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INTERACTIVE AND DIRECT EFFECTS OF METHOD OF INSTRUCTION, LEVEL OF DEVELOPMENT OF OPERATIONAL THOUGHT, AND TYPE OF CONCEPT IN CONCEPT FORMATION

The University of Nebraska - Lincoln ED.D. 1980

University Microfilms International 300 N. Zeeb Road, Ann Arbor, MI 48106

INTERACTIVE AND DIRECT EFFECTS OF METHOD OF INSTRUCTION, LEVEL OF DEVELOPMENT OF OPERATIONAL THOUGHT, AND TYPE OF CONCEPT IN CONCEPT FORMATION

by

Marilyn S. Moore

A DISSERTATION

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Education

Major: Interdepartmental Area of

Administration, Curriculum, and Instruction

Under the Supervision of Professor Willis D. Moreland

Lincoln, Nebraska

December, 1980

TITLE

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ACKNOWLEDGMENTS

This odyssey has been shared with many friends and colleagues, whose help and support I gratefully acknowledge.

Dr. Willis Moreland, chair of my committee, is my mentor. He has asked the hard questions, waited patiently for thoughtful answers, and demonstrated well a life-long zest for learning. Dr. John Lux has provided both friendship and encouragement. His sense of humor during the hard times has been greatly appreciated. Dr. Ron Joekel, Dr. McLaran Sawyer, and Dr. James O'Hanlon, members of my committee, were particularly helpful and supportive in the initial stages of planning and designing the study. To these good people, many thanks.

Dr. Clarice Ramsey and Mich Zeman have listened, asked questions, explored ideas, and provided emotional support. Neal Cross and Ron Brandt sparked the initial interest in the study with their able instruction of a staff development class. Mary Stentz has typed many drafts of this paper, with good cheer. To these good people, many thanks.

My parents, who taught me to set goals and work to achieve them, continue to believe in and encourage me. My husband, David, has provided methodological and statistical assistance, in addition to the patience and understanding that we've both found necessary to see the humor in a two-dissertation household. To these good people, many thanks.

Finally, I wish to acknowledge the hundreds of junior high students I have taught, who continually captivate me with their energy, their enthusiasm, and their growth. To those good people, many thanks.

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CHAPTER 1

INTRODUCTION

Concept formation, concept attainment, and concept learning, are all terms which refer to the process of categorizing and determining the critical attributes of a group of stimuli. This process has important implications for learning in formal education, because it is the acquisition of concepts that makes it possible for students to organize the wealth of information to which they are exposed in and out of school. Teachers cannot hope to teach even a small fraction of all the specific stimuli a student will encounter in his/her world (Gagne, 1970). If a student can acquire a concept through the use of examples and non-examples of the concept, he/she can then respond to the myriad of stimuli which fall in the category of the concept.

A concept is a class of stimuli (objects, persons, events, or ideas) which have common characteristics or attributes. Concepts are formed by categorizing groups of stimuli with common characteristics under a label. Bruner, Goodnow and Austin (1956) noted five reasons for categorizing or conceptualizing groups of stimuli. First, categorizing reduces the complexity of the environment. It is not necessary to learn to respond separately to dozens of varieties of dogs; the general response "dog" will do for all. Second, categorizing is a means by which objects are identified. Third, it reduces the need for constant learning. Fourth, categorizing provides direction of instrumental activity. To know that a red light is on the next corner is to know in advance appropriate and inappropriate responses to make. Fifth, categorizing permits ordering and relating classes of events. From concepts such as "prejudice" and "discrimination" come generalizations such as "prejudice causes discrimination."

Concept formation prior to or outside of school is largely a matter of observation, comparison, trial and error, with a growing sense that certain stimuli do fit together. There is little conscious thought given to the process of forming concepts; children don't realize they have formed a concept when they have learned to call certain kinds of plants "trees." Through the process of interacting with and talking about their environment, children learn the categories and labels for the concepts which are part of their everyday lives. Examples of such concepts are "family," "sharing," "work," "play," and "home."

Concept formation in school tends to be a more formal and purposeful activity, although, without question, students continue to learn many concepts informally from their school environment. As part of the curriculum, however, students are expected to learn many concepts, such as "revolution," "desert," and "planet," for which many examples and non-examples are not part of their everyday environment. In addition, students are expected to learn concepts such as "molecule," "element," and "social norm," for which there are many examples and non-examples in their everyday environment, but which are not normally identified as such in everyday language. Also, in the school curriculum there are some concepts, such as "city," "environment," and "value," with which students have had experience and for which they have learned the label. These concepts often have a precise meaning in some disciplines, however, so the everyday understanding the student has may be inadequate. In all of these cases, teachers need to provide instruction that allows and facilitates formation of these designated concepts.

Teaching of concepts is particularly important in the social studies for four reasons. First, concepts help make sense of a complex environment. Students, and adults, live in a social environment. The barrage of stimuli with which we are confronted daily is the content of the social studies: events, and their causes and effects; relationships between and among people and their environment; the social institutions of family, school, work, church, and government, and the expectations and demands of each; the economic system. To make sense of this social environment, historians and social scientists develop theories, based on concepts, which explain the social phenomena. The concepts are a way of organizing or structuring vast amounts of material. A student need not learn the particulars of every government in history; it is both more realistic and helpful to learn the general characteristics of the concept "government," and then be able to apply that knowledge in current and future encounters with government. The content of history and social sciences, as of the environment in which students live, is too vast to be learned detail by detail; concepts provide a framework for organizing those details.

A second reason for the importance of teaching concepts lies in the interdisciplinary nature of the world. An event is seldom only sociological, or only psychological, or only political. It may happen because of causes which are both sociological and economic, and have effects which are political and psychological. A view of the world which is totally sociological or totally economic is seldom a complete view. The social studies teacher who teaches key concepts of the social studies[1] may select content samples from among the several disciplines that best illustrate the concept. In that way, the framework which students acquire for organizing facts and events includes the perspective from all the social sciences.

A third reason for the importance of teaching concepts in the social studies is seen in the nature of the social sciences: it is the purpose of the social sciences to describe, explain, and/or predict various aspects of human behavior. These descriptions, explanations and predictions most often take the form of generalizations. Generalizations, such as "repression causes revolution," "abused children often become child abusers," and "a tax cut will stimulate a depressed economy," are all based on the relationship between two concepts. Without an understanding of the concepts, the student cannot use the generalization to describe, explain, or predict human behavior.

The fourth reason for teaching concepts in the social studies is associated with that expectation of social studies that is concerned with attitude--the expectation that as a result of being in a social studies class the student will care about his community and nation and

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[1] For one listing of key concepts in the social studies, see Price, Smith and Hickman, 1965.

world, and will work to make them better places to live (Barr, Barth, and Shermis, 1977, p. 59; Mehlinger, 1977, p. iv; Gross, 1975). How this attitude can be developed in students (and adults, for that matter) is not within the scope of this study. It does seem clear, however, that if anyone is to set about being a constructive citizen, some understanding of such concepts as "democracy," "civil rights," "inflation," "norms," "nurturing," and "interdependence" is necessary. More than a general willingness to "do good" is called for; some knowledge of the society and the people with whom one lives is also necessary. Knowledge of these concepts provides a base which extended experience will make more meaningful.

In recent years, concept learning as an objective for the social studies has received considerable attention from social studies educators. Many curriculum projects have been developed around social science concepts (e.g., American Political Behavior, People and Technology, High School Geography Project). Several educational theorists (e.g., DeCecco, 1968; Gagne, 1970; Travers, 1967) have proposed general models for teaching concepts. These models include the common elements of exposing students to examples and non-examples of the concept and assuring that students know the name, or label, for the concept. For each model, the test of concept learning is the student's ability to identify new examples and non-examples of the concept. Variations in the models are found in the order in which examples and non-examples are presented, the inclusion of additional information or clues about the concept, and the amount of direct teaching to be done by the teacher.

This research began as an attempt to determine the effect of different teaching methods on student achievement in concept formation. As the literature was reviewed, it became apparent to the researcher that in addition to teaching method, two other variables should be considered for their effect on student achievement in concept formation: level of development of operational thought of the student, and type of concept to be learned.

The review of the literature suggested that different teaching methods vary both what the teacher does and the thought processes the student is asked to use to participate in that learning situation. For example, the teacher behaviors required in conducting a simulation game are different from those required to lead a small group discussion. Likewise, the behaviors and thought processes required by students in those learning situations are different. If a teacher asks a student a recall question, the student must use a different thought process in responding than if the teacher asks a synthesis question.

The research in concept formation attends to various ways of organizing and ordering teacher behaviors and/or programmed instruction materials. With each change in teacher behavior or material, there is also a change in the thought process a student is required to use. It is reasonable to speculate that a student's ability to use the required thought process will affect achievement in concept formation.

Piaget's work on intellectual development has long been regarded as a major theory in the development of thought processes (Flavell, 1963). His descriptions of concrete operational thought, formal operational thought, and the transition between the two, indicate the kind of thought processes of which students at each level are capable. In this study, these descriptions were the criteria against which student ability to use different thought processes were measured.

The third variable to be considered in student achievement in concept learning is that of the type of concept to be learned. Bruner, Goodnow and Austin (1956) categorized concepts as conjunctive, disjunctive, or relational. They proposed that teaching method should differ depending on the type of concept to be learned. Vygotsky (1962) proposed a different classification scheme for concepts, labeling concepts as either spontaneous or scientific. He suggested that the thought processes involved in learning the two types of concepts are different.

This study proposed a classification of concepts relevant to social studies, based in part on Glaser's (1968) mention of concepts "where the stimulus values are perceptually clear," and concepts which are "intricate to verbalize." From this distinction made by Glaser, and from the researcher's own experience with concept development in the social studies, this study proposed that social studies concepts could be classified as concrete or abstract.

Piaget's work suggests a possible interaction between method of instruction and level of development of operational thought of the student as an effect on student achievement in concept formation. From the work of Bruner and Vygotsky, interactive effects of type of concept and method of instruction, and type of concept and level of thought process, are also suggested. This study examined the nature of interactive and direct effects of three variables on student achievement in concept formation: method of instruction, level of development of operational thought, and type of concept.

Statement of the Problem

This study was designed to investigate the interactive and direct effects of method of instruction, level of development of operational thought of the student, and type of concept in student achievement in concept formation.

Assumptions

The researcher made the following assumptions which are pertinent to this study:

1. Student achievement in concept learning can be measured by asking the student to identify new examples or non-examples of the concept which was learned, and to identify the presence or absence of critical characteristics which makes the item an example or non-example of the concept. (Institute for Curriculum and Instruction, 1976)

2. A student's level of development in thinking processes can be identified through a paper-and-pencil test, consisting of Piagetian-like tasts. (Tomlinson-Keasey, 1975 and Santmire, 1976)

3. Concepts can be classified as concrete or abstract.

4. The instruments used in this study and the methodology selected for this study were appropriate for the purpose of the study.

Definition of Terms

Concept - A class of stimuli (objects, persons, events, or ideas) which have common characteristics or attributes.

Example - A positive example of a concept; an item which has all the critical characteristics of the concept.

Non-example - A negative example of a concept; an item which has none or some, but not all, of the critical characteristics of the concept.

Concrete Concept - A concept which has specific, easily-noted, observable attributes.

Abstract Concept - A concept which does not have easily-noted, observable physical attributes; a concept by definition, rather than by observation.

Inductive Teaching - A method of teaching which requires students to formulate a general rule or definition from an examination of a number of specific cases.

Deductive Teaching - A method of teaching which requires students to apply a given general rule or definition to a number of specific cases.

Concrete Operational Thought - That level of development described by Piaget as being characterized by the ability to apply rules, to deal with one variable in a problem-solving situation, and to respond to empirical, physical evidence.

Formal Operational Thought - That level of development described by Piaget as being characterized by the ability to think logically, to generate and test hypotheses, to deal with more than one variable in a problem-solving situation, and to reflect on thinking.

Hypotheses

The following null hypotheses were investigated in this study:

Interaction Hypotheses:

Null: There is no interaction among the variables of method of instruction, level of development of operational thought, and type of concept with respect to student achievement in concept formation.

Null: There is no interaction between the variables of method of instruction and level of development of operational thought with respect to student achievement in concept formation.

Null: There is no interaction between the variables of method of instruction and type of concept with respect to student achievement in concept formation.

Null: There is no interaction between the variables of level of development of operational thought and type of concept with respect to student achievement in concept formation.

Direct Effects Hypotheses:

Null: Method of instruction does not affect student achievement in concept formation.

Null: Level of development of operational thought does not affect student achievement in concept formation.

Null: Type of concept does not affect student achievement in concept formation.

Design of the Study

Participants

Students in six intact ninth-grade social studies classes at Goodrich Junior High School in Lincoln, Nebraska, were the subjects. Scores on the Formal Operations Test, a series of Piagetian-type tasks which measure student development toward formal operations, were available for each student from school records.

Procedures

Students received instruction on two concepts, one concrete and one abstract. The concept of "prairie" (concrete) was taught first, and the concept of "interdependence" (abstract) was taught two days later. The concepts were selected because they were related to the geography unit the students were studying at that time, they had been identified by the classroom teacher as concepts which were regularly taught in ninth grade social studies, and they have been identified as important geographic concepts in the literature (Price, Smith and Hickman, 1965; Oregon School Districts, 1976).

Each class was randomly assigned one of two treatments (deductive or inductive instruction) for instruction on the first concept, "prairie." Each class received the other method of instruction for the second concept, "interdependence." Those classes which received deductive instruction on the concept of "prairie" received inductive instruction on the concept of "interdependence."

In this study, instruction was provided by the investigator. The investigator was not the students' regular social studies teacher, but was known to the students as a teacher in the school.

A written pretest was given to determine knowledge of each concept prior to instruction. A posttest was given immediately following instruction on each concept to determine student achievement in learning that concept.

Analysis

The three independent variables, method of teaching, level of development of operational thought, and type of concept, were analyzed for their interactive and direct effects on the dependent variable, student achievement in concept learning. Multiple regression was used to analyze the data. The level of significance used in the study was .05.

Limitations

This study was conducted with six intact ninth-grade social studies classes in one school. The study is limited in that all students were approximately the same age. Groups of ninth graders typically demonstrate a wide range in development of thought processes, from very concrete to formal, and this group was no exception. However, there were far fewer formal operational students than concrete operational students, and although that can be controlled statistically, it nevertheless is a limitation.

In addition, there has been some suggestion recently (Flavell, 1977) that formal operations continue to develop after initial emergence. That is, as a person initially develops the ability to handle such formal operations as separating variables or handling correlation, he/she will be able to use that operation at a beginning level, perhaps with some hesitiation, perhaps with some error, perhaps in some, or most, but not all, circumstances. As that person uses, and by using, practices, those formal operational skills, the likelihood of his/her being able to use those skills without error in any given circumstance increases. If such is the case, it could be expected that students who have been formal operational for several years would be more able to apply those formal operations in any given instructional setting than those who have just recently become formal operational. Because of the age of the students in this study, it is safe to assume that for those who are formal operational, it is a fairly recent development. As such, the results of this study should not be automatically generalized to older students and adults who may have been formal operational for several years.

