THE EFFECTS OF FOUR METHODS OF INSTRUCTION UPON THE ABILITY OF SECOND AND THIRD GRADE STUDENTS TO DERIVE VALID LOGICAL CONCLUSIONS FROM VERBALLY EXPRESSED HYPOTHESES

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This is to certify that the

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ABSTRACT

THE EFFECTS OF FOUR METHODS OF INSTRUCTION UPON THE ABILITY OF SECOND AND THIRD GRADE STUDENTS TO DERIVE VALID LOGICAL CONCLUSIONS FROM VERBALLY EXPRESSED HYPOTHESES

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Purpose

The main purpose of the study was to ascertain whether or not different types of instruction would improve the ability of second and third graders to derive valid logical conclusions from items in sentential logic. The effects of the training were also compared to find if the training helped students in their perceptual reasoning ability and in their ability in classification.

Procedure

The students involved in the study were 200 second graders and 200 third graders from Monroe County, Indiana. At each grade level two classes of 25 children were randomly assigned to each of three experimental groups and a control group.

The instruction was once a week, for approximately fifty minutes, for a period of thirteen weeks. One experimental group received instruction using attribute block materials, a second group

received instruction using pictorial logic, and a third group received instruction using some of the basic elements of set theory. The fourth group was a control group.

The students were given three posttests; one involved items from sentential logic; the second was the Coloured Progressive Matrices Test; and the third was a test of classification abilities. The data was analyzed using an Analysis of Variance with the α-level of .05.

Findings

1. On the test of sentential logic, students in the experimental groups at both grade levels scored significantly higher than students in the control groups, with one exception.

2. On the Coloured Progressive Matrices Test, students in the experimental groups at both grade levels scored higher than students in the control groups, but the differences were not significant.

3. On the test of classification, students in the experimental groups at both grade levels scored significantly higher than students in the control groups.

4. Third-grade students scored higher on each of the three measures than did second-grade students who were taught by the same method. The differences were significant with three exceptions.

Robert LeRoy McGinty

Discussion

The study, while answering some questions about the abilities of young children to do logical thinking, has raised additional questions. Since instruction appears to have positive effects on certain logical abilities of children, the questions become not only those that this thesis has attempted to explore, i.e., What methods should be used for instruction? How should the students be instructed? When should the students be instructed? but also: Should such instruction be part of the curriculum and, if so, what will be replaced?

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Robert LeRoy McGinty

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CHAPTER I

THE PROBLEM

Introduction

There are of course many goals that an educational system strives for, but one of the major purposes of education is to help students learn how to think. In 1961, the Educational Policies Commission stated:

> The purpose which runs through and strengthens all other educational purposes--the common thread of education--is the development of the ability to think. This is the central purpose to which the school must be oriented if it is to accomplish its traditional tasks or those newly accentuated by recent changes in the world. To say that is it central is not to say that it is the sole purpose or in all circumstances the most important purpose, but that it must be a persuasive concern in the work of the school. (21:11)

One of the purposes of teaching mathematics is to help develop the ability to think, for as Fawcett states:

> I am in vigorous agreement with Professors J. W. Young of yesterday and George Polya of today who say that one of the great purposes in teaching mathematics is to teach young people to think, and one of the essential elements in the achievement of this highly desirable purpose is actually to increase their intellectual power through the intelligent use of symbols. (23:452)

The term "thinking" is a broad term which has different connotations and meanings to different people. The aspect of thinking with which the current study is concerned is the ability to derive valid logical conclusions from verbal premises.

If we are to develop the thinking ability of children, more information is needed on their cognitive abilities. Sigel and Hooper state:

> There is a great need for research data describing in detail the cognitive capability of elementary school children so that curriculum innovations may be more rationally based, utilizing knowledge about competencies and abilities of children. (87:133)

In particular, curricular innovations in mathematics should be based on knowledge about the abilities of children. Along with knowledge about the abilities of children, curriculum developers need to know more about creating problem sequences in mathematics. As Kilpatrick notes:

> The Cambridge Conference on School Mathematics (1963) urged curriculum developers to devote more time and energy to the creation of problem sequences with special emphasis on problems that can be used to introduce new mathematical ideas. (45:162)

At present, the knowledge about particular sequences in mathematics instruction is lacking, as Heimer points out:

> It seems reasonable to conclude that the extent of substantive knowledge about construction of efficient instructional sequences in mathematics is at present desperately sparse. (34:506)

In particular, we need more information on the construction of instructional sequences in the teaching of logic to children. Also, in conjunction with instructional sequences, more study on the use of selected materials in instructional sequences is needed. Harshman, Wells, and Payne call for more study of materials:

> While most modern arithmetic programs contain suggestions on the use of visual aids and manipulative materials, much remains to be done in evaluating the effectiveness of selected materials . . . . Certainly, further study is needed on the use, effectiveness, nature, and variety of manipulative materials for arithmetic instruction. (33:188)

Thus, there is a definite need for more information on the use of materials in mathematics instruction and on instructional sequences in mathematics in which the instruction is aimed at developing the thinking abilities of children. The present study is concerned with instructional sequences in mathematics which are directed toward developing the abilities of children to derive logical conclusions from verbally expressed hypotheses, involving items from sentential logic.

In addition to the previously expressed needs, there is another reason why the ability to derive logical conclusions from items in sentential logic should be developed in children. While not usually stated explicitly, the type of reasoning that children are asked to do when working many problems in arithmetic is the "if-then" type of reasoning. For example, when working a subtraction problem involving regrouping, the child could reason that since one ten equals ten ones, then if there is one ten it could be replaced by ten ones.

Within the limitations of the study, an attempt was made to add information: on the cognitive capabilities of elementary school children in relation to their ability to derive valid logical conclusions from verbal premises; on the construction of efficient instructional sequences to teach children logical thinking; and on the effectiveness of selected materials in the teaching of logic to elementary school children.

Purpose

The main purpose of the study was to investigate the effects of four methods of instruction on second and third grade children's ability to derive logical conclusions from verbal premises. Also, the effects of instruction on the abilities of second and third grade children in classification and perceptual reasoning were studied. The four methods of instruction or treatments were:

Treatment 1. A control group in which students received their normal classroom instruction in mathematics.

Treatment 2. Students in this group used a modification of the logic materials of Furth (26).

Treatment 3. Students in this group used a modification of the logic materials of Dienes (19).

Treatment 4. Students in this group received instruction in logic using some of the basic concepts of set theory.

Definition of Terms

Thinking: According to Gagné (28) in the events called problem solving, individuals use principles to achieve some goal. When the goal is reached then something more has been learned and the individual is now capable of achieving new goals using this new knowledge. What is learned is a higher-order principle which is the combination of the two or more lower-order principles. A principle is the combining of two or more concepts. One of the simplest forms of a principle is the "if-then" type. Problem solving requires the internal events called "thinking." The aspect of thinking that was studied was the ability of children to derive logical conclusions from verbal premises.

Logical Conclusions from Verbal Premises: The verbal premises that were used in the study were from sentential logic, and the students were asked to derive logical inferences from these premises. An example of an item to test whether or not a student is able to draw a logical conclusion to verbal premises is the following:

If it rains today then we cannot go out to play.
It is raining today.
Can we go out to play?

Classification: The ability to recognize that an object may be classified by one or more than one of its attributes. For example, an object could be classified by color or size, or by both color and size.

Perceptual Reasoning: The ability to form comparisons and to reason from analogy along with the capability of organizing spatial perceptions into systematically related wholes.

The instrument used to measure children's ability to draw logical conclusions from verbal statements was a modification of the test of Hill (35). The test developed by R. Raven (77) was used to measure the student's ability in multiple classification. The Coloured Progressive Matrices Test of J. C. Raven (76) was used to measure the ability of children in perceptual reasoning.

Hypotheses

The particular hypotheses investigated were:

1. Third-grade students who are taught by Methods One through Four respectively will achieve higher scores on the average at the end of the treatment on all three tests, than will second grade students who are taught by the same method.

2. On the test of sentential logic, students in both grades two and three who are taught by Methods Two, Three, and Four will achieve higher scores on the average at the end of the treatment than will students who are taught by Method One. In addition, students who are taught by Methods Two and Three will achieve higher scores than will students who are taught by Method Four.

3. On the test of perceptual reasoning, students in both grades two and three who are taught by Method Three will achieve higher scores on the average at the end of the treatment than will students who are taught by Methods One, Two, and Four.

4. On the test of classification, students in both grades two and three who are taught by Methods Three and Four will achieve higher scores on the average at the end of the treatment than will students who are taught by Methods One and Two.

Overview of Organization

The study is organized into five chapters. In Chapter I are found the relevance of the study, the hypotheses that were investigated, and definition of terms used in the study. In Chapter II the literature which is significantly related to the study is reviewed. In Chapter III is found the method of the investigation. In Chapter IV there is an analysis of the data with respect to the specific hypotheses investigated. In Chapter V there are a summary of conclusions, implications and recommendations for future research.

It might be helpful to read the summary at the end of Chapter II first, before beginning the chapter. This is much like looking at a road map before starting the journey. The summary begins on page 26.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The 1969 Cambridge Conference also felt that the ability to think should be developed in children, for they stated:

> A primary message of education should we believe be that thinking is worthwhile . . . . Worthwhile thinking involves both the imagination and the ability to apply previously acquired knowledge . . . . The child must learn to respect his own thinking. To do so, the child must see that his own thinking can improve his ability to cope with the world. His teachers must respect his thinking and they must have curricular materials which will call forth in him a response worthy of respect. (30:6)

As was noted in the first chapter, the aspect of thinking that will be focused upon is the ability of children to derive logical conclusions from verbal premises. The curricular materials to be examined are the materials used in teaching logic to the three experimental groups. In order to give the background for the three experimental methods, the literature which is relevant to the current study will be reviewed in three sections. The first section deals with the literature related to the method advocated by Dienes (19), the second section deals with the literature related to the method advocated by Furth (26), and the third section deals with the literature related to the method which uses the basic principles of set theory.

<u>Literature Related to Dienes Method</u>

One of the curricular materials in use is manipulative aids. The idea of using manipulative materials in the teaching of arithmetic is by no means a new or even recent idea. Pestalozzi (1746-1827) believed that children should use beans, pebbles, etc., when first learning arithmetic (47). Colburn (12), in a book which was first published in 1821, stated the belief that younger children could learn arithmetic using the aids advocated by Pestalozzi. Grube (4) in 1842 published a book in which he said that children should use marbles and other things to be introduced to new ideas in arithmetic. Wentworth (100) in 1885 in his book said teachers should use sticks in bundles of ten when talking about large numbers to give children the idea of place value. Montessori (92) believed that manipulative materials should be used in all subjects to introduce new concepts to children. She advocated a sequence of manipulative materials leading to some desired goal.

There are several reasons why people have advocated the use of manipulative materials in the teaching of children. Pottenger and Leth express why they think children should be exposed to concrete-activity types of learning experiences in the following way:

> The concrete-activity type of trial-and-error problem solving is important because it involves those students who often give up when faced with a more abstract problem. It requires the student to think, to organize his trials from easier to harder, to use previously learned experiences in successive trials, to check his solutions. Most important, it gives every student an opportunity for success. (74:23)

Kallet feels that one reason for using manipulative materials with children is the interaction of the child and the materials, for he states:

> It may be useful to think of a dialogue between the child and the materials, accompanied by a second dialogue, or monologue, which the child carries out in his mind . . . . At times no words may be involved at all, much of the "dialogue" being an interplay of images or unverbalized thoughts. But there surely is some sense in which materials "speak" to a user before, during, and after they are used. . . . Children approach materials with differing expectancies and competencies, and may receive from them quite different meanings and proceed in many different directions. (45:38)

Davis feels that there are at least three reasons why physical materials should be used in the classroom, for he states:

> Why should we bother with physical apparatus in the mathematics classroom? The rationale in support of physical materials and experiences comes from three sides: the cognitive psychology of Jean Piaget, the "reality-authoritarian" dualism of modern science and modern psychoanalytic theory, and the nature of mathematics in today's world . . . . All three reasons suggest that we need much more use of physical apparatus which the children manipulate themselves. (13:356)

Davis noted that the rationale in support of physical materials came from three sides, one of which was the cognitive psychology of Jean Piaget. From his early work with children in Paris and through his continuing work at the Institute of Genetic Epistemology in Geneva, Switzerland, with which he has been associated for the past 40 years, has come the developmental theory of Jean Piaget. Piaget believes that the intellectual development of children goes through four stages.

The first stage he calls <u>Sensori-Motor</u>, and this stage concerns the infant's early development. During this stage the child is object oriented and if he cannot see the physical object, he does not realize that the object can exist. In the Sensori-Motor Stage the child moves from apparently uncoordinated reflex responses to successively more complex responses. He develops an initial sense of the persistence of permanent objects and whether or not something is an inanimate object or an animate creature. A child leaves this stage when he is about two years old.

The second stage is called <u>Pre-Operational</u>. In this stage we have the beginnings of language, and the permanency of objects. A child realizes an object exists without it being physically present. Also in this stage if we pour liquid from one glass to another of a different shape, the pre-operational child will think there is more liquid in one glass than in the other. The child perceives only one relationship at a time, actions are not reversible and judgments are often based on intuition and dominated by perception. All results are possible, things are what they seem, not what they are. The child leaves this stage when he is about seven years old.

The third stage is called <u>Concrete Operations</u>. During this stage the child can consider two or three dimensions simultaneously instead of successively. In the liquid experiment he realizes that the lack of height of the liquid is compensated for by the width of the second container. However, these are called concrete operations.because they operate on concrete objects, and not yet on verbally expressed hypotheses. The stage of Concrete Operations is a prolonged state during which a child becomes able to perceive stable and reversible relationships in concrete materials repeating an operating many times before he is sure of it. The child leaves this stage between the ages of eleven and twelve.

