest. It evolves from situations which cause disequilibration for which concrete operations prove to be inadequate. However, the ability to think formally does not guarantee its use in all situations. The attainment of this level of thought only means that the individual is capable of behaving in a certain way that was impossible before (Tanner & Inhelder, 1960).

Piaget's initial experiments with adolescents determined that formal reasoning began around the age of eleven or twelve years. Subsequent researchers, as well as Piaget himself, have felt that this age was based on a somewhat privileged population and the average shift into this stage is later. There is evidence that many college students are still functioning on the concrete level (Piaget, 1976; Chiappetta, 1976; Renner et al., 1976; Phillips, 1979). Some adults never attain the level of formal operational thought (Piaget, 1971).

Formal operations encompass all the characteristics of concrete thought but in a much more complex framework. As possible combinations expand when increased from two objects to four or more, so do the mental abilities of the formal thinker expand. The formal thinker's system of mental operations has reached a high degree of equilibrium. Thought is flexible and effective; complex problems of abstract reasoning can be dealt with. The individual has the ability to imagine the many possibilities inherent in a situation (Inhelder & Piaget, 1958). The formal thinker can consider hypotheses and determine what should follow if they were true; s/he can follow the form of reasoning while ignoring its content. Formal logic is essentially a logic of speech. It is based on the manipulation of ideas rather than objects (Piaget, 1976).

Piaget has differentiated structures of formal operations which include the ability to separate, exclude, or disjoin variables, to consider "all other things being equal," and to recognize reciprocal implications. There is considerable overlapping of skills among the designated structures. This study examines four skill areas: conservation of volume; propositional logic; combinatorial logic; and proportional logic. The first of these areas, conservation of volume, involves thought which is four-dimensional. Length, width, and height from both internal and external perspectives must be considered simultaneously. Conservation abilities of concrete operations are additive compensations while conservation of volume presupposes proportionality. Empirical evidence is insufficient for discovery, but conservation of volume, like all conservation abilities of concrete operations, is verifiable. This characteristic differentiates conservation of volume from even higher level conservation tasks such as conservation of motion which cannot be empirically verified within given limits of time and space.

Propositional logic involves new operations performed on propositions themselves rather than on classes and relations. It is executed in terms of the total number of possibilities and necessary relations and is evidenced by the capacity to study statements and implications dealing with the possible rather than limited to the actual. It is represented by "if . . . then . . . therefore" reasoning.

The third area to be examined is the combinative network in which operations involving combinatorial analysis and permutation systems are executed. Through the application of combinatorial logic the student takes into account all possible combinations of eventualities in an exhaustive way. This process necessitates the mental manipulation of some variables while holding others constant.

Proportional logic, the fourth area of formal thinking, is the capacity for reasoning employing two reference systems at the same time. This thought structure, as do the other areas mentioned, involves the group of four transformations Piaget refers to as INRC. This group consists of two complementary aspects of a structure represented by identity, negation, reciprocity, and correlation. This grouping creates two combinations which are equal to each other with each pair possessing the ability to cancel itself (Piaget, 1968, 1972, 1976).

Figurative/Operative Thought

Piaget describes two different aspects of representational thought, the figurative and the operative. Figurative thought is composed of configurations or static mental images and can be compared to imprinting an image onto a receptor. Figurative thought requires little interaction of learned material with the mental processing of the child. It is based on associative learning, on one-to-one correspondence, and is derived from imitation. It lacks understanding of transformations, or the processes by which changes occur.

Operative thought includes the actions which lead from one state to another. A given state is understood to be the result of some transformation and the point of departure for another transformation. It is this ability to modify objects mentally or to comprehend these actions that differentiates operative from figurative thought.

The pre-operational child is limited to figurative thought because s/he does not understand transformations. Guided by perceptions and mental pictures the child simply compares the initial and final states without giving attention to the transformations or changes which occur between these two events. Thought, as a result, is one-dimensional for the pre-operational thinker.

The child's attention is focused, for example, on either length or width but not on both at the same time. As the change in dimensions is exaggerated or the child is encouraged to notice the other dimension, the focus will shift with the resultant loss of the first dimension. There will be oscillation between focus on either dimension; both will not be coordinated until the attainment of operational thought.

It is at the stage of concrete operations that the child discovers the relationship between length and width; then adjustment or compensation can be made mentally between changes in these dimensions. This results in thinking in terms of the transformation process and not just the initial and final states. Thus, the operative aspect of thought includes operations and the actions which lead from one state to another. When this level of thought has been developed, figurative aspects become subordinated to the operative aspects. Transformations become the primary content of thought; states are understood as they relate to transformations (Piaget, 1976).

The philosophical base of the figurative mode of teaching is that of external application of a pre-existing body of knowledge. Learning is seen as an accumulation of discrete facts and is best accomplished through drill and repetition. Associations tie one configuration to another through the process of addition. This mode of teaching consists of transfer and recording of information. When teachers limit instruction to presentation of facts, or emphasize perception and memory, figurative thought is employed.

The operative mode of teaching depends on the fundamental relation of assimilation or the enlarging and expanding of previous knowledge and is multiplicative rather than additive. It results from logical conflicts and contradictions which encourage the student to develop greater understanding through problem solving. These contradictions evolve from content that is related to student life experience in both time and space. Operative teaching is expressly concerned with the construction of meaning, with making sense out of the world, and with establishing connections between concepts and symbols (Elkind, 1976).

Summary

The relationship between the ability to use abstract logic and reasoning and success in learning for secondary students has received increased attention in recent years. The research of Piaget and Inhelder has provided the framework with which to study the dynamics of this relationship. Their work has delineated the stages of the development of knowedge and logical thought from birth to adolescence and has demonstrated the qualitative difference in children's thinking at each level.

Researchers have examined the cognitive requisites of curriculum areas of science and mathematics and have determined that successful performance in these areas is closely related to the level of cognitive ability attained by secondary students. More recently attention has been focusing on other areas of the secondary curriculum which also demand a level of cognitive development often not possessed by many students. This study was conducted to determine whether secondary students use formal operational reasoning, the last level of Piaget's stages of cognitive development. A related question was whether instructional materials and techniques can increase the number of students able to use abstract logic.

CHAPTER II

REVIEW OF THE LITERATURE

The problem addressed in this study has been the examination of the relationship between formal operations and secondary school performance, particularly in economics and the effects of intervention on the increase of formal operational thought. This chapter will present a review of research and related literature relevant to the study of formal reasoning in secondary students. The review of literature was conducted by manual searches of ERIC (Educational Resources Information Center), *Dissertation Abstracts International*, *Education Index*, and other resources. Also, a computer search was conducted by AIRS (Automated Information Retrieval Services) at the University of California at Davis.

Material reviewed will be presented in five sections:

1. Commentaries on Formal Operational Thought
2. Increasing Formal Operations Through Instruction
3. The Social Studies Curriculum and Formal Reasoning
4. Assessment of Formal Operations
    a. Clinical interview
    b. Group assessment
5. Empirical Studies of Formal Operations
    a. Replication studies
    b. Experimental intervention studies

Commentaries on Formal Operational Thought

Piaget (1972) described formal operations as thinking that encompasses the real, but at the same time goes beyond reality. This description implies the subordination of the real to the realm of the possible and, consequently, the linking of all possibilities to one another by necessary implications. As a result, the individual can adopt opposing points of view; s/he can become interested in problems beyond his/her immediate field of experience, understand and construct theories, and participate in society through involvement with ideologies of others.

Formal operations is a process of organizing classes or relations into higher-order classes or relations; the inference of relationships between classes of elements is not derivable directly from concrete elements. These relationships must be constructed; the construction is based on the results of first-order operations of classification with the addition of two new cognitive strategies. These new strategies involve the systematic combination of elements and the isolation of variables. These strategies reflect a structured whole that has properties resembling a mathematical group (Kuhn, 1979).

In contrast, concrete operational thought involves certain logical reasoning processes but is limited to applying operations to concrete objects or events which make up the real world. The concrete operational individual acts directly upon materials through the process of trial and error. Elements are classified or ordered without isolating all factors involved. The concrete structure cannot be generalized to different heterogeneous contents but remains attached to a system of objects or properties of these objects (Piaget, 1972). Concrete thinking can be defined as thinking that is dependent upon the "immediacy of claim" where the individual is unable to detach himself from the uniqueness of an object and fails to see it as representative of a class (Lowell, 1979).

The concrete thinker reasons in terms of direct experiences. S/he reasons from concrete objects and works with logical operations that refer to empirical reality (Cantu & Herron, 1978). After considerable experience with exercising concrete operations the individual becomes aware of the limitations of concrete operational modes of functioning (Kuhn, 1979). This awareness results, finally, in the logical necessity of moving from trial and error to the recognition of all possible hypotheses, isolating those factors involved, and studying the effects of each in turn (Piaget, 1972).

Movement to formal operational thought requires the understanding of abstract concepts. Abstract concepts do not have the defining attributes and observable examples of concrete concepts that are learned through sensory observations of examples and nonexamples (Cantu & Herron, 1978).

Formal operations cannot result from direct instruction.

Students do acquire socially arbitrary knowledge through direct instruction but that knowledge consists mostly of linguistic and cultural conventions. Development of formal operational thought is stimulated through opportunities for students to construct physical and logico-mathematical knowledge. Physical knowledge results from actions and forms of discovery of the physical properties of objects. This knowledge is culturally universal and nonarbitrary. It is derived from empirical abstraction of sensory input. Logico-mathematical knowledge consists of nonobservable relations among objects and events whose source is reflective abstraction constructed by the individual, rather than cultural or sensory input (Nucci & Gordon, 1979).

Kuhn (1979) commented that the process of acquiring formal operational thought has profound and far-reaching implications for education. Berzonsky (1978) asserted that adolescence may be a more critical period for instruction than the period of childhood. Although progress through the three earliest stages of cognitive development is relatively independent of specific environmental stimulation, the growth of formal operations seems to depend on the type and quality of instruction (Case & Fry, 1972; Siegler, Liebert, & Liebert, 1973).

<u>Increasing Formal Operational Thought Through Curriculum Change</u>

Cronbach (1964) observed that many so-called innovations in curriculum have been based on the same principles of pedagogy in use for a long time. These principles consist of emphasizing exactly what you want the student to do, teaching the student to do it, providing opportunities for practice, and then rewarding when the job is done right. In a similar vein, Nucci and Gordon (1979) stated that neither the traditional nor modern approaches to secondary education distinguish information that can be learned through direct instruction from knowledge the student must construct independently. Traditional methods lead to accumulation of information without concern for the way in which students organize this information. In contrast, modern approaches fail to coordinate the conceptual complexity of presented ideas with the developmental level of the student. This failure results in a consistent risk of mismatch between the structure of information and the student's cognitive structure. Consequently, the student neither comprehends what is presented nor develops more advanced forms of thought.

Piaget (1964) has stated that a student can receive information through language and/or teaching only if s/he is in a state where s/he can understand this information, that is, if the student has the prerequisite cognitive ability to assimilate this information. Education should capitalize upon the operations the student has already mastered. When something is taught early it may be learned in a false way (Cronbach, 1964).

According to Lawson, Karplus, and Adi (1978), intellectual ability is developmental rather than being a consequence of direct and short-term instruction. Cognitive schemes are not developed until the student is confronted with certain kinds of data. These schemes become internalized only after repeated successful and unsuccessful experiences with many problems. This observation implies that curricula designed to promote acquisition of these reasoning abilities should provide opportunities for equilibrium to occur.

Ausubel (1964) stated that the emergence of abstractions must always be preceded by an adequate background of direct, non-verbal experience with empirical data. The concrete thinker is unable to relate abstract relational propositions to cognitive structure and, as a result, these are devoid of meaning. S/he is largely restricted to a sub-verbal, concrete, or intuitive level of cognitive functioning, a level that falls far short of the clarity, precision, explicitness, and generality associated with the more advanced stage of abstract reasoning. The transition from one stage to another presupposes the attainment of a critical threshhold level of cognition that is reflective of extended and cumulative experiences. These experiences allow the student to draw on various transferable elements of an overall ability to function at an abstract-verbal level of logical operations. Abstract thought in a variety of subject matters is not possible during the initial phase of formal operations but only after sufficient concrete background experiences in each content area have been attained, maintain Stone and Ausubel (1969).