A third limitation of this study is that only two concepts were taught: one concrete and one abstract. There may have been characteristics of the two concepts selected which made the results idiosyncratic to those concepts. Data collected on the results of concepts taught over the course of a semester would perhaps be more reliable.

Plan of the Study

In chapter two, the literature regarding each of the three independent variables, method of instruction, level of development of operational thought, and type of concept, is reviewed for findings which related to student achievement in concept formation. Findings are summarized, and issues to be addressed by the study are stated.

A description of the procedures used in the study is found in chapter three. Demographic information about the subjects, a detailed description of the two methods of instruction, and specific information about the instruments used in the study are included. In addition, a discussion of reliability and validity of developmental measures is found in this chapter.

In chapter four, the method of analysis of the data is explained. The data are presented and examined with respect to each of the seven null hypotheses developed in chapter one.

A summary of the study and the findings of the study are presented in chapter five. Instructional implications are suggested. Issues and questions raised by the study are posed, with recommendations for further research.

CHAPTER 2

REVIEW OF LITERATURE

The literature reviewed in this chapter is focused primarily on research on concept formation. Since the main purpose of the study was to investigate the relationship between method of instruction, student level of development of operational thought and the type of concept to be taught, the organization of this chapter correlates with these three issues. The first section of the chapter is concerned with an analysis of the rather extensive literature which reports various aspects of the effect of several teaching strategies upon concept formation. The second section is a review of those elements of Piaget's theory of intellectual development which appear to relate to the thought processes involved in learning concepts. A summary of the literature on types of concepts and the instructional implications of teaching different types of concepts is found in the third section. The selection of the literature to be included for review was made upon the basis of either its theoretical application to the general areas which are a focus of the study or the results of experimental research which provide the basis upon which the structure of this study rests.

Method of Instruction

A number of investigators have been concerned with attempting to assess the most effective way to teach concepts. The results of these investigations are reported in this section. Within the general category of effective instruction, a substantial number of studies have been concerned with the effectiveness of presenting examples and non-examples of the concept in assisting students to develop understanding of concepts. In addition, several studies have been concerned with the value of additional instruction which provides further elaboration of examples and non-examples in students' acquisition of concepts. Research in concept formation has focused on four basic issues: the usefulness of examples and/or non-examples in concept formation; the order in which examples and non-examples are presented to students; the structure of examples and non-examples; the usefulness of providing additional information and/or instruction at the time examples and/or non-examples are presented.

Since the process of learning a concept involves seeing the similarities among a collection of stimuli, there is little dispute over the value of having students examine examples of the concept to be learned. By examining several examples of the concept to be learned, each with the critical characteristics clearly discernable, the student is able to formulate some statement about what the concept is. Alternatively, if the student has been told the definition of the concept, by examining several examples of the concept he/she can see how those critical characteristics look in real, as opposed to hypothetical, situations. In either case, an examination of examples of the concept assists the student in learning what the concept is.

The value of the use of non-examples as an important element in concept formation has not been so clearly accepted. Using non-examples in an instructional strategy involves having students look at those stimuli which are not examples of a particular concept. The emphasis is upon looking at what a concept is not, as distinguished from an analysis of those characteristics which are related to a particular concept. The question is whether using non-examples to provide information about what a concept is not will assist students in discriminating between new examples and non-examples of the concept.

A number of studies have been concerned with testing the effectiveness of the use of non-examples in learning concepts. Bruner, Goodnow and Austin (1956) noted a general inability or unwillingness of students and adults to use efficiently information which was based on non-examples or which may have been derived from an indirect test of a hypothesis. Braley (1963) conducted a study to specifically test students' use of the information in non-examples. The subjects, high school and college students, were to learn the concept of a particular combination of geometric shape and color, such as a small blue triangle. They were presented with both examples and non-examples of the concept, with directions to use both as sources of information about the concept. Following the experiment, the subjects were interviewed about the process they used in attempting to discern the critical characteristics of the concept. Braley found that the students used the non-examples only to test an already-formed hypothesis about the concept, not for the information the non-examples themselves contained. This was attributed to the greater demands placed on memory by the use of non-examples. Because of the increased strain on memory, Braley concluded that the use of non-examples is a higher-order problem-solving skill. His study suggested the possibility that non-examples of a concept are helpful in learning the concept only in very specific ways, and that the non-examples are more useful if they follow the examples in presentation.

A similar conclusion concerning how students use non-examples was reached by Houtz, Moore and David (1973) in a study conducted with eighth grade students. The students' task was to form a concept of a particular geometric shape, which was shaded or contained designs. Six groups of students were tested, with two groups receiving eight examples of the concept to be learned. The four remaining groups received four examples and four non-examples, in alternating order. The researchers concluded that the students who had received non-examples of the concept used them to eliminate irrelevant attributes of the concept. This would indicate there is some value in presenting non-examples in situations where students are expected to learn new concepts.

A study which provided additional support for the inclusion of non-examples in an instructional approach designed to assist students in learning new concepts was reported by Markle and Tiemann (1972), as described in Klausmeier, Ghatala and Frayer (1974). In a concept formation task, college students were to learn the concept "morpheme." Students who had received only examples made fewer discrimination errors, that is, an error of identifying a non-example as an example, than students who received only non-examples. However, students who had received both examples and non-examples of the concept made fewer errors in identifying new examples and non-examples than either the group who had received only the examples or the group who had received only non-examples. A reasonable conclusion from their work is that presenting both examples and non-examples is more effective than presenting either alone.

Similar results were noted by Swanson (1972), as described by Klausmeier, Ghatala and Frayer (1974). In a study of sixth-graders, in which the task of the students was to learn the concept "habitat," one group of students received only examples of the concept and one group received both examples and non-examples. Swanson concluded that presentation of both examples and non-examples resulted in better recognition of new examples of the concept than presentation of examples only.

In addition to Bruner, Goodnow and Austin (1956), whose assertion that people are generally unable or unwilling to use information from non-examples was noted earlier in this section, two other general theorists in the field of concept formation have addressed the issue of the usefulness of non-examples. Gagne (1970) stated that presenting non-examples of the concept is necessary in order for the student to be able to discriminate between examples and non-examples of the concept. In his own illustration of teaching a child the concept "edge," the child is shown the top, side, and corner of an object as non-examples of "edge." When the child is able to discriminate between the edge and the side, for example, of another object, Gagne concluded the child had learned the concept "edge." Ausubel (1968) recognized the difficulty many people have in using non-examples in learning a new concept, and he suggested that teachers should explicitly train students to make better use of the information in non-examples when learning new concepts.

A reasonable conclusion from the studies reviewed is that presentation of non-examples is of some value in assisting students to learn new concepts. While people may have more difficulty in using information from non-examples than from examples when learning a new concept, non-examples are useful in checking tentative ideas about the concept. The research of Markle and Tiemann (1972) and Swanson (1972) suggests that presentation of both examples and non-examples is more effective in assisting students in learning a new concept than presentation of either examples or non-examples separately.

The second issue to be examined is the question of whether there is a specific order in which examples and non-examples should be presented. In an analysis of 250 concept formation studies conducted between 1940 and 1970, Clark (1971) noted that six of the studies dealt with the question of order of presentation of examples and non-examples of conjunctive concepts. A conjunctive concept, as defined by Bruner, Goodnow and Austin (1956), is one in which all the relevant attributes must always be present. From the six studies that dealt with order of presentation of examples and non-examples, Clark concluded that if both examples and non-examples are to be presented, it is more effective to present a sequence of several examples followed by a sequence of several non-examples than to present a mixed list of examples and non-examples. This conclusion was supported by all six of the studies.

More recent research in concept formation has addressed the issue of the structure of the examples and non-examples that are used to teach concepts. This research on structure also addressed indirectly the issue of order of presentation. Structure of the examples and non-examples refers both to the content of the items and the manner in which they are organized and presented. Markle and Tiemann (1969), as described in Klausmeier, Ghatala and Frayer (1974), proposed examples and non-examples be structured and presented in rational sets. The concept of "rational set" developed from an investigation of how many examples and non-examples were necessary for students to be able to both generalize (recognize new examples of the concept) and discriminate (recognize new non-examples of the concept). They found that to ensure generalization, enough examples must be included to vary all irrelevant attributes. To ensure discrimination, enough non-examples must be presented to exclude each relevant attribute. The number of examples needed to ensure generalization was defined as a rational set of examples. The number of non-examples needed to ensure discrimination was defined as a rational set of non-examples. In their research, Markle and Tieman found that presenting a rational set of examples followed by a rational set of non-examples was the most effective strategy in assisting students to learn new concepts.

The concept of rational sets of examples and non-examples was developed further by Tennyson, Woolley and Merrill (1972). They suggested three elements of structure be considered when constructing examples and non-examples: probability, matching examples and non-examples, and divergent examples.

Probability is the degree to which an example or non-example will be identified correctly by a person who has been given only the definition of the concept. An example or non-example which is easily identified as such is defined as having high probability, while one which is not easy to identify is defined as having low probability. Probability values for examples and non-examples were determined by giving subjects a definition of the concept being studied, and then asking them to identify examples and non-examples from a mixed list of items. Those items which were most often identified correctly received high probability values; those items most often identified incorrectly received low probability values.

An example and a non-example were defined as matching when irrelevant attributes of the concept were as similar as possible in the example and non-example. For example, if the concept to be learned were "triangle," and a square was being used as a non-example of "triangle," the two items, square and triangle, would be matched if the irrelevant attributes of size and color were as similar as possible.

While "matching" refers to pairs of examples and non-examples, "divergency" refers only to examples of the concept. Divergent examples are those in which the irrelevant attributes vary as much as possible from one example of the concept to the next. Consider the previous illustration of teaching the concept "triangle." If the irrelevant attributes of color and size were varied from one example of the concept to the next, the examples would be defined as being divergent.

Tennyson, Woolley and Merrill (1972) studied the effect of these three elements of structure on student achievement in learning a new concept. College students were asked to learn the concept "trochaic meter," and the measure of their learning was a test which asked them to identify new examples of the concept. The results of the study suggest achievement in concept learning could be enhanced by three strategies: first, presenting examples and non-examples from all probability levels; second, presenting matched examples and non-examples; third, presenting divergent examples. The use of other combinations caused particular kinds of errors. A conclusion about order may be inferred from this study, in that matched examples and non-examples must be presented alternately.

The previous two studies, Markle and Tiemann (1969) and Tennyson, Woolley and Merrill (1972) suggest structure of the examples and non-examples does affect student achievement in learning a new concept. Such a conclusion is not supported by two studies conducted by Wager and Broderick (1974) in which it was the task of primary students to learn the concept "noun." The students were presented with groups of three sentences in which examples of the concept were underlined. Three different types of sentences were used: asynchronous type 1, asynchronous type 2, and synchronous.

In asynchronous type 1 sentences, the examples of the concept "noun" are not changed from one sentence to the next, but the non-examples are changed. Illustrations of asynchronous type 1 sentences are as follows: Mary wants two books. Mary reads many books. Mary likes to color in books. In asynchronous type 2 sentences the examples are varied, but not the non-examples. A set of asynchronous type 2 examples looks like this: Mary went to the store. John went to the library. Sally went to the playground. A set of synchronous sentences varies both the examples and non-examples: Mary wants two books. John went to the library. Sally likes popcorn. Two studies were conducted to determine the effect of type of sentence used in instruction on student achievement in learning the concept "noun."

The first study was conducted with first-grade students as subjects. Each student was given a programmed instruction booklet containing several sets of sentences, all of the same type. Some students received sets of asynchronous type 1 sentences; some received sets of asynchronous type 2 sentences; some received synchronous sentences. The examples of the concept were underlined in each sentence in all the booklets. The students worked through the booklet, then took a test in which they were asked to select the examples of the concept from a mixed list of words. The second study was similar to the first in design, except the subjects were second and third-graders. Also, a control group was added in the second study. The students in the control group were given a list of nouns to study, and then were given the same test as the students who received the programmed instruction booklets. In both studies, type of sentence in the booklet made no significant difference in student achievement in learning the concept "noun." In the second study, those student who had been given synchronous sentences made more errors as they worked through the programmed instruction booklets, but no more test errors, than the students who received the other types of sentences. All three treatment groups in the second study did significantly better on the test than the control group. Wager and Broderick concluded that the structure of the examples and non-examples made no difference in learning of concepts.

It should be noted here that Wager and Broderick expected primary children to use self-instructional materials. The materials required a large amount of individual reading on the part of the children, and it is possible the task, instead of one of concept formation, was actually one of reading. This would cast some questions on the validity of their findings and conclusions.

Securro and Wallo (1971) looked at a different aspect of the structure of examples and non-examples. They tested fifth-graders to see if concept learning would occur more accurately if lifelike stimuli rather than artificial stimuli were used. In order to learn the concept "two, large" some children looked at cards with small and large circles of varying numbers. Other children were shown cards with children's and adults' faces of varying numbers. Between the two stimuli, no significant difference in the degree of accuracy with which students learned the concept was found.

Studies cited to this point have been primarily concerned with questions about the use of examples and non-examples in concept formation. At this point, three conclusions may be briefly stated. First, presenting examples and non-examples is more effective in teaching new concepts than presenting either alone. Second, it is most effective to present a set of examples followed by a set of non-examples, unless the examples and non-examples are matched and divergent. In that case they must be presented alternately. Third, particular kinds of structures of examples and non-examples, specifically rational sets and matched and divergent, have been shown to have a significant effect on student achievement in concept learning. In addition to this research on examples and non-examples, there is another body of research concerned with the effect on learning of concepts when additional instruction is given in the presentation of examples and non-examples.

George (1974) conducted a study with eighth-grade students to determine the effectiveness of different treatments on the task of identifying slides as examples or non-examples of the concepts of freedom or justice. She found a significant difference in the achievement in concept learning of the group who received definitions of the concept, followed by the presentation of two non-examples and then two examples, with the relevant attributes of the concept specifically identified. This group had a significantly higher achievement rate in learning the concept than the other four treatment groups in the study. The other four treatment groups tested were as follows: one group received only a definition of the concept; the second group received the definition and two examples of each concept; the third group received the definition, and two examples and two non-examples of each concept; the fourth group received the definition, two non-examples and two examples of each concept. The findings of this study suggested that noting the relevant attributes of the concepts contributed to significantly greater achievement in concept formation.