The fourth stage is called <u>Formal Operations</u>. In this stage the child can now reason on hypotheses, and not only on objects. The child attains new structures which are more complicated and more mobile than those of the concrete operational. At the level of concrete operations, the operations apply within an immediate neighborhood. The child attains the facilties to become capable of logical thought, based on symbolic and abstract symbols.

These stages are not abrupt changes, but rather the child progresses gradually from one stage to the next. It should be noted that the stages have to appear in order, as confirmed by Lovell (50) among others, but their time of appearance varies with the particular child and with the particular society. As an example, children in Martinique were found to be delayed several years in reaching various stages when compared to children in Montreal.

The stage of Concrete Operations extends over most of the elementary school years. The child develops many of his concepts through manipulation of concrete materials. According to Piaget, all learning calls for organization of material or of behavior on the part of the learner, and the learner has to adapt also and is changed in the process.

The question, in relation to teaching mathematics in the elementary school, is what types of materials should be used by children to help develop mathematical concepts. Lovell (49:280) suggests that based on the Piagetian cognitive-developmental model that the elementary school should provide "the opportunity for pupils to act on physical materials and to use games in the manner suggested by Dienes."

Dienes (19) has developed a set of activities to be used with logic blocks or attribute blocks. The logic blocks are of three colors, four shapes, two sizes, and two thicknesses. By using various games and activities with the blocks, Dienes introduces such ideas as intersection, union, conjunction, disjunction, negation, and introducing "if-then" statements.

Dienes and Golding believe that the logical thinking ability of young children can be developed through attribute block training, for they state:

> Young children learn best from their own, not other people's experiences. The logical relationship that we might wish children to learn should therefore be embodied in observable relationships between distinguishable attributes such as color, shape, etc. This technique has been used for some time for the testing of logical thinking (concept formation); it was probably first used systematically by the Russian psychologist Vygotsky. William Hull was the first to show in practical ways that five-year-olds could indeed engage in some high order logical thinking, provided the tasks were suitably chosen and adjusted to the stage of development of such young children and provided that great care was taken that excessive verbalism did not stand in the way of concept formation. (19:12)

Lucas (51) studied the effect of attribute block training on: (1) first-grade children's understanding of multiplication of relations; and (2) on their conceptualization of addition-subtraction relationships. He used 208 first-grade children; they were divided into an experimental group which received attribute block instruction and a control group which used the Greater Cleveland Mathematics Program for first grade. Among his findings were that the children in the experimental group:

1. Show an ability to conserve cardinality which is greater than that of children taught more conventionally.

2. Show a superior ability to conceptualize addition-subtraction relations when compared to children instructed in a more conventional manner.

3. Do not show unusual gain in the ability to apply a specific arithmetic operation to a verbal problem-solving situation unless it has been specifically taught.

4. Do not learn computational procedures to the same extent as children taught in a conventional arithmetic program.

5. Exhibit a slight but regular superiority over conventionally-taught students in the multiplication of graphic collections.

Weeks (99), although he also used attribute block training with children, did not study the same effects as Lucas. He studied the effect of attribute block training on the development of logical patterns of thought of second and third grade children. He used 30 second graders and 30 third graders, of which 15 at each grade level were assigned to an experimental and a control group. The experimental groups received attribute block instruction from Weeks, and the control groups received remedial instruction in mathematics from their regular classroom instructor. The following conclusions were suggested:

1. The attribute block training had a strong positive effect in the development of logical reasoning ability and perceptual reasoning ability.

2. This effect was significant at both grade levels.

3. There was no signficant difference at the 0.01 level in this effect at the two grade levels; however, the "near significance" in favor of the second graders on Test 6 indicated that the attribute block training might be more appropriate for the second graders in the development of logical reasoning ability.

4. The attribute block training had a positive effect in the development of abilities in sentential logic and quantificational logic; this effect was stronger in the development of quantificational logic than in the development of sentential logic.

5. The ability to recognize valid and invalid conclusions in sentential logic and quantificational logic was positively affected by the attribute block training.

6. The eight-week period from pretests to posttests had a strong positive effect on the development of logical reasoning abilities and perceptual reasoning abilities for the experimental and control groups, but the effect was stronger for the experimental groups, and

7. The time effect was stronger in the development of sentential logic than in the development of quantificational logic. (99:86)

Nicodemus (61) conducted an investigation involving the use of attribute blocks with children. He noted that as suggested by Gagné (28) one should build a hierarchical structure when teaching children new tasks and that when children worked with attribute blocks, performance of complex behavior was facilitated by experience with simpler subordinate behaviors.

One of the methods used in the present study involved the use of attribute blocks and the logic games of Dienes (19). Using these logic games the children were exposed to simpler subordinate behaviors and then more complex behavior. The terminating behavior was the ability to derive logical conclusions from verbal premises. Also the sequence of activities that led to this terminating behavior was one of the instructional sequences that was studied.

Literature Related to Furth's Method

A second method of instruction used in the study was a modification of the logic materials of Furth (26). While Dienes' methods involved the use of manipulative materials, Furth's method did not use such materials. In Furth's method, children begin by using familiar symbols and they are gradually led through a series of exercises, involving the symbols, which introduce the concepts of intersection, union, conjunction, disjunction, negation, and the use of "if-then" statements. In working through these exercises the child's view of certain situations is gradually changing, and thus it appears that the process the child is going through is what Piaget terms equilibration. In equilibration the child is attempting to assimilate and accommodate information into his existing structure or an abandoning of a part of the structure of knowledge. This may involve a change of his existing structure or an abandoning of a part of the structure, and in either case he proceeds through a sequence of levels of equilibrium. As he receives new information, this may or may not change the equilibrium of his existing structure, and if it does, he then proceeds to a higher level of equilibrium brought upon by his interaction with the new information.

Woodworth provides an instructive example of assimilation and accommodation: "A child on first seeing a squirrel called it a 'funny kitty.'" (104:469). The child was trying to assimilate the new animal into his existing cognitive structure, but he was not able to completely accommodate the new image since he called it "funny."

In Piaget's view, equilibration requires that the child must have existing structures which interact with new information. Palmer believes that the disruption of an individual's equilibrium is one of the most important instructional implications of Piaget's theory and that this disruption can lead to cognitive growth:

> . . . one of the most important instructional implications of the Piagetian position, which is that through induced disruptions of the individual's equilibrium it may be possible to bring about cognitive conflicts which the individual will resolve in a constructive manner, giving rise to a higher level of cognitive differentiation . . . . However, until he has attained certain cognitive prerequisites, he may fail to perceive the discrepancy. (65:319)

In relation to equilibration it is interesting to note that Dewey also felt that thinking was caused by some type of disequilibrium within the individual, for he states:

> . . . the origin of thinking is some perplexity, confusion, or doubt. Thinking is not a case of spontaneous combustion; it does not occur just on "general principles." There is something specific which occasions or evokes it. General appeals to a child (or to a grown-up) to think, irrespective of the existence in his own experience of some difficulty that

troubles him and disturbs his equilibrium, are as futile as advice to lift himself up by his boot-straps. (15:12)

Thus, if we are to increase the capacity of individuals to do logical thinking, it appears that guided disruptions of their equilibrium are to be encouraged. The sequencing of the materials used in the experimental methods in the current study attempted to use this approach.

O'Brien and Shapiro also believe that cognitive growth might be enhanced by disruptions of the individual's equilibrium, for they state:

> Just as it may not be the teacher-dominated classroom "instruction" so widely practiced that is most productive of cognitive growth, so it may not be the "exercise," which is almost exclusively employed by teachers and curriculum-makers, that brings about such growth. Perhaps it is the situation slightly different from the student's existing cognitive structure which causes him to query the existing structure and change it as necessary to restore equilibrium between the internal and the external world. That is, perhaps it is the "problem" that causes change in cognitive structure, i.e., learning. By "problem" we mean a situation faced by a person who does not have the tools to resolve it . . . . By "exercise" we mean a situation that affords practice of an action. Thus for most students the "work problems" so often used in elementary school mathematics texts are exercises rather than problems. The role of the problem in the schools has not been widely investigated, but if Piaget is correct, it is the problem and not the exercise that is a central vehicle for cognitive growth. (63:12)

In the sequencing of the materials in the current study, an attempt was made to incorporate problems and not just exercises into the instruction of students in the deriving of logical conclusions to verbal permises.

Smedslund sees some promise in the use of equilibration to help students in the derivation of logical conclusions, for he states:

> Logical inferences are not derived from any properties of the external world, but from the placing into relationship (<u>mise-en-relation</u>) of the subject's own activities. The process of equilibration is not identical with maturation, since it is highly influenced by practice which brings out latent contradictions and gaps in mental structure and thereby initiates a process of inner reorganization. (89:13)

One question is: To what extent can educational experiences promote the cognitive growth of children? Hooper comments on the Piagetian position in regard to the role of instruction in the development of children:

> The role of learning and educational experiences are not denied by Piaget, but they are qualified chiefly through his emphasis on the equilibration process. Thus, he acknowledges the potential effect of the right kind of experience at the right time for the developing organism. These aspects correspond to curriculum content and timing considerations within the general area of educational application. (87:424)

In the current study, the curriculum content under consideration was the three methods of teaching logic, and the timing considerations were the effects of such instruction on the logical abilities of second- and third-grade children.

Another concern of educators and psychologists in relation to curriculum is to what extent educational experiences can accelerate the stages of development of children.. Stages are those as defined by Piaget. There is some disagreement over how much instruction can accelerate the stage of development. As Kilpatrick and Wirszup state:

> The interrelationship between instruction and child development is a source of sharp disagreement between the Geneva School of psychologists, led by Piaget, and the Soviet psychologists. The Swiss psychologists ascribe limited significance to the role of instruction in the development of a child. According to them, instruction is subordinate to the specific stages in the development of the child's thinking . . . stages manifested at certain age levels are relatively independent of the conditions of instruction . . . Soviet psychologists ascribe a leading role to instruction. They assert that instruction broadens the potential of development, may accelerate it, and may exercise influence not only upon the sequence of the stages of development of the child's thought, but even upon the very character of the stages. (45:4)

In assessing the situation with regard to how much the stages of development can be accelerated, Shulman in 1967 noted:

> The question that has not been answered, and which is engaging the activities of dozens of psychologists and educational researchers all over the country now, is the empirical question--is it possible, through a Gagnéan approach, to accelerate what Piaget maintains is the unvarying clockwork of order. Studies being done in Scandinavia by Smedslund and in this country by Irving Sigel, Egon Mermelstein, and others are attempting to identify the degree to which these processes can be accelerated. If I had to make a generalization, I would have to conclude that at this point, in general, the score for those who say you cannot accelerate is somewhat higher than the score for those who say that you can. But to maintain our ballgame analogy, I think we're in about the third inning. The game is far from over: we need much more inventive attempts to accelerate than we have had thus far. (37:32)

Mermelstein (55) studied the effect of lack of formal schooling on number development. In agreement with the Piagetian position, he concluded that the number development or the concept of conservation of substance appears to come about by a natural process of adaptation by the child to his environment. Smedslund (90, 91) showed that inducing cognitive conflict among nonconservers of substance, or amount, may result in the attainment of this concept.

In a study involving the teaching of formal thinking to children, Joyce notes that some types of instruction might accelerate the stages of Piaget:

> We cannot conclude, that the single month's instruction was effective in inducing formal thinking, although the fifth-grade results suggest that a closer look at this question might be productive. It is possible that the onset of what Piaget calls formal operations might be accelerated by some kinds of instruction. (42:306)

At the present time the results are mixed as to whether or not the developmental stages as defined by Piaget can be accelerated by instruction. Some people believe that acceleration can occur while others do not believe acceleration can occur. Some of the reasons advanced for the failure to accelerate were enumerated in 1970 by Neimark:

> Most experimental attempts at hastening cognitive development through direct tuition have dealt with conservation; they have not been very successful. Their failure may well be attributable to inadequate analysis of the prerequisite component skills and/or insufficient or inappropriate training . . . . Only after an adequate repertoire of classifications and rules has been acquired is it possible to work on higher-order skills for transforming and organizing information; one must first have something to transform and organize. (60:362)

A third side of the coin of whether or not acceleration is possible is the question of whether or not acceleration should occur, for as Wohwill notes:

> I would place the emphasis in teaching scientific and mathematical subjects to young children on a focused enrichment of their experience aimed at generalization and transfer rather than at acceleration per se. Get them actively involved in measuring the sizes, shapes, weights, temperature, etc., of the objects around them, in many different and even novel ways; set them problems to solve and operations to perform, giving them an opportunity to apply their measurement skills and techniques and the concepts embodied in them. Providing the child with a broad base of experience which assures him extensive practice in abstracting structural similarities and common principles from diverse material contents or specific tasks may surely be expected to influence the development of his cognitive skills in a very favorable sense. (103:226)

Thus, Wohwill would concentrate on enrichment of their educational experiences rather than concentrating on "acceleration per se."

Furth also believes that schools should concentrate on broadening the experiences of the elementary school child and that schools should reorganize their teaching patterns, for he states:

> A child of elementary school age is capable of operative, intelligent thinking years ahead of his spoken language. More dramatically, the thinking of this child is light years ahead of what he can read or write. Traditionally, the response to this observation was: Teach him reading and writing so that he can express and expand his thinking. In Piaget's perspective the answer is: Strengthen his thinking so that the child will develop to the point where he can use the verbal medium intelligently. These are not merely opposing views of the focus of elementary school activities; within Piaget's framework, the traditional view is simply false. Language never expands thinking, if expansion

> means a more intelligent use of language. Thinking grows by means of formal abstraction from the general coordinations of actions, not from language. (26:145)

As one part of the implementation of a program for elementary schools, Furth has developed a sequence of activities to promote the logical thinking ability of children. One of the methods used in the present study made use of this sequence of Furth's.