In agreement with the preceding statements, Arons (1976) concluded that formal operations are not attained through telling about concepts, modes of thought, or lines of reasoning. Rather they are built through questioning, through direct personal experiences with phenomena, inference, quantitative reasoning, and verbalizing perceived relationships. Ideas must precede names; words acquire meaning only as a result of experience. Griffith (1976) found that the addition of technical vocabulary for nonformal thinkers prevented them from recognizing their failure to solve problems. They were convinced that their use of jargon had resolved the issue. Even when errors were brought to their attention they persisted in regarding the use of words as the solution to the problem.

McKinnon and Renner (1971) stated that a period of physical manipulation of objects is a necessary first step for building abstract ideas. Until the student has had many manipulative experiences s/he cannot recognize those concepts in the context of a broader generalization. Leaving a student alone, however, to discover is not nearly so effective as providing him/her with guided sequences to maximize development (Cronbach, 1964). Students taught how to question and investigate show more rapid intellectual development than students not having such experience (McKinnon & Renner, 1971).

These authors also hypothesize that a properly designed curriculum does enhance logical thought patterns by increasing the ability to hypothesize, verify, restructure, synthesize, and predict. Boulanger (1976) found that instruction did have a mediating effect in promoting reciprocal growth in solving formal reasoning problems in a different context than the training problems.

Herron (1976) asserted that too often secondary teachers present "formal aspects" when students would gain far greater benefit from concrete experience which provide the basis for future formal thought. Ausubel (1964) described the conditions for transition to formal operations. These consist of a sufficient mediating or transactional vocabulary and a body of abstract ideas that are clear and stable and allow for greater integration of related ideas and different aspects of the same problem. Raven (1974) offered three factors necessary for an instructional strategy to facilitate acquisition of logical operations. These factors are (1) task organization which must correspond to the student's level of reasoning, (2) incorporating active engagement of the student in construction of rules and concepts, and (3) concrete referents provided whenever possible. According to Inhelder and Matalon (1960) the process of acquisition can be accelerated by training.

In this same vein, Lawson and Renner (1976) proposed seven steps to allow for self-regulation. It is through this process that abstract concepts are constructed. The first step is to arrange the sequence of instruction to begin with concrete ideas defined through demonstrations, examples, and actions. Step two involves student exploration before introduction of a new concepts, giving opportunity to work with objects and make observations. The third step consists of beginning discussions with simple demonstrations and challenging the student to raise questions or to predict outcomes and then compare these with actual results. The fourth step suggests allowing for student interaction during discussions, experiences, and problem-solving. Then step five involves having students justify conclusions, predictions, and inferences, whether true or false. Step six recommends that the teacher be receptive to all hypotheses, and the seventh and final step requires students to reason out loud, to provide a variety of hypotheses, consider alternatives, deduce implications, and to examine evidence. Group work involving the views of others causes students to be more aware of their own reasoning. Formal thinking patterns serve as role models which offer short cuts in reasoning.

A related principle of instruction incorporating cognitive development stresses the proper combination of new with previously learned material. Kolodiy (1977) asserted that the educational experience must not only bear relevance to what the student already knows but at the same time be sufficiently novel to provoke conflicts and mental disequilibrium. As the student incorporates past experiences and learning from teachers and peers with this challenge, thinking is reorganized. This process produces intellectual development through the establishing of new and more stable equilibrium with increased understanding of subject matter and problem-solving capability. Teaching becomes a process of focusing on the development of reasoning rather than a mastery of content.

As stated earlier, Nucci and Gordon (1979) maintained that teachers need to differentiate between content which can be taught directly and knowledge which students must construct on their own. There is knowledge which may be instructed and knowledge which must be constructed. The recognition of the difference in types of knowledge presupposes identifying student reasoning patterns and levels of comprehension. The teacher must then identify the conceptual emphasis and demands of the subject matter and help students develop more advanced reasoning patterns (Rowell & Hoffmann, 1975, Karplus, 1977).

As the teacher becomes familiar with the developmental process, the necessity to evaluate content and assign materials and activities consonant with students' developmental needs becomes imperative. The interaction with very carefully designed and sequenced concrete materials which serve as concrete examplars of formal concepts aids students in transcending concrete modes. Students must be allowed to interact with materials and also be provoked to reflect the consequences of their actions. This interaction encourages students to reach a point at which properties of materials can be abstracted from specific content. Students should be allowed to make their own mistakes or to confound variables, then discuss these mistakes to provoke reflection upon their results and procedures (Lawson & Blake, 1976). Teachers need to recognize and appreciate individual differences in reasoning ability and understand the demands that their subject matter places upon these abilities. This recognition will result in better articulation between subject matter and level of student reasoning and is a prerequisite for using subject matter to affect an advance in reasoning (Lawson & Nordland, 1976). Herron (1976) stated, however, that considerable research is needed in the area of assisting students in transition from concrete to formal operational thought before we can prescribe materials and procedures for teachers to use.

Social Studies Curriculum and Formal Operations

Study of what is involved in the transition from concrete to formal thinking has been devoted also entirely to science. Though Piaget has done some work with propositional reasoning, it has been quite limited compared to his research in the physical sciences (Inhelder & Piaget, 1958). Little attention has been given to the need for formal reasoning in other areas of the curriculum. Some students of Piagetian thought, however, have recognized the relationship between formal operations and curriculum areas such as social studies. Elkind (1976) and Lovell (19[illegible]1) maintained that the concrete thinker is limited in comprehension to the immediate in time and space.

However, Hallam (1979) posed the problem of whether it is appropriate to adapt criteria derived from scientific experiments to a subject such as history. He then qualified this issue with the argument that both history and science rest upon the understanding of logic of classes and relations. They both use inductive and hypothetico-deductive reasoning and deal essentially in probabilities rather than certainties. Other writers support this assertion. Lovell (1961) stated that it is unlikely that thinking skills are relevant only to science; it is reasonable to suppose they are also relevant to problem solving in history and geography. Kohlberg and Gilligan (1971) maintained that logical abilities of formal operations should be evident in nonscientific fields.

According to Nucci and Gordon (1979), social studies texts usually assume certain logical abilities in students rather than providing the context for the development of those abilities. Much of the social studies content for even very young children is very abstract. For example, society as a system is not usually understood until late adolescence (Nucci & Gordon, 1979). Lovell (1971) found that formal thought in history comes late in intellectual development. Hunkins et al. (1977) supported the view that social studies curricula fail to acknowledge the need to coordinate content with student reasoning abilities. They maintained that social studies materials appear, with few exceptions, to have paid little attention to the developmental factors of relating types of activities and experiences with required intellectual tasks. Chronological sequence of history has overshadowed psychological learning sequence (Osborne, 1975).

Martorella (1977) concurred with the assertion that much of the social studies data with which students are asked to contend are highly abstract. He maintained that developmental research suggests that learning problems will occur as long as texts continue to emphasize symbolic forms and remain the nearly exclusive medium of social studies curriculum. Ellis (1979), in discussing the psychology of learning economics, asserted that symbolic language is by definition abstract; words are substitutes for sounds and/or meanings. To become an expert in logical manipulation it is necessary to employ formal thought. He concluded that the discipline of economics can learn a great deal from developmental psychology.

Meinke et al. (1975) found that students in grades four, six, and eight indentified as abstract thinkers did significantly better than concrete thinkers on criterion measured dealing with concepts of freedom, justice, and their negations.

Hallam (1979) stated that concrete thinkers are able to give organized answers but are limited to what is apparent from the text. They are able to forecast from evidence available but not able to formulate hypotheses. Formal thinkers are able to postulate mature hypotheses that can be confirmed, modified, or refuted. They commit themselves to possibilities and reason by implication at the abstract level. As a result they can realize a multiplicity of possible relationships.

Brown (1978), in examining children's thinking in relation to social studies, observed that the ability to coordinate relationships in dealing with impersonal subject-matter content has its parallel in the understanding of real-life social relationships. This understanding presupposes the ability to hold in suspension two points of view. Formal operations, however, demands a third perspective, that of an independent and objective party. Concrete operational thinkers have the ability to handle two different perspectives simultaneously. However, when confronted with an emotional topic dealing with interpersonal relationships, they may revert to pre-operational thinking and be able to consider only one viewpoint. The concrete thinker is able to deal with the past only when the event, place, or person studied is related to the present and the familiar (Brown, 1978). Adelson (1971), in a similar vein, contended that during early adolescence the child's mind is locked into the present. Not only do children not understand concepts taught in social studies but they also have their own version of these concepts. Teachers are usually unaware of this situation; they assume if the student can define terms they can understand concepts (Osborne, 1975).

According to Martorella (1977), the most important application of developmental research to social studies lies in the recognition of differing capabilities of students to process symbolic or abstract data such as written texts. Teaching specific information or educational content should be coordinated with the student's ability to meaningfully comprehend what is being taught. Content should include references to topics just beyond the student's immediate understanding but not so complex as to make comprehension unlikely (Nucci & Gordon, 1979).

Presseisen and D'Amico (1975), in looking at the social studies curriculum from a Piagetian perspective, recommended providing opportunity for the learner to act upon the content of learning. S/he must be the primary subject of the learning act rather than a recipient of predigested knowledge. Conditions of cognitive conflict should be created to lead to structural change rather than providing instruction concentrated on modelling correct responses (Hallam, 1979). The learner must relate the substance of learning to what s/he already possesses. New knowledge must attach itself to earlier roots of learning both perceptually and linguistically.

Then the learner must carry the significance of this new knowledge beyond the point at which s/he acquired it and transform it into something greater than when s/he began (Presseisen & D'Amico, 1975).

Martorella (1977), writing in Research in Social Studies Learning and Instruction, concluded that the understanding of intellectual capabilities, predispositions, and limitations related to developmental stages can influence social studies in two basic ways. Materials and strategies need to be designed to prevent fixation at a given stage. They should also be constructed to facilitate or accelerate stage transition. In both cases social studies tasks should be matched to the developmental profile of the student. According to Brady (1970), however, this awareness of student's level of cognitive development is not easy to achieve even when the need for it is acknowledged.

Assessment of Formal Operations

Inhelder's and Piaget's (1958) definitive work with the reasoning patterns of adolescents has provided the foundation for investigation by numerous researchers attempting to either replicate or refute the analysis of formal operations. Kuhn (1979) described methodological problems in the research to date. Exact methods of administration and scoring criteria have not been established. It is up to each investigator to decide how Piagetian tasks are to be administered and how the responses are to be classified. Disparaties in research methods make it difficult to compare and integrate results across studies. Walker et al. (1979) commented that the literature indicates confusion over the reasoning patterns required for an individual to be designated as a formal thinker. This designation is given somewhat arbitrarily by the individual investigator.

There are two types of measures used to determine levels of cognitive development: clinical interview and group administered assessments.

Clinical Interview

The clinical interview has been the method employed by Piaget throughout his years of research into how children think. There are some definite advantages to the "methode clinique." The opportunity to investigate student thought beyond standardized working allows for greater clarity in understanding the deeper meaning of children's responses. Individual assessment permits students to manipulate testing materials and examiners to probe for understanding of student reasoning. The one-to-one engagement of student and examiner in experienceing and exploring solutions to cognitive tasks is the first and primary step in developing understanding of formal operational thought, according to Reifman (1978).

Disadvantages to the clinical interview are significant, however. In translating the implications of Piagetian theory of formal operations into classroom use larger groups of students need to be assessed. The clinical method is inadequate for this task because of numbers of students and constraints on teachers' time. If teachers are to be cognizant of the cognitive characteristics of students they must use group tests (Raven, 1973; Rowell & Hoffmann, 1975; Lawson, 1978). Valid, streamlined assessments would expedite much Piagetian research and make possible more comprehensive studies (Patterson & Milakofsky, 1978).

<u>Group Administered Assessments</u>

Researchers have been developing group administered assessments of formal thinking over the last few years with varying degrees of success. The first group administered pencil and paper measure of intellectual developmental levels was developed by Longeot (1962) in French. Rowell and Hoffmann (1975) observed that the group method of administration loses some of the sensitivity inherent in the clinical approach as employed by skillful researchers. Others (Bart, 1971; Tisher, 1971; Raven 1973; Neimark, 1975) contended that research supports the feasibility of constructing objective and quantitative measures of formal operational skills.