The findings of Tennyson, Woolley and Merrill (1972) suggested that the use of matched and divergent examples and non-examples contributed to student achievement in concept formation. They used the term "organized items" to refer to matched and divergent examples and non-examples. Tennyson, Steve and Boutwell (1975) examined the concept of organized items further, with the addition of an analysis statement. The analysis statement explained, for each example or non-example, the presence or absence of the relevant attributes. They paired analysis statements with organized items and with random items. Random items were examples and non-examples ordered by use of a random number table.

In the study, which involved college students whose task it was to learn the concept "trochaic meter," the students who received instruction including the analysis statements achieved higher scores on a concept formation test than did students who received no analysis statements. This was true whether the items were organized or random. The group with the highest achievement on the concept formation test was the one who had received organized items and the analysis statements. The group that received random items and no analysis statements had the lowest achievement on the concept formation test. Tennyson, Steve, and Boutwell concluded that the presence or absence of analysis statement made a greater difference in student achievement in concept formation than the types of items presented.

In a second part of that same study, a strategy statement was added as another variable in learning concepts. The strategy statement consisted of a paragraph given to students which suggested ways in which the students could examine and study the examples and non-examples. In this experiment, there were six treatment groups. The first group received organized items, the strategy statement and the analysis statements. The second group received random items, the strategy statement and the analysis statements. The third group received organized items and the analysis statements. The fourth group received random items and the analysis statements. The fifth group received organized items alone, and the sixth group received random items alone.

The task of the student was to identify examples of RX_2 crystals, a complex molecule. The results showed that those students with the highest achievement on the concept formation test following the instruction were those for whom both the strategy and analysis statements were presented, with those who were given organized items having greater achievement on the test than those who were given random items. Tennyson, Steve and Boutwell concluded the presence of strategy and analysis statements produced better learning than analysis statements without the strategy statement, and either or both strategy and analysis statements, used with examples and non-examples, are more effective than sets of examples and non-examples alone, regardless of the structure (organized or random) of the items.

From the studies of George (1974) and Tennyson, Steve and Boutwell (1975) it is possible to conclude that additional instruction which focuses on the critical characteristics on the concept affects achievement in concept formation. The role of the definition of the concept as a particular kind of additional instruction has been the focus of several other studies.

In research mentioned earlier, Swanson (1972) concluded that the learning of a particular concept was increased when student received both examples and non-examples. In the first experiment of that particular research, sixth-grade students had received instruction on the concepts "population," "habitat," and "community." Each student, except those in the control group, received self-instructional lessons on each of the three concepts. One treatment group received a full rational set of both examples and non-examples; the second group received a rational set of examples; the third group received two examples. None of the groups received concept definitions. The findings showed significantly higher achievement on the concept test following instruction by those students who had received the rational sets of examples and non-examples.

The second experiment of the research (Swanson, 1972, as described in Klausmeier, Ghatala and Frayer, 1974) attempted to determine the effect upon student learning of concepts when students were presented with the definition of the concept. This experiment was very similar to the first one, in that once again sixth-grade students received self-instructional materials on each of the concepts "population," "habitat," and "community." Three treatment groups received the same lessons as described in the first experiment, but a definition of each concept was included in each lesson. The students in the control group received no instruction on the concepts. In this study, where all three treatment groups had the definition, all three treatment groups showed significantly higher achievement on the concept test than the control group, and there was no significant difference among the treatment groups.

In his conclusion, Swanson did not compare the achievement of those groups of students in the first experiment who did not have the definition with those in the second experiment who did have the definition, so no conclusions can be drawn on the absolute effect of the definition. However, Swanson concluded that the results of the first experiment suggested that in the absence of a definition, number and type of examples do affect student learning of concepts, but the results of the second study suggested that when a definition is presented, number and type of examples have no significant effect on student learning of concepts.

Inferences about the value of the use of the definition in concept learning can be made from two studies cited previously. In the study by Wager and Broderick (1974), each of three groups of students received different types of sentences in instructional materials: asynchronous type 1, asynchronous type 2, and synchronous. In addition to the sentences, a definition was also presented in each of the self-instructional booklets. The results of the study, that there were no significant differences among the treatment groups in achievement on the concept test, could be attributed to the presence of the definition for each group. Such a conclusion would be in agreement with the conclusion reached by Swanson (1972), which stated that in the presence of a definition, number and type of examples do not affect student achievement in concept formation.

A different conclusion must be drawn, however, from the Tennyson, Woolley, and Merrill (1972) study, which concluded that sets of examples and non-examples that are matched and divergent produce greater achievement in concept learning. In that study, all the treatment groups also had a definition given with the instruction. The results, unlike the Swanson (1972) and Wager and Broderick (1974) studies, suggested that even in the presence of the definition of the concept, type of examples and non-examples affected student achievement in concept formation.

Two additional studies address the question of the value of the use of the definition in concept learning. Klausmeier and Feldman (1975) conducted an experiment with fourth-graders, who were to learn the concept "equilateral triangle." Students were assigned to one of four treatment groups or a control group. Each group received a set of self-instructional booklets. The control groups had lessons on a different concept, such as Roman numerals. One treatment group received a definition of the concept with no examples; the second group received a rational set of examples and non-examples; the third group received the definition and one rational set of examples and non-examples, and the fourth group received the definition and three rational sets of examples and non-examples. The findings in this study were that on a test in which students were asked to identify equilateral triangles all treatment groups did significantly better than the control group. There were no significant differences in achievement on the test among the groups who received only the definition, only the rational set of examples and non-examples, or the definition and one rational set of examples and non-examples. However, the group who received the definition and three rational sets of examples and non-examples demonstrated better achievement on the concept test than the group who received only the definition. Klausmeier and Feldman concluded that the significant factor in concept formation suggested by this study was the extra rational sets of examples and non-examples.

In a study conducted by Woodson (1974), it is concluded that for the college students who were the subjects of the experiment, the most effective instructional strategy to be used with this group was to identify a list of relevant attributes of the concept to be learned. The listing of relevant attributes was a more effective instructional strategy than that in which the definition of the concept was presented alone. Listing the relevant attributes or presenting the definition were more effective instructional strategies than those strategies which used examples, non-examples, irrelevant attributes, use of analogies, or the domain on the concept. Woodson pointed out that college students are accustomed to learning by the use of definitions and relevant attributes, and because of this the findings of his study are not necessarily generalizable to student populations of different ages.

Several conclusions can be drawn from the literature which attempts to assess the degree of effectiveness of many strategies in concept formation. With regard to the issue of the value of the use of non-examples in concept formation, the research appears at first glance to be contradictory. Braley (1963) and Bruner, Goodnow and Austin (1956) indicated that students were unable or unwilling to use the information from non-examples in concept formation. More recent research (Houtz, Moore and Davis, 1973; Markle and Tiemann, 1972; Swanson, 1972) would seem to indicate otherwise. In addition, the later research of Tennyson, Woolley and Merrill (1972), Tennyson, Boutwell and Steve (1975) and Klausmeier and Feldman (1975) has not included as an independent variable the use or non-use of non-examples, indicating, perhaps, that for these researchers in the field of concept formation, the value of non-examples in concept formation had been demonstrated. Since the later research focused on a particular kind of non-examples, either part of a rational set of non-examples or matched to an example, it may be concluded that if non-examples are structured and presented in one of these patterns, students can use the non-examples in concept formation. If non-examples are not so structured and presented, errors of overgeneralization are likely to occur.

A second conclusion can be drawn concerning the order in which examples and non-examples are presented to students. The evidence presented by Clark (1971) in his review of literature strongly suggests that if both examples and non-examples are used in instruction, the most effective order of presentation is examples followed by non-examples. The second most effective order is presentation of examples and non-examples alternately. Although little research has been done recently on the order of presentation of examples and non-examples, research on the question of structure of items indirectly addresses the issue of order. Swanson (1972) demonstrated the effectiveness of presenting a rational set of examples followed by a rational set of non-examples as an instructional strategy in concept formation. Tennyson, Woolley and Merrill (1972) concluded matched and divergent sets of items facilitated concept formation. In order to have matched and divergent items, the examples and non-examples must be presented alternately. From Clark's review, and the later research of Swanson and Tennyson, Woolley and Merrill, it may be concluded that concept formation is facilitated by presentation of examples followed by non-examples, if the items are rational sets, or alternate presentation of examples and non-examples, if the items are matched and divergent.

A third issue concerns the value of structuring the examples and non-examples in a certain way. Markle and Tiemann (1969) and Swanson (1972) developed a convincing argument for the use of rational sets of examples and non-examples. Likewise, the findings of Tennyson, Woolley and Merrill (1972) in regards to the use of matched and divergent examples and non-examples are convincing. It should be noted that rational sets and matched and divergent items are not two entirely different structuring schemes. Tennyson, Woolley and Merrill started with the concept of rational sets of examples and non-examples and refined it to matched and divergent examples and non-examples. Wager and Broderick (1972) concluded that the structuring scheme of synchronous and asychronous sentences did not affect student achievement in concept formation. A procedural concern about their research, that they expected primary children to read self-instructional materials, has already been noted. Securro and Wallo (1971) found that the use of lifelike or artificial stimuli made no significant difference in student achievement in concept formation. From these studies, it may be concluded that some structuring schemes, specifically the use of rational sets or matched and divergent examples and non-examples, do significantly affect student achievement in concept formation.

A fourth area of research deals with the issue of providing additional information and/or instruction at the time of presentation of examples and non-examples. The findings here are not as conclusive as in other areas. Swanson (1972) concluded that if a definition is given, number and type of examples are not as important. If a definition is not given, number and type of examples are important. From his data, he draws no conclusion about the effect of a definition when number and type of examples are held constant. Klausmeier and Feldman (1975) found the absence or presence of a definition is not as important in concept formation as the opportunity for repeated exposure to rational sets of examples and non-examples. However, they had only one treatment group with more than one rational set of examples and non-examples. That group received the concept definition, also, so there is no way of knowing if the definition had an effect on learning. Tennyson, Steve and Boutwell (1975) concluded the presence of analysis statements and strategy statements facilitated concept formation. Woodson (1971) found that identifying for students the list of relevant attributes and providing them with a definition are the most effective instructional strategies in concept formation. He qualified this with the comment that this may be true of the college students he tested because of the nature of their learning experiences; that is, they have learned to learn by definition. George (1974) also concluded that noting the relevant attributes of the concept contributed significantly to concept formation.

The findings of Tennyson, Steve and Boutwell (1975), Woodson (1971) and George (1974) demonstrate the positive effect of providing additional instruction, in the form of analysis or strategy statements or noting of relevant attributes, at the time examples and non-examples are presented. The research on the value of providing a definition of the concept to be learned is inconclusive.

Level of Development of Operational Thought

If a definition is to be used in the teaching of concepts, it may be used in one of two ways. The first approach is to have the definition presented at the beginning of instruction, in order that students may use it to examine each example and non-example. This is essentially a deductive process, in that the student learns a general rule and then applies it to a specific case. The second way that a definition may be used is to present students first with examples of the concept, and then ask them to develop the concept definition by noting similarities and differences among the examples. The definition can then be further refined by examining non-examples of the concept and comparing them to the examples. This is essentially an inductive process, since it calls for the student to note specific instances and derive from them the rule or definition that is applicable to all examples of the concept.

Different teaching methods may require different thought processes to be used by students. In addition to the different methods for teaching concepts mentioned above, methods for teaching generalizations or cause-effect relationships may require inductive or deductive thinking on the part of the student, depending on the teaching method selected. For example, a social studies teacher may wish students to learn the generalization "Cultures are influenced in their development by their physical environment." One way to teach this generalization would be for the teacher to present this generalization, then have students examine several different cultures as examples of the generalization. Such a method would require deductive thinking by the students; they would be applying a rule to specific cases. In another method, the teacher would present several descriptions of cultures and environments, and ask the students to make some general statements about the relationship between culture and environment. This method would require inductive thinking by the students; they would have to derive the rule about cultures and environments from an examination of specific cases.

It is reasonable to speculate that the student's ability to use the thought process demanded by a particular teaching method will have an effect on student achievement in concept learning. Piaget's work on intellectual development has long been regarded as a major theory in the development of thought processes (Flavell, 1963). His descriptiors of concrete operational and formal operational thought are examined as a part of the literature base for this study for those points which may be relevant to concept formation.

Piaget's theory proposes four stages of development of thought processes. These stages, which are of a fixed order but may vary in length, describe the cognitive structures of children at various points in development. The stages are sensory-motor (from birth to about two years), preoperational (ages three to six), concrete operations (age seven to early adolescence), and formal operations (emerging sometime during adolescence). Each stage builds on the accomplishments and structures of the previous stage, and each is a stepping stone to the final product, formal operational thought. For the purposes of this paper, concrete operations and formal operations will be explored in some detail, since these two stages encompass most children of school age.

Children who are concrete operational <u>are</u> concrete; that is, their structuring and organizing activity is oriented towards real things and events in the immediate present (Flavell, 1963, p. 203). Their ability to extend the real to the possible or potential is limited; that is a perspective they do not yet have. A major task of concrete operations is organizing and stabilizing that which is perceived directly by the senses; dealing with what might be is a task for a later stage.

The child who is concrete operational can deal with only one variable at a time. In solving a problem, a student who is concrete operational may be able to consider separately the effect of two different variables on the problem under consideration, but lacks the cognitive structure to consider both variables or all possible combinations of variables.

An important attribute of concrete operational children, in terms of their ability to learn concepts, is their ability to apply rules to a particular instance (Elkind, 1974, p. 97-99). For example, the concrete operational child who has learned that a red traffic light means "stop" will know to stop if he/she sees a red traffic light, even if on a street corner where he/she has never been before. Similarly, the concrete operational student who has learned that the plus sign (+) designates numbers to be added will know to add the numbers in any mathematics problem with that sign, even if it is a problem not before encountered. Likewise, the concrete operational student who has learned the rule which defines "island" will be able to identify an island as such, whether or not the student has seen that particular island before.

The formal operational student, on the other hand, realizes that just as rules can be applied, they can also be discovered. This happens as a result of the general property of formal operational thought of being able to see beyond what is real to what is possible, to see that what is real is a special case of what is possible, and that rules simply define the reality. Rules are derived from an examination of all the possibilities.

This new orientation of looking at what is possible includes three other important characteristics of formal thought: hypothesis testing, being able to formulate hypotheses about what is possible and then to systematically test them; propositional thinking, making logical connections between groups or events; and combinatorial analysis, generating all possible combinations of variables, and considering more than one variable at a time (Flavell, 1963, p. 206). These traits of formal thought, then, make scientific reasoning possible; the student has the necessary tools for sorting out the variables which are critical, or causal, from those which are superfluous. "During this (formal operations) period, Piaget holds that the child can truly plan scientific investigation because he is now ready to handle all kinds of combinations in a systematic order whereas previously he could handle only one variable at a time." (Sigel, 1964, p. 222)

The important aspect of formal operational thought for Piaget is not so much that it mandates a specific kind of behavior, but rather that those behaviors develop from a generalized orientation toward problem-solving. This orientation toward problem-solving reflects more specifically an orientation toward organizing data (combinatorial analysis), toward isolation and control of variables, towards the hypothetical, and towards logical justification and proof (Flavell, 1963, p. 211).