The modifications of the methods of both Dienes and Furth which were used in the current study attempt to lay a firm basis from which, through the process of equilibration, the child is led through a series of problems which attempt to improve his logical reasoning ability.

The third experimental method used in the study, which involved the use of sets, also attempted to improve the logical reasoning ability of children in a manner similar to the other two methods. Dienes' method involves the use of physical materials which the other two methods do not.

Literature Relating to the Use of Sets in Logic Instruction

The third experimental method used in the study might be classified as the traditional way of teaching logic to students. In the current study, the children begin by using sets of objects and they are gradually led through a series of exercises, involving sets, which introduce the concepts of intersection, union, disjunction, conjunction, negation, and the use of "if-then" statements.

Suppes believes that the schools should stess the teaching of logical principles in order to encourage critical thinking:

> The encouragement of critical thinking is generally acknowledged as one of the legitimate objectives of our schools. Yet there has been little effort to translate this goal into

> behavioral terms. If this objective is to be realized, a clear notion of the relevant skills must guide the selection of classroom subject matter and teaching methods. Critical though requires the ability to make logically correct inferences, to recognize fallacies, and to identify inconsistencies among statements. If the school is to encourage these skills significantly, instruction must deal specifically with the ability to derive logical conclusions from given sets of premises, evidence, or data. (94:188)

Suppes explored the possibility of teaching the elements of mathematical logic to fifth and sixth grade students. Among his conclusions were:

> 1. The upper quartile of elementary school students can achieve a significant conceptual and technical mastery of elementary mathematical logic. The level of mastery is 85 to 90 percent that achieved by comparable university students.
>
> 2. This mastery of the subject matter by elementary school students can be accomplished in an amount of study time comparable to that needed by college students if study is allocated over a longer period of time and if the students receive considerably more direct teacher supervision. (94:194)

Hyram conducted a study in which an experimental group of children, ages 9 through 11, were given instruction on rules of logic; while a control group received no such instruction. He concluded that:

> 1. Correct or logical thinking does depend upon a knowledge of the principles of logic.
>
> 2. According to this sample, upper grade pupils can be taught to think critically and therefore logically through the use of instructional procedures which emphasize the principles of logic as the <u>learning content</u>. (40:130)

In a study involving children aged 10 to 12, and 12 to 14, Donaldson (20) found the ability to infer valid conclusions increased with age, but the ability to recognize invalid patterns of inference showed little improvement with age. She also found that deductive reasoning at a purely verbal level may be within the capacity of five year olds. However, she cautioned that the same children who tackled a problem deductively on one occasion might not proceed in a deductive fashion on similar problems, or even the same problem on another occasion.

Howell (38) found that accelerated junior high school students were able to understand some valid principles of conditional reasoning, but did not recognize invalid principles. He found that growth in inferential reasoning ability without formal instruction in logic improves slightly with increasing grade level.

Gardiner (29) found that students in grades 4 to 12 had mastered some principles of conditional reasoning but not others, and that invalid principles were the least well mastered at a given grade level.

Paulus (66) studied how well children in grades 5 to 12 could draw conclusions from the premises of deductive arguments and how well they could evaluate conclusions to deductive arguments. He concluded that the differences between the abilities to deduce and to assess conclusions to deductive arguments are sufficiently important to warrant caution in the drawing of inferences about mastery of principles on a deducing test, given only knowledge of his score on an assessing test. As age increased, children became better in both abilities.

Miller (56) in a study involving students in grades 8, 10, and 12, found that students in all three grades were able to select valid conclusions to valid patterns, but were unable to recognize invalid patterns as invalid but accepted them as valid. He concluded that formal sentential logic was within the grasp of 8th grade students.

McAloon (53) compared the effects of teaching logic interwoven with mathematics and teaching logic separately from mathematics in grades 3 and 6. Among her findings were:

1. The group taught logic scored significantly higher on a mathematics achievement test than the group not taught logic.

2. The groups taught logic scored significantly higher than groups not taught logic on tests of reasoning in both grades.

3. There was no significant difference in scores on the class and conditional reasoning tests between those taught logic interwoven with mathematics and those taught logic separated from mathematics.

4. Students in grade 6 scored significantly higher than the students in grade 3 on the reasoning and logical thinking tests.

5. There was no significant difference in the logic or mathematics achievement between boys and girls at either third or sixth grade level.

6. Fallacy principles and the principles of contraposition and converse were the most difficult to teach at both grade levels.

7. Test items with a correct answer of Maybe were answered the least well of any group on both class and conditional reasoning tests.

Hill (35) studied the abilities of first, second, third graders to derive valid logical inferences from sets of verbal premises. She constructed a 100-item test which contained items on: Sentential Logic (60); Classical Syllogism (13); and Logic of Quantification (27); all of the items could be answered with a "yes" or a "no." The test was administered to 270 children who were from 6 to 8 years old. Among the findings were:

1. Children in the age range of six years through eight years old are able, to a marked degree, to recognize valid conclusions derived from hypothetical premises.

2. Significant increases in the recognition of logical validity are associated with increase in age from six to seven and from seven to eight.

3. The addition of negation to the regular form of a logical principle increases the difficulty of recognizing a valid conclusion derived by means of that principle. A single logical principle plus negation is more difficult than the compound form which combines that principle and another, for children ages six, seven, and eight. (34:80)

Roberge (82) studied the abilities of children in grades 4, 6, 8, and 10 to reason with basic principles of deductive reasoning. He confirmed the finding of Hill that negation of a major premise made it more difficult for students to recognize the validity of a conclusion. He found that modus ponens was the easiest principle to recognize at all grade levels, and he concluded that classroom instruction in some of the valid principles of conditional reasoning could begin as early as grade 4.

O'Brien and Shapiro (64) replicated Hill's study and studied the additional factor of the ability of children aged 6 to 8 to test the logical necessity of a conclusion. To study this additional factor the test constructed by Hill was used as one test, and another test was constructed from the original test by the addition of the response "Not Enough Clues" to the responses of "Yes" and "No." One-third of the items on the altered test were changed so that "Not Enough Clues" was the correct response. The findings of Hill were confirmed, with the additional finding that children had great difficulty in testing the logical necessity of a conclusion as evidenced by children of all ages scoring below chance on the 33 items which had "Not Enough Clues" for a correct response.

In a follow-up study, Shapiro and O'Brien (86) investigated the developmental patterns of two aspects of logical thinking. "In what way does the ability to test for logical necessity develop in children up to 13 years of age and how does this developmental pattern compare with that for discriminating between a necessary conclusion and its negation?" They found that students had considerable success in recognizing logically necessary conclusions and they "level off" high in the 6 to 8 year-old age range. In testing for logical necessity, there was growth over the 6 to 13 age span, but there was no evidence of any high leveling off and the children encountered considerable difficulty with these items at all ages. Another interesting result was found in that when dealing with "if-then" statements, students in large numbers consistently interpreted "if-then" as "if and only if." As children increased in age the "if and only if" responses decreased and the "if-then" responses increased. Shapiro and O'Brien state:

> This pattern suggests that as children get older, they tend to switch from a child's logic interpretation to one which is consistent with mathematical logic. (86:824)

Anastasiow, *et al.* (2), compared three methods of teaching the principles of set, intersection, form and color to 5 and 6 year-olds. The three methods were discovery, guided discover, and rule-example or didactic. Their results indicated that rule-example may be most efficient for mastery of content taught in the early stages of the curriculum, and that guided discovery appeared to be more efficient for mastery of more complex principles.

The foregoing review of studies indicate varying degrees of success in the teaching of logical reasoning to students with the general agreement that training does make a difference. The ability to reason logically appears to increase with age, while students at all grade levels have difficulty with: negatively worded statements; invalid patterns of reasoning; and determining the logical necessity of conclusions.

While the foregoing studies either compared one method of teaching logic with no instruction in logic or the studies tried to ascertain the achievement level of pupils in logical ability, the current student examined different ways of teaching logic at different grade levels.

In conjunction with the foregoing studies, it should be noted that Weeks used a modification of O'Brien and Shapiro's test as one measure. The present study used a generalization of a similar test. Also, both Weeks and Lucas used Raven's Coloured Progressive Matrices Test as one measure. Weeks found the groups given attribute block training to be superior to the groups not given such training on Raven's Coloured Progressive Matrices Test while Lucas found no difference with his groups. The present study also used Raven's Coloured Progressive Matrices Test as one measure.

A third measure used in the present study was a classification test developed by R. Raven. Raven (77) used his test to study the effects of a structured learning sequence on second and third grade children's classification achievement. The purpose of his study was to determine if achievement on classification tasks could be improved by instruction in the rules of classification. He found that third grade students achieved higher scores than second grade students, and students who received instruction in the rules of classification achieved higher scores than students who received no training in classification.

Summary

There is general agreement that the development of thinking in children should be one of the goals of education. The question is:

What are the appropriate means to develop the ability to think, and furthermore, what ways are appropriate for different age groups?

One of the ways suggested has been the use of physical material, and in particular the use of attribute blocks. The use of physical material in the teaching is not a new idea, but it has achieved recent prominence through interpretations of Piaget's work. The Nuffield Project in England (105) is an example of a large-scale support of the use of physical materials in the teaching of arithmetic. The Nuffield Project places heavy reliance on the involvement of children in using concrete materials and apparatus to solve problems. One method used in the present study to introduce logic to children made use of physical materials, namely attribute blocks and the logic games of Dienes (19).

A second way that has been suggested is the evoking of thought by some disturbance. This method, while advocated earlier by Dewey, has received recent prominence through interpretations of Piaget's notion of equilibration. Furth (26) has proposed "A School for Thinking" based on the works of Piaget. One method used in the present study used the ideas of Furth in the teaching of logic to children.

A third way that has been suggested, which might be classified as a "traditional way," is the teaching of the principles of logic. One method in the present study used the basic principles from set theory.

Within the limitations of the study it is hoped that some light has been shed on some of the issues raised in the literature.

CHAPTER III

DESIGN OF THE STUDY

Introduction

During the school year 1971-72, the Training Teacher Trainers (TTT) Project was operating in three schools in Monroe County, Indiana. The TTT is a federally-financed program that encourages the involvement of classroom teachers, college professors, pre-service teachers and the community in innovative techniques in the training of pre-service teachers. As a part of the TTT program, pre-service elementary education majors do their student teaching in the schools for the entire school year. Sixteen of these student teachers participated in the current study; eight who were student teaching in second grade, and eight who were student teaching in third grade. The sixteen student teachers received instruction in the use of the materials employed in the current study, and they in turn instructed their second and third grade students.

Subjects

The study was conducted in the Monroe County Community School Corporation of Monroe County, Indiana. In conjunction with the sixteen student teachers, sixteen teachers in three schools participated in the study: eight second-grade teachers and eight third-grade teachers. There were 200 second-grade children and 200 third-grade children involved in the study.

Descriptive information of the subjects appears in Table 3.1, 3.2 and 3.3. Table 3.1 shows the number of boys and girls in the different treatments in the study; Table 3.2 shows the I.Q. of the third-grade students as measured by the Lorge-Thorndike Intelligence Test-Form 1 Level A; and Table 3.3 shows the achievement of the third-grade students as measured by the Iowa Tests of Basic Skills-Form 3. There were no such data available on the second-grade students as the school district did not begin a testing program until the third grade.

TABLE 3.1

SEX OF SUBJECTS

Sex	Treatment 1	Treatment 2	Treatment 3	Treatment 4
		Grade 2		
Male	28	29	29	29
Female	22	21	21	21
		Grade 3		
Male	27	25	24	25
Female	23	25	26	25

TABLE 3.2

I.Q. OF SUBJECTS IN GRADE 3 AS MEASURED BY
LORGE-THORNDIKE INTELLIGENCE TEST-FORM 1 LEVEL A

Treatment	Verbal	Non-Verbal	Total
T_1	96.5	101.4	99.2
T_2	95.6	101.7	98.8
T_3	92.8	100.9	97.0
T_4	95.1	99.5	97.5

TABLE 3.3

ACHIEVEMENT OF SUBJECTS IN GRADE 3 AS MEASURED BY THE IOWA TESTS OF BASIC SKILLS-FORM 3

	Test V	Test R	Test L	Test W	Test A			
				Work				
			Lang.	study	Arithmetic skills			
Treatment	Vocab.	Read.	skills	skills	Concepts	Probs	Total	Composite
T_1	31.2	31.6	30.7	32.2	33.1	31.6	32.3	31.6
T_2	30.7	32.1	29.2	31.3	32.9	31.3	32.1	31.0
T_3	30.4	30.1	28.4	30.2	29.0	28.8	29.0	29.7
T_4	32.1	32.4	29.0	30.0	33.0	31.2	32.2	31.1

Treatments

Four treatments were used in the study, and at each grade level two classes of 25 students were randomly assigned to each treatment.

Treatment 1 was designated as the control group in which students received their normal classroom instruction in mathematics, where the instruction did not include material from sentential logic.

Treatment 2. Students received instruction in some of the basic principles of logic using a modification of the logic materials of Furth (26). The principles of logic that were introduced to the students were: conjunction; disjunction; negation; and simple rules of inference. The students began by using pictures and letters and they were gradually introduced into verbalizing statements about the pictures and letters and finally into writing such statements. It should be noted that in regard to the statements involving sentential logic, care was taken to provide students with problems in which the conclusions drawn were not only logically correct but also conclusions that the students could verify with the materials at hand. An outline of the content of the lessons can be found in Appendix A.