Lawson (1978) attempted to retain important aspects of the clinical method while allowing entire classes of students to be assessed with a substantial number and variety of problems. He listed several criteria for an assessment of operational reasoning to be valuable. These criteria include the ability to measure both concrete and formal reasoning, the inclusion of a variety of problems to assure reliability, and the use of physical materials. Also needed is a format requiring little reading and writing and which allows for administration to whole classes in a short period of time with ease of scoring. Lawson, as well as other investigators, stressed the inclusion of student justification of their answers (Lawson, 1978; Nucci & Gordon, 1979; Walker et al., 1979). However, Struthers and De Avila (1967) and Goldschmid and Bentler (1968) found a correlation of $r = .90$ between scores obtained with and without justification.

Scoring of group administered assessments presents a problem not inherent in clinical interviews. Some researchers have attempted to build tests of progressive operational reasoning (Rowell & Hoffmann, 1975; Lawson & Blake, 1976). Piaget's deliniation of stages (IIA, IIB, IIIA, IIIB) were often used. However, some researchers used new substages of IIA/B and IIB/IIIA (Shayer et al., 1976; Kuhn & Angelev, 1976). Additional studies have established criteria based on percentages correct in each subtest (McKinnon & Renner, 1971; Sayre & Ball, 1975). In most instances the criterion has been set at 75 - 80%. Lawson (1978) established a criterion of 80% which he felt was supported by principal-components analysis, item analysis, and previous knowledge of what the items measured. He contended, however, that the classroom test may slightly underestimate capabilities of a class as a whole.

There have been various methods employed to establish reliability and validity of group administered assessments. De Avila and Pulos (1979) utilized Cronbach's Alpha Reliability Coefficient with various administrations of their instrument with populations ranging from 1288 - 6146 students and obtained reliability figures ranging from $r = .62$ to $r = .88$. More often the Kuder-Richardson formula was employed (Benefield & Capie, 1976; Lawson, 1978; Roberge & Flexer, 1979). These figures ranged from $r = .25$ to $r = .98$ with the majority in the .70 - .80 range. The test-retest determination of reliability has been used less often. Lawson et al. (1974) found the carry-over effect to be significant with administrations 1 week apart. Walker et al. (1979) found no evidence if this with a 6 week time span.

The process of validation has been more complex. Bart (1972) stated that content validity is established if items in the test require behaviors for successful resolution that are proper to the trait being measured. Roberge and Flexer (1979) concluded that validity is established when the results are not at variance with earlier studies using Piaget and Inhelder's tasks. Gray (1978) asserted that explanation of response is the Piagetian approach to validation. Lawson (1978) used a panel of six judges to establish content validity. Concurrent validity has been established by various researchers through the process of correlating group tests with individual assessments. Tisher (1971) found a 77% agreement between the two measures that he used. Renner et al. (1978) determined, by using chi square, that 94% of the results agreed in the cases where both individual interviews and pencil and paper group tests were administered. Bart (1971, 1972) and Kolodiy (1977) established internal consistency among test items through Pearson Correlation matrices with resulting moderate correlations.

Establishing construct validity is a more involved process employing factor analyses. Lawson and Nordland (1976) isolated two components which were identified as early concrete and early formal operations. Bart (1971) found a bifactor structure with differences among contents of measurement rather than differences among reasoning modes. On the basis of principal component analysis, Lawson (1978) concluded that the classroom test of logical thinking can be said to have factorial validity. Bart (1972) asserted that formal reasoning tests have demonstrated substantial content validity, modest concurrent validity, and limited construct validity. He concluded that these measures are moderately successful but do not exhibit "pure" validity.

The emphasis on constructing reliable and valid measures is important, according to Kuhn (1979). She stated that the formal stage of operations, if it is to survive as a useful construct, must be defined in its broadest and most comprehensive form. She also concluded that a sound curriculum designed to induce certain cognitive competencies cannot be constructed without defining exactly what these competencies are. Renner et al. (1978) maintained that a valid pencil and paper group test will enable the teacher to understand the differences between concrete and formal reasoning, to recognize the use of these thinking patterns with subject matter, and to find a better match between what is taught and what students are capable of learning.

Empirical Studies of Formal Operational Thought

The studies measuring formal operations can be grouped into two classifications, replication and experimental. Each will be discussed in turn.

Replication Studies

The earliest replication studies were conducted by Lovell (1961) and Elkind (1961). The conclusions drawn from these studies were in agreement with Inhelder and Piaget (1958), though both found a slower development of formal reasoning than indicated by Piaget. Numerous studies conducted since have found that a substantial percentage of secondary students are not formal thinkers (Lunzer, 1965; Lawson & Renner, 1974; Chiappetta, 1976). Shayer et al. (1976) administered group assessments to 10,000 students aged 9 - 14 in Britain. They demonstrated the progressive quality of formal thought which is correlated with age but they concurred with other researchers that only a small fraction of students construct full formal reasoning ability. McKinnon and Renner (1971) assessed 131 entering college freshmen and found that 75% were not formal thinkers. They asserted that no work can be found with American students, which verified Piaget's conclusions that formal operations are established between ages 11 - 15. Karplus et al. (1977) stated that a major percentage of students ages 13 - 15 lack the ability to articulate proportional reasoning and/or control of variables. In measuring seventh-twelfth grade students, Nordland et al. (1974) and Renner and Stafford (1972) found that only 6 - 15% were formal thinkers. Nucci and Gordon (1979) drew the conclusion that these data further demonstrate the failure of current approaches to coordinate instruction with intellectual development.

The literature does not provide clear-cut evidence for either similarity of differences in cognitive development between males and females. Data concerning gender differences on measures of formal operational ability has been conflicting. Earlier studies such as Elkind (1961) and Tuddenham (1971) found males significantly superior in formal reasoning skills to females. Other, more recent, studies have determined that no significant difference between gender is present (Burney, 1974; Sayre & Ball, 1975; O'Neill, 1978; Phillips, 1979). Some researchers have found a significant difference between males and females on some subtests but not on others (Karplus et al., 1977; Roberge & Flexer, 1979). Renner and Stafford

(1976), investigating formal reasoning abilities of 588 students in grades 7 - 12, were surprised to find significant differences between males and females at every grade level. No explanation could be proposed for this phenomenon, though it was determined that the difference was primarily due to greater frequency of formal operational level explanations for males. They found greater variability of male performance when compared to females. The performance curve for females was less linear. It was proposed that, given a constant curve, females would attain formal operations equal to males at approximately 22 years of age.

Experimental Intervention Studies

Experimental studies have involved training sessions conducted to determine whether greater numbers of students receiving training would be classified as formal operational and whether the quality of thought displayed by early formal reasoning was increased. Lovell (1961) concluded, after testing 190 primary and secondary students, that instruction does not seem to have affected results as much as had been expected. He felt that instruction generally seemed to be of greatest value when certain thinking skills were available or almost available to students. When the requisite cognitive level was not present, knowledge gained by instruction was either forgotten or became rote learning.

Case and Fry (1973) developed training components intended to teach control of variables using written materials and apparatus. Fifteen high school students performed significantly better than controls did on a paper and pencil measure. Hyram (1975) used guided class discussions for 4 months. The experimental group improved in reasoning ability and logical thinking as measured by problems similar to those used for training. Two groups of fifth and seventh grade students received 4 30-minute individual training sessions (Lawson & Wollman, 1976). Both groups made significant gains over control groups as a result of treatment. The researchers concluded that instruction can affect the transition from concrete to formal cognitive functioning in the ability to control variables but is limited to specific transfer. This conclusion is supported by Lawson et al. (1975) who determined that students improved in ability to do problems taught in a program but made no gains in ability to control variables when presented with new problems.

Cantu and Herron (1978) found that both concrete and formal students benefited from instruction over 6 weeks, with a retention test given 3 weeks later, when compared to control groups. Instruction did not reduce the gap in achievement between concrete and formal students, however. The researchers concluded that the level of understanding of concrete operational students will not be adequate unless instruction procedures are carefully designed. Linn and Thier (1975) studied the logical thinking ability of fifth grade students studying Science Curriculum Improvement Study units and determined that their reasoning exceeded control groups and approached that of a comparison group of eighth grade students. Seigler and Atlas (1976) proposed that children as young as 10 may be able to understand a wide variety of formal science concepts which uninstructed 15 - 16 year olds often do not. They concluded that the acquisition of formal science reasoning may be far more dependent on specific instructional experience than on maturation. Hale (1976) assessed 108 eighth grade students who had completed Level I on the Intermediate Science Curriculum Study. He found no significant gain in the ability to think more abstractly, and no student could be considered fully formal operational.

When studying the effectiveness of concrete and formal instructional procedures with concrete and formal students, Sheehan (1970) found that formal operational students achieved significantly higher scores from concrete than from formal instruction. He also concluded that formal operational thinkers demonstrate a great deal more understanding of concrete than formal concepts. In support of this, Lawson (1974) determined that formal thinkers understood less than half of those formal concepts on which they were tested. Lawson and Blake (1976), investigating transition from concrete to formal thought, found that formal operations do contribute to the understanding of concrete concepts. They hypothesized that the larger frame of reference available allows the learner to see relationships previously unrecognized, thereby bringing deeper meaning to concrete as well as formal content.

Wollman and Lawson (1978) used two instructional groups to determine if a difference exists between active and verbal treatment The active group was superior on both immediate and delayed posttests. The use of physical materials was found to be more effective than verbal, textbook procedures. They concluded that internalization of knowledge needs concrete, flexible, and action-oriented contexts. As a result of manipulating materials and actually seeing the principle operate, the student can then be supplied with symbolic representations. This process gives the student the opportunity to gradually abstract a principle from its concrete exemplars. Kuhn and Angelev (1976) recommended that more attention should be given to the role individuals themselves play in the process of constructing their own more advanced cognitive structures by means of progressive auto-regulatory processes. Relatively less attention is needed in devising external experimental demonstrations or training which the experts think will accomplish the job.

Levine and Linn (1977) made a somewhat different recommendation based on their experimental study. They stated that once students are alerted to a concept such as controlling variables they make progress in applying the idea during free exploration. However, exploration without introduction is less effective. Duckwork (1974) made similar observations. And, Levine and Linn (1977) asserted that successful programs should emphasize recognizing and organizing relevant information rather than simply emphasizing a particular strategy such as "making all things equal" to control variables.

There have been few experimental studies relating levels of logical thinking to social studies. Hallam (1979) used taught and untaught stories from history to assess the development of logical thinking with both primary and secondary students. Variable results were obtained from the two age groups. There was significant gain with some groups on some stories when students were measured for logical thinking on historical stories. No results were significant, however, for comparisons among groups when scores were averaged. His conclusion was that the majority of students may have been consolidating their understanding at the concrete level.

Project PROBE (1971), developed by the Catskill Area School Study Council in Oneonta, New York, implemented a program to upgrade economic literacy. A curriculum guide to be used throughout elementary and secondary grades was developed. Results indicated that students showed significant gains in critical thinking skills. However, no control group was used; therefore no definitive conclusions can be drawn.

There is no definitive empirical evidence which exists about most of the key issues (Kuhn, 1979). However, Kuhn (1979) argued that the evidence of the lack of universality in attainment of formal operations suggests an important role for education to play in this stage of cognitive development. Significant challenges remain before the educational implications of theory and research in formal operations can be fully understood and utilized.

Summary

This chapter has reviewed the literature and research pertinent to the present study. Chapter II was divided into five major sections: (1) Commentaries on Formal Operational Thought; (2) Increasing Formal Operations Through Instruction; (3) The Social Studies Curriculum and Formal Reasoning; (4) Assessment of Formal Operations; and (5) Empirical Studies of Formal Operations.

The following findings can be considered consistent with the research evidence accumulated at this time:

1. Formal reasoning ability provides the student with thinking skills which are expanded beyond those of concrete reasoning. This increased logical ability allows greater flexibility in problem solving which is not limited to first-order relationships or to objects and mental representations of objects.

2. The use of formal, abstract modes of instruction does not allow students limited to concrete operations to deal effectively with the school curriculum.