The stages of concrete operations and formal operations are developmental in nature; formal operations builds upon the intellectual competencies achieved during concrete operations. As a child becomes very competent at the cognitive skills acquired in concrete operations, he/she realizes the limitations of the skills and begins, in a very groping manner, to build upon those skills (Flavell, 1977). Clearly, the process by which a person develops formal operational skills is evolutionary and there is always a period of transition between concrete and formal operations.

Because of the capabilities of the formal operational person to organize data and handle combinations of variables, it is reasonable to propose that a student who is formal operational is more able to use the thought processes required by inductive thinking. In addition, since a person gradually develops from concrete to formal operational thought, it is reasonable to propose that as a person becomes more nearly formal operational, his/her capacity to use the thought processes required by inductive teaching increases. This would suggest that in teaching concepts, an inductive teaching method would be more appropriate for students who are further along in development toward formal operations than for students who are still concrete operational. Furthermore, it suggests that students who are concrete operational are more likely to be able to learn concepts from a deductive method of instruction than from an inductive method of instruction.

Type of Concept

An additional factor influencing student achievement in concept formation may be the concept itself. Bruner, Goodnow and Austin (1956) divided concepts into three categories: conjunctive, disjunctive, and relational. Conjunctive concepts are those which are defined by the joint presence of two or more attributes. The concept of "representative democracy" is an example of a conjunctive concept. For a government to be a representative democracy, the laws must be made by the elected representatives of the citizens, and basic human rights must be guaranteed to the citizens. Disjunctive concepts are those which have at least one of two or more attributes. The concept of "power" is a disjunctive concept. A person who has power has either the authority to command people to do as he/she wishes, or the ability to persuade people to do as he/she wishes. Relational concepts are those which are defined by a specifiable relationship between defining attributes. An example of a relational concept is "population density," which is defined in terms of the relationship between number of people and amount of space. Bruner, Goodnow and Austin found that conjunctive concepts are more easily learned than disjunctive or relational concepts.

Vygotsky (1962) classified concepts as either spontaneous or scientific. Spontaneous concepts are those with which a student has had direct, personal experience. Some examples of spontaneous concepts which many students may have learned are "family," "rules," "transportation," "city," and "work." Scientific concepts are those concepts which must be deliberately learned and are outside the realm of personal experience. Some examples of scientific concepts, for most students in this country, are "slavery," "civil war," "monopoly," "longitude," and "Buddhism." Vygotsky suggests that the process of developing a scientific concept is different from that which is involved in developing a spontaneous concept. Spontaneous concepts are developed from involvement with examples of the concept in a concrete situation, while scientific concepts are developed by learning the rule or definition in an instructional setting, then filling in content examples as they are experienced or encountered (p. 108).

Concepts may also be classified as concrete or abstract. Such a distinction may be inferred from Glaser (1968), who wrote of concepts "where the stimulus values are perceptually clear" and concepts "which are intricate to verbalize" (p. 27). Concrete concepts are those which have specific, easily-noted, observable attributes. The attributes of concrete concepts can be illustrated with physical, empirical props. Concrete concepts tend to be objects or persons rather than events or ideas. Some examples of concrete concepts that student are frequently expected to learn are "plant," "liquid," "island," "sonnet," and "isthmus." Abstract concepts, on the other hand, do not have easily-noted, observable, physical attributes. They are concepts by definition, rather than by observation. Abstract concepts tend to be events or ideas rather than objects or persons. Some examples of abstract concepts that students are expected to learn are "government," "democracy," "chronology," "sovereignty," and "cooperation."

Of course, there are concepts which have both concrete and abstract elements. The concept of "city" is an example. The defining attributes of "city" include objects (streets, buildings, parks), persons (families, teachers, doctors, store owners, garbagemen), events (elections, celebrations), and ideas (government, economic viability, interaction, city-state relationship). There are other examples of concepts which have both concrete and abstract elements which are commonly taught in social studies, such as "war," "labor strike," and "nation."

The distinction between concrete and abstract concepts is a relevant one when considering concepts commonly taught in social studies. While there are many concrete concepts students are expected to learn, such as "landform," "natural resource," and "artifact," the concepts which have been identified in the literature as the major concepts which social studies should address are almost totally abstract. Indeed, of the eighteen substantive concepts and five value concepts identified by the Social Studies Curriculum Center (1965) as major concepts for the social studies, all are abstract concepts.[2] The literature concerning concept formation is based almost entirely on research where students are learning concrete concepts. As Martorella (1971, p. 30) noted, there is some difficulty in generalizing findings from the concept formation research to the social studies, because of the nature of most social studies concepts, which tend to not be

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[2]The concepts are as follows: sovereignty, conflict, industrialization, urbanization, secularization, compromise and adjustment, comparative advantage, power, morality and choice, scarcity, input and output, modified market economy, habitat, culture, institution, social control, interaction, dignity of man, empathy, loyalty, government by consent of the governed, freedom and equality.

precise or have easily observed characteristics. Most of the significant social studies concept are abstract, and there is practically no empirical evidence on the teaching strategies most likely to assist students in attaining these abstract concepts.

It is reasonable to speculate that the type of concept being learned (either concrete or abstract) will influence student achievement in concept formation. For example, students operating at a concrete operational level of thought may be able to learn concrete concepts more easily than abstract concepts, because of the physical, empirical nature of the attributes of concrete concepts. In terms of teaching strategies, Glaser (1968, p. 27) suggested that abstract concepts, those which are "intricate to verbalize," may be more easily learned by induction, and he urged research dealing with, among other topics, concepts which might be more efficiently learned deductively.

In summary, concepts have been classified in several ways, and it is reasonable to assume that type of concept, along with method of instruction and level of development of operational thought toward formal operations, is a variable affecting student achievement in concept formation.

Conclusions Drawn From the Review of Literature

There is a large body of research on various aspects of teaching concepts. Questions concerning the ordering and type of examples and non-examples appear to be resolved. Also, the evidence suggests the effect of providing students with additional supporting instruction such as analysis statements or strategy statements is a positive one with regard to student achievement in concept formation. The question of the use of the definition of the concept in concept learning is unclear from the literature review.

It is possible the effectiveness of a given teaching strategy may depend on the ability of the student to use the thought processes demanded by the teaching strategy. From Piaget's work on intellectual development, it is apparent that students at various levels of development have mastered different kinds of thought processes. Furthermore, since the age at which students become formal operational varies, and since there is a transition period between concrete operations and formal operations, for any one group of adolescents, all of the same age, student level of development of operational thought may range from very concrete, to transitional, to formal. Therefore, a teaching method which is appropriate for some, because the students were able to use the thought processes required by the method, may be very inappropriate for other students, who have not yet developed to that point.

The research concerning teaching different types of concepts is less extensive and less clear. Most research on teaching concepts has been done with concrete concepts. Some writers in the field of social studies educational suggest that effective teaching methods, or thought processes required, vary depending on the type of concept.

This study was designed to explore the interaction among and direct effects of teaching method, level of development towards formal operational thought, and type of concept, on student achievement in concept learning.

CHAPTER 3

PROCEDURES

Sources of the Data

The study was conducted with ninth grade social studies classes at Goodrich Junior High School in Lincoln, Nebraska, where the investigator was on the Teacher Corps staff, a project in the school, during the 1978-1979 school year. Goodrich is the newest junior high school in Lincoln, having opened in 1968. The school's population of nearly 800 students in grades six through nine is drawn from three separate and distinct communities in the northwest corner of Lincoln. The area is predominantly working and lower-middle class, although an increasing number of middle-class and professional families are moving into the area. The school's population is primarily white, with approximately eight percent of the students coming from non-white ethnic backgrounds. Nearly all the students go to Lincoln High School, the oldest of the city's four public high schools, upon promotion from Goodrich. An emphasis in the ninth grade academic classes is on preparation of students for high school.

All students are required to take social studies each of the years they are at Goodrich. Ninth grade social studies at the time of the study included an extensive study of physical and cultural geography, with content samples taken primarily from third-world peoples. During the 1978-1979 school year, there were ten sections of ninth grade social studies at Goodrich, including two sections designed for low-reading students. Except for the sections for low-readers, no particular plan was used in assigning students to sections of social studies.

Six sections of ninth grade social studies, which did not include either of the low-reading sections, were taught by one teacher. These six sections were chosen for use in this study so that all students in the study would have had similar social studies instruction that year. The study was conducted during the second week of October, 1978. Permission to conduct the study was granted by the Lincoln Public Schools.

Procedures for Collecting Data

Students in six intact ninth grade social studies classes were the subjects of this study. Scores on the Formal Operations Test, which was given at the beginning of the school year, were available for each student from school records.

During the course of the study, students in each of the six classes received instruction on two concepts, one concrete and one abstract. The concrete concept was taught and tested on the first two days of the week, and the abstract concept was taught and tested on the last two days of the week. The schedule was approved by the regular social studies teacher, who conducted class on the day between instruction on the two concepts.

Selection of Concepts

The selection of concepts to be taught in this study received careful attention. Several criteria had to be met. The criteria were determined by the needs of the regular classroom teacher and the needs of the study. First, the concepts had to be appropriate ones to be learned in a ninth grade social studies class. Second, because of the variable to be investigated, one had to be concrete and one had to be abstract. Third, the concepts had to be identified in the social studies literature as being important; they could not be "made-up" concepts, invented for the study. Fourth, the concepts had to be related to the geography unit the students were studying at the time.

Most studies on concept formation reviewed by the investigator were conducted with either elementary students or college students as subjects, learning a concrete concept. (George's (1974) study of eighth-graders learning the concepts "freedom" and "justice" is a notable exception.) Little guidance for selection of concepts was found in these studies. The researcher then turned to the literature concerned with identification of concepts important in the social studies (Martorella, 1971; Price et.al., 1965; and Oregon School Districts, 1976). Several possible concepts were identified from these sources. After consulting with the classroom teacher, "prairie" was selected as the concrete concept and "interdependence" was selected as the abstract concept to be taught in this study. The two concepts met the previously identified criteria: they were appropriate for ninth grade students, being identified as concepts normally taught by the classroom teacher; one was concrete and one was abstract; they were identified as being important concepts in the literature; they were related to the geography unit the students were studying.

Methods of Instruction

Each method of instruction incorporated strategies shown in the literature to be successful in teaching concepts. Each included a rational set of examples and a rational set of non-examples of the concept to be learned. In addition a data retrieval chart was provided to assist students in organizaing data for analysis. The procedure followed in each method of instruction is described here:

Method of Instruction A (Deductive): The teacher presented the name and the definition of the concept to be learned to the students, writing them on the board so students could refer to them. Students were asked to copy the definition, clarifying any part about which they were uncertain. Students then examined a rational set of examples of the concept, (see appendices C and D) using a data retrieval chart (see appendices E and F) to record specific information about the example. Students then compared each non-example (see appendices C and D) to the definition, noting which critical characteristics were missing from each non-example. The process took place as a class discussion under teacher direction, with the teacher asking guiding and clarifying questions as deemed necessary by the teacher.

Method of Instruction B (Inductive): The students were not told the name or definition of the concept to be learned at the beginning of instruction. Instead, they were told they would be learning about "a particular kind of geographic area," in the case of "prairie," or "a particular kind of relationship," in the case of "interdependence." Students were given a rational set of examples (see appendices C and D) of the concept to be learned. They examined each example, recording specific information about each on the data retrieval chart (again, see appendices E and F). With teacher direction, students then considered all the examples, noting differences and similarities among them. From the similarities, each student wrote a tentative definition of the concept, specifying the relevant critical characteristics of the concept in the definition. The students shared their definitions, and a class definition, incorporating all individual attempts supported by the examples, was constructed. At this point, the teacher provided the name of the concept. Next, students were asked to examine a rational set of non-examples (see appendices C and D) of the concept, again using the data retrieval chart to record specific information. Students then compared the non-examples to the examples, noting similarities and differences between them. From the differences, they refined the concept definition as necessary. This process, under teacher direction, took place as a class discussion, with the teacher asking guiding and clarifying questions as deemed necessary by the teacher.[3]

Procedures

Random selection procedures were used to assign one of two methods of instruction (deductive or inductive) to each of the six classes for instruction on the first concept, "prairie." Each class then received

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[3]This strategy is essentially that outlined as the concept formation strategy in BASICS (Institute for Curriculum and Instruction, 1976).

the other method of instruction for the second concept, "interdependence." As a result of the random assignments, students in periods 2, 6, and 7 received inductive instruction on the concept of "prairie" and deductive instruction on the concept of "interdependence." The students in periods 3, 4, and 8 received deductive instruction on the concept of "prairie" and inductive instruction on the concept of "interdependence."

Because complete random assignment of students to methods of instruction was not possible (classes, not individual students, had been randomly assigned methods of instruction), a pretest was given prior to instruction. The data in this study were analyzed using a multiple regression design, and in multiple regression, any variable, such as a pretest, entered into the multiple regression equation, serves as a statistical control (Kerlinger and Pedhazur, 1973). The pretest for each concept (see appendices A and B) was given on the first day of instruction on the concept.

Following the pretest, which took ten to fifteen minutes, instruction as described above was presented on the concept for the remainder of the class period. Class periods were 45 minutes in length. On the second day, instruction was completed, using fifteen to twenty minutes of class time. The posttest was given in the remaining class time. In no case was a student unable to complete the posttest because of lack of time.

Instruction in this study was provided by the researcher. As part of her job with a project in the school, the researcher had done demonstration teaching in several different classrooms in the school the previous three years, for time periods ranging from a few days to several weeks. As such, most students had at one time or another been in a classroom where she was a visiting teacher. The students in this study were not told they were part of a research study. They were told the researcher would be teaching two concepts relating to their geography unit, and they would be tested over those concepts.

The total enrollment of the six classes was 140. One hundred twenty-six students were present for both days of instruction and testing on the concept of "prairie." Six of these students did not have Formal Operations Test scores, so their concept test scores were excluded from the study. This left 120 students whose concept test scores were considered as indicators of student achievement in learning the concept "prairie." Fifty-four of these received deductive instruction and sixty-six received inductive instruction. One hundred twenty-five students were present for both days of instruction and testing on the concept of "interdependence." Of these, eight did not have Formal Operations Test scores, so their concept test scores were excluded from the study. This left 117 students whose concept test scores were considered as indicators of student achievement in learning the concept "interdependence." Sixty-seven of these received deductive instruction and fifty received inductive instruction. The total 'n' of the study was 237.