Treatment 3. Students received instruction in some of the basic principles of logic using a modification of the logic material of Dienes (19). The principles of logic that were introduced to the students were: intersection; union; conjunction; disjunction; negation; and simple rules of inference. The students began by using manipulative materials and they were gradually introduced into verbalizing statements about the materials and finally into writing such statements. It should be noted that in regard to the statements involving sentential logic, care was taken to provide students with problems in which the conclusions drawn were not only logically correct but also conclusions that the students could verify with the materials at hand. An outline of the content of the lessons can be found in Appendix B.

Treatment 4. Students received instruction in logic using some of the basic concepts of set theory. The principles of logic that were introduced were intersection, union, conjunction, disjunction, negation, and simple rules of inference. The students were introduced to sets and then to operations on sets, and they were gradually introduced into verbalizing statements about sets and finally into writing such statements. It should be noted that in regard to the statements involving sentential logic, care was taken to provide students with problems in which the conclusions drawn were not only logically correct but also conclusions that the students could verify with the materials at hand. An outline of the content of the lessons can be found in Appendix C.

In all cases the instruction was once a week for approximately 50 minutes for a period of 13 weeks. The instruction was taken from the time normally allotted to mathematics instruction.

Measures

Thirty items from the Coloured Progressive Matrices Test of J. C. Raven (76) was used as one measure. This test was chosen because it was felt that the instruction that the children received could affect their performance on this test.

Both Lucas (51) and Weeks (99) used Raven's Coloured Progressive Matrices Test as one measure in their studies, and they both used attribute block materials in their instruction. Lucas found no differences between first-grade children who used attribute block materials and those who did not; while Weeks found a difference in favor of second and third-grade children who used attribute block materials compared to those who did not use these materials.

J. C. Raven's Coloured Progressive Matrices Test begins with easy problems and gradually becomes more difficult. Raven (76) describes the test as "a test of observation and clear thinking" and not a test of "general intelligence." The test indicates a person's ability in forming comparisons and reasoning by analogy; and to show how well he can organize spatial perceptions into systematically related wholes. This ability is referred to as perceptual reasoning ability. One advantage in using this test is that it is non-verbal.

While J. Raven noted that his test is not a test of general intelligence, it correlates highly with some intelligence tests. Martin and Wiechers (52) found correlations of .91, .84, and .83 between J. Raven's test and the Wechsler Intelligence Scale for Children on the Full Scale, Verbal, and Performance I.Q.'s respectively. Green and Ewert (31) found a correlation of .78 between J. Raven's test and Otis Mental

Age. The reliability of the test as reported in the test manual is 0.90 (76:17). The reliability of the test on the sample used in the current study is .87 as computed by the test-retest method (10) with N = 50.

A second measure used in the study included thirty items from a test developed by R. Raven (77). This test was used to measure children's ability to classify an object on one or more dimensions. For example, a leaf could be classified by color or by size, or both by color and size simultaneously.

The format in R. Raven's test has a picture of some objects, such as trees, at the top of the page. Below this appears pictures of three or four ways of grouping the objects. The student is then asked to place a mark on the picture at the bottom of the page that shows all of the objects from the picture at the top of the page that belong together. In order to choose the correct answer, the student must be able to classify an object on one, two, or three dimensions. The 30 problems begin with easier classifications and gradually become more difficult.

R. Raven's test was used because it was felt that the instruction the students received could affect their ability in classification. The reliability of R. Raven's test on the sample used in the current study was .78 as computed by the test-retest method (10) with N = 50.

The third measure used in the study was similar to a part of a test developed by Hill (35). The 100-item test of Hill was divided into two parts; the first 60 items involved sentential logic while the remaining 40 items dealt with quantificational logic. Each of the items were in the form of two or three premises plus a conclusion presented as a question. The correct answer in each case was a "yes" or a "no."

Shapiro and O'Brien (86) modified Hill's test by changing one-third of the items so that the correct response to the altered items would be "maybe." This allowed them to measure how well children could determine the logical necessity of a conclusion.

The instrument used in the present study consisted of 30 items from sentential logic. The correct answers to the items are "yes," "no," or "maybe." The 30 items were divided into five groups of six items each. The five groups were:

I. Items of the form: If P then Q; P; ∴ Q.

II. Items of the form: If P then Q; Q; ∴ not necessarily P.

III. Items of the form: If P then Q; not Q; ∴ not P.

IV. Items of the form: P or Q; P; not necessarily Q.

V. Items of the form: P or Q; not Q; ∴ P.

The 30 items were generated by the technique of a Universe-Defined Scheme as used by Hively, Patterson and Page (36). In a Universe-Defined Scheme the test items are randomly sampled from a pre-defined universe of test items. The advantage of using a Universe-Defined method is that, in addition to a large pool of test items, one can generalize the results of a study to a larger population of questions than just those given on a particular test that is used in a study.

The items used in the present study were basically of two types: (1) If P then Q; (2) P or Q. Each of these two types were divided into two subtypes and a Universe-Defined Scheme was applied to each of the subtypes, where three items of each subtype were in each group.

<u>Type 1</u>. For items of the form: If P then Q, the two subtypes are:

A. If 1 2 3 then 4 5 6.

B. If 7 8 then 9 10.

The words that were randomly selected to be put in the groups one through ten respectively were:

1. Proper first names.
2. Affirmatives or negatives.
3. Places, events and comparisons.
4. Proper first names.
5. Affirmatives or negatives.
6. Items compatible with Number 3.
7. Affirmatives or negatives.
8. Comparisons, places and objects.
9. Affirmatives or negatives.
10. Items compatible with Number 8.

An example of an item for subtype A is: If John is big then Mike is not big. The words "John, Is, Big, Mike, Not, and Big" are randomly selected from groups one through six respectively.

An example of an items for subtype B is: If this is room 9 then it is a first-grade room. The words "Is, Room 9, Is, and First-Grade Room" are randomly selected from groups seven through ten respectively. The universe of items for groups one through ten can be found in Appendix D.

Type 2. For items of the form: P or Q, the two subtypes are:

C. Either 11 12 13 or 14 15.

D. 16 either 17 18 or 19 20.

The words that were randomly selected to be put in the groups eleven through twenty respectively were:

11. Proper first names.

12. Affirmatives or negatives.

13. Comparisons, events, and objects.

14. Affirmatives or negatives.

15. Items compatible with Number 13.

16. Proper first names.

17. Affirmatives or negatives.

18. Comparisons, events, and objects.

19. Affirmatives or negatives.

20. Items compatible with Number 18.

An example of an item for subtype C is: Either Mary rides the bus or she walks to school. The words "Mary, Does (understood) Ride, Bus, Does (understood) Walk, and School" are randomly selected from groups eleven through fifteen respectively.

An example of an item for subtype D is: Dick either has a sister or he has a brother. The words "Dick, Has, Sister, Has, and Brother" are randomly selected from groups sixteen through twenty respectively. The universe of items for group eleven through twenty can be found in Appendix D.

Once the statements were formed from the universe of items, they were put into the form of the sentential logic groups I through V. It was further stipulated that of the six questions in each group, two would involve affirmatives, two would involve negatives, and two would involve affirmatives and negatives. The test used in the current study can be found in Appendix E.

The reason that an instrument similar to Hill's was constructed is that the instruction was geared toward developing skills in dealing with problems involving sentential logic. The reliability of this instrument on the sample used in the current study was .69 as determined by the test-retest method (10) with N = 50.

Retention

The three tests were administered to the students on three separate occasions; once following the instruction period, and twice again at three week intervals.

Design

				R_1			R_2			R_3	
			M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
G_2	T_1	C_1									
		C_2									
	T_2	C_3									
		C_4									
	T_3	C_5									
		C_6									
	T_4	C_7									
		C_8									
G_3	T_1	C_9									
		C_{10}									
	T_2	C_{11}									
		C_{12}									
	T_3	C_{13}									
		C_{14}									
	T_4	C_{15}									
		C16									

The design used in the study is classified by Kirk (46) as a split-plot design, where R is retention, M is measure, C is classroom, T is treatment, and G is grade. Campbell and Stanley (11) note that this is a true experimental design because it controls for sources of invalidity, such as history, maturation, testimony, instrumentation, regression, and selection.

Hypotheses

The particular hypotheses that were investigated were:

1. Null hypothesis: No differences will be found on the average on all three tests at the end of the treatment between third-grade students who are taught by Methods One through Four respectively and second-grade students who are taught by the same method.

   Alternate hypothesis: The average score of third-grade students at the end of the treatment will be higher on all three tests than the average score of second-grade students who are taught by the same method.

2. Null hypothesis: On the test of sentential logic, students in grades two and three respectively will achieve the same on the average at the end of the treatment regardless of method.

   Alternate hypothesis: On the test of sentential logic, students in grades two and three who are taught by Methods Two, Three, and Four will achieve higher scores on the average at the end of the treatment than will students who are taught by Method One. In addition, students who are taught by Methods Two and Three will achieve higher scores than will students who are taught by Method Four.

3. Null hypothesis: On the test of perceptual reasoning, students in grades two and three respectively will achieve the same on the average at the end of the treatment regardless of method.

   Alternate hypothesis: On the test of perceptual reasoning, students in both grades two and three who are taught by Method Three will achieve higher scores on the average at the end of the treatment than will students who are taught by Methods One, Two, and Four.

4. Null hypothesis: On the test of classification, students in grades two and three respectively will achieve the same on the average at the end of the treatment regardless of method.

   Alternate hypothesis: On the test of classification, students in both grades two and three who are taught by Methods Three and Four will achieve higher scores on the average at the end of the treatment than will students who are taught by Methods One and Two.

Analysis

The analysis of the data was performed using an Analysis of Variance on the split-plot design. To achieve equal cell frequency, two classes of 25 students each, were randomly assigned to each of the treatment groups. With equal cell frequency, the assumption of homoscedasticity is robust in a balanced design. The assumption of normality is also robust in an analysis of variance for fixed variables. The classroom was used as the experimental unit in order to meet the assumption of independence of experimental units.

In a split-plot design, the test for significance of measures and the test for significance of measures by treatment interaction requires the assumption that the off diagonal elements of the repeated measures by repeated measures intercorrelational matrix are equal. However, a conservative test which does not require this assumption was used. The conservative test is the regular Analysis of Variance with reduced degrees of freedom. Since all of the assumptions for using an Analysis of Variance for a split-plot design were met, the data were analyzed by this method. A more comprehensive discussion of the assumptions for an Analysis of Variance is found in Kirk (46).

Summary

The study was conducted in the Monroe County Community School Corporation of Monroe County, Indiana. The study involved 200 second graders, 200 third graders, and 32 teachers and student teachers. Two classes of 25 students at each grade level were randomly assigned to one of four treatment groups.

Students in Teatment 1 were the control group; students in Treatment 2 used the logic materials of Furth (26); students in Treatment 3 used the logic materials of Dienes (19); and students in Treatment 4 used more traditional logic materials. The instruction was given during the time allotted to mathematics instruction and it was given once a week for about 50 minutes for a period of 13 weeks.

The four treatments were compared on three variables. One variable was the student's ability in perceptual reasoning, as measured by J. C. Raven's Coloured Progressive Matrices Test (76); the second variable was the student's ability to classify objects, as measured by R. Raven's Classification Test (77); and the third variable was the student's ability in sentential logic, as measured by a test similar to Hill's Test (35). The tests were administered at the conclusion of the instruction period and twice again at three week intervals.

The design used in the study was a split-plot design (46) in which the data was analyzed using an Analysis of Variance.

CHAPTER IV

ANALYSIS OF RESULTS

Introduction

The results of the analysis of the data will be presented in three sections. The first section deals with the comparison of the four treatments, the second section is a comparison of second and third graders, and the third section deals with retention.

The mean scores that the students received on the posttests are listed in Table 4.1; where R is retention, M_1 is the sentential logic test, M_2 is J. C. Raven's test, M_3 is R. Raven's test, T_1 is the control group, T_2 utilized Furth's method, T_3 utilized Dienes' method, and T_4 utilized set materials, C is classroom, and G is grade.

Since the data consisted of three different measures, an attempt was made to put the measures in a common metric. Each observation on the posttests was divided by the standard deviation of the posttest. The transformed scores are recorded in Table 4.2.

The group means and standard deviations, of each of the measures, for the four treatments are reported by grade levels in Table 4.3. The repeated measures by repeated measures correlational matrix appears in Table 4.4.