3. Transition from concrete to formal operational thought is a complex process which responds to an appropriate

learning environment. Extended experience at the concrete level and an optimal balance of instruction between new and previously learned material are necessary before this transition can occur.

4. The limit imposed on the concrete thinker to thought which is immediate in time and space is related to the teaching of social studies. However, much of the social studies curriculum incorporates abstract symbols and concepts.

5. Current research in formal operations is hampered by methodological inconsistencies which result in difficulty with comparing and integrating findings across studies.

6. Group assessments are necessary to substantiate and utilize in classrooms Piaget and Inhelder's original research in formal operations. Reliable and valid pencil and paper instruments to measure whole classes must be perfected.

7. Replication studies have consistently found that adolescents are much less likely to exhibit formal operational ability than proposed by Piaget.

8. Conclusive evidence has not been substantiated to determine whether a difference exists between males and females in cognitive development.

9. Experimental findings have not always been consistent but evidence is substantial that instruction affects the attainment of formal operations.

10. The role of education in understanding and utilizing formal operations poses a significant challenge to researchers

and educators.

The available research on Piagetian formal operations is not a tightly constructed body of knowledge. Some tentative conclusions about the relationship between instruction and operational thought have been reached. However, only as the body of research grows, can more definitive conclusions germaine to the topic of expanding formal thought within the school setting be made.

CHAPTER III

METHODOLOGY

This study investigated the relationship between the use of instructional materials in economic education and levels of cognitive development. The treatment, or primary independent variable consisted of instruction in economic understanding, with sex as a classificatory variable. One dependent variable was the level of cognitive development as measured by the Piagetian Assessment of Formal Thinking (PAFT), and the second was the score in economic understanding as measured by the Junior High School Test of Economics (JHSTE).

Subjects selected for this research were ninth grade students in Northern California whose teachers participated in the field testing of materials developed by the Center for the Development of Economic Education. Students were included on the basis of enrollment in eight social studies classes where the economics materials were utilized. The control groups were eight comparable classes of other sections of ninth grade social studies not receiving instruction in economics within each of the same schools.

Four experimental teachers in three school districts of Northern California were selected on the basis of agreement to participate in the field testing as specified by a signed contract. The school districts included in the study represent a cross-section of socio-economic levels. San Juan

School District, a large suburban area of Sacramento, California, participated in the study with four classes selected from one high school and one class from the second high school. The two schools represented a middle to upper-middle class composition. Five classes from these two schools, along with one class in an inner-city junior high school in Oakland and two classes in a comparatively small high school, with an approximate enrollment of 600, in the rural area of Linden, California comprised the experimental population. All students were enrolled in a required course in social studies and were heterogenously grouped in regards to scholastic abilities. No attempt was made to establish the racial-ethnic composition of the study sample.

The Center for the Development of Economic Education

This center is a project privately funded through the Foundation for the Teaching of Economics and is under the auspices of the School of Education, University of the Pacific, Stockton, California. It has functioned since 1975 for the purpose of increasing economic literacy through the preparation of textbook materials designed for the junior high school level. The materials have been constructed as case studies using products and services which are familiar to junior high school students.

The case study approach was selected to change the emphasis of economics from abstractions and generalities to concrete examples of the creation of specific projects. The major themes throughout the materials stress concepts which relate closely to student life experience. Each case study presents unifying economic concepts from the perspective of production of specific goods and services which directly affect the lives of students (Clawson, 1980).

Numerous concrete activities have been included as a major aspect of the instructional package. These activities have as their goal the active involvement of the student. This involvement permits interaction between student and objects or materials. It is this interaction which Piaget stresses as being necessary for cognitive growth.

The experimental classes received instruction using the economic materials for one nine-week period. Each class was to study the introductory and final chapters of _Our Economy: How It Works_ (Clawson, 1980). Two of the three case studies, "The Story of Artificial Light", "Steel: The Heaviest of the Heavy Industries", and "The Story of Shoes" were also to be studied.

Instrumentation

This investigation was concerned with determining whether a relationship does exist between economic understanding and level of cognitive development. Two measures were used for this purpose: (1) _Junior High School Test of Economics_, and (2) Piagetian Assessment of Formal Thinking (Appendix A). The following sections describe these instruments.

Economic Understanding

The *Junior High School Test of Economics* (*JHSTE*) (Schur, Donegan, Tanck, Zitlow, & Weston, 1974) is a standardized test developed by the Joint Council on Economic Education. The 40-item examination is designed to measure student knowledge and understanding of economics. The content validity of the instrument was determined by a panel of teachers and economists. The authors report that the test contains facts and concepts generally accepted by economic educators as being important for intelligent economic citizenship. Questions were designed to be answered correctly by junior high school students who have studies economics.

The *JHSTE* has been normed on a national sample of over 12,000 junior high school students, and national score data are provided in the test manual for purposes of comparison with scores obtained by individual classes. A Kuder-Richardson Formula 20 reliability figure of .78 is given. A test-retest correlation coefficient based on the five project classes resulted in a reliability figure of $r = +.62$. There was a 9 week time span between the two administrations of the test. The posttest reflected the effect of treatment using the economics materials. These two conditions resulted in a reliability figure somewhat lower than can be expected from a test-retest with a lesser time span and no treatment.

Cognitive Development

The Piagetian Assessment of Formal Thinking (PAFT) was designed by the author. It is composed of 12 tasks developed by different researchers using techniques based on Piaget's experiments with formal thinking. The tasks are arranged into four subtests. These consist of conservation of volume, propositional logic, combinatorial logic, and proportional logic. There are three items in each subtest with each item requiring an answer and an explanation, providing a maximum of six points for each subtest with 24 points total. It is a pencil and paper test administered to class groups during a single class period. This method was selected over the traditional, clinical method of assessment to accommodate larger numbers of students, as the secondary classroom situation does not allow for extensive time to be spent on individual assessment.

The description of the test content follows. There were three conservation tasks. The first involved water displacement using a clay ball dropped into a jar (Elkind, 1961). Two equal clay balls were displayed, one ball was changed into a sausage shape, then each mass was dropped into a jar separately. Students were asked to imagine the jar contained water and then decide which shape caused the water to rise the highest. The second was a drawing of a jug 1/3 full of water (Piaget & Inhelder, 1969). Students were asked to draw a line representing the water line of the same jug tilted. The third used two test tubes to indicate water displacement by weight (Nolen, 1976). Tubes were illustrated with cylinders of equal size and shape but of unequal weight. The water level of the tube with the lighter weight submerged was shown. Students were to mark the water level of the second tube if the heavier weight were submerged in it.

The second subtest measured propositional logic through "if . . . then" reasoning, keeping several variables in mind. The first two tasks (Lawson & Blake, 1976) were multiple choice questions. Task 1 required students to select statements which were correct based only on the information provided. The second task necessitated the recognition that only one statement of the four given dealt with all conditions described in the given paragraph. The third task (Nolen, 1976) measured students' ability to refrain from definite conclusions without sufficient information given.

The third subtest, combinatorial logic, required the recognition of relevent variables and the elimination of irrelevant ones. Two diagrams were given requiring students to choose the correct response and explain their choice (Lawson & Wollman, 1976). Task 1 involved recognition of experimental conditions which must be kept constant and those independent variables which result in different dependent variables. Task 2 measured the ability to distinguish two independent and two dependent variables of unequal effect. The third task of combinatorial logic (Lawson & Blake, 1976) asked students to calculate how many combinations of two digits could be made using the figures 1, 2, 3, 4, and 5 using each figure only once in each combination.

In the fourth subtest proportional logic was measured through the use of mathematical problems using ratio. The first task was a problem of equivalant fractions (Piaget, 1976). The second task (Lowry, 1974) necessitated the examiner's demonstration. A picture of a man and a string of 1½" paper clips were illustrated. The examiner measured the picture of the man with large 2" paper clips. Students were asked to imagine a drawing of a larger man and, when given his height in large clips, estimate how tall the larger man would be measured with the small paper clips. The final task (Lawson & Renner, 1976) required the use of proportionality and probability. Given an unknown population of frogs students were to estimate how large this population might be by comparing the proportion of frogs caught, banded and then caught again with the total number of frogs caught.

The PAFT was used in 1977 with groups of ninth and tenth grade students and was compared to the California Test of <u>Basic Skills</u> (<u>CTBS</u>). A correlation of $\underline{r} = .68$ was obtained. The alternate forms reliability figure given in the <u>CTBS</u> manual is .94. In Buros (1965) it is stated that the uniformly high correlation of coefficients between subtests of <u>CTBS</u>, <u>Stanford Achievement Test</u>, and <u>Metropolitan Achievement Test</u> are evidence of construct validity of the <u>CTBS</u>.

As addressed in Kerlinger (1973), a moderate correlation, (e.g., $\underline{r} = .68$), between two tests is evidence of both common factor variance and specific variance. The correlation figure represents the communality shared by the two tests and indicates the criterion validity of the instrument. The amount of variance not contained within the correlation represents the specific variance plus the error variance. Specific variance is that portion of an instrument which measures a factor not included in the criterion instrument. The reliability is represented by the communality plus the specificity. The correlation of $\underline{r}$ = .68 is evidence of both criterion validity and reliability.

Two other procedures were employed to measure reliability and validity of the PAFT. To establish reliability the PAFT was administered twice within 2 weeks to three ninth grade history classes in an integrated high school in Stockton, California. A correlation of $\underline{r}$ = .75 was obtained with 58 students taking the test both times. Validity was determined by randomly selecting 30 students from this group of 58 students and administering an individual assessment using Piagetian tasks as closely matched as possible to the items on the PAFT (Appendix B). The items selected for the individual assessment were judged to be comparable, by an independent expert, Dr. Kenneth Beauchamp, to subtests of the PAFT.

Two tasks were administered for each subtest of the PAFT. Each task was based on the work of Inhelder and Piaget (1958) in delineating concrete and formal operational thought. A description of each task follows: (1) Conservation of volume was measured by (a) having each student estimate the water level on two glasses of equal capacity but of different shape (Piaget, 1968), and (b) indicating water displacement of two balls equal in volume but different in weight (Renner, et al., 1978). (2) Propositional logic was measured by requiring the student to (a) think in terms of less than in relation to more that ($A > C$; $B > C$; $D > A$; which is least?) (Lawson & Blake, 1976), and (b) visualize the relationship of movement between a friction toy and a board with four equal sections if both were moving at equal speed in the same or opposite direction (Inhelder & Piaget, 1958). (3) Combinatorial logic or the ability to hold variables constant while manipulating others was assessed by (a) determining the number of different combinations that can be made with four letters (Lawson & Wollman, 1976), and (b) experimenting with a pendulum to determine which variable controls speed of oscillation. (4) Proportional logic or the ability to think in ratios was measured by (a) constructing equivalent fractions ($9/15 = 6/x$) by placing the correct number of chips in the proper shape to represent x when nine chips had been placed over fifteen and six placed over the space indicated as x, and (b) using the balance bar to determine that distance is to weight as weight is to distance (Inhelder & Piaget, 1958).

Performance on the individual assessment was determined to be formal operational if a score of 6/8 was obtained with at least one item in each subtest answered correctly. The

PAFT was scored using as the criterion a minimum of four points on each subtest with a minimum total score of 16. The comparison between the scores of the two measures is presented in Table 1, page 69.

On the PAFT two students obtained a score of 17 total, but did not meet the criterion of four points on each subtest and therefore were classified as concrete operational. Only one student received a score of six or greater on the individual assessment and was classified as formal operational on this measure though he was not classified as formal operational on the basis of the PAFT. Twenty-nine of the 30 students to whom the individual assessment was administered were classified as concrete operational on both measures. On the basis of this procedure it can be stated that the PAFT demonstrates limited concurrent validity on the basis of its ability to correctly classify primarily concrete operational students.

Procedures

Data for this study was collected by the investigator and each of four classroom teachers during the 1978-1979 school year. The JHSTE was administered by classroom teachers to all experimental subjects as both a pretest and a posttest. The PAFT was administered by the investigator to five experimental and five control classes as a pretest and to eight experimental classes and eight control classes as a posttest.