Instruments Used in the Study

Three instruments were used in the study. A Formal Operations Test measured the independent variable of student level of development of operational thought. The posttest was used to measure the dependent variable of student achievement in concept formation. The pretest was used to measure student knowledge of the concept prior to instruction, as a control for non-random assignment of students.

Formal Operations Test

The Formal Operations Test was developed by Tomlinson-Keasey in 1975, and the scoring was modified by Santmire in 1976. The test was developed to provide a relatively quick determination of students' level of development of operational thought. Since it is a paper-pencil test, it can be administered to a group of students at one time. This makes it more convenient and practical for use in schools than the practice of using the "hands-on" tasks originally developed by Piaget and Inhelder, which required the tester tc talk with each subject as the subject attempted to complete the tasks. The Formal Operations Test consists of four Piagetian-style tasks, presented to the students as puzzles to be solved (see appendix I). The tasks in the test measure the student's ability to generate combinations, devise strategies, draw conclusions, perform critical tests, handle probability and correlation, separate variables, and hold one variable constant while testing another. These abilities are all mental operations which are involved in formal operational thought. For each puzzle, the student is asked to write his/her solution. In some cases, the student is asked to write a sentence explaining how he/she figured out the answer.

Student responses to the puzzles are scored on the basis of the solution the student gives for each puzzle and, in some cases, his/her written reason for the solution. For each puzzle, an indication of the thought process the student used in working the problem is sought, from the solution itself or from the reason the student wrote. Possible scores on each puzzle range from 0 to 3, with a score of 0 representing an unconsolidated concrete response, a score of 1 representing a concrete response, a score of 2 representing a transitional response, and a score of 3 indicating completely developed formal operations. The composite Formal Operations Test score for a student is the mean of the scores on each puzzle.

When any instrument is used as a measure of a variable, the issues of validity and reliability must be considered. Validity addresses the question, "Does this test measure what the investigator intends it to measure?" In the case of the Formal Operations Test, does the test actually measure a student's development of operational thought, or does it measure something else, such as math or reading skills? To judge the validity of this test (and according to Kerlinger (1973), content validity consists essentially of judgment), it is necessary to examine the work from which the concept for "formal operations" developed. Piaget described the stages of concrete and formal operations after watching and talking with children of varying ages as they solved, or tried to solve, problems or tasks. These problems or tasks ranged from the conservation tasks which determined concrete operations to the combination of chemicals task which required formal operations to solve. A detailed description of the tasks can be found in Inhelder and Piaget (1958) and Flavell (1963). From Piaget's work with children as they worked at the tasks, the levels of development were described. In turn, the tasks were then used to determine the level of development of other children.

In developmental research, the use of Piagetian-style tasks is frequently used as a measure of developmental growth in thinking. The tasks are presented to subjects in one of two ways. In many studies, (e.g., Bernstein and Cowan, 1975; Cometa and Eson, 1978; Damon, 1975) the tasks are presented individually to subjects, as Piaget and Inhelder presented them. In other studies, (e.g., Cloutier and Goldschmid, 1976) where a large number of subjects are to be tested in a group setting, the tasks are reduced to paper-pencil form, so they may be administered more easily. The Formal Operations Test is in the latter category. Its validity may be judged in that the tasks which are used to determine formal operations are of the same type as those used by Piaget to describe formal operations, and that the way in which the tasks are presented to students has been judged acceptable by other researchers in the field of developmental psychology.

Reliability of a measure refers to its dependability and consistency. It addresses the question, "If we measure the same set of objects again and again with the same instrument, will we get the same results?" Presuming no change in the objects being measured, an instrument which produces the most similar measurements each time it is applied is said to be the most reliable.

Two common techniques of measuring the reliability of an instrument are the test-retest and split-half methods (Bohrnstedt, 1970). In the test-retest method, the instrument, an IQ test, for example, is administered to a sample of a population at a point in time. At some time later, the instrument is administered to the sample again. Presuming no change in the actual IQ of the sample tested, an IQ test which shows no change is judged to be reliable. Reliability may also be determined by the split-half procedure. In this method, the scores on a random sample of half the items are correlated with the scores on the other half of the items. The stronger the correlation, the more reliable the instrument is. The assumption behind this procedure is that if all items are to be measuring the same thing, basic math facts, for example, there should not be significant differences in scores on the two halves of the test.

Reliability is difficult to determine for a developmental measure such as the Formal Operations Test. It is not valid to use a test-retest procedure because, unlike IQ, change is expected, and scores on a measure of development should change over time. Likewise, the split-half procedure is not valid because each item, or puzzle, is not designed to test the same thing; each item is constructed to test one or more specific mental operations that comprise formal operations. Since people develop these abilities separately, and in varying sequence, it would not be expected that an individual's responses to the puzzles would necessarily be consistent from item to item. The best indicator of reliability of developmental measures at this time is inter-rater reliability. That is, to what degree do two raters, both of whom are knowledgeable about what is being measured, agree on the score to be assigned to a particular response?

The Formal Operations Test was given to all students in the school where the study was conducted at the beginning of the 1978-1979 school year. The tests were scored by two graduate students in educational psychology, both of whom had worked with the test and scoring procedures in previous years.

Inter-rater reliability was established at .92.[4]

Posttest

The dependent variable, achievement in concept learning, was measured by the score (number correct) on the posttest. This test required the students to identify new examples and non-examples of the concept and state his/her reasons for identifying them as such (see appendices G and H). The test contained a mixed list of eight items, four examples and four non-examples of the concept. For both concepts, the test items were constructed by the investigator, using classroom materials and social studies reference books. Examples were selected which contained all the critical characteristics of the concept. Non-examples were selected which were missing one or more critical characteristic. So that the test score would represent more than a possible lucky guess on a yes-no question, the researcher added the

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[4]For a further discussion of reliability and validity of developmental measures, see a doctoral dissertation by P. Kolm, University of Nebraska-Lincoln, forthcoming.

question which asked the student to state his/her reasons for identifying the item as an example or non-example. This answer provided an indication of the extent of the students' learning of the critical characteristics of the concept.

For each item, the student was asked if the item was an example of the concept, and why or why not. Students were directed orally that if they answered that an item was an example of the concept, they must include all the reasons why it was in their answer to the "Why or why not?" question. In addition, they were told that if they identified an item as not being an example of the concept, they must include all the reasons why it was not in their answer to the "Why or why not?" question. Students were not told how many examples and non-examples were in the test.

The content validity of this test can be judged in two ways. First, this test was designed to measure achievement. Content validity of a test of achievement, given a definition of achievement and items which correspond to that definition, can be assumed (Kerlinger, 1973). The definition of achievement in concept learning which was used in this study was "the extent to which a student is able to identify new examples and non-examples of the concept, explaining the presence or absence of the critical characteristics which makes each item an example or non-example." Since the test items required students to demonstrate their knowledge of the concepts tests as specified in the definition of achievement in concept learning, the test may be judged a valid measure of achievement in concept learning. Nearly every study on concept learning has used a similar testing procedure. (See, for example, Klausmeier and Feldman, 1975; Markle and Tiemann, 1969; Swanson, 1972; Tennyson, Woolley and Merrill, 1972.)

The second judgment of the content validity of the test concerns the items themselves: are they truly examples and non-examples of the concepts being tested? Usually other competent "judges" should judge the content of the items (Kerlinger, 1973). A social studies teacher in the school in which the study was done, who had had a great deal of training and experience in teaching concepts, was asked to judge the content of the items. His comments and suggestions were considered as the items were written in final form for the posttest.

Reliability of each posttest was determined by the use of Cronbach's alpha reliability coefficient (Bohrnstedt, 1970), which essentially computes an overall correlation coefficient based on the computation of every possible split-half correlation.[5] The alpha coefficient for the posttest on the concept of prairie was .90. The alpha coefficient for the posttest on the concept of interdependence was .79.

The posttests were scored by the researcher in the week following the instruction. To be scored as correct, an example had to be identified as such, and all critical characteristics had to be included in the answer to the "Why or why not?" question. To be scored as correct,

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[5]For a brief, clear explanation of alpha reliability coefficient, see SPSS Update: New Procedures and Facilities for Releases 7 and 8, pp. 125-126.

non-examples had to be identified as such, and the missing critical characteristic(s) had to be identified in the answer to the "Why or why not?" question. The number of examples and non-examples scored correct was recorded as the measure of achievement in concept learning.

Pretest

The pretest for each concept was constructed in the same manner as the posttest. The alpha coefficient for the pretest on the concept of prairie was .62. The alpha coefficient for the pretest on the concept of interdependence was .79.

The pretests were scored by the researcher in the week following the instruction. The scoring criteria were the same as those for the posttests. The number of examples and non-examples scored correct was recorded as the measure of knowledge of the concept prior to instruction.

CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

The purpose of this study was to determine interactive and direct effects of method of instruction, level of development of operational thought, and type of concept on student achievement in concept formation. In this chapter the method by which the data were analyzed is described. The results of the tests of the hypotheses developed in chapter one are then reported and analyzed in terms of the variables specified in each hypothesis.

Method of Analysis

The data were analyzed through the use of multiple regression. Multiple regression was a desirable tool to use for the following reasons:

1. Four hypotheses posited an interaction among three independent variables. Multiple regression is an appropriate procedure to use to determine if such an interaction exists.

2. One independent variable (level of development of operational thought) is continuous; that is, scores on the Formal Operations test may assume any value from 0.0 to 3.0. Multiple regression allows the analysis of continuous data without breaking it down into categorical data. Thus, all variance found in the original data is retained.

3. Since class size varied, it was expected that there would be an unequal distribution of students between deductive and inductive teaching. While in a classical analysis of variance design this would pose severe problems, in a multiple regression design the problem is negligible.

4. Multiple regression allows the consideration of control variables as well as independent and dependent variables. Since it was not possible to assign students randomly to treatment groups, it was important in this study to consider prior knowledge of the concept to be learned (as indicated by pretest scores) as a control variable.

5. Multiple regression allows analysis of the direct, as well as the interactive, effects of the variables. Such an analysis is not possible using a classical analysis of variance design.

The full regression model with interactions is:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_1x_2 + b_6x_1x_3 + b_7x_2x_3 + b_8x_1x_2x_3 + e$$

where. . .

y is posttest score	interval discrete, range = 0 to 8
x_1 is method of instruction	x_1 = 0 if deductive x_1 = 1 if inductive
x_2 is level of development of operational thought	interval continuous, range = 0.0 to 3.0
x_3 is type of concept	x_3 = 0 if concrete x_3 = 1 if abstract
x_4 is pretest score	interval discrete, range = 0 to 8

and. . .

x_1x_2 is interaction between method of instruction and level of development of operational thought.

x_1x_3 is interaction between method of instruction and type of concept

x_2x_3 is interaction between level of development of operational thought and type of concept

$x_1x_2x_3$ is interaction among method of instruction, level of development of operational thought, and type of concept

e is error term, which contains the effects of all other variables not specified in the equation.

The first step in the analysis of the data was the determination of whether or not there was statistically significant interaction among the variables. To make this determination, the full regression model, as shown in the above equation, was compared to a reduced model, from which the interaction terms had been deleted. The difference between the explained variance of the two models was then examined. With degrees of freedom of 8,228, the F-ratio for the difference between the two models was 7.5805, which is significant at the .001 level. This indicated the presence of statistically significant interaction.

Having determined the presence of statistically significant interaction in the model, a second level of analysis was performed to identify which of the four possible interactions were significant. The four possible interactions were the ones specified as interaction hypotheses in chapter one:

1. There is no interaction among the variables of method of instruction, level of development of operational thought, and type of concept with respect to student achievement in concept formation.

2. There is no interaction between the variables of method of instruction and level of development of operational thought with respect to student achievement in concept formation.

3. There is no interaction between the variables of

method of instructional and type of concept with respect to student achievement in concept formation.

4. There is no interaction between the variables of level of development of operational thought and type of concept with respect to student achievement in concept formation.

In this analysis, the full regression model was compared to a series of reduced models. In each reduced model, the interaction term being tested was deleted from the full model. The results of this analysis are shown in Table 1. The F-ratio for the interaction of method of instruction and type of concept was 6.8927, which was significant at the .001 level. The other three interactions were not statistically significant.

TABLE 1
CONCEPT POSTTEST SCORES: TEST OF INTERACTION HYPOTHESES USING MULTIPLE REGRESSION

Variable	df	b	F-Ratio	Level of Significance
Interaction of Method of Instruction, Level of Development of Operational Thought, and Type of Concept	4,228	-0.8112	.5047	ns
Interaction of Method of Instruction and Level of Development of Operational Thought	4,228	0.8067	.9942	ns
Interaction of Method of Instruction and Type of Concept	4,228	4.2670	6.8927	.001
Interaction of Level of Development of Operational Thought and Type of Concept	4,228	-0.6270	.6172	ns

At the third level of analysis, the interactions which were not statistically significant were dropped from the regression model, leaving a revised full regression model of:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_1x_3 + e$$

where. . .

y is posttest score	interval discrete, range = 0 to 8
x_1 is method of instruction	x_1 = 0 if deductive x_1 = 1 if inductive
x_2 is level of development of operational thought	interval continuous, range = 0.0 to 3.0
x_3 is type of concept	x_3 = 0 if concrete x_3 = 1 if abstract
x_4 is pretest score	interval discrete, range = 0 to 8

and. . .

x_1x_3 is interaction between method of instruction and type of concept

e is error term, which contains the effects of all other variables not specified in the equation.

The revised full model was examined to determine the strength of the significant interaction and the level of significance of each of the variables as direct effects. This was accomplished by comparing the revised full model to a series of reduced models. In each reduced model, one variable had been deleted. The results of this analysis are shown in Table 2. The F-ratio for the interaction of method of instruction and type of concept was 25.3561, which was statistically significant at the .001 level. The F-ratios for each of the three independent variables as direct effects were as follows: method of instruction, 35.2052; level of development of operational thought, 24.5202; type of concept, 15.4617. Each of these was significant at the .001 level. The pretest, which had been included as a control variable because of lack of random assignment of students, was not statistically significant.[6]

TABLE 2

CONCEPT POSTTEST SCORES: TEST OF REVISED MODEL USING MULTIPLE REGRESSION

Variable	df	b	F-Ratio	Level of Significance
Interaction of Method of Instruction and Type of Concept	1,231	3.1952	25.3561	.001
Method of Instruction	1,231	-2.6244	35.2052	.001
Level of Development of Operational Thought	1,231	1.4142	24.5202	.001
Type of Concept	1,231	-1.7478	15.4617	.001
Pretest	1,231	.1376	.3199	ns

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[6]For a complete discussion of multiple regression analysis, see Kerlinger and Pedhazur, 1973 or Statistical Package for the Social Sciences, 1975, p. 320-342.