TABLE 4.1

MEAN SCORES ON POSTTESTS

			R_1			R_2			R_3	
		M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
T_1	C_1	10.44	13.44	8.04	10.56	16.52	9.36	10.64	16.60	9.12
	C_2	11.16	12.80	8.28	11.28	16.16	9.24	10.96	15.68	9.64
T_2	C_3	10.84	14.24	11.44	10.88	17.04	12.62	10.80	16.92	12.92
	C_4	10.08	13.64	11.04	10.28	16.88	12.36	10.44	17.16	12.44
G_2 T_3	C_5	12.68	14.68	11.88	13.10	16.00	13.20	12.88	16.32	13.28
	C_6	12.24	16.08	11.84	13.40	17.62	13.88	12.72	17.72	13.56
T_4	C_7	12.08	15.96	10.08	11.84	17.16	11.04	11.96	17.32	11.24
	C_8	12.76	14.08	10.68	12.76	16.28	11.32	12.64	16.28	11.64
T_1	C_9	11.40	17.68	12.64	11.16	19.24	13.68	11.04	19.48	13.96
	C_{10}	10.92	16.76	12.28	11.88	18.04	12.92	11.48	18.12	13.48
T_2	C_{11}	13.32	17.48	15.44	13.40	20.40	15.60	13.16	20.72	15.76
	C_{12}	13.68	18.44	15.68	13.24	21.20	15.00	13.48	21.04	15.40
G_3 T_3	C_{13}	12.68	16.64	14.12	12.60	19.24	13.40	12.76	19.08	14.76
	C_{14}	13.12	17.96	14.68	13.24	18.80	14.36	13.32	19.44	14.08
T_4	C_{15}	13.16	20.88	15.28	12.96	23.20	15.08	13.04	23.40	15.84
	C_{16}	13.20	19.72	15.24	13.28	21.32	15.88	13.44	21.64	15.16

TABLE 4.2

TRANSFORMED SCORES OF POSTTESTS

			R_1			R_2			R_3		
			M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
G_2	T_1	C_1	28.22	17.01	21.73	28.54	20.91	25.30	28.76	21.01	24.65
		C_2	30.16	16.20	22.38	30.49	20.46	24.97	29.62	19.85	26.05
	T_2	C_3	29.30	18.03	30.92	29.41	21.57	34.11	29.19	21.42	34.92
		C_4	27.24	17.27	29.84	27.78	21.37	33.41	28.22	21.72	33.62
	T_3	C_5	34.27	18.58	32.11	35.41	20.25	35.68	34.81	20.66	35.89
		C_6	33.08	20.35	32.00	36.22	22.30	37.51	34.38	22.43	36.65
	T_4	C_7	32.65	20.20	27.24	32.00	21.72	29.84	32.32	21.92	30.38
		C_8	34.49	17.82	28.86	34.49	20.61	30.59	34.16	20.61	31.46
G_3	T_1	C_9	30.81	22.38	34.16	30.16	24.35	36.97	29.84	24.66	37.73
		C_{10}	29.51	21.22	33.19	32.11	22.84	34.92	31.03	22.94	36.43
	T_2	C_{11}	36.00	22.13	41.73	36.22	25.82	42.16	35.57	26.23	42.59
		C_{12}	36.97	23.34	42.38	35.78	26.84	40.54	36.43	26.63	41.62
	T_3	C_{13}	34.27	21.06	38.16	34.05	24.35	36.22	34.49	24.15	39.89
		C_{14}	35.46	22.73	39.68	35.78	23.80	38.81	36.00	24.61	38.05
	T_4	C_{15}	35.57	26.43	41.30	35.03	29.37	40.76	35.24	29.62	42.81
		C_{16}	35.68	24.96	41.19	35.89	26.99	42.92	36.32	27.39	40.97

TABLE 4.3

GROUP MEANS AND STANDARD DEVIATIONS OF THE SCORES OF THE POSTTESTS

		M_1			M_2			M_3		
		N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.
G_2	T_1	6	10.84	.35	6	15.20	1.66	6	8.95	.64
	T_2	6	10.55	.35	6	15.98	1.59	6	12.14	.73
	T_3	6	12.84	.42	6	16.40	1.14	6	12.94	.87
	T_4	6	12.34	.42	6	16.18	1.16	6	11.00	.55
G_3	T_1	6	11.31	.35	6	18.22	1.01	6	13.16	.65
	T_2	6	13.38	.20	6	19.88	1.54	6	15.48	.28
	T_3	6	12.95	.31	6	19.36	1.06	6	14.23	.49
	T_4	6	13.18	.17	6	21.70	1.47	6	15.41	.35

TABLE 4.4

REPEATED MEASURES BY REPEATED MEASURES CORRELATIONAL MATRIX

	M_1	M_2	M_3
M_1	1.00	.68	.75
M_2	.68	1.00	.87
M_3	.75	.87	1.00

The results of the Analysis of Variance on the transformed scores of the posttests are summarized in Table 4.5, with an α-level of .05.

TABLE 4.5

RESULTS OF THE ANALYSIS OF VARIANCE

Source of variation	S.S.	d.f.	M.S.	F-ratio	Significance level
G	1081.53	1	1081.53	522.47	.05
T	470.61	3	156.87	76.15	.05
R	93.02	2	46.51	116.28	.05
M	4270.36	2	2135.18	1036.50	.05
GT	148.03	3	49.34	23.95	.05
GR	11.87	2	5.93	14.83	.05
TR	3.08	6	0.51	1.28	N.S.
GM	236.01	2	118.00	57.56	.05
TM	185.21	6	30.87	14.99	.05
RM	38.60	4	9.65	20.53	.05
C:GT	16.53	8	2.07	--	--
GTR	4.94	6	0.82	2.05	N.S.
GTM	112.30	6	18.72	9.09	.05
GRM	10.92	4	2.73	5.81	.05
TRM	7.25	12	0.60	1.28	N.S.
CR:GT	6.46	16	0.40	--	--
CM:GT	32.88	16	2.06	--	--
GTRM	10.91	12	0.91	1.94	N.S.
CRM:GT	14.88	32	0.47	--	--

It should be noted that in the ensuing discussion and interpretation of the results of the data, that when the word students is used, this should not be taken to mean individual students; but rather a group of students as the classroom was used as the experimental unit.

Comparison of Treatments

The highest order interaction involving treatments that occurred was the grade-by-treatment-by measures interaction. The Geisser-Greenhouse Conservative F-Test (46:262) using reduced degrees of freedom was employed, and the F-ratio of 9.09 which appears in Table 4.5 was significant. To find if the grade-by-treatment interaction held for each measure, three Two-way Analyses of Variance were performed, one on each measure. The α -level of .05 was divided into three equal pieces. The results of the analyses are summarized in Table 4.6.

The F-ratio for interaction was significant for Measures One and Three, but not for Measure Two. The cell means of the treatments are listed by grade level in Tables 4.7, 4.8, and 4.9 for Measures One, Two, and Three respectively. The cell means were used to draw the graphs of the treatment-by-grade-by-measures interaction which appears in Figure 4.1.

TABLE 4.6

ANALYSIS OF GRADE-BY-TREATMENT INTERACTION FOR EACH MEASURE

Measure	Source of variation	S.S.	d.f.	M.S.	F-ratio	Significance Level
M_1	Grade	99.19	1	99.19	42.39	.05
	Treatment	184.96	3	61.65	26.35	.05
	Interaction	96.50	3	32.17	13.75	.05
	Within	18.69	8	2.34		
M_2	Grade	254.70	1	254.70	96.84	.05
	Treatment	50.05	3	16.68	6.34	N.S.
	Interaction	30.09	3	10.03	3.81	N.S.
	Within	21.04	8	2.63		
M_3	Grade	963.65	1	963.65	796.40	.05
	Treatment	420.82	3	140.27	115.93	.05
	Interaction	133.74	3	44.58	36.84	.05
	Within	9.69	8	1.21		

TABLE 4.7

CELL MEANS OF TREATMENTS BY GRADE LEVEL
FOR MEASURE ONE

	T_1	T_2	T_3	T_4
G_2	29.30	28.52	34.70	33.35
G_3	30.58	36.16	35.01	35.62

TABLE 4.8

CELL MEANS OF TREATMENTS BY GRADE LEVEL
FOR MEASURE TWO

	T_1	T_2	T_3	T_4
G_2	19.24	20.23	20.76	20.48
G_3	23.07	25.17	23.45	27.46

TABLE 4.9

CELL MEANS OF TREATMENTS BY GRADE LEVEL
FOR MEASURE THREE

	T_1	T_2	T_3	T_4
G_2	24.18	32.80	34.97	29.73
G_3	35.57	41.84	38.47	41.66

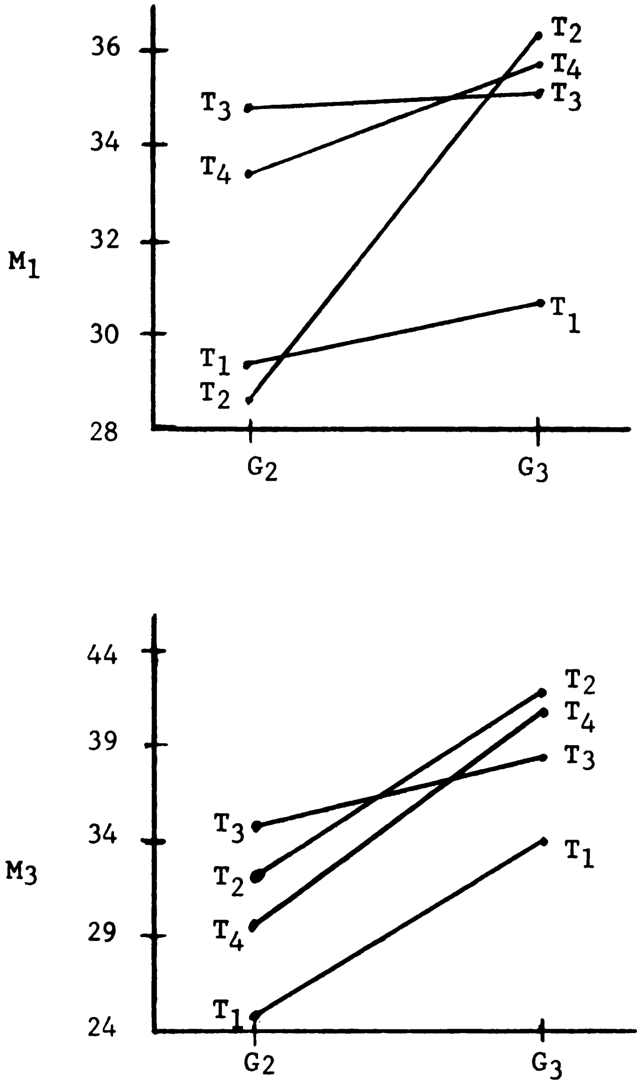

Fig. 4.1 Graph of Treatment-by-Grade Interaction for Measures One and Three

To find if the differences among treatments were significant on each of the two measures at each grade level, four one-way analyses of variance were performed, one on each grade level.. The results are summarized in Tables 4.10 and 4.11, with the α -level equally divided to keep the overall α -level at .05

TABLE 4.10

ANALYSIS OF TREATMENT-BY-MEASURES INTERACTION
FOR GRADE TWO

Measure	Source of variation	S.S.	d.f.	M.S.	F-ratio
M_1	Between treatments	164.04	3	54.68	52.58
	Within treatments	20.79	20	1.04	
M_3	Between treatments	394.97	3	131.66	35.97
	Within treatments	73.14	20	3.66	

TABLE 4.11

ANALYSIS OF TREATMENT-BY-MEASURES INTERACTION
FOR GRADE THREE

Measure	Source of variation	S.S.	d.f.	M.S.	F-ratio
M_1	Between treatments	117.42	3	39.14	76.75
	Within treatments	10.29	20	.51	
M_3	Between treatments	159.59	3	53.20	33.67
	Within treatments	31.62	20	1.58	

The F-ratio was significant for Measures One and Three at both grades. Tukey's HSD Test (46:88) was used to make all pairwise comparisons between treatments. The results are summarized in Tables 4.12 and 4.13 with the overall α-level of .05.

TABLE 4.12

PAIRWISE COMPARISONS OF TREATMENTS FOR MEASURES ONE AND THREE IN GRADE TWO

Measure	Comparison	Difference of Means	HSD Statistic	Sig. Level
M_1	$T_1 - T_2$	.78	2.06	N.S.
M_1	$T_3 - T_1$	5.40	2.06	.05
M_1	$T_4 - T_1$	4.05	2.06	.05
M_1	$T_3 - T_2$	6.18	2.06	.05
M_1	$T_4 - T_2$	4.83	2.06	.05
M_1	$T_3 - T_4$	1.35	2.06	N.S.
M_3	$T_2 - T_1$	8.62	3.92	.05
M_3	$T_3 - T_1$	10.79	3.92	.05
M_3	$T_4 - T_1$	5.55	3.92	.05
M_3	$T_3 - T_2$	2.17	3.92	N.S.
M_3	$T_2 - T_4$	3.07	3.92	N.S.
M_3	$T_3 - T_4$	5.24	3.92	.05

TABLE 4.13

PAIRWISE COMPARISONS OF TREATMENTS FOR MEASURES ONE AND THREE IN GRADE THREE

Measure	Comparison	Difference of Means	HSD Statistic	Sig. Level
M_1	$T_2 - T_1$	5.58	1.51	.05
M_1	$T_3 - T_1$	4.43	1.51	.05
M_1	$T_4 - T_1$	5.04	1.51	.05
M_1	$T_2 - T_3$	1.15	1.51	N.S.
M_1	$T_2 - T_4$	.54	1.51	N.S.
M_1	$T_4 - T_3$	.61	1.51	N.S.
M_3	$T_2 - T_1$	6.27	2.56	.05
M_3	$T_3 - T_1$	2.90	2.56	.05
M_3	$T_4 - T_1$	6.09	2.56	.05
M_3	$T_2 - T_3$	3.37	2.56	.05
M_3	$T_2 - T_4$	.18	2.56	N.S.
M_3	$T_4 - T_3$	3.19	2.56	.05

With the exception of Treatment Two in grade two on Measure One, students in each of the three experimental groups, in both grades, scored significantly higher than the control groups on Measures One and Three. In addition, in grade two, students in both Treatments Three and Four scored significantly higher than students in Treatment Two on Measure One; while students in Treatment Three scored significantly higher than students in Treatment Four on Measure Three. Also, in the third grade, students in both Treatments Two and Four scored significantly higher than students in Treatment Three on Measure Three.