Table 1

Comparison of Group with Individual Piagetian Assessment of Formal Thinking

Number of Students $\underline{N} = 30$		Individual Assessment: Concrete	Individual Assessment: Formal
PAFT	Concrete	29	1
	Formal	0	0

The treatment consisted of 9 weeks of instruction using the introductory and final chapters of Our Ecomony: How It Works and two of the three case studies which were being field-tested by the teachers. Six of the eight classes kept within the 9 week framework. One class, because of teacher absence, spent less than 9 weeks and another class, because of interruptions, had instruction spread over two 9 week periods. Both the JHSTE and the PAFT pretests and posttests were administered on the first and last weeks of instruction. Table 2, page 71, illustrates the actual case studies completed by each class.

Hypotheses

Five null hypotheses were tested in the study. They were:

H_1: There is no relationship between cognitive development and economic understanding, as measured on a pretest of the PAFT and JHSTE.

H_2: There is no significant difference in posttest scores on the PAFT between experimental and control classes.

H_3: There is no relationship between posttest scores in economic understanding and posttest scores in cognitive development for experimental classes as measured on the JHSTE and the PAFT.

H_4: Sex is not related to cognitive development as measured on the posttest of the PAFT for experimental classes.

H_5: Sex is not related to economic understanding as measured on the posttest of the JHSTE for experimental classes.

Table 2

Case Studies Completed by Teacher and by Class

Teacher	Class	Intro	Light	Shoes	Steel	Final	N-Weeks
1	1	X	X		X	X	9
	2	X	X		X	X	9
	3	X	X		X	X	9
	4	X	X		X	X	9
2	5	X	X		X	X	9
	6	X	X		X	X	9
3	7	X			X	X	18
4	8	X	X	X			8

Statistical Analysis

Computer analyses of all data collected for this study was conducted on the Burroughs B-6700 at the University of the Pacific, Stockton, California. An alpha level of .05 with a two-tail test of significance was chosen for all analyses. The following section describes the specific statistical treatments used to test each of the hypotheses in the study.

Hypotheses 1 and 3 addressed the relationship between levels of economic understanding and cognitive development on both pretest and posttest measures. For these hypotheses the Pearson Product Moment Correlation (Pearson r) was used to determine the relationships. SPSS subprogram PEARSON CORR was employed in the computer analysis of these data.

Hypothesis 2 was concerned with the effects of treatment on the criterion variable, level of cognitive development. Treatment consisted of 9 weeks of instruction in economics using concrete materials and activities. Level of cognitive development was determined by posttest of the PAFT. The posttest scores were compared for experimental and control classes to determine if, indeed, instructional materials do affect cognitive development. A Two-Way Analysis of Covariance (ANCOVA) was used to make this comparison with pretest scores on the PAFT constituting the covariate. Student gender was employed as a classificatory variable to determine if an interaction was present between treatment and sex, i.e., did one sex benefit from the treatment more than the other? SPSS subprogram ANOVA with a covariate list was utilized for this analysis.

The Solomon four-block design was used to control for test-retest contamination by omitting the pretest of the criterion variable in one block of experimental and one block of control classes. Five of the eight experimental and five of the eight control classes were administered the pretest of the PAFT. Three classes in each category were not given the pretest. Table 3, page 74, illustrates this distribution. All experimental and control classes were given the PAFT posttest.

Hypotheses 4 and 5 measured the effect of sex on posttests of cognitive development and economic understanding. Pretest scores on the PAFT served as covariate for Hypothesis 4; JHSTE pretest scores served as covariate for Hypothesis 5. Analysis of Covariance (ANCOVA) was used to analyze these data and the SPSS subprogram ANOVA was employed.

Summary

This study explored the relationship between the use of instructional materials in economic education and levels of cognitive development. The instructional materials were prepared through the Center for the Development of Economic Education for use in grades 7 - 9. The Junior High School

Table 3

Solomon Four-Block Design by Class
And by Number of Students

	Pre	No Pre	Total
Experimental	5 N = 117	3 N = 69	8 N = 186
Control	5 N = 115	3 N = 86	8 N = 201
Total	10 N = 232	6 N = 155	16 N = 387

Test of Economics was administered both as a pretest and a posttest to measure economic understanding of participating students in the eight experimental classes. The Piagetian Assessment of Formal Thinking was administered to five experimental and five control classes as a pretest and to eight experimental and eight control classes as a posttest. The control classes were not administered the JHSTE.

Four questions were examined in this study. They were: (1) Does Knowledge of economic concepts correlate with cognitive development? (2) Does instruction in economics have an effect on cognitive development? (3) Did experimental classes score significantly differently in cognitive development from control classes? (4) Is there a difference in cognitive development and economic understanding between boys and girls? Chapter IV presents the results of the study.

CHAPTER IV

ANALYSIS OF RESULTS

The purpose of this study was to determine the relationship between use of instructional materials in economic education and levels of cognitive ability. The Piagetian Assessment of Formal Thinking (PAFT) was used to determine the level of cognitive ability of participating ninth grade students. The Junior High School Test of Economics (JHSTE) was used to measure economic understanding.

Three high schools and one junior high school in Northern California comprised the population from which the sample was drawn. Students were selected on the basis of enrollment in ninth grade social studies classes whose teachers were participating in field testing materials from Our Economy: How It Works (Clawson, 1980) for a 9 week period during the fall or winter quarter of the 1978-1979 school year. Comparable control classes in social studies were selected with the one difference of not receiving instruction in economics. The number and distribution of participating students is presented in Table 4, page 75.

All experimental students were given the pretest and posttest of the JHSTE. Five experimental and five control classes were given the pretest of the PAFT, while all experimental and control classes (eight each) were given the posttest of the PAFT. This design was selected to determine if the pretest had an influence on the posttest when administered

Table 4

Numbers of Students Tested in
Experimental and Control Classes
Classified by School

School	Number of Classes	Experimental	Control
1	2	23	35
2	4	50	45
3	2	24	13
4	8	111	108
Total	16	*208	201

* Twenty-two pretest scores were included from students whose posttests were not available but who had JHSTE pretests. These scores were used for pretest correlation between PAFT and JHSTE only. The sample size for the remaining data analyses is 387.

9 weeks apart. Table 5, page 77, presents the number of students given pretest and posttest of the PAFT. It will be noted that the different number of students in each cell resulted in different N's for the various data analyses.

Five hypotheses were operationally defined and subjected to statistical analysis. The .05 level of significance with a two-tailed test was employed using Pearson Product Moment Correlation (PEARSON CORR) and Analysis of Covariance (ANCOVA) as the basic statistical procedures. Student *t*-tests were used to compare mean score differences between pretest and posttest scores of the PAFT and the JHSTE for experimental groups and the PAFT for control groups. A Two-Way Analysis of Variance was employed to determine if an interaction effect existed between treatment and student gender. Crosstabulation program (CROSSTAB) was used to determine the classification of students in experimental and control groups by concrete and formal operations.

Presentation of Results

The first null hypothesis was:

H_1: There is no relationship between cognitive development and economic understanding, as measured on a pretest of the PAFT and JHSTE.

The 24 point PAFT which measured student ability to use formal operational logic was compared to the 40 item JHSTE measuring economic concepts which ninth grade students, having received instruction in economics, would be expected

Table 5

Numbers of Students Given Pretest/Posttest
And Posttest Only Classified by
Experimental and Control Classes

		Pretest/Posttest	Posttest Only
Experimental	8 N = 186	5 N = 117	3 N = 69
Control	8 N = 201	5 N = 115	3 N = 86
Total	16 N = 387	10 N = 232	6 N = 155

to have mastered. Table 6, page 79, presents the Pearson Product Moment Correlation between the two pretests of the experimental group. Since the critical value required to reject the null hypothesis was $\underline{r}$ = .195 and the attained correlation was $\underline{r}$ = .59 the first null hypothesis was rejected. These data indicate that there was a significant positive relationship between formal operational thought and ability to deal with economic concepts.

The second null hypothesis was:

H_2: There is no significant difference in posttest scores on the PAFT between experimental and control classes.

The comparison between experimental and control groups is presented in Table 7, page 82. A Two-Way Analysis of Covariance (ANCOVA) was used to make this comparison with pretest scores constituting the covariate. The two factors were treatment through instruction in economics and student gender. A critical value of $\underline{F}$ = 3.84 was needed for rejection at the .05 level of significance. A value of $\underline{F}$ = 2.764 was obtained; therefore, the null hypothesis was not rejected. Treatment by instruction in economics using the materials developed at the Center for the Development of Economic Education did not result in significantly different scores on the PAFT between experimental and control groups.

Table 8, page 83, and Table 9, page 84, present the comparisons of means between the two groups. The control group had higher pretest scores than the experimental group and they attained higher gain scores. However, when pretest

Table 6

Pearson Correlation Coefficient for Pretest Scores in Economic Understanding and Cognitive Development

Scores	*r*	*p*
Economic Understanding and Cognitive Development (*N* = 118)	+.59	$<.001$

Table 7

Analysis of Covariance Between Male and Female Students of Entire Sample in Cognitive Development After Adjusting for Pretest Differences

	Sum of Squares	*df*	Mean Square	*F*	*p*
Pretest PAFT (Covariate)	2426.574	1	2426.574	274.050	$<.001$
Main Effect	70.569	2	35.284	3.985	$<.05$
Student Sex	45.695	1	45.695	5.161	$<.05$
Exper/Control	26.886	1	26.886	3.036	N.S.
2-Way Interaction	2.168	1	2.168	.245	N.S.
Explained	2499.310	4	624.828	70.566	$<.001$
Residual	1815.170	205	8.854	--	--
Total	4314.481	209		--	--

*An $F \geq 3.84$ was required for significance at the .05 level

Table 8

Table of Adjusted Means on PAFT
for Experimental and Control Groups

	Pretest Mean	Posttest Mean	Adjusted Mean
Experimental (N = 95)	7.8105	8.8737	9.12
Control (N = 115)	8.4175	10.0448	9.84

Table 9

Table of *t*-tests for Mean Gain Scores
Between Pretest and Posttest of PAFT
For Experimental and Control Groups

	Pretest Mean	Posttest Mean	Mean Difference	t-ratio	*p*
Experimental	7.81	8.87	1.06	3.05	$<.01$
Control	8.42	10.04	1.62	5.90	$<.001$

scores were statistically controlled by the Analysis of Covariance, the posttest means were not significantly different. Through the use of *t*-tests (see Table 9, page 82) it was determined that both experimental and control groups scored significantly higher on the posttest. Numerically, the control group outperformed the experimental group but the difference was not statistically significant.

In relation to Hypothesis Two, the Solomon design to control for pretest effect was employed. Table 10, page 86, presents the results of this procedure. From these data it can be stated that the pretest of the PAFT did not significantly affect the posttest scores.

The third null hypothesis was:

> H_3: There is no relationship between posttest scores in economic understanding and posttest scores in cognitive development for experimental classes as measured on the PAFT and the *JHSTE*.

The Pearson Product Moment Correlation (PEARSON CORR) was used to determine if the relationship between posttest scores in cognitive development and economic understanding was maintained after treatment. A correlation of $r = +.43$ was obtained (Table 11, page 87) resulting in the rejection of the null hypothesis. Though the correlation continued to be significant at the .001 level, it can be noted that the posttest correlation was not as high as the pretest correlation.

Table 10

Analysis of Variance for Cognitive Development
Students Receiving Pretest/Posttest
And Students Receiving Pretest Only

Source	Sum of Squares	df	Mean Squares	F*	p
Between Groups	8.032	1	8.032	.412	N.S.
Within Groups	7512.888	385	19.514	--	--
Total	7520.920	386	--	--	--

*An $F \geq 3.84$ was required for significance at the .05 level

Table 11

Pearson Correlation Coefficient for Posttest Scores in Economic Understanding and Cognitive Development

Scores	r	p
Cognitive Development and Economic Understanding (N = 187)	+.43	$<.001$

The fourth null hypothesis was:

H_4: Gender is not related to cognitive development as measured on the posttest of the PAFT for experimental classes.