Analysis of Data Related to Hypotheses

In the following sections, the statistics relating to each of the hypotheses are presented. For purposes of presenting the data, the continuous variable of level of development of operational thought has been reduced to categorical data. Student scores on the Formal Operations test have been grouped into four categories: scores of less than 0.8 which generally represent an early concrete development; scores between 0.8 and 1.49, which generally represent concrete development; scores between 1.5 and 2.24, which generally represent a transition between concrete and formal operations; scores of 2.25 and above, which generally represent substantial development toward formal operations. The reader is reminded that the Formal Operations test scores were analyzed as continuous data; they are presented as categorical data for the purpose of clarity.

Interaction of Method of Instruction, Level of Development of Operational Thought, and Type of Concept

Hypothesis 1. There is no interaction between the variables of method of instruction, level of development of operational thought, and type of concept with respect to student achievement in concept formation.

The research hypothesis tested by this null hypothesis posited an interaction among the three variables with respect to student achievement in concept formation. A breakdown of student posttest scores by all three variables is shown in Table 3. While there are differences in the test scores, with respect to each of the three independent variables, the interaction among the three variables, as shown by the F-statistic in Table 1, is not statistically significant. The null hypothesis cannot be rejected.

TABLE 3

CONCEPT POSTTEST SCORES ACCORDING TO LEVEL OF DEVELOPMENT OF OPERATIONAL THOUGHT, METHOD OF INSTRUCTION, AND TYPE OF CONCEPT

Level of Development of Operational Thought	Method of Instruction	Type of Concept	Mean Score	Standard Deviation	N
Less than 0.8	Deductive	Concrete	6.30	1.25	10
		Abstract	3.41	1.84	22
	Inductive	Concrete	2.40	2.82	20
		Abstract	4.40	3.13	10
0.8 to 1.49	Deductive	Concrete	5.00	2.09	22
		Abstract	5.20	2.40	20
	Inductive	Concrete	2.57	2.52	21
		Abstract	5.33	2.17	18
1.50 to 2.24	Deductive	Concrete	7.42	1.02	19
		Abstract	4.42	2.70	24
	Inductive	Concrete	4.96	3.25	25
		Abstract	5.16	2.34	19
2.25 and Above	Deductive	Concrete	7.67	0.58	3
		Abstract	4.00	0.00	1
	Inductive	Concrete	--	--	0
		Abstract	6.00	1.73	3

Interaction of Method of Instruction and Level of Development of Operational Thought

Hypothesis 2. There is no interaction between the variables of method of instruction and level of development of operational thought with respect to student achievement in concept formation.

The research hypothesis tested by this null hypothesis posited an interaction between the variables of method of instruction and levels of development of operational thought. Specifically, theories developed by Piaget and described by Elkind would suggest that students with a higher level of operational development would be more able to learn from inductive teaching than students at a lower level of operational development. Those same theories would suggest that students at all levels of operational development, from concrete to formal, could learn equally well from deductive teaching.

The data related to this hypothesis are displayed in Table 4 and Figure 1. In Table 4, posttest scores are broken down according to level of development of operational thought and method of instruction. For students at an early concrete level of development, those who received deductive instruction had a mean score of 4.31, while those who received inductive instruction had a mean score of 3.07. The mean score for students at a concrete level of development was 5.10 for those who had deductive instruction and 3.85 for those who had inductive instruction. At the transitional level of development, those students who received deductive instruction had a mean score of 5.74, and those who received inductive instruction had a mean score of 5.05. Those students at or nearly at a formal operational level of development had mean scores of 6.75 and 6.00, respectively, for deductive and inductive instruction. A general statement can be made that students at higher levels of operational development were more successful in concept formation, as measured by posttest scores, than students at lower levels of development. In addition, regardless of the level of operational development, students were more successful in learning the concept when taught deductively than when taught inductively.

TABLE 4

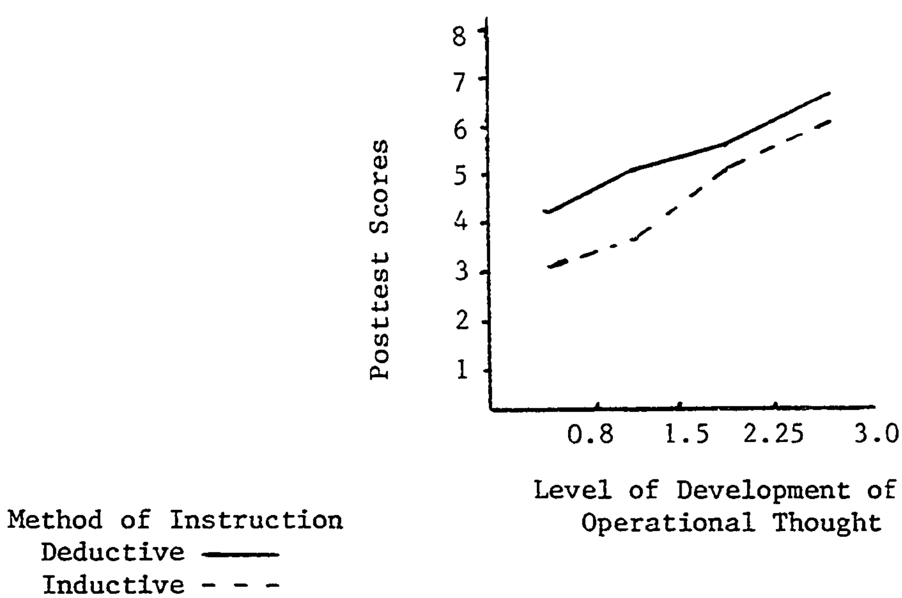
CONCEPT POSTTEST SCORES ACCORDING TO LEVEL OF DEVELOPMENT OF OPERATIONAL THOUGHT AND METHOD OF INSTRUCTION

Level of Development of Operational Thought	Method of Instruction	Mean Score	Standard Deviation	N
Less than 0.8	Deductive	4.31	2.15	32
	Inductive	3.07	3.03	30
0.8 to 1.49	Deductive	5.10	2.22	42
	Inductive	3.85	2.72	39
1.5 to 2.24	Deductive	5.74	2.59	43
	Inductive	5.05	2.86	44
2.25 and Above	Deductive	6.75	1.89	4
	Inductive	6.00	1.73	3

The relationship of the variables of level of development of operational thought and method of instruction to the concept posttest scores can be seen more clearly in the graph in Figure 1. Those students who were at a higher level of development were more successful in learning inductively than the students at lower levels of development. The same statement can be made, however, for deductive teaching. For students at all levels of development, posttest scores were higher when the students were taught deductively than when they were taught inductively. The difference in achievement between the two methods is less for students of higher operational development than for students of lower operational development. It is possible that students who are at higher levels of development of operational thought are more easily able to adapt to different methods of instruction than students at lower levels of development.

FIGURE 1

RELATIONSHIP OF CONCEPT POSTTEST SCORES TO LEVEL OF DEVELOPMENT OF OPERATIONAL THOUGHT BY METHOD OF INSTRUCTION



The data would suggest each of the two variables may be a significant direct effect in concept learning, but, as the F-statistic in Table 1 shows, there is no statistically significant interaction between the variables of method of instruction and level of development of operational thought. The null hypothesis cannot be rejected.

Interaction of Method of Instruction and Type of Concept

Hypothesis 3. There is no interaction between the variables of method of instruction and type of concept with respect to student achievement in concept formation.

The research hypothesis tested by this null hypothesis posited an interaction between the two variables. Specifically, from Glaser's description of concepts which are "intricate to verbalize" (1968, p. 27) it was suggested that abstract concepts would be learned more easily from inductive instruction while concrete concepts would be learned more easily from deductive instruction.

The F-statistic for this interaction variable, as shown in Table 1, indicates this interaction is statistically significant in student achievement in concept formation. The data displayed in Table 5 and Figure 2 reveal the nature of the interaction. As shown in Table 5, deductive instruction was more effective for the concrete concept (mean posttest score of 6.24) than for the abstract concept (mean posttest score of 4.31). The reverse was true for inductive instruction, which was more effective for the abstract concept (mean posttest score of 5.12) than the concrete concept (mean posttest score of 3.42).

TABLE 5

CONCEPT POSTTEST SCORES ACCORDING TO METHOD OF INSTRUCTION AND TYPE OF CONCEPT

Method of Instruction	Type of Concept	Mean Score	Standard Deviation	N
Deductive	Concrete	6.24	1.90	54
	Abstract	4.31	2.40	67
Inductive	Concrete	3.42	3.10	66
	Abstract	5.12	2.40	50

The interaction is displayed graphically in Figure 2. For the concrete concept, "prairie," deductive instruction was more effective than inductive teaching with respect to student achievement in concept learning. For the abstract concept, "interdependence," the reverse was true. Inductive teaching was more effective than deductive teaching with respect to student achievement in concept formation.

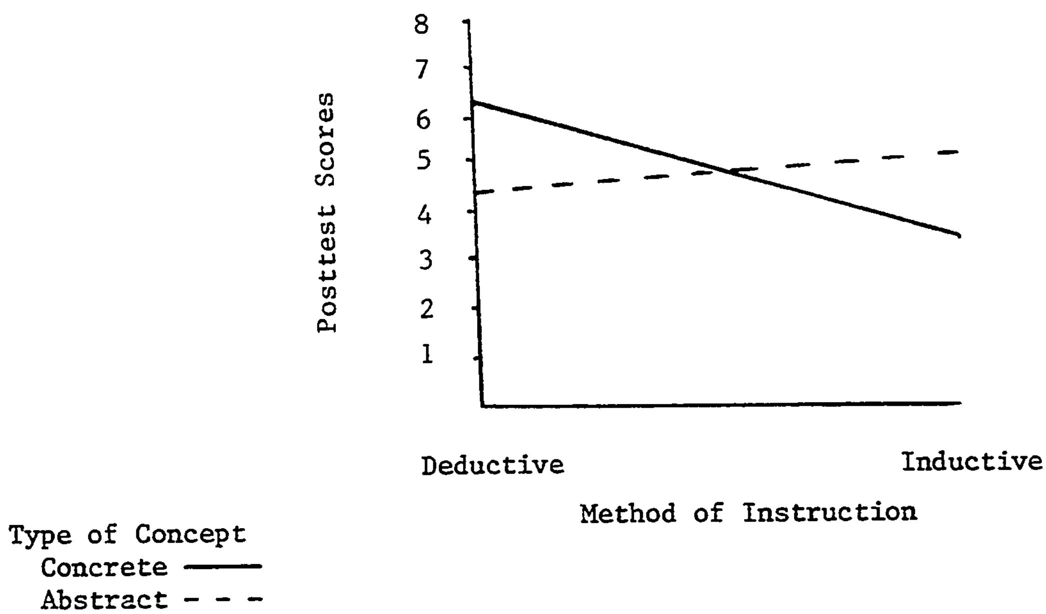
Interaction of Level of Development of Operational Thought and Type of Concept

Hypothesis 4. There is no interaction between the variables of level of development of operational thought and type of concept with respect to student achievement in concept formation.

The research hypothesis tested by this null hypothesis posited an interaction between the variables of level of development of

FIGURE 2

RELATIONSHIP OF CONCEPT POSTTEST SCORES TO METHOD OF INSTRUCTION BY TYPE OF CONCEPT



operational thought and type of concept. Specifically, the work of Piaget suggests that students of lower levels of development of operational thought may be more successful at learning concrete concepts than abstract concepts because of the precise, empirical nature of the concrete concepts. In addition, abstract concepts may be more easily learned by students of higher levels of development of operational thought than students of lower levels of development, because of the less precise nature of abstract concepts.

The data related to this hypothesis are displayed in Table 6 and Figure 3. In Table 6, mean scores are broken down according to type of concept and level of development of operational thought. In learning the concrete concept, students at an early concrete level of development had a mean score of 3.70; students at a concrete level of development had a mean score 3.81; students at a transitional level of development had a mean score of 6.02, and students at or nearly at a formal operational level of development had a mean score of 7.67. For the abstract concept, the mean posttest scores were 3.72, 5.26, 4.74, and 5.50 for the four levels of development of operational thought.

TABLE 6

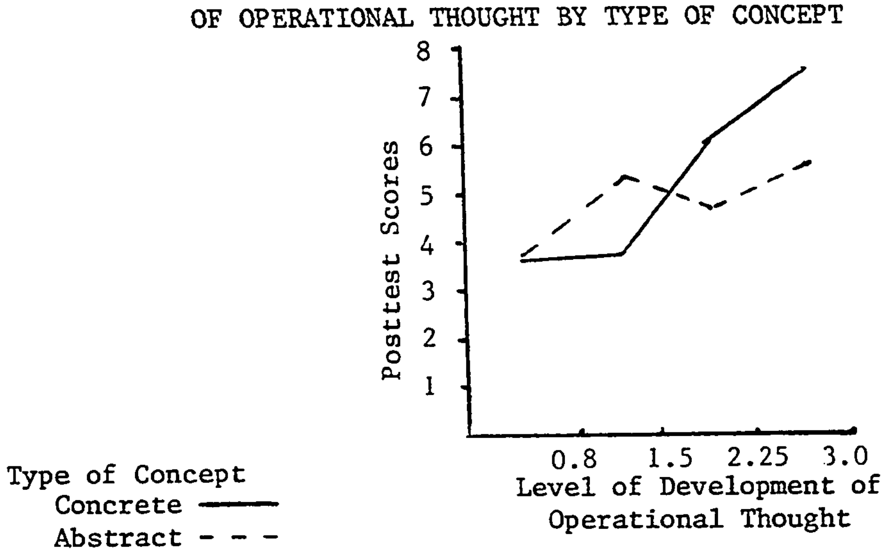
CONCEPT POSTTEST SCORES ACCORDING TO TYPE OF CONCEPT AND LEVEL OF DEVELOPMENT OF OPERATIONAL THOUGHT

Type of Concept	Level of Development of Operational Thought	Mean Score	Standard Deviation	N
Concrete	Less than 0.8	3.70	3.03	30
	0.8 to 1.49	3.81	2.59	43
	1.5 to 2.24	6.02	2.80	44
	2.25 and Above	7.67	0.58	3
Abstract	Less than 0.8	3.72	2.32	32
	0.8 to 1.49	5.26	2.26	38
	1.5 to 2.24	4.74	2.55	43
	2.25 and Above	5.50	1.73	4

The relationship of the variables of type of concept and level of development of operational thought to posttest scores is shown graphically in Figure 3. The graph indicates an interaction, though not in the direction anticipated from the literature. Those students of lower operational development, particularly those whose scores on the Formal Operations test fall between 0.8 and 1.49, were more successful in learning the abstract concept than they were in learning the concrete concept, while students at higher levels of operational development were more successful in learning the concrete concept than they were in learning the abstract concept. Although an interaction is indicated by the graph, the interaction is not statistically significant, as shown in Table 1. As such, the null hypothesis cannot be rejected.