Next, it was of interest to analyze the treatment-by-measures interaction. The results of the Analysis of Variance are summarized in Table 4.14, using an α -level of .05. The Geisser-Greenhouse Conservative F-test (46:262) using reduced degrees of freedom was employed.

TABLE 4.14

TREATMENT-BY-MEASURES INTERACTION

Source of variation	S.S.	d.f.	M.S.	F-ratio
TM	185.21	6	30.87	14.99
CM:GT	32.88	16	2.06	

The F-ratio was significant. The cell means of the treatments are listed by measure in Table 4.15. Three One-Way Analysis of Variance were performed on the treatments, one on each measure, in order to find if the differences among treatments were significant. The results are summarized in Table 4.16 with the α -level of .05 divided into three equal pieces.

TABLE 4.15

CELL MEANS OF TREATMENTS BY MEASURE

	T_1	T_2	T_3	T_4
M_1	29.94	32.34	34.85	34.49
M_2	21.15	22.70	22.11	23.97
M_3	29.87	37.32	36.72	35.69

TABLE 4.16

ANALYSIS OF TREATMENT-BY-MEASURE INTERACTION

Measure	Source of variation	S.S	d.f.	M.S.	F-ratio
M_1	Between treatments	184.96	3	61.65	11.97
	Within treatments	226.77	44	5.15	
M_3	Between treatments	50.04	3	16.68	1.83
	Within treatments	400.32	44	9.10	
M_3	Between treatments	420.82	3	140.27	5.13
	Within treatments	1202.16	44	27.32	

The F-ratios of Measures One and Three were significant. Tukey's HSD Test (46:88) was used to make all pairwise comparisons between treatment means on Measures One and Three. The results of the pairwise comparisons are summarized in Table 4.17, with an α - level of .05.

TABLE 4.17

PAIRWISE COMPARISONS OF TREATMENTS FOR MEASURES ONE AND THREE

Measure	Comparison	Difference of means	HSD Statistic	Sig. level
M_1	T_2 - T_1	2.40	1.67	.05
M_1	T_3 - T_1	4.91	1.67	.05
M_1	T_4 - T_1	4.55	1.67	.05
M_1	T_3 - T_2	2.51	1.67	.05
M_1	T_4 - T_2	2.15	1.67	.05
M_1	T_3 - T_4	.37	1.67	N.S.
M_3	T_2 - T_1	7.45	3.92	.05
M_3	T_3 - T_1	6.85	3.92	.05
M_3	T_4 - T_1	5.82	3.92	.05
M_3	T_2 - T_3	.60	3.92	N.S.
M_3	T_2 - T_4	1.63	3.92	N.S.
M_3	T_3 - T_4	1.03	3.92	N.S.

For Measures One and Three, across both grade levels, the three experimental groups scored significantly higher than the control group. In addtion, on Measure One, students in Treatments Three and Four scored significantly higher than students in Treatment Two.

Comparisons of Second and Third Graders

In the previous section, the grade-by-treatment-by-measures interaction was discussed in terms of the differences between treatments. It is also of interest to examine this interaction in relation to the differences between second and third graders. The interest lies not only in whether or not third graders scored higher than second graders, but also to find if second graders were brought up to the level of third graders on any of the three tests.

The cell means from Tables 4.7 - 4.9 were used to draw the graphs, of the grade-by-treatment interaction for each of the three measures, which appear in Figure 4.2.

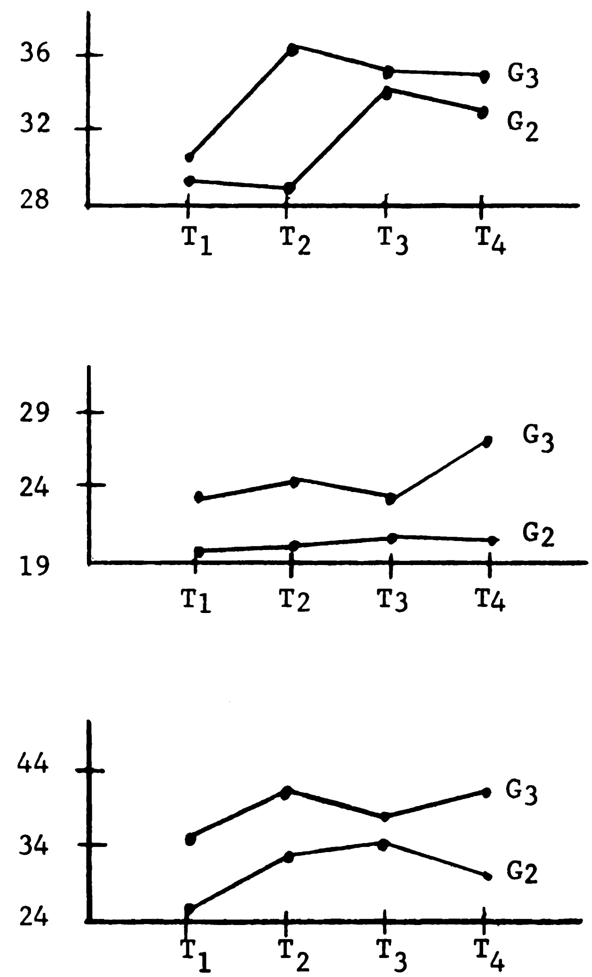

Fig. 4.2 Graph of Grade-by-Treatment Interaction for Measures One, Two, and Three

To find if the differences were significant for each of the treatments, twelve One-Way Analyses of Variance were performed, one on each treatment for each measure. The results are summarized in Tables 4.18 - 4.20, with the overall α -level held at .05.

TABLE 4.18

COMPARISON OF GRADES TWO AND THREE FOR TREATMENTS ONE THROUGH FOUR ON MEASURE ONE

Treatment	Source of variation	S.S.	d.f.	M.S.	F-ratio	Sig. level
T_1	Between grades	4.90	1	4.90	5.56	N.S.
	Within grades	8.76	10	.88		
T_2	Between grades	175.03	1	175.03	323.12	.05
	Within grades	5.38	10	.54		
T_3	Between grades	.29	1	.29	.31	N.S.
	Within grades	9.25	10	.93		
T_4	Between grades	15.46	1	15.46	20.08	.05
	Within grades	7.69	10	.77		

TABLE 4.19

COMPARISON OF GRADES TWO AND THREE FOR TREATMENTS ONE THROUGH FOUR ON MEASURE TWO

Treatment	Source of variation	S.S.	d.f.	M.S.	F-ratio	Sig. level
T_1	Between grades	43.89	1	43.89	14.58	.05
	Within grades	30.13	10	3.01		
T_2	Between grades	73.06	1	73.06	18.54	.05
	Within grades	39.39	10	3.94		
T_3	Between grades	31.68	1	31.68	11.18	.05
	Within grades	19.35	10	1.94		
T_4	Between grades	146.16	1	146.16	54.94	.05
	Within grades	26.65	10	2.66		

TABLE 4.20

COMPARISON OF GRADES TWO AND THREE FOR TREATMENTS ONE THROUGH FOUR ON MEASURE THREE

Treatment	Source of variation	S.S.	d.f.	M.S.	F-ratio	Sig. level
T_1	Between grades	388.97	1	388.97	12.37	.05
	Within grades	30.28	10	3.03		
T_2	Between grades	244.81	1	244.80	109.78	.05
	Within grades	22.26	10	2.23		
T_3	Between grades	36.65	1	36.65	10.01	N.S.
	Within grades	36.56	10	3.66		
T_4	Between grades	426.97	1	426.97	271.95	.05
	Within grades	15.67	10	1.57		

Thus, for each of the treatments, and on each of the measures, third-grade students scored higher than second-grade students. The differences in favor of third graders were significant with the following exceptions: the differences on Measure One for students in Treatment One; the differences on Measure One for students in Treatment Three; and the differences on Measure Three for students in Treatment Three.

Also, on Measure One, second-grade students in Treatments Three and Four scored higher than third-grade students who were in the control group.

Retention

In regard to retention, the highest order interaction that occurred was the grade-by-measures-by-retention interaction. The results of the Analysis of Variance are summarized in Table 4.21, with an α -level of .05. The Geisser-Greenhouse Conservative F-test (46:262) using reduced degrees of freedom was employed.

TABLE 4.21

GRADE-BY-MEASURES-BY-RETENTION INTERACTION

Source of variation	S.S.	d.f.	M.S.	F-ratio
GRM	10.92	4	2.73	5.81
CRM:GT	14.88	32	.47	

The F-ratio was significant. To find if the retention-by-grade interaction held on each measure, three Three-Way Analyses of Variance were performed, one on each measure. The results are summarized in Table 4.22, with the α -level of .05 divided into three equal pieces.

TABLE 4.22

ANALYSIS OF GRADE-BY-RETENTION INTERACTION
FOR EACH MEASURE

Measure	Source of variation	S.S.	d.f.	M.S.	F-ratio	Sig. Level
M_1	Grade	99.19	1	99.19	42.39	.05
	Retention	1.01	2	.50	1.38	N.S.
	Interaction	.57	2	.28	.78	N.S.
	Within	5.69	16	.36		
	Error	18.69	8	2.34		
M_2	Grade	254.70	1	254.70	96.84	.05
	Retention	84.50	2	42.25	264.06	.05
	Interaction	.42	2	.21	1.31	N.S.
	Within	2.63	16	.16		
	Error	21.03	8	2.63		
M_3	Grade	963.65	1	963.65	796.40	.05
	Retention	46.11	2	23.05	28.49	.05
	Interaction	21.81	2	10.90	13.46	.05
	Within	13.02	16	.81		
	Error	9.68	8	1.21		

The interaction of grades and retention was significant for Measure Three. The cell means of grades two and three are listed by retention periods for Measures One, Two, and Three in Tables 4.23 - 4.25 respectively.

TABLE 4.23

CELL MEANS OF GRADES BY RETENTION PERIOD
FOR MEASURE ONE

	R_1	R_2	R_3
G_2	31.18	31.79	31.43
G_3	34.28	34.38	34.36

TABLE 4.24

CELL MEANS OF GRADES BY RETENTION PERIOD
FOR MEASURE TWO

	R_1	R_2	R_3
G_2	18.18	21.15	21.20
G_3	23.03	25.55	25.78

TABLE 4.25

CELL MEANS OF GRADES BY RETENTION PERIOD
FOR MEASURE THREE

	R_1	R_2	R_3
G_2	28.14	31.43	31.70
G_3	38.97	39.16	40.01

The interaction was examined in relation to grades and then in relation to retention periods. The cell means were used to draw the graphs of the grade-by-retention interactions which appear in Figures 4.3 and 4.4.

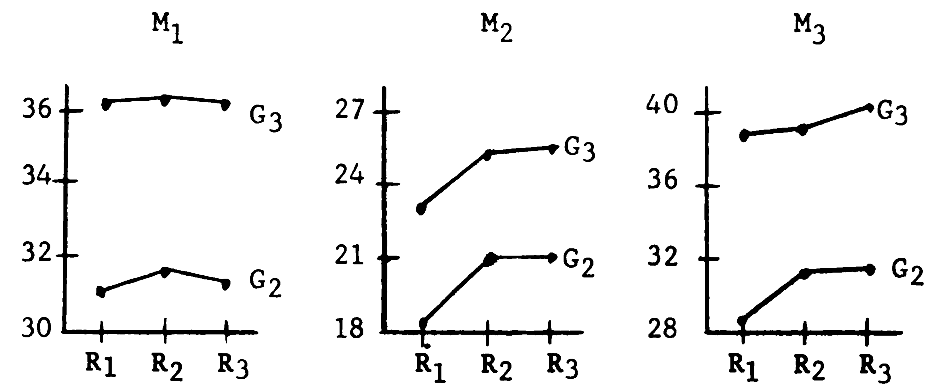

Fig. 4.3 Grade-by-Retention Interaction for Measures One, Two and Three

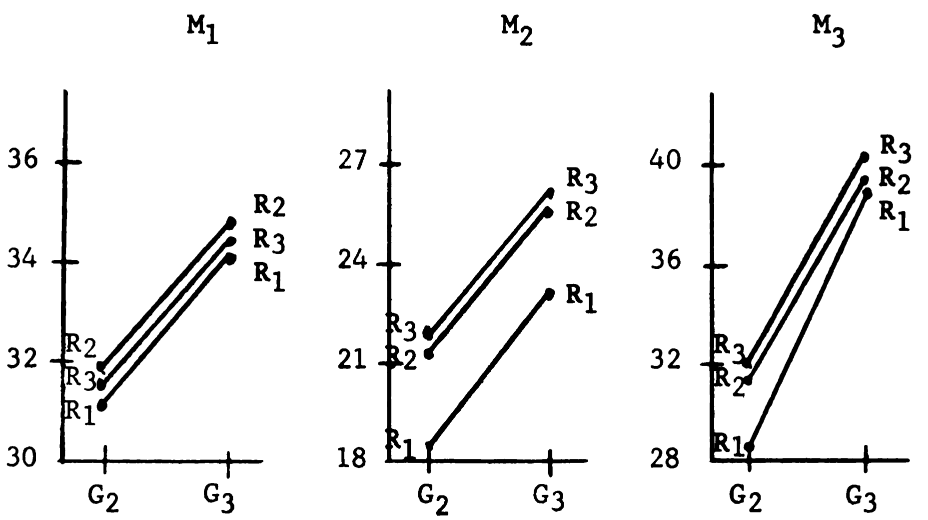

Fig. 4.4 Retention-by-Grade Interaction for Measures One, Two and Three

Thus, at each of the three retention periods, students in grade three scored higher than students in grade two on each of the measures.