Analysis of Covariance (ANCOVA) was used to test this hypothesis with pretest scores of the experimental group as the covariate. Table 12, page 89, presents the ANCOVA summary. These data show no significant difference between male and female students of the experimental group in cognitive development. Therefore, the null hypothesis is not rejected, as stated. Table 13, page 90, and Table 7, page 82, however, show the comparison between male and female students for the entire sample, including the control group. There was a significant difference, at the .05 level of significance, between male and female students. A ratio of $F = 5.15$ was obtained with a critical value of $F = 3.84$ needed to reject the null hypothesis. It can be stated that, for the experimental group, gender was not a significant factor, but for the entire sample a significant difference between gender was determined to exist, with males exceeding females in cognitive development as measured by the posttest of the PAFT.

The Analysis of Covariance procedure employed for Hypothesis Two was analyzed to determine if an interaction existed between treatment and gender of experimental subjects. Table 15, page 90, shows that, though there was a significant difference between gender for the entire study sample, there was no significant interaction between treatment and gender for

Table 12

Analysis of Covariance Between Male and Female Students of Experimental Group on PAFT After Adjusting for Pretest Differences

	Sum of Squares	df	Mean Square	F*	p
Pretest PAFT (Covariate)	681.571	1	681.571	71.513	<.001
Between Gender	14.088	1	14.088	1.478	N.S.
Explained	2499.31	4	624.828	70.566	<.001
Residual	1815.170	205	8.854	--	--
Total	4314.481	209		--	--

*An $F \geq 3.84$ was required for significance at the .05 level

Table 13

Table of Adjusted Means on PAFT
For Male and Female Students
in Experimental and Control Groups

	Pretest Mean	Posttest Mean	Adjusted Mean
Male ($\underline{N}$ = 92)	8.86	10.19	10.04
Female ($\underline{N}$ = 118)	8.13	8.98	9.10

Table 14

Analysis of Covariance Between Male and Female Students on the JHSTE After Adjusting For Pretest Differences

	Sum of Squares	df	Mean Square	F^*	p
Pretest JHSTE (Covariate)	3841.298	1	3841.298	148.753	.001
Between Gender	4.274	1	4.274	.165	N.S.
Explained	3845.570	2	1922.786	74.459	.001
Residual	4286.665	116	25.823	--	--
Total	8132.237	168		--	--

*An $F \geq 3.84$ was required for significance at the .05 level

the experimental group.

The fifth null hypothesis was:

H_5: Gender is not related to economic understanding as measured on the posttest of the JHSTE.

Analysis of Covariance (ANCOVA) was used to test this hypothesis also, with pretest scores on the JHSTE as the covariate. Table 14, page 92, presents the ANCOVA summary for this question. Again, the data show no significant difference between male and female students of the experimental group in economic understanding. The critical value needed to reject the null hypothesis at the .05 level of significance is F = 3.84. The obtained ratio was F = .165. Therefore, the null hypothesis is tenable.

Table 15, page 93, illustrates the classification of percentages of students of experimental and control groups by concrete or formal operational. Crosstabulation program (CROSSTAB) was employed to determine the distribution of this classification. For the experimental group 97% of the students were concrete operational for both pretest and posttest; 2% demonstrated formal operational thought on the pretest only and 1% demonstrated formal reasoning only on the posttest. No experimental students were determined to be formal operational for both measures. For the control group, 91% were concrete operational and 2% were formal operational for both pretest and posttest. 2% were determined to be formal thinkers on the pretest while 5% exhibited movement into formal operations on the posttest only.

Table 15

Distribution of Students by Concrete and Formal Classification of Pretest and Posttest of PAFT By Number and Percentage

Experimental Group			Control Group		
	Posttest			Posttest	
Pretest	Not Formal	Formal	Pretest	Not Formal	Formal
Not Formal	N = 92 97%	N = 1 1%	Not Formal	N = 105 91%	N = 6 5%
Formal	N = 2 2%	N = 0 0%	Formal	N = 2 2%	N = 2 2%

Summary

Five hypotheses were tested which analyzed the relationship between cognitive development and economic understanding, and between subgroups in cognitive development. Cognitive ability was measured by the Piaget Assessment of Formal Thinking (PAFT) and economic understanding by the Junior High School Test of Economics (JHSTE).

Pearson Product Moment Correlation (PEARSON CORR) was used to determine whether a relationship existed between cognitive development and economic understanding. Analysis of Covariance (ANCOVA) procedures were used to determine whether differences in cognitive development existed between experimental and control groups as a result of treatment, and between males and females for both cognitive development and economic understanding. The .05 level of significance with two-tailed tests were used for all hypotheses tested.

Significant results were indicated for Hypotheses One and Three. Data on the PAFT and the JHSTE indicated that significant positive relationships exist between cognitive ability and economic understanding for both pretest and posttest measures.

The data from this study did not allow for the rejection of Hypothesis Two. No significant difference in cognitive ability was measured between students receiving instruction in economics and those receiving no instruction.

In relation to Hypotheses Four and Five, no significant difference was demonstrated to exist between males and females in the experimental group for either cognitive ability or economic understanding. However, when both experimental and control groups were examined, a significant difference in cognitive ability was measured between males and females, with males scoring higher.

It was determined that all but a few students in both the experimental and control groups were concrete operational on both the pretest and posttest of the PAFT.

CHAPTER V

DISCUSSION

Researchers in the field of secondary education have demonstrated a relationship between success in some academic endeavors and formal operational thought as described by Piaget and Inhelder in their seminal work in adolescent reasoning. Although the methodology has not been formalized, there is mounting evidence of a relationship between some modes of instruction and increase in formal operations among secondary students.

The primary purpose of this study was to examine the effect of Piagetian oriented instruction in economics on the formal reasoning level of ninth grade subjects. The Piagetian Assessment of Formal Thinking (PAFT) was used to identify levels of cognitive development for participating students, while the Junior High School Test of Economics (JHSTE) was used to determine the degree of economic understanding. Treatment consisted of 9 weeks of instruction using case studies from Our Economy: How It Works in classes selected for field-testing of the materials. Five null hypotheses were advanced and stated in Chapter III. Of these five, only the first and third hypotheses were rejected.

Chapter V is organized into three sections: (1) Summary and discussion of findings; (2) Conclusions of the study; (3) Recommendations for further research.

Summary and Discussion of Findings

Hypothesis One

> There is no relationship between cognitive development and economic understanding, as measured on a pretest of the PAFT and JHSTE.

As the results of the previous chapter showed, the first null hypothesis was rejected. There was a significant relationship between level of cognitive development as measured on the pretest of the PAFT and economic understanding as measured on the JHSTE. This outcome was predicted. Although no causal relationship can be extracted from these data, the assumption that mastery of abstract economic concepts is related to movement into formal operational reasoning is supported.

While the relationship was significant ($p < .001$), the correlation ($r = +.59$) was moderate. This means that the PAFT and the JHSTE are moderately related in requisite skills but are also measuring some abilities unique to each individual measure. The determination that a significant relationship does exist between cognitive development and economic understanding presupposes that those students who utilize logical operations more successfully are better able to deal with economic concepts. It can also be assumed that students not as successful in using logical operations are not able to deal successfully with economics. This relationship between cognitive development and economic understanding then supports the assumption that students scoring low in a measure of logical operations need an instructional approach commensurate with their cognitive level. Such an instructional approach includes experiences with empirical data rather than abstract concepts. In economics this involves extensive discussion and questioning, direct personal experience with phenomena, making inferences, using quantitative reasoning, and verbalizing perceived relationships.

Hypothesis Two

> There is no significant difference in posttest scores on the PAFT between experimental and control classes.

Hypothesis Two examined the relationship between treatment using the economic education materials and logical reasoning abilities of ninth grade students. This null hypothesis was not rejected. Significant effects of treatment were not measured when the experimental and control groups were compared. The gains in logical thinking between pretest and posttest scores were significant for the experimental group ($p < .01$) and for the control group also ($p < .001$). Therefore, no results can be attributed to treatment.

Several factors may account for this lack of treatment effect. Primarily, the length of treatment time may be related to growth of logical operations. As discussed in Chapters I and II, cognitive development, particularly formal operations, is an interaction of internal and external forces.

These forces are reflected in the theory as those factors responsible for stage development. They include maturation, social interaction, experience, and equilibration. Both maturation and equilibration are internal processes that teachers can affect only indirectly. Research has supported the idea that the combination of maturation, learning environment, and student cognitive participation are all important for logical skills to develop. This interaction of distinct forces makes learning a complex process which does not necessarily respond directly to a single external factor. The design of the present study did not permit the examination of the effects of a full year's instruction using a concrete teaching approach on the development of logical ability.

A second factor influencing the lack of results may have been the nature of the classroom instruction. The materials were designed to involve students actively in the learning process through case studies closely related to their life experiences and through concrete activities imbedded in the instructional materials. In nearly all the classrooms the materials were taught in a didactic manner contrary to the recommendations of both the theory of cognitive development and the emphasis of the economic education materials. Few, if any, activities were used by the students. As part of the field-test process the participating teachers were to check and evaluate all activities used. No teacher used the activities to the extent that they were designed; some teachers used none. The constraint of time was a serious, contributing factor in this case.

A third influence on these findings was that of discipline. In one-half of the control classes the teacher provided little or no supervision during the pretest. The posttest situation was very different as another teacher was in charge who maintained an instructional climate conducive to a testing situation. This unavoidable contrast in classroom discipline could account for part of the gain scores of the control group.

A fourth factor may have accounted for the lack of significant difference between experimental and control groups. The research literature has indicated that students in transition between stages seem to advance cognitively as a result of instruction. Students still in a solidly concrete mode are involved in the very important process of establishing logical thinking abilities relating to first-order operations, a horizontal rather than a vertical learning process. As discussed in Chapter IV, only a very small portion of students could be classified as fully formal thinkers either on the pretest or the posttest. The large majority of the sample population was very solidly concrete operational and their cognitive development had perhaps not yet reached a point of progression.

A fifth aspect relating to Hypothesis Two deals with those educational experiences intended to strengthen logical operations which are, of necessity, process rather than content-oriented. This means that there will not be a one-to-one relationship between these experiences and criterion measures. The internal process of self-regulation requires time for new experiences to be equilibrated into pre-existing mental structures. Therefore, the relationship between concrete experiences and thinking skills is not as linear as can sometimes be expected between instruction and mastery in a given content area.

A sixth and final factor to be discussed in relation to the lack of significance due to treatment is the question of generalizability of logical operations dealing with physical objects and mathematical groupings to the nonscience disciplines. Whether propositional logic is closely associated with quantitative reasoning has not been established definitively. The ability to use abstract logic consistently across curriculum areas is an assumption which needs to be investigated more extensively.

Another question discussed under Hypothesis Two was whether the pretest of the PAFT would have an influence on posttest scores. This question was investigated by the use of the Solomon design. Three of the eight classes in each of the control and the experimental groups received only the posttest of the PAFT. The difference between the groups was found not to be significant. With a sample size of 387 it can be assumed that administration of an assessment of formal thinking with 9 weeks between pretest and posttest does not affect the outcome of the posttest scores.

The results of the data comparing cognitive development for experimental and control groups verify the need in experimental research for a well selected control group. Without this control group, support would have seemed to exist for the hypothesis that instruction in economics would result in increased use of formal operational reasoning. However, because the control group demonstrated score gains without instruction in economics, the measured gain in cognitive development could not be attributed to the treatment. Misinterpretation of data with resulting incorrect conclusions can occur unless the experimental design is carefully controlled.

Though the conclusion that instruction based on concrete methods and materials is related to advances in cognitive development cannot be substantiated in this study, the possibility that such a relationship may exist should not be disregarded. Two assumptions having educational implications can be offered in connection with this study. First, the cognitive tasks of a concrete thinker are important in establishing a basis for logical reasoning, with concrete objects or representations, and then with ideas and relationships. If the basic step is not adequately provided for, both levels of logical operations may be deficient. Second, providing content which closely related to student life experience, materials which offer opportunity for manipulation, and activities which involve maximum student interaction with objects and with other students will benefit students functioning on both levels of logical operations.

Hypothesis Three

> There is no relationship between posttest scores in cognitive development and posttest scores in economic understanding for experimental classes as measured on the JHSTE and the PAFT.