FIGURE 3

RELATIONSHIP OF CONCEPT POSTTTEST SCORES TO LEVEL OF DEVELOPMENT OF OPERATIONAL THOUGHT BY TYPE OF CONCEPT



Method of Instruction

Hypothesis 5. Method of instruction does not affect student achievement in concept formation.

The data related to this direct effect hypothesis are displayed in Table 7. Holding all other variables constant, deductive instruction is a more effective method of instruction for concept formation than inductive instruction, with respect to student achievement in learning the concept. As shown in Table 2, this is a statistically significant finding, and the null hypothesis is rejected.

It should be noted that the variable of method of instruction is part of a statistically significant interaction, and conclusions about the direct effect of method of instruction cannot appropriately be drawn without reference to the interaction.

TABLE 7

CONCEPT POSTTEST SCORES ACCORDING TO METHOD OF INSTRUCTION

Method of Instruction	Mean Score	Standard Deviation	N
Deductive	5.17	2.38	121
Inductive	4.15	2.93	116

Level of Development of Operational Thought

Hypothesis 6. Level of development of operational thought does not affect student achievement in concept formation.

The data related to this direct effect hypothesis are displayed in Table 8. Holding all other variables constant, the more highly developed a student is in operational thought, the more successful he/she is in learning concepts. As shown in Table 2, this is a statistically significant finding, and the null hypothesis is rejected.

TABLE 8

CONCEPT POSTTEST SCORES ACCORDING TO LEVEL OF DEVELOPMENT OF OPERATIONAL THOUGHT

Level of Development of Operational Thought	Mean Score	Standard Deviation	N
Less than 0.8	3.71	2.66	62
0.8 to 1.49	4.49	2.53	81
1.5 to 2.24	5.39	2.74	87
2.25 and above	6.43	1.72	7

Type of Concept

Hypothesis 7. Type of concept does not affect student achievement in concept formation.

The data related to this direct effect hypothesis are displayed in Table 9. Holding all other variables constant, students were more successful in learning the concrete concept than in learning the abstract concept. As shown in Table 2, this is a statistically significant finding, and the null hypothesis is rejected.

TABLE 9

CONCEPT POSTTEST SCORES ACCORDING TO TYPE OF CONCEPT

Type of Concept	Mean Score	Standard Deviation	N
Concrete	4.69	2.98	120
Abstract	4.66	2.43	117

It should be noted that the variable of type of concept is part of a statistically significant interaction, and conclusions about the direct effect of type of concept cannot appropriately be drawn without reference to the interaction.

CHAPTER 5

CONCLUSIONS

This chapter is composed of five sections. In the first, the context, problem and procedures of the study are summarized. The findings of the study are summarized in the second section, and instructional implications of the findings are suggested in the third. The fourth section describes observations which the researcher made as she was doing the experimental teaching. These observations were related to, but not a part of, the study. In the fifth section, several issues and questions raised by the study are explored.

Summary of the Study

Concept formation refers to the process of categorizing and determining the critical attributes of a group of stimuli. This process has important implications for formal education in general and social studies education in particular. Concepts help make sense of a complex environment, by organizing and structuring vast amounts of information. A framework of concepts from several social science disciplines gives students an opportunity to process information and events from several perspectives. Concepts are linked together to describe, explain and/or predict various aspects of human behavior. Knowledge of some concepts would seem to be a prerequisite for constructive citizenship.

This research began as an attempt to determine the effect of different teaching methods on student achievement in concept formation. As the literature was reviewed, it became apparent that two additional variables should be considered for their effect on student achievement in concept formation: level of development of operational thought of the student, and type of concept to be learned.

The Problem

This study was designed to investigate the interactive and direct effects of method of instruction, level of development of operational thought of the student, and type of concept on student achievement in concept formation.

Hypotheses

The following null hypotheses were investigated in this study:

Null: There is no interaction among the variables of method of instruction, level of development of operational thought, and type of concept with respect to student achievement in concept formation.

Null: There is no interaction between the variables of method of instruction and level of development of operational thought with respect to student achievement in concept formation.

Null: There is no interaction between the variables of method of instruction and type of concept with respect to student achievement in concept formation.

Null: There is no interaction between the variables of level of development of operational thought and type of concept with respect to student achievement in concept formation.

Null: Method of instruction does not affect student achievement in concept formation.

Null: Level of development of operational thought does not affect student achievement in concept formation.

Null: Type of concept does not affect student achievement in concept formation.

Procedure

Students in six intact ninth grade social studies classes were the subjects of the study. Scores on the Formal Operations test, a series of Piagetian-type tasks which measure level of development of operational thought, were available for each student from school records.

Students received instruction on two concepts, one concrete and one abstract. The concrete concept (prairie) was taught first, and the abstract concept (interdependence) was taught two days later. The concepts were selected because they were related to the geography unit the students were studying at that time, they had been identified by the classroom teacher as concepts normally taught in ninth-grade social studies, and they had been identified as important geographic concepts in the literature.

Each class was randomly assigned one of two methods of instruction (deductive or inductive) for the first concept, "prairie." Each class received the other method of instruction for the second concept, "interdependence." Three classes received deductive instruction on the concept of "prairie" and inductive instruction for the concept of "interdependence." Three classes received inductive instruction on the concept of "prairie" and deductive instruction on the concept of "interdependence." Instruction was provided by the researcher.

A written pretest was given to determine prior knowledge on each concept. A written posttest was given immediately following instruction of each concept to determine student achievement in learning that concept.

Multiple regression was used in analyzing the data to determine the presence of interactive or direct effects.

The 'n' of the study was 237.

Summary of Findings

An analysis of the data resulted in these findings related to the hypotheses posed in chapter 1.

1. There is no significant interaction among method of instruction, level of development of operational thought, and type of concept with respect to student achievement in concept formation.

2. There is no significant interaction between method of instruction and level of development of operational thought with respect to student achievement in concept formation. Students at higher levels of development showed greater achievement in concept formation regardless of method of instruction than students at lower levels of development of operational thought.

3. There is a significant interaction between method of instruction and type of concept with respect to student achievement in concept formation. For the concrete concept, students' achievement as measured by the posttest was greater when deductive instruction was used than when inductive instruction was used. For the abstract concept, student achievement was greater when inductive instruction was used then when deductive instruction was used.

4. There is no significant interaction between level of development of operational thought and type of concept. An interaction is

indicated by the data as shown in Figure 3 in chapter 4, but the interaction is not statistically significant.

5. Method of instruction dces affect student achievement in concept formation. If other variables are controlled, deductive instruction is more effective with respect to student achievement in concept formation than inductive instruction. This variable is part of a significant interaction, however, and should not be considered as a direct effect apart from the interaction.

6. Level of development of operational thought does affect student achievement in concept formation. The higher a student's level of development of operational thought, the higher his/her achievement in concept formation.

7. Type of concept does affect student achievement in concept formation. If other variables are controlled, students are more successful in learning concrete concepts than abstract concepts. This variable is part of a significant interaction, however, and should not be considered as a direct effect apart from the interaction.

Instructional Implications

Two implications for instruction are suggested by the findings of this study. The first is related to the finding that there is a statistically significant interaction between method of instruction and type of concept. In terms of student achievement on a concept test, deductive instruction is most effective for concrete concepts and inductive instruction is most effective for abstract concepts. The instructional implication is fairly obvious: teacher selection of the method of instruction to use in teaching a new concept should include consideration of the type of concept to be learned. This suggests that teachers need to be able to use the two methods of instruction, and they need to be able to distinguish between type of concepts.

The two methods of instruction studied in this research are fairly straight-forward and frequently-used teaching methods. The deductive method, in particular, is that kind of teacher-directed, recitation-discussion method, with which most teachers are familiar and comfortable. The inductive method requires more sophistication of the teacher's questioning skills, as the teacher must be able to follow student responses with questions which clarify, redirect, narrow the focus, or whatever is necessary and appropriate. Many teachers have these skills; for those who do not, school districts and colleges of education usually provide inservice or courses that deal in part with questioning skills.

In addition to using the two methods of instruction, teachers need to be able to distinguish between types of concepts. There are many concepts which are clearly concrete: they tend to be objects or persons, with specific, easily-noted, observable characteristics. Likewise, there are many concepts which are clearly abstract: they tend to be events or ideas, with characteristics which are rather nebulous and not observable. Many, perhaps most, concepts which teachers choose to teach will fit easily into one category or the other. Inevitably, some will not. In those instances, the teacher must depend on his/her professional judgment as to which type of concept it is most like.

The second instructional implication is related to the finding that holding all other variables constant, the higher a student's level of development of operational thought, the higher his/her achievement in concept formation. This finding suggests that if all students are expected to achieve a designated level of mastery in learning a new concept, students of lower levels of operational development are likelier to need more instruction and practice than students of higher levels of development. If a designated level of mastery is desired, the teacher would need to prepare additional instructional and practice materials for those students who do not achieve mastery after one instructional session. The difference in achievement because of differing levels of development of operational thought would also seem to have implications for teacher expectations and grading of students.

Related Observations

The researcher observed, as she was doing the inductive teaching, that it was much more difficult for students to notice similarities than to notice differences. This was particularly true when students were asked to notice similarities among a group of items, rather than between two items. Often, in response to the question "What are some ways all these areas are alike?" several students would respond with differences before any would name a similarity. It was frequently necessary for the researcher to ask more specific questions, such as "What similarities do you notice about the rainfall of these four areas?" before students were able to respond with specific similarities.

Since noting similarities among a group of stimuli is the very heart of concept formation, whether in school or in the "real world," the difficulty students, or at least these students, have in identifying similarities is a concern. It may be that students have had more practice in noting differences. It may be that noting similarities is a function of cognitive development. Whatever the reason, it would seem that the skill of noting similarities is difficult for many students, and teachers should be aware of that.

Whether or not practice will increase a student's ability to note similarities depends on the nature of the skill. If noting similarities is a function of cognitive development, then practice will not be effective unless the student has reached whatever level of cognitive development is necessary. However, Piaget (Flavell, 1973) describes concrete operations as a time when children organize the real-life concepts of their world, by noting the way things are alike. It is reasonable to conclude, then, that students who are concrete operational or higher have the cognitive structures to note similarities. Since most students in upper elementary and secondary schools are concrete operational or higher, their difficulty in noting similarities is more likely to be a function of lack of practice in the skill than cognitive ability to do the skill. It may be helpful to students if practice situations for noting similarities are provided.

A second observation made by the researcher as she was teaching the two concepts was that classroom management seemed to be more difficult when students were asked to learn inductively than when they were asked to learn deductively. During inductive teaching, there seemed to be more off-task behavior, with some students talking to each other, interrupting or ignoring whoever was speaking, or withdrawing from the class by reading or writing letters or notes. In addition to the off-task behavior, there seemed to be a longer period of time between directions being given and students starting to work when the instruction was inductive than when it was deductive.

A large measure of the off-task behavior and time lapse in beginning to work may be explained by a related observation: the students seemed much less sure of the pattern of instruction, and specifically of what they were expected to do, when instruction was inductive rather than deductive. They seemed quite comfortable learning deductively: they were given a definition, some situations against which to apply the definition, and then a test situation. During this instruction, the students frequently anticipated the next step, and seemed to know what was happening. Such was not the case during inductive instruction. Students seemed confused about the process, and someone would usually say, sometime during the discussion, something like "Why don't you just tell us the definition for these kinds of areas?" Most students were willing to try to do as requested, but the process of the instruction seemed to cause them more trouble than the content of the concept. Indeed, the process may have distracted them from the content.

This raises the process vs. content question, which is an ever-present one in education. It is not the purpose of this study to address that specific issue. However, the observations of the researcher suggest that a trade-off is involved, either with respect to achievement, as in the case of the concrete concept, or with respect to classroom management, in the case of either concept, if inductive teaching is selected because it more nearly parallels the natural process of concept formation.

It should be noted that a contributing factor to the frustration experienced by many students with inductive teaching may have been their relative unfamiliarity with that teaching method. In spite of the "new" social studies, and the emphasis by much of the professional literature on inquiry teaching and learning, the fact remains that most social studies education continues to be content-oriented, with a great amount of information-giving and directing by the teacher. As a result, students truly are more accustomed to learning concepts in social studies by being told the definition than by "discovering" it. It may be that the frustration with inductive learning was not related to the specific characteristics of the method of teaching, but to the newness of the situation. If that is so, repeated exposure to both methods of instruction should result in students being familiar with each, and teachers being able to select a method of instruction based upon its appropriateness for the material, not its likelihood of causing or not causing classroom management difficulties.

It may also be that, for students of a lower level of development of operational thought, particularly those whose scores on the Formal Operational test were less than 0.8, frustration with inductive learning was a result of being asked to do something they were not cognitively capable of doing. It is difficult for students at a concrete level of development to work with more than one variable at a time. In the situation where students were asked to learn the concept "prairie" inductively they needed to be able to respond to at least five specific variables with respect to four areas at one time. Clearly, this would have been beyond the cognitive capabilities of some students, and frustration would be a logical result for some of them.

A third observation of the researcher is related to the findings of Tennyson, Steve and Boutwell (1975). They found that supporting concept instruction with analysis and/or strategy statements increased student achievement in concept formation. In this study, students were given data retrieval charts to use in examining the examples and non-examples. The charts enabled students to focus on the information in the items in a consistent and systematic manner. There was no intent in the study to assess the effectiveness or usefulness of the data retrieval charts, but the researcher observed that all students were able to use the charts and that the charts appeared to help students to organize the information.

A final observation of the researcher was that students seemed to have a great deal of difficulty in making concluding statements. In some respects, this difficulty is related to the earlier comments about difficulties with noting similarities. In the classes where inductive teaching was used, students were asked to notice first the differences, then the similarities of the examples, then make a concluding statement that included all the similarities and excluded all the differences. Most students had some difficulty with the concluding statement; very few were able to write a statement which included all the similarities and no differences.

Students in these classes were given a sentence stem and asked to use it to begin their concluding statement. For the concept "prairie," the sentence stem was "These are all areas of the world which...." Even with the sentence stem, many students appeared confused about the content of the statement they were to write. Some students responded with inaccurate statements, such as "These are all areas of the world which have the same kind of grass." Others responded by finishing the statement accurately but not completely. Though directed to write a concluding statement that included all the similarities among the items, many students wrote statements which included just one or two of the similarities, such as "These are all areas of the world which receive 20 to 40 inches of rainfall each year."

By asking clarifying and focusing questions, the researcher elicited from the various members of the class that information which should have been included in the concluding statement. By combining several students' responses, the class was able to construct, by the end of the instructional period, a concluding statement which included all the similarities and none of the differences. Each student then wrote that statement, so each student had access to it for the next phase of instruction.