On Measure One there were only slight differences at each grade level between the three retention periods. However, in both grades two and three, on Measure Two, higher scores were obtained at retention periods two and three than were obtained at retention period one. While for Measure Three, in grade two, higher scores were obtained at retention periods two and three than at retention period one; and in grade three higher scores were obtained at retention period three than at retention periods one and two.

Summary

Three different posttests were administered to the students. An attempt was made to put the posttests in a common metric; this was done by dividing each observation on the posttest by the standard deviation of that posttest. The transformed scores were analyzed by using an Analysis of Variance on a split-plot design. The results of the analysis of the data in relation to the hypotheses are summarized in the following, with the α-level of .05.

Hypothesis 1: Second and third-grade students who are taught by the same method will achieve the same on the average on all three measures.

Findings:

a. On Measure One third-grade students, in each of the treatments, scored higher than second-grade students, but the differences were not significant for students in Treatments One and Three.

b. On Measure Two third-grade students, in each of the treatments, scored significantly higher than second-grade students.

c. On Measure Three third-grade students, in each of the treatments, scored higher than second-grade students, and the differences were significant for all treatments except Treatment Three.

Hypothesis 2: In grades two and three respectively, students will achieve the same on the average on the test of sentential logic (Measure One) regardless of treatment.

Findings:

a. In Grade Two students in Treatments Three and Four scored significantly higher than students in the control group. Also, students in Treatments Three and Four scored significantly higher than students in Treatment Two.

b. In Grade Three students in each of the experimental groups scored significantly higher than students in the control group.

c. In addition, it was found that on Measure One, second-grade students who were in Treatments Three and Four scored higher than third-grade students who were in the control group.

Hypothesis 3: In grades two and three respectively, students will achieve the same on the average on the test of J. C. Raven (Measure Two) regardless of treatment.

Findings:

a. In Grade Two students in all of the experimental groups scored higher than students in the control group, but none of the differences were significant.

b. In Grade Three students in all of the experimental groups scored higher than students in the control group, but none of the differences were significant.

Hypothesis 4: In grades two and three respectively, students will achieve the same on the average on the test of R. Raven (Measure Three) regardless of method.

<u>Findings</u>:

a. <u>In Grade Two</u> students in all three experimental groups scored significantly higher than students in the control group. Also, students in Treatment Three scored significantly higher than students in Treatment Four.

b. <u>In Grade Three</u> students in all three experimental groups scored significantly higher than students in the control group. Also, students in Treatments Two and Four scored significantly higher than students in Treatment Three.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The main purpose of the study was to ascertain whether or not different types of training could improve the ability of second and third graders to derive valid logical conclusions from items in sentential logic. The effects of the training were also compared to find it the training helped students in their perceptual reasoning ability and in their ability in classification.

In the review of the literature it was noted that one of the central purposes of education is to teach young people to think, and the ability to draw logical conclusions from verbal hypotheses is one aspect of thinking.

Three different methods of teaching logic to children that have been advocated in the literature were employed in the study. One method is that of Dienes (19), a second method is that of Furth (26), and a third method uses some of the basic elements of set theory. All three methods were modified to focus on teaching children to draw logical conclusions from verbally expressed hypotheses.

The children involved in the study were 200 second-grade children and 200 third-grade children from the Monroe County Community School Corporation in Monroe County, Indiana. At each grade level two classes of 25 children were randomly assigned to each of the three experimental groups and one control group.

The instruction was provided by 16 student teachers along with their supervising teachers. The instruction was once a week for approximately 50 minutes, for a period of 13 weeks. Three posttests were given at the end of the instruction and the students were retested twice at three-week intervals.

Of the three posttests, one was a modification of a sentential logic test developed by Hill (35), the second test was a test of perceptual reasoning ability developed by J. Raven (76), the third test was a test of classification developed by R. Raven (77).

The scores of the posttests were analyzed using an Analysis of Variance on a split-plot design with an α-level of .05. Since the classroom was the experimental unit, students should be thought of as groups of students rather than individual students.

Findings

In the analysis of the scores of the posttests, the following results were obtained:

1. Third-grade students scored higher on each of the three measures than did second-grade students who were taught by the same method. The differences were significant with the exceptions of students in Treatment Three on Measures One and Three and students in Treatment One on Measure One. The higher achievement of third-grade students compared to second-grade students held at each of the three retention periods on each of the three measures.

2. On Measure One, students in each of the experimental groups at both grade levels scored significantly higher than students in the control group with the exception of second-grade students in Treatment Two. Also, in second grade, students in Treatments Three and Four scored significantly higher than students in Treatment Two. In addition, on Measure One, second-grade students who were in Treatments Three and Four scored higher than third-grade students in the control group.

3. On Measure Two, students in each of the experimental groups at both grade levels scored higher than students in the control groups; however, the differences were not significant.

4. On Measure Three, students at both grade levels in the experimental groups scored significantly higher than the students in the control group. Also, students in second grade in Treatment Three scored significantly higher than students in Treatment Four. While students in third grade in Treatments Two and Four scored significantly higher than students in Treatment Three.

Conclusions

Within the limitations of the study, the following conclusions seem justified:

1. At the second-grade level, attribute block instruction and set material instruction each have significant positive effects on students' abilities on items from sentential logic.

2. At the third-grade level, attribute block instruction, pictorial logic instruction, and set material instruction each have significant positive effects on the students' abilities on items from sentential logic.

3. At both the second and third-grade levels, attribute block instruction, pictorial logic instruction, and set material instruction each have positive effects on students' abilities in perceptual reasoning.

4. At both the seond and third-grade levels, attribute block instruction, pictorial logic instruction, and set material instruction each have significant positive effects on students' abilities on items in classification.

5. Third-grade students show more ability than second-grade students on items from (1) sentential logic; (2) perceptual reasoning; and (3) classification.

6. Second-grade students who receive instruction using either attribute materials or set materials can be brought up to the third-grade level in items from sentential logic.

7. Attribute block instruction seems to work better for second-grade students than for third-grade students. Instruction using pictorial logic seems to work better for third-grade students than for second-grade students. Instruction using set materials seems to work well for both second and third-grade students.

8. The positive effects of the instruction holds across the retention periods.

9. The superiority of third-grade students over second-grade students holds across the retention periods.

Discussion

The finding that attribute block instruction worked better for second-grade students than for third-grade students was in accord with an earlier finding by Weeks (99). However, Weeks also found that the attribute block training had a significant positive effect in perceptual reasoning ability for both second and third graders. In the current study, attribute block training had a positive effect for both second and third graders, but the effect was not significant. Lucas (51), who used attribute block training with first graders, found a positive effect in perceptual reasoning, but the effect was not significant.

Weeks also found that attribute block training had a significant positive effect for both second and third graders on a test of logical reasoning ability that was similar to the sentential logic test used in the current study. The current study substantiated these findings in that attribute block training has a positive effect on both second and third-grade students.

The current study has looked at the effects of other types of training, as well as attribute block training, for both second and third grades. It was found that different types of training can produce positive effects in the abilities of second and third graders in items from sentential logic, perceptual reasoning, and classification.

It should be noted, in regard to the training in sentential logic, that the instruction involved providing background materials which the students could draw from when attempting to formulate logical conclusions from statements. It was initially felt that attribute block materials would provide the best background material. This was true for second graders but not for third graders. The set materials seemed to provide good background for both grades. One reason for this could be that the mathematics texts in use in the schools made quite extensive use of sets of objects.

Also, as was previously noted, in the instruction in sentential logic care was taken to provide the students with problems in which the conclusions drawn were not only logically correct but also conclusions that the students could verify with the materials at hand. Thus, it does not seem that the results of the current study should be taken to mean that second and third-grade children can be trained to do logico-mathematical reasoning as described by Piaget. Nor do the results of the study indicate that second and third-grade students cannot be trained to do logico-mathematical reasoning. Rather, the results of the current study seem to indicate that second and third-grade students can have some success in answering certain items from sentential logic when they were exposed to instruction which allowed them to have first-hand experiences with the materials, and when the students are given the opportunity to incorporate these experiences into their cognitive structure.

Implications for Future Research

The current study, like other research of this nature, adds one more piece to the picture of cognitive development of children. However, unlike pieces from picture puzzles, we do not know for certain the "true" shape of the piece of research.

One recommendation then is a replication of all, or part, or modifications of the current study in order to clarify the shape of the current piece of research as well as the shape of adjacent pieces. Such modifications might include such things as: using different grade levels; varying the length of the training period--perhaps using a two or three-week block of time where the instruction occurs daily; using other methods of instruction; and comparisons of methods of instruction with ability groupings of children.

A second recommendation is that comparisons between the right and wrong answers to different types of questions could be made in relation to the methods used in instruction.

A third recommendation is that comparisons could be made between variations in the nature of instruction. For instance, one method might include only practice on questions similar to test questions, a second method could include background materials as well as practice questions, and a third method could include only background materials. Also, combinations of two or more methods of instruction could be used for a single class.

A fourth recommendation is that comparisons could be made to find is such training has an effect on the student's performance in mathematics or in other subjects.

A fifth recommendation is the use of small groups of students in order to study in detail their reasoning patterns.

Since instruction appears to have positive effects on certain logical abilities of children, the questions become not only those that this thesis has attempted to explore, i.e., What methods should be used for instruction? How should the students be instructed? When should the students be instructed? but also: Should such instruction be part of the curriculum and, if so, what will be replaced?

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APPENDICES

APPENDIX A

OUTLINE OF DAILY LESSON PLANS
FOR TREATMENT 2

<u>Introduction</u>

The students were each given a booklet which contained problems that are similar to problems suggested by Furth (26). After completion of the booklet, the students were given additional mimeographed pages which contained more problems.

The materials were handed out to the students at the beginning of the lesson and collected at the end of each lesson.

The instruction was given each Monday from 1:00 p.m. to 1:50 p.m. The testing was done on the Tuesday following the last lesson.

<u>Day One</u>

The students were introduced to the four letters "S, A, H, and T" that they would be working with during the course of their instruction. This was done by writing the following on the chalkboard:

SUN	S → 
APPLE	A → 
HOUSE	H → 
TREE	T → 

The students were told that since S was the first letter of the word "sun" that S goes with sun, and similarly for the other letters.

The students were told to notice that there were letters on the left, an arrow in the middle, and a picture on the right. The reason for stressing the positions of left, middle, and right is that in the problems in the booklet one of the three positions would be blank and the children had to fill in the appropriate symbol.

The students were then asked to look at the first pages in their booklet and to fill in the blanks. The first several problems were gone over orally with the students. They were then told that if they finished page one to proceed to page two which contained similar problems.

Day Two

The material from day one was reviewed and the students continued working problems similar to problems from day one.

Day Three

The material from day one was again reviewed and a new symbol was introduced to the students. The new symbol was $\not\rightarrow$, and they were told this means "does not go with." Examples were given illustrating the new symbol and the students worked problems, similar to day one, involving the new symbol.

Day Four

The materials from the first three days were reviewed and the students were introduced to another new symbol. The new symbol was " ¯ ", and they were told that this meant "not." Examples were written on the chalkboard, such as $\overline{A}$, and it was explained that this meant "not an apple." Again, the students worked problems similar to previous days involving the new symbol.

Since the problems could now involve " $\overline{\ \ }$ " and $\nrightarrow$ the students were exposed to double negatives, and this appeared to be a difficult concept for the students.

Day Five

Review problems were presented to the students and they were introduced to the words "if" and "then." This was done by writing $S \rightarrow$ on the chalkboard and the students were told to think of the problem as: If there is an S then there is a sun.

Day Six

The new symbol " $\wedge$ " was introduced to the students and they were told that this meant "and." Problems involving conjunction, similar to previous problems, were worked by the students.

Day Seven

The symbol " $\wedge$ " was reviewed and contrasted to the new symbol " $\vee$ " which was introduced to the students. They were told that the symbol " $\vee$ " meant "or." Problems involving disjunction which were similar to previous problems were worked by the students.

Day Eight

The students did review problems which were similar to problems from the previous seven days.

Day Nine

For the first time, the students were given a worksheet in which the problems were written instead of only using letters, arrows, and pictures. For example: If it is an S then it is the __________.

The students were asked to write the correct response in the blank space and then to recopy the problem in the space provided below the problem. First they recopied the problem in words, and then they had to translate the problem into letters, arrows, pictures, and symbols.

Day Ten

The students were given practice in drawing valid conclusions from given premises. The premises involved the materials that the students had been working with, for example:

If there is an S then there is a sun.

There is an S.

Is there a sun?   Yes   No   Maybe

The students were encouraged to rewrite the problem using letters, arrows, and pictures before trying to formulate an answer.

Students were given practice on problems in which the correct answer was "yes," in which the correct answer was "no," and in which the correct answer was "maybe."

Day Eleven

The students were given practice in drawing valid conclusions from premises involving disjunction, for example:

There is either a sun or a tree.

There is not a tree.

Is there a sun?   Yes   No   Maybe

Again the students were encouraged to rewrite the problem using letters and symbols before formulating an answer.

Days Twelve and Thirteen

Students were given practice in problems similar to the problems from days ten and eleven. The students were now asked to see if they could answer the question without rewriting the problem.

APPENDIX B

OUTLINE OF DAILY LESSON PLANS FOR TREATMENT 3

Introduction

The students were given instructions based on the logic materials of Dienes (19). Each student made his own set of attribute pieces from construction paper, and the pieces were kept in an envelope. Mimeographed materials were also used by the students.

The envelopes containing the attribute pieces along with the mimeographed materials were passed out to the students at the beginning of each lesson and collected at the end of each lesson.

The instruction was given each Monday from 1:00 p.m. to 1:50 p.m. The testing was done on the Tuesday following the last lesson.