Hypothesis Three examined whether the relationship between cognitive development and economic understanding as determined by Hypothesis One was maintained after treatment. The null hypothesis was rejected at the .001 level of significance. The correlation between the two measures on the posttest was $r = +.43$, while the pretest correlation was $r = +.59$. These data support the assumption that cognitive development and economic understanding are related.

Hypothesis Four

> Gender is not related to cognitive development as measured on the posttest of the PAFT for experimental classes.

Hypothesis Four was employed to determine if a difference existed between boys and girls of the experimental group in cognitive development. The null hypothesis was not rejected. There was also no measured interaction between treatment and student gender for the experimental group. However, when gender for the entire sample was compared ($N = 387$) there was a significant difference between the sexes ($p < .05$). It can be stated that results based on the larger sample reflect a more accurate measure of this characteristic.

The data from this study concerning the difference between gender in the attainment of formal operations does not allow for the assumption to be made that instruction which differs for boys and girls would be of benefit. If such a difference were established by additional research, it would be imperative to examine which modes of instruction were best suited for each sex. However, at this point, whether girls would benefit from an instructional approach more closely related to their interests is only conjecture.

Hypothesis Five

> Gender is not related to economic understanding as measured on the posttest of the *JHSTE*.

There was no significant relationship between gender and economic understanding; therefore, null Hypothesis Five was not rejected. This conclusion was in agreement with larger studies using the *JHSTE* which consistently have found no difference between boys and girls in mastery of economics. As a result, there is no evidence to suggest differentiation in instructional approach for males and females is needed for economic education.

Conclusions of the Study

The findings of this study did not provide definitive results with regard to the efficacy of treatment through the use of concrete instructional materials in economics to increase formal operational thought. Though there was found to be an important relationship between measures of cognitive development and economic understanding, instruction in economics did not significantly affect cognitive development when experimental and control groups were compared. Both groups made significant gains in cognitive development between pretest and posttest measures. However, when without treatment the control group demonstrated significant increase, it can be assumed that some other phenomenon, not identified, contributed to the gain in scores for both groups. The determination of a relationship between gender and attainment in cognitive development remains inconclusive on the basis of this study, though student gender was found not to be significantly related to economic understanding.

The difficulties of conducting research which remains free of extraneous variables is illustrated by this study. Schools are not laboratories. Classes, though hetergeneously grouped, often differ widely in abilities due to scheduling factors within a school. Interpersonal dynamics within a particular class often influence the dominant characteristics of that class. Experiences in other classes and outside the school day all affect the cognitive structure of students. Teachers, though selected for similarity of subjects taught and instructional approach, differ significantly in personality and their relationships with students. All of these factors tend to confound data and obscure experimental results. Educational research must deal with the resulting lack of clarity of conclusions as long as real people in real situations are the subjects of study. The state of the art is tentative at best. However, researchers bear the responsibility of establishing experimental conditions which approach as closely as possible control of all variables.

The PAFT, used in this study, has provided an instrument which has, through several processes, been shown to have both reliability and validity. Reliability was established through correlation with the California Test of Basic Skills (CTBS) and through test-retest procedure. Validity was determined also through correlation with the CTBS, whose validity had been previously established, and through comparison with an individual assessment based on Piagetian tasks. In the latter comparison both measures classified students similarly, though it must be noted that, due to the sample population, only concrete students were identified on both measures. However, it can be concluded that the PAFT is a useful instrument to give teachers information concerning levels of cognitive development of their students. This information permits teachers to plan curriculum which more nearly matches the cognitive needs of students. It also provides teachers with the evidence that students do differ qualitatively in their thinking and that traditional instructional activities are often not related to the cognitive skills of many students. The responsibility of education is to allow students to achieve maximum learning. Therefore, it is imperative that teachers understand the cognitive abilities of all students.

Recommendations for Further Research

Interest in the relationship between formal operations and secondary school performance has been accompanied by interest in including in the curriculum concrete materials and activities that are attuned to student life experiences. Though some of this work has had promising results, particularly in the sciences, conclusions regarding the efficacy of increasing formal operations through instruction are only tentative at best.

It seems clear from the research that few secondary students have fully attained formal operational reasoning ability. A continuation of research is needed into productive methods of encouraging the development of formal operational reasoning among adolescent students. On the basis of this assertion and the data in this study, the following recommendations are submitted.

1. The present study should be replicated but with these modifications.

   a. Teachers who are familiar with the experimental materials and known to encourage student use of hypothetico-deductive reasoning should be selected to participate in the research.

   b. The time span of the experiment should be increased, preferably to one school year.

c. Smaller group size should be used which would allow for closer supervision of research implementation.

d. Testing conditions within classrooms should be consistent.

e. Students in grades 10 - 12 should be selected to provide for the possibility of a larger number of formal thinkers.

2. More experimental studies should be conducted in all areas of the curriculum to determine which teaching approaches relate to current cognitive abilities of students and which approaches result in increasing use of logical operations. The research would be concerned with cognition and reasoning ability rather than mastery of subject matter.

3. Further validation of the PAFT should occur. Teachers should have some training in interpreting the results and in possibly implementing change of instruction based on these results.

4. Reappraisal of current secondary school curriculum should be conducted to examine and modify those areas requiring formal operations. Curriculum in all academic disciplines should include more opportunity for concrete activities and experiences.

Summary

Chapter V summarized the research on the effects of treatment on the cognitive development of ninth grade subjects.

Eight experimental classes receiving instruction in economic education were compared to eight control classes not receiving such instruction. Both groups made significant gains in logical thinking over the treatment period but there was no significant difference between the gains of the two groups. Therefore, no benefit to logical operational ability could be attributed to the treatment.

The Piagetian Assessment of Formal Thinking (PAFT) was used to measure cognitive development and the Junior High School Test of Economics (JHSTE) was used to measure economic understanding. A significant relationship was found to exist between the two measures for both the pretest and the posttest.

Attainment of cognitive ability and economic understanding was compared between the sexes. No definitive conclusions on differential attainment of cognitive ability could be drawn, as the experimental group demonstrated no significant difference between boys and girls but the total sample which included the control group did demonstrate such a difference. No significant difference between students on the basis of gender was found for economic understanding.

Research to develop methods of increasing operational thought was strongly recommended. Replication with modification of the present study was suggested. Training of classroom teachers in recognizing levels of student cognition and matching instructional tasks to these levels was also recommended, as was the study of present secondary curriculum for the purpose of changing the curriculum so that it more closely matches the cognitive levels of secondary students.

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APPENDIX A

PIAGETIAN ASSESSMENT OF FORMAL THINKING

NAME_____________________________

A. Conservation of Volume:

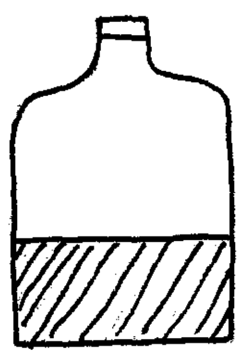
1. I will demonstrate with two lumps of clay, each of equal volume and weight. If I shape one lump into the shape of a sausage and submerge each piece in a tumbler of water, which shape will take up more space and cause the water to rise the highest?

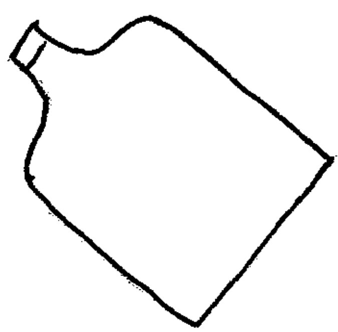
____

Explain your answer _______________________________

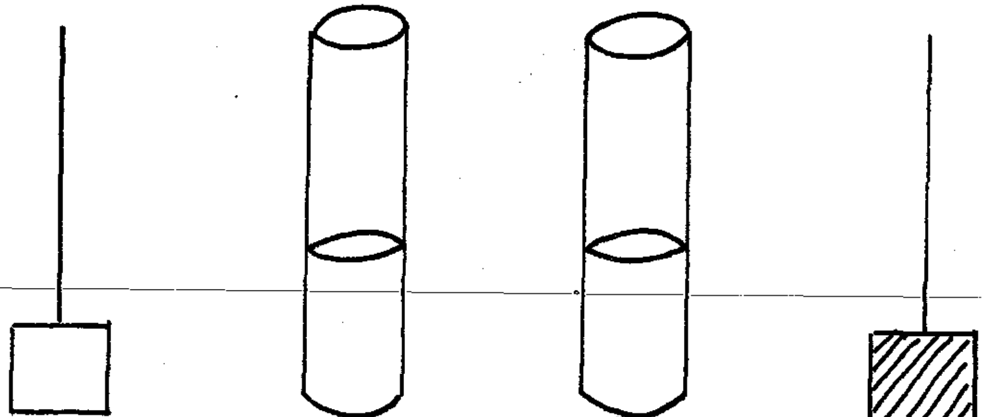
____

2. A jug partly filled with water is drawn below. Another picture shows the jug tipped on its side. Draw a line to show where the water line would be when the jug is tipped.

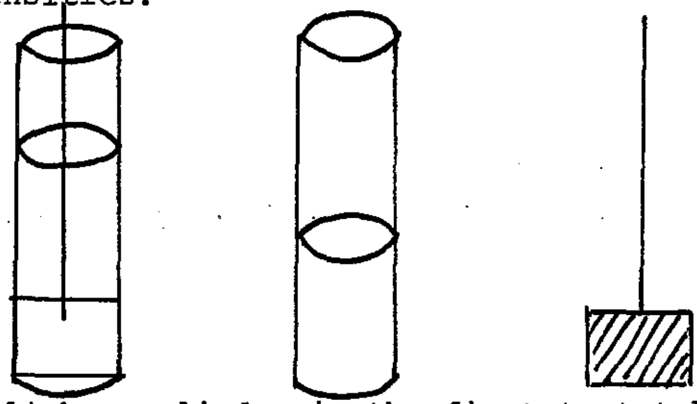




3. Conservation of Volume



Here are two test tubes partly filled with equal amounts of water and two metal cylinders of equal volume, but of different densities.



Placing the ligher cylinder in the first test tube causes the water level to rise. How far will the water rise when the heavier cylinder is lowered into the other test tube?

1. Draw the predicted water level.

2. Explain your prediction________________________________

____

____

B. Propositional Logic:

1. If you are going to go swimming, then it is nice weather. If you are going boating, then it is nice weather. Finally, you are going boating. Conclusions:

Circle the number of the correct answer or answers.

1. It is nice weather.
2. It is not nice weather.
3. You are going swimming.
4. You are not going swimming.
5. One cannot know whether you are going swimming.

2. The first garage holds 24 vehicles; there are 4 trucks and 20 cars there now. The second garage holds 54 vehicles; it now has 9 trucks and 45 cars in it. The third garage holds 36 vehicles, with 6 trucks and 30 cars in it now. Unknown to the drivers, each garage has a "Lucky Parking Spot." In which garage is it most likely that a truck is parked in the lucky spot? Conclusions:

Cirlce the number of the correct answer.

1. In the third garage, for it contains more trucks than the first garage and fewer cars than the second garage.
2. In the second garage, for this one contains the most trucks.
3. In the first garage, for this one contains the fewest cars.
4. In any of the garages, for they all have the same number of trucks in relation to the total number of their vehicles.

3. I was looking at my friend's rose garden. He had been spraying his rose leaves with a chemical to kill a leaf disease. I saw sprayed leaves which were healthy and I saw unsprayed leaves, some of which were diseased and some healthy.

   1. Can I way anything definite about the effect of the spray on the disease? ______________________

   ____

   2. Explain your answer ______________________

   ____

2. An experimenter wanted to test the response of mealworms to light and moisture. To do this he set up four boxes as shown in the diagram below. He used lamps for light sources and watered pieces of paper in the boxes for moisture. In the center of each box he placed 20 mealworms. One day later he returned to count the number of mealworms that had crawled to the different ends of the boxes.
The diagrams show that mealworms respond (respond means move to or away from) to:

1. light but not moisture

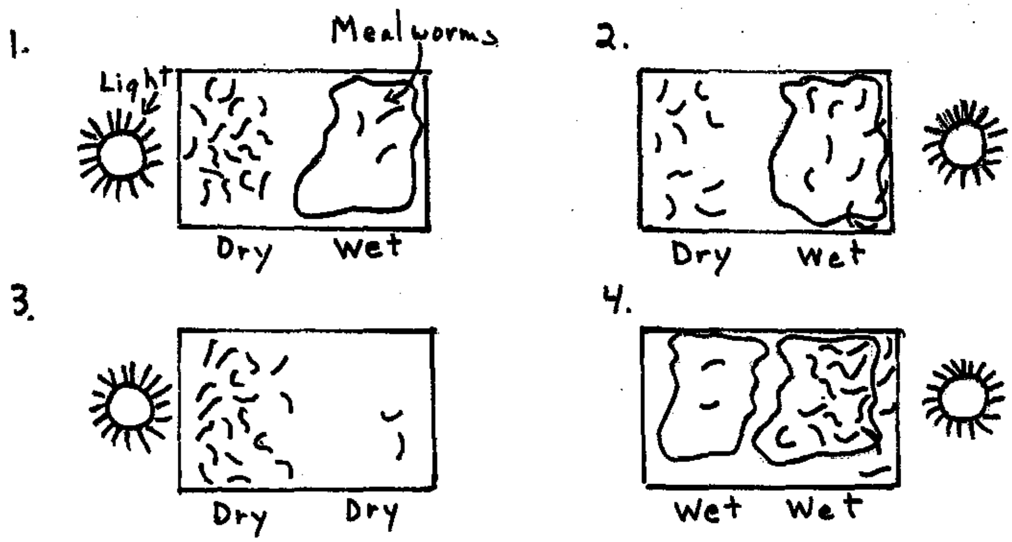
2. moisture but not light

3. both light and moisture

4. neither light nor moisture

Why is this true?______________________________

____



3. How many numbers of two figures are there when the numbers are made with the figures 1, 2, 3, 4, 5, using each figure only once in any number? Write the total amount of numbers.______________
(Do all the figuring in your head.)

How did you figure this?______________________

____

C. Combinatorial Logic:

1. Fifty pieces of various parts of plants were placed in each of five sealed jars of equal size under different conditions of light and temperature. At the start of the experiment each jar contained 250 units of carbon dioxide. The amount of carbon dioxide in each jar at the end of the experiment is shown in the table. Which two jars would you select to make a fair comparison to find out if temperature makes a difference in the amount of carbon dioxide used?

Jar	Plant Type	Plant Part	Color of Light	Temp. (^{o}C.)	Carbon Dioxide
1.	Willow	Leaf	Blue	10	200
2.	Maple	Leaf	Purple	23	50
3.	Willow	Root	Red	18	300
4.	Maple	Stem	Red	23	400
5.	Willow	Leaf	Blue	23	150

Explain your answer ______________________________

____

____

D. Proportional Logic:

1. Solve the Following ratio:

   4/6 = 20/X   X = ________   Why is this number correct?

   ____

2. Measuring height by paper clips. This problem is about Mr. Short, who is just like the man on your paper, and Mr. Tall, who is simlar to Mr. Short but larger. I will measure how high Mr. Short is with my chain of big paper clips. Mr. Short is 4 big clips and Mr. Tall is 6 big clips high. Using the small paper clips do three things. First, measure Mr. Short using your small clips. Second, predict the height of Mr. Tall if you could measure him with the small clips. Third, explain as best you can how you decided the number of small clips in your prediction.

   1. Number of small paper clips needed to measure Mr. Tall.__________________________

   2. Your explanation__________________________

      ____

3. Professor Thistlebush, an ecologist, conducted an experiment to determine the number of frogs that live in a pond near the field station. Since he could not catch all the frogs, he caught as many as he could, put a white band around their left hind legs, and then put them back in the pond. A week later he returned to the pond and again caught as many frogs as he could. Here are the Professor's data: First trip to the pond: 55 frogs were caught and banded. Second trip: 72 frogs were caught; 12 were banded ones. The Professor assumed that the banded frogs had mixed thoroughly with the unbanded ones, and from his data he was able to approximate the number of frogs that live in the pond. If you can compute this number, please do so and then explain how you calculated your results.

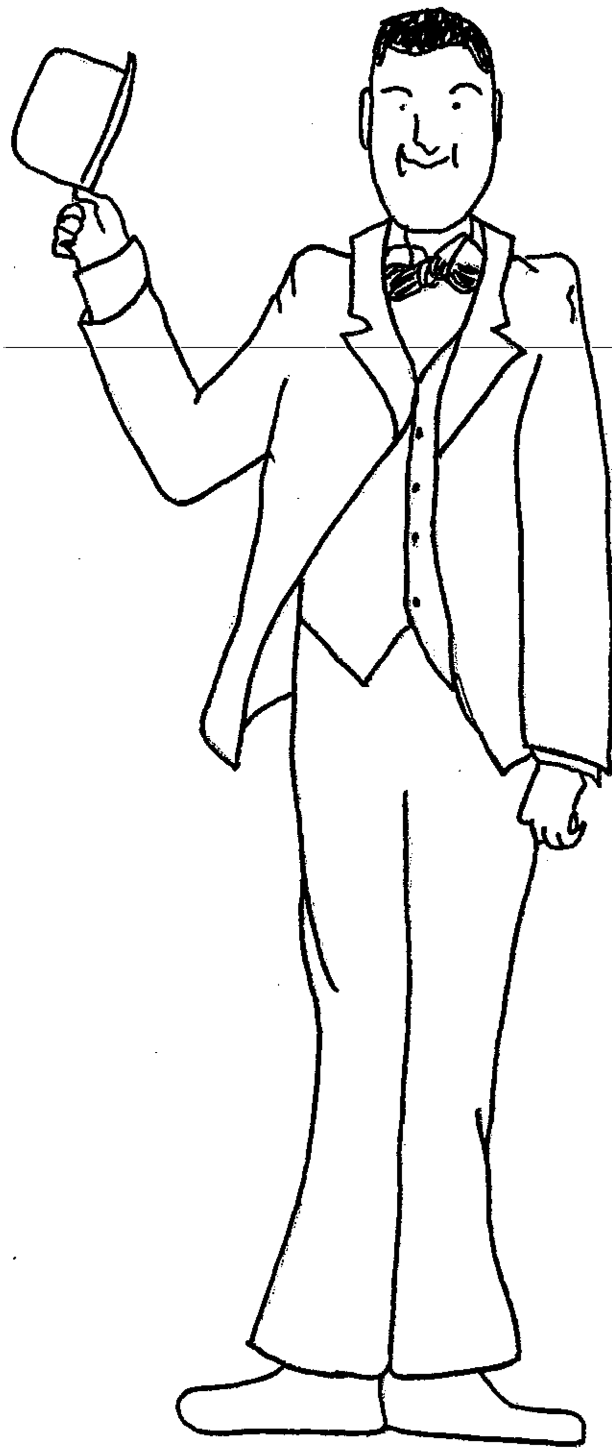
   1. Number of frogs____________________________

   2. Explanation_______________________________

      ____

FIGURE

Mr. Short



How tall is Mr. Short when measured with small paper clips?

Predict the height of Mr. Tall When measured with small paperclips.

Explain how you figured out your prediction.

APPENDIX B

INDIVIDUAL ASSESSMENT OF FORMAL THINKING

I. Conservation of Volume:

A. Predicting water level of 2 different shaped glasses (equipment needed - 2 8 oz. pitchers - 1 straight 8 oz. glass - 1 tulip-shaped 8 oz. glass - 16 oz. water - grease pencil)

1. Pour the water from 1 pitcher into the straight glass.
2. Look at the tulip glass & decide where the same amount of water will come to in this glass.
3. Mark with a grease pencil where you think the water line will be.

B. Water displacement (equipment needed - 2 pint jars - lead ball same size as golf ball - golf ball - grease pencil - water)

1. Examine both balls - lead & golf.
2. Place lead ball in pint jar with 8 oz. water.
3. Notice how much the water rises when the lead ball is submerged.
4. Mark with a grease pencil on the second pint jar how high you think the water will rise when the golf ball is submerged.

II. Propositional Logic:

A. Four types of rats were bred for laboratory experiments. Type A rats were found to be more resistant to disease than Type C rats. Type B rats were more disease resistant than Type C rats. Type D rats were more disease resistant than Type A rats. Which type of rats was least disease resistant? (equipment needed - letter blocks A, B, C, D)

B. INRC Group - Ladybug on a Board (equipment needed - board 12 inches long divided into 4 sections - friction toy that can move forward and backward)

1. Try to visualize the ladybug moving forward or backward 1 section and the board moving either direction at the same speed as the ladybug.
2. As each situation is described try to decide which combination will cause the ladybug to move the farthest distance on the board.
   a. ladybug moves right - board stays still
   b. ladybug stays still - board moves left
   c. ladybug moves right - board moves left
   d. ladybug moves right - board moves right

III. Combinatorial Logic:

A. Letter combinations
(equipment needed - letter blocks A, B, C, D)
How many bike license plates can you make using all 4 letters for each? You may move the letters around to figure this. You will have 5 minutes.

B. Pendulum
(equipment needed - stand - 4 lengths of string - 4 bobs of graduated weights)

1. There are 4 different things that can be changed which may affect the oscillation speed of the pendulum.
2. Try varying the lengths of the strings & the weight of the bobs.
3. Test to see if the height of the drop or the strength of the push affect the speed of the oscillation.
4. Decide if it is the weight of the bob, the length of the string, the angle of drop, or the force of the push, or any combination of these 4 variables which makes the pendulum swing faster.

IV. Proportional Logic:

A. Numerical ratio
(equipment needed - 40+ small blocks - board with 4 sections - 9, 15, 6 blocks in the first three sections)
How many blocks do you need to put in the 4th section to make a fraction equivalent to 9/15?

B. Balance bar
(equipment needed - balance bar with equal distances from the fulcrum - 20+ weights)

1. 10 units of weight have been placed 5 units of of distance from the fulcrum.
2. Using as many weights as you need place them on 1 location on the other side of the fulcrum, not using location 5 to make the bar balance.

BIOGRAPHICAL STATEMENT

Beverly Redden Phillips

Born in Loma Linda, California, October 2, 1932

Graduated from Arizona Academy, Phoenix, Arizona, 1950

B.A., Music Education, Pacific Union College, Angwin, California, 1954

M.A., Elementary Education, University of the Pacific, Stockton, California, 1972

Certification

State of California, Standard Teaching Credential: Elementary

State of California, General Teaching Credential: Secondary

State of California, Ryan Reading Specialist Credential

State of California, Administrative Services Credential

Professional Experience

Title I Mathematics Specialist, Victory Elementary School, Stockton Unified School District, 1980

Teacher, Grade 6, Taft Elementary School, Stockton Unified School District, 1979-1980

Graduate Assistant, School of Education, University of the Pacific, Stockton, California, 1977-1979

Title I Intermediate Reading Specialist, Montezuma Elementary School, Stockton Unified School District, 1974-1977

Teacher, Reading and English, Grades 7 - 9, Learning Center, Marshall Middle School, Stockton Unified School District, 1969-1974

Teacher, Grades 5-6, Stockton Seventh-day Adventist Elementary School, Stockton, California, 1965-1968

Teacher, Grade 7, Fort Saskatchewan, Alberta, 1962-1963

Teacher, Grade 7, Inglewood Elementary, Edmonton, Alberta, 1960-1061

Teacher, Music, Auburn Academy, Auburn, Washington, 1955-1956

Professional Organizations

California Educational Research Association
Jean Piaget Society
Phi Delta Kappa
International Reading Association
Association for Supervision and Curriculum Development
National Council for the Social Studies

Professional Papers Presented

"Increasing Formal Operational Thought Through Instruction in Economics," paper presented at the National Council for the Social Studies, November, 1979

"Thinking About Thought-the Growth and Nurture of the Formal Thinker," North Central Alberta Teachers' Association, February, 1979

"Adolescent Thought-Curriculum Applications," Eigth Annual Interdisciplinary Conference on Piagetian Theory, 1978

"Formal Thinking Assessment," California Educational Research Association, 1977

"Five Piagetian Tasks and Their Relation to Reading," California Educational Research Association, 1976

"Report of Piagetian Research in Pre-operational/Concrete Thinking," California Reading Association, 1976

"Questioning Techniques-Bloom's Taxonomy Applied to Content Area Reading," International Reading Association, 1976