Day One

The students made their own set of attribute pieces from construction paper. The set consisted of 24 pieces: four shapes, two sizes, and three colors. After the pieces were cut out, the teacher would have a student hold up one of his pieces and the other students would have to find a piece that was different from the one being held.

The students were then asked how the piece they picked was different from the piece being held.

Day Two

The students again practiced distinguishing the attributes of the pieces by the same method as day one.

In addition, the students were asked to arrange their pieces in some pattern on their desks. They then made several more patterns of their own choosing.

Day Three

The students were given a mimeographed sheet on which was drawn a three-by-four matrix. They were asked to arrange twelve of their pieces in some pattern on the matrix. They then made other patterns on the matrix.

They were also asked to arrange their pieces in a line on their desks so that each piece was different in one way from the adjacent pieces. Again, they made several similar patterns.

Day Four

The students practiced the same activities as day three with the added stipulation that when the pieces were placed on a matrix, or in a line, adjacent pieces must be different in two attributes. This difference was then increased to three attributes.

Day Five

The students were given mimeographed pages on which streets were drawn intersecting at right angles. For example, one street would be triangle street and an intersecting street would be red street. The students were told to place the appropriate pieces on the streets and pieces that were red and triangular would be placed at the intersection. The students did several problems of this type.

Day Six

The students practiced problems similar to day five. In addition, they practiced the words "and" and "or" by being asked to hold up a piece that was red and a triangle, etc.

Day Seven

The students again practiced the words "and" and "or" as in day six. In addition, they practiced statements involving the words "if" and "then." This was done by having the teacher hold up a piece such as a small red triangle and having the students write statements involving the attributes of the piece, such as:

$$\Delta \rightarrow \text{ red, etc.}$$

The students were told that the way to read these statements was: If it is this triangle, then it is red. The students did several problems of this type.

Day Eight

The students did problems similar to day seven.

Day Nine

For the first time, the students were given a worksheet in which the problems were written. For example: If it is this triangle then it is _______________ .

The students were asked to fill in the blank by looking at a piece the teacher was holding and to recopy the problem in the space provided below the problem. Then they were asked to find one of their pieces that matched the problem. They were then asked to reformulate the problem as in day seven, for example:

$$\Delta \rightarrow \text{ red.}$$

Day Ten

The students were given practice in drawing valid conclusions from given premises. The premises involved the materials that the students had been working with, for example:

If it is this Δ then it is red.

It is this Δ .

Is it red? Yes No Maybe

The students were encouraged to reformulate the problem using their pieces before trying to answer the question.

Students were given practice on problems in which the correct answer was "yes," in which the correct answer was "no," and in which the correct answer was "maybe."

Day Eleven

The students were given practice in drawing valid conclusions from premises involving disjunction, for example:

The triangle is either red or it is small.

The triangle is not red.

Is it small? Yes No Maybe

Again, the students were encouraged to reformulate the problem using their pieces to help them answer the question.

Day Twelve and Thirteen

Students were given practice in problems similar to the problems from days ten and eleven. The students were now asked to see if they could answer the questions without reformulating the problem.

APPENDIX C

OUTLINE OF DAILY LESSON PLANS FOR TREATMENT 4

Introduction

The students received instruction in some of the basic elements of set theory. The students were given mimeographed materials which contained problems involving sets. The mimeographed materials were passed out to the students at the beginning of the lesson and collected at the end of each lesson.

The instruction was given each Monday from 1:00 p.m. to 1:50 p.m. The testing was done on the Tuesday following the last lesson.

Day One

The students were introduced to the concept of a set by the use of objects in their rooms. For example, the set of boys in the room, the set of desks in the room, etc.

Then the names of certain students were written on the chalkboard, for instance: The girls in the first row. A circle was then drawn around their names to show they belonged in one set. Similar sets were drawn using the names of other students and then the sets were designated by a letter.

The students were then asked to list members of each of the sets. This procedure was repeated several times.

Day Two

The students reviewed the activities from day one. Three non-intersecting sets, A, B, and C, whose members were numerals were then drawn on the chalkboard.

The students were given a mimeographed page containing problems relating to the sets on the chalkboard. The problems required the students to list the members of the three sets and then to list members of both sets A or B, etc. The symbol " $\cup$ " was introduced in this context. A similar procedure was then followed using new examples.

Day Three

The students were given problems similar to day two.

Day Four

The activities of day three were reviewed. Two intersecting sets, D and E, whose members were numerals were then drawn on the chalkboard. A mimeographed sheet containing problems relating to sets D and E was given to the students.

The students were asked to list members of the two sets and to list members common to sets D and E. The symbol " $\cap$ " was introduced in this context. A similar procedure was followed using new examples.

Day Five

Problems similar to day four were given to the students.

Day Six

Problems similar to days one through five were reviewed with the students. Also, the word "and" was stressed in relation to " $\cap$," and the word "or" was stressed in relation to " $\cup$."

Day Seven

The students were introduced to "if-then" statements. This was done by drawing intersecting sets A and B, whose members were numerals, on the chalkboard. The students were then asked to formulate statements involving members of the sets, such as:

$1 \rightarrow A$

$5 \rightarrow B$, etc.

They were told that the way to read these statements was: If it is a one then it is in set A.

<u>Day Eight</u>

The students again practiced on if-then statements as in day seven.

<u>Day Nine</u>

For the first time, the students were given a worksheet in which the problems were written. For example: If it is a one then it is in set ______________.

The students were asked to fill in the blank by using the figures that were drawn on the chalkboard, and to recopy the problem in the space provided below the problem. They were then asked to reformulate the problem as in day seven, for example:

$1 \rightarrow A$

<u>Day Ten</u>

The students were given practice in drawing valid conclusions from given premises. The premises involved the materials that the student had been working with, for example:

If it is a 1 then it is in set A.

It is a 1.

Is it in set A? Yes No Maybe

The students were encouraged to reformulate the problem as in day seven before trying to answer the question.

Students were given practice on problems for which the correct answer was "yes," for which the correct answer was "no," and for which the correct answer was "maybe."

Day Eleven

The students were given practice in drawing valid conclusions from premises involving disjunction, for example:

It is either in set A or in set B.

It is not in set A.

Is it in set B? Yes No Maybe

Again, the students were encouraged to reformulate the problem as in day seven before trying to answer the question.

Days Twelve and Thirteen

Students were given practice in problems similar to the problems from days ten and eleven. They were now encouraged to try to answer the questions without reformulating the problem.

APPENDIX D

ITEM FORMS FOR CATEGORIES 1 THROUGH 20

In using a Universe-Defined (36) system of generating test items, certain categories were defined and items were randomly selected from each category. The following is a list of categories one through twenty with the items that were included in each category. Correct English was used when the items were combined into sentences.

1. Proper First Names: Twelve names found in children's books were used, six girls' names and six boys' names. Three boys' names and three girls' names were randomly assigned to category one and the six remaining names were assigned to category four. The six names for category one were: Amy, Bill, Dick, Gail, John, and Susan.

2. Affirmatives or Negatives: Affirmatives or negatives were randomly selected for use in conjunction with items from category three.

3. Comparisons, Events, Objects, and Places: Words that are found in children's books were used for items in category three. The following items were used:

    A. Comparisons

        a. Age: old, young
        b. Lunch: fruit, candy
        c. Money: dime, quarter
        d. Movement: rides (bus, bike) or walks; home or school
        e. Relative: brother, cousin, sister
        f. Size: big, small
        g. Weight: fat, thin

    B. Events

        a. Activity: game, race
        b. Birthday: day, month
        c. Entertainment: circus, movie
        d. Weather: rain, snow, sunshine

C. Objects (First a color was chosen, then a type).

a. Animal

1. Color: brown, black, white
2. Type: cat, dog, horse

b. Toy

1. Color: red, blue, green
2. Type: ball, wagon, bike

D. Places

a. Grade: 1-6
b. Room: 1-10
c. Locale: city, country

4. Proper First Names: The remaining six names from category one were used. The names were: Jack, Jane, Janet, Mary, Mike, and Tom.

5. Affirmatives or Negatives: Affirmatives or negatives were randomly selected for use with items from category six.

6. Items Compatible with Category Three: Items for category six were from the same group as items chosen in category three.

7. Affirmatives or Negatives: Affirmatives or negatives were randomly selected for use with items from category eight.

8. Comparisons, Events, Objects, and Places: The items for category eight were the same as the items from category three.

9. Affirmatives or Negatives: Affirmatives or negatives were randomly selected for use with items from category ten.

10. Items Compatible with Category Eight: Items for category ten were from the same group as items chosen in category eight.

11. Proper First Names: Same as category one.

12. Affirmatives or Negatives: Affirmatives or negatives were randomly selected for use with items from category thirteen.

13. Comparisons, Events, Objects, and Places: Same as category three.

14. Affirmatives or Negatives: Affirmatives or negatives were randomly selected for use with items from category fifteen.

15. Items Compatible with Category Thirteen: Items for category fifteen were from the same group as items chosen in category thirteen.

16. Proper First Names: Same as category four.

17. Affirmatives or Negatives: Affirmatives or negatives were randomly selected for use with items from category eighteen.

18. Comparisons, Events, Objects, and Places: Same as category three.

19. Affirmatives or Negatives: Affirmatives or negatives were randomly selected for use with items from category twenty.

20. Items Compatible with Category Eighteen: Items for category twenty were from the same group as items chosen in category eighteen.

APPENDIX E

SENTENTIAL LOGIC TEST

The items for the test on sentential logic were generated from the items in Appendix D. The 30 questions on the test were divided into five groups of six items each. The five groups were:

I. Items of the form: If P then Q; P; ∴ Q

II. Items of the form: If P then Q; Q; ∴ not necessarily P.

III. Items of the form: If P then Q; not Q; ∴ not P.

IV. Items of the form: P or Q; P; ∴ not necessarily Q.

V. Items of the form: P or Q; not P; ∴ not Q.

It was further stipulated that of the six questions in each group, two would involve affirmatives, two would involve negatives, and two would involve both affirmatives and negatives.

The following list of items constituted the 30-item test that was used in the current study to measure how well students were able to derive valid logical conclusions from verbally expressed hypotheses. The test was read to the students and they were asked to circle the correct answer.

1. If John is big then Jane is big.
   John is big.
   Is Jane big? Yes No Maybe

2. Either Bill has a red ball or he has a blue bike.
   Bill has a red ball.
   Does Bill have a blue bike? Yes No Maybe

3. If it is a black cat then it is not an old cat.
It is not an old cat.
Is it a black cat? Yes No Maybe

4. If Amy is in the race then Jack is in the race.
Jack is not in the race.
Is Amy in the race? Yes No Maybe

5. If it is Tuesday then there is a circus.
There is a circus.
Is it Tuesday? Yes No Maybe

6. Jack either has a black cat or he has a brown dog.
Jack does not have a black cat.
Does Jack have a brown dog? Yes No Maybe

7. Mike either does not have a red ball or he does not have a green bike.
Mike has a red ball.
Does Mike have a green bike? Yes No Maybe

8. If John is in first grade then he is not in room 10.
John is in room 10.
Is John in first grade? Yes No Maybe

9. If Gail goes to the circus then Mike will not go to a movie.
Mike did not go to a movie.
Did Gail go to the circus? Yes No Maybe

10. Janet either will not go to the game or she will not go to the race.
Janet did not go to the race.
Did Janet go to the game? Yes No Maybe

11. If it is room 6 then it is a third grade room.
It is room 6.
Is it a third grade room? Yes No Maybe

12. If it is not raining then it is not snowing.
It is not raining.
Is it snowing? Yes No Maybe

13. If there is no game then it is Tuesday.
It is not Tuesday.
Is there a game? Yes No Maybe

14.. Either Susan has fruit in her lunch or she does not have a dime.
Susan has a dime.
Does Susan have fruit in her lunch? Yes No Maybe

15. Mary either has a brother or she does not have a cousin.
Mary has a brother.
Does Mary have a cousin? Yes No Maybe

16. If Bill is not old then Mary is not young.
Bill is not old.
Is Mary young? Yes No Maybe

17. If there is not a red wagon then there is not a blue bike.
There is a blue bike.
Is there a red wagon? Yes No Maybe

18. If there is a dime then there is a quarter.
There is no quarter.
Is there a dime? Yes No Maybe

19. Either Dick is not in the race or he is not in the game.
Dick is not in the game.
Is Dick in the race? Yes No Maybe

20. Either John is in room 4 or he is not in third grade.
John is not in third grade.
Is John in room 4? Yes No Maybe

21. If Dick has a white cat then Jane does not have a brown cat.
Dick has a white cat.
Does Jane have a brown cat? Yes No Maybe

22. Either Susan likes snow or she likes sunshine.
Susan does not like snow.
Does Susan like sunshine? Yes No Maybe

23. Jack is either not big or he is not small.
Jack is big.
Is Jack small? Yes No Maybe

24. If Bill does not ride his bike then Tom will not ride the bus.
Tom will ride the bus.
Will Bill ride his bike? Yes No Maybe

25. If Susan has a red ball then Mary has a red wagon.
Mary has a red wagon.
Does Susan have a red ball? Yes No Maybe

26. If there is not a white cat then there is a brown dog.
There is not a white cat.
Is there a brown dog? Yes No Maybe

27. Jack either has a brother or he has a sister.
Jack has a brother.
Does Jack have a sister? Yes No Maybe

28. Mary either is in room 1 or she is not in first grade.
Mary is not in room 1.
Is Mary in first grade? Yes No Maybe

29. If Dick is not big then Jane is not small.
Jane is not small.
Is Dick big? Yes No Maybe

30. If it is not Wednesday then it is not January.
It is not January.
Is it Wednesday? Yes No Maybe