Because each student did eventually have a complete concluding statement, it is unlikely that the difficulty students had in drawing conclusions had an effect on their eventual achievement in learning the concept. But because drawing conclusions is widely held to be an important social studies skill, there is some concern that these ninth grade students had a great deal of difficulty in doing this. The difficulty seemed to be two-fold: first, a lack of understanding of what was meant by a conclusion or a summary statement; second, when given more specific direction about what such a statement should include, an inability to construct that statement accurately and completely.

The difficulty students experienced with this task may be because their cognitive development was not sufficient for the task, or it may be because they haven't had sufficient instruction and practice in the skill of drawing conclusions. It's possible that drawing conclusions is a skill that requires a person to be formal operational to be able to do it, but it seems more likely that drawing conclusions is an extension of noting similarities, and can therefore be done by students who are concrete operational. If this is the case, it is reasonable to conclude from these students' behavior that the ability to draw conclusions doesn't just happen; students need both instruction and practice in order to be able to draw conclusions.

Questions and Issues

During the course of this study, several questions and issues arose, some related directly, some only incidentally, to the study itself. In this section, these questions and issues are explored, not with the intent of suggesting definite solutions, but with the hope of stimulating further thought and consideration.

The first issue has to do with the purpose or value of selecting an inductive teaching method, or any teaching method which asks students to replicate a thinking process used in the "real world," where people don't learn just from books. These comments about inductive teaching, therefore, may be applicable to inquiry teaching, the scientific method, and simulations as well. Two major arguments are often advanced for inductive or inquiry teaching. First, students will learn the content better if they figure the answers out for themselves, rather than if they are told the answers by a teacher or a book. Second, they will learn a "process" of learning, which, if practiced often enough, will be theirs for life, whether they remember the content or not.

This study addresses the first of these two arguments, although, as is often true of educational research, the findings are not necessarily what they appear to be on the surface. In response to the question, "Do students learn concepts better if they figure out the definitions for themselves?" the answer from this study is at best a definite, "Sometimes." In a straight comparison of achievement of those students taught deductively with those students taught inductively, inductive teaching appears to be less effective. A further analysis, though, shows that initial comparison to be somewhat simplistic. Depending on the type of concept to be learned, either method of instruction may or may not be more effective than the other. Hence, the definite, "Sometimes." For abstract concepts, inductive instruction is indeed more effective, in terms of student achievement, than deductive instruction. For concrete concepts, however, the results are reversed.

The second argument often advanced in favor of inductive teaching, that students will learn the process of concept formation, as well as the content of the concept, was not addressed by this study. This argument raises a number of interesting questions. Do students realize they are learning a process, as well as the concept? Can concrete operational students consciously learn a complex thinking process? Do students learn a process by doing it several times, or do they need direct instruction on the process? If students have used a process once, or twice, or several times, will they be able to recognize the next appropriate learning situation for that process? That is, can students generalize the process from one lesson to the next, from in-school to out-of-school learning?

A wealth of literature exists on thinking skills and process skills in the social studies (e.g., Fair and Shaftel, 1967; Fair, 1977; Fraenkel, 1980). Much of this consists of specific exercises to be done in classrooms to help students practice these skills and processes. It would seem important to address three additional questions. First, what level of cognitive development is necessary to internalize these processes? Second, is direct instruction, or just practice, necessary for learning these processes? Third, what are effective techniques for helping students generalize a learned process from one situation to the next?

A second issue relates to the finding that for concrete concepts, deductive instruction is more effective, in terms of student achievement, than inductive instruction. The issue arises when this finding is juxtaposed with the theories of Piaget (as described by Elkind, 1974 and Flavell, 1977) about how children form concepts outside of school. Specifically, that theory suggests children learn concepts naturally in an inductive manner. For example, a child learns the concept "dog" by encountering many different animals, labeled by someone as "dog," and gradually sorting out those characteristics which all dogs share. This process is much more like the inductive instructional method tested in this study than the deductive method; few children learn the concept "dog" by first learning a definition, and then being shown a collection of dogs followed by a collection of non-dogs. Yet in the classroom setting, students showed greater achievement in learning a concrete concept when they had been taught deductively than when they were taught inductively.

This seeming paradox may be examined in the light of two considerations. First, it's possible that a time factor may be involved in this finding. While a child is learning the concept "dog" in his/her environment outside the school, there is no specific time line to be followed. The child may spend several weeks, months, or years forming the concept in a rather haphazard manner. This is obviously not the case in school, when direct instruction on a particular concept usually occupies only a few class periods. It is possible that this compression of time in which the concept is to be learned accounts for the difference in learning concrete concepts in school and outside of school.

A second possibility for this paradox may be the nature of the concept itself. The issue here is not whether the concept is concrete or abstract, because both "dog" and "prairie" are concrete concepts, but whether or not the examples of the concept are part of the child's daily environment. Most children, at least those in the United States, see many examples of "dogs" in their environment and hear people talk about and refer to dogs. The same is not true of "prairie;" even those children who may live on land which in its natural state is a prairie may not see the land in its natural state, and they probably will not often hear of land being referred to as a prairie. This suggestion, that the difference is in the concept itself, even though both are concrete concepts, is in accordance with Vygotsky's work. He asserted that there are two types of concepts: spontaneous concepts, which are part of the child's environment and are learned by example, and scientific concepts, which are found in school subjects and are learned by rule.

The third issue arising from this study is related to the finding that inductive instruction is the more effective method of instruction, in terms of student achievement, for abstract concepts. What is there about abstract concepts that makes inductive instruction more effective than deductive instruction? A possible answer to this question lies in Glaser's (1968) description of concepts which are "intricate to verbalize." That description was used earlier in this study in the suggestion that concepts could be categorized as concrete or abstract. An abstract concept which is "intricate to verbalize" may be more than the rule which defines it. That is, it may be necessary to have in addition to the concept definition, a "feel" for, or "sense of, what the concept is, in order to know the concept. If that is the case, inductive teaching, which requires that students spend time looking at and working with the examples of the concept before thinking about the definition, may enhance the possibility of students acquiring a "sense" of the concept in addition to learning the rule of the concept.

The fourth issue arose during the design of this study, when concepts were being selected for experimental teaching. As various abstract concepts were considered, it became apparent that for many, if not most of them, it was very difficult to define the concept in terms of its critical characteristics, in such a way as to also include the "spirit" of the concept. For example, defining "democracy" as "any system of government in which laws are made by the citizens or their elected representatives and which secures basic civil rights of citizens" may capture those cognitive critical characteristics of the concept, but it falls short in capturing the affective essence of democracy. Examples of that affective essence can be cited, but it seems impossible to state with any degree of specificity those affective elements of a democracy which are critical. Yet all who have studied governments to any extent have some sense that there is more to a democracy than those cognitive characteristics typically included in a definition. Martorella (1971, p. 39) referred to this when he suggested that many important social studies concepts are difficult to define precisely.

From an instructional point of view, this can be rather discouraging. It would appear that most of the social studies concepts identified as important in the literature are abstract. Every model of concept formation begins with the identification of the critical characteristics of the concept. Yet when an abstract concept is reduced to what seems to be the critical characteristics, the very spirit of the concept seems to have been left out. So, what can classroom teachers do to provide an opportunity for students to get beyond the definition and into the spirit of the concept? It is possible that activities which expand the students' exposure to the concept will be helpful in this respect. Activities such as simulations, community projects, research, group problem-solving, and predicting consequences, could assist students in acquiring, over a period of time, the spirit of those abstract concepts deemed most important by the teacher. It may be the case that for abstract concepts the concept formation lesson should be the first step in a series of activities planned to assist the student to acquire both the definition and the spirit of the concept.

A fifth issue raised by this study is related to the level of assessment of student knowledge of the concept used in the study. Students' knowledge was assessed at the application level. That is, they were asked to apply a definition they had learned to another item, to determine if that item was an example or non-example of the concept. All findings of the study were based on this level of assessment of student knowledge of the concept. An interesting question to ponder is what difference, if any, it would have made if the assessment had been at the analysis, or synthesis, levels. What if students had been asked to predict the consequences of building a large city in the midst of a natural prairie? Or, given the requirements of certain kinds of crops, what if students were asked to decide whether or not that crop could be grown on a prairie? Or, what if students were asked to predict the consequences of a breakdown in an interdependent relationship? Or to support or attack the statement that all peoples of the world are interdependent on each other?

It seems possible that if these kinds of questions had been asked, as a measurement of student achievement, the findings would have been different. For example, since both methods of instruction focused on learning the concept definition, it's possible there would have been little if any effect on students' ability to analyze, based on method of instruction. It's possible there would have been an even more dramatic direct effect of level of formal operational development, with students of higher operational development far more able to deal with analysis and synthesis questions than students at lower levels of development.

Since dealing with content at the analysis or synthesis level is an important goal of the new social studies, it would seem to be important to examine the relationship of method of instruction, including a much wider variety of instructional methods than studied in this research, and level of development of operational thought with student ability to deal with the concept at a level above the application level.

A sixth issue is related to the reliability coefficient for the pretest on "prairie." As was reported in chapter three, the alpha coefficient of reliability for the pretest on prairie was .62; the coefficient for the posttest was .90. For the concept "interdependence," the reliability coefficient was .79 for both the pretest and posttest. The pretest and posttest for each concept were constructed in the same way. Eight examples and eight non-examples of each concept were written, then randomly assigned, four of each, to the pretest and posttest. The researcher attempted to assure that all items were of approximately the same degree of difficulty. Since items were presumed to be approximately equal in difficulty, and since they were randomly assigned to pretest and posttest, it seems reasonable to conclude the reliability coefficient of the pretest and posttest on each concept would be approximately equal. While this is true of the tests on "interdependence," it is not true of the test of "prairie."

The low reliability coefficient for the pretest on "prairie" is easily explained when one looks at the pattern of responses. The pretest, consisting of eight questions, asked students to identify each of eight areas as examples or non-examples of a prairie. For each question, students were also asked to explain why they answered as they did. In order for a question to be scored as correct, the student had to both correctly identify the area as an example or non-example of a prairie, and specify all the critical characteristics of a prairie which were present or missing. It was anticipated that few students would answer any questions correctly, given the nature of the test and the fact that it was unlikely students had had prior instruction on the concept. This, indeed, was true. One hundred thirty-two students took the pretest on "prairie." Since there were eight questions on the pretest, there was the possibility of 1,056 correct responses. In actual fact, there only nineteen correct responses.

It is the pattern of those correct responses which explains the low reliability coefficient. Eighteen of those nineteen correct answers were the correct identification and explanation of a non-example of a prairie. Because of that pattern, the reliability coefficient of any split-half except the one which had two examples and two non-examples in each half would be very low. Since every possible split-half is considered in the computation of the alpha coefficient of reliability, the alpha coefficient is therefore low.

There are at least two possible explanations for this pattern of responses on the "prairie" pretest. The first lies in the construction of the items. It is possible that on the pretest the non-examples were simply "easier" items than the examples. This seems unlikely, because of the way in which the test was constructed. As described earlier, items were written and randomly assigned to the pretest and posttest. It's unlikely that four "easy" non-examples would have been assigned to the pretest. Because of the difference between the reliability coefficients for the pretest (.62) and the posttest (.90) on prairie, it seems more likely that the fact the test was a pretest influenced the pattern of responses.

The task, then, is to determine, why, in a pretest setting, students found it much easier to correctly identify non-examples of "prairie" than examples. A possible suggestion is that is a student had some idea of what a prairie was, he/she would be able to identify those items which were clearly not prairies, and point out those characteristics which seemed to be unlike prairies. On those items which were examples of a prairie that same student could probably identify them as such, but would probably not be able to specify all and only the critical characteristics in response to the "Why?" question.

A question which logically follows from the above suggestion relates back to the pretest on the other concept, "interdependence." If the pattern of responses on the "prairie" pretest was related to the tests being a pretest, why was the same pattern not seen on the "interdependence" pretest? How was the pretest on "prairie" different from the pretest on "interdependence?" An immediate difference, of course, is that one concept is concrete and one is abstract. This distinction does not seem particularly helpful in explaining differences in patterns of responses on pretests. Another difference may be more helpful: the concept of "prairie" has three critical characteristics while the concept of "interdependence" has only two. In future concept studies involving the use of a pretest, attention should be paid to a possible correlation between number of critical characteristics and reliability coefficients of pretests.

The final issue which occurs to the researcher is related to the finding that no significant interaction was found between method of instruction and level of development of operational thought. When that particular relationship was examined, it was noted that students of higher levels of development of operational thought scored higher on the posttest than students of lower level of development when the method of instruction was inductive. That was expected; the work of Piaget would suggest that students who were nearly formal operational would be better able to handle the number of variables associated with inductive learning than students who were concrete operational.

What was not expected was the finding that students of higher levels of development of operational thought would also score higher on the posttest than students of lower development when the method of instruction was deductive. Elkind's work (1974) particularly suggests that students who are concrete operational can learn rules and apply them to new situations. Learning the rule, or the concept definition, and applying it to a new situation, the test items, essentially describes deductive learning. Yet students who were at the concrete level of development were not able to do this as well, as indicated by posttest scores, as students of higher levels of development.

Since the method of instruction, deductive, was the same, and because according to Elkind, students at or above the concrete level of development have the cognitive structure to handle that kind of learning, there must be another factor operating to explain why students of higher levels of development scored higher on the posttest than students of lower levels of development of operational thought. A tentative suggestion which can be raised at this point is that memory is that other factor. Flavell (1977), in describing stages and processes of memory, theorizes that as children get older, their memory improves because they are more able to associate information they encounter with knowledge and processes they already have. He suggests this is developmental in nature, that as operational processes develop, memory improves. Flavell notes that research in memory as a function of cognitive development is in initial stages, but he cites some studies that would appear to support his suggestion (p. 194). It is possible that this study, quite unintentionally, also suggests a relationship between cognitive development and memory.

This study, as do many others in educational research, answers some questions and raises many more A final recommendation would be that teachers who are interested in learning which methods of instruction are most effective for particular kinds of content and particular kinds of students have opportunities to learn to conduct ongoing research in their classrooms. It is in the classrooms, not the college laboratories, where real students learn real content.

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APPENDIX A

PRETEST ON THE CONCEPT OF "PRAIRIE"

Name____________________

Date____________________

Period__________________

1. In western Nebraska, needle grass grows to a height of ten inches. Cottonwood and willow trees grow along the river banks. The area receives 10 to 20 inches of rain each year. The average temperature in the summer is 70 degrees to 80 degrees. In the winter, the average temperature is 10 degrees to 20 degrees.

Is this area an example of a prairie?

Why or why not?

2. In southern Minnesota native grass grows to a height of two to three feet. There are several kinds of trees, which grow along rivers and streams. Winters are cold. The temperature is between 10 and 20 degrees. Summers are hot with the temperature reaching 80 degrees. This area of Minnesota receives 20 to 30 inches of rain each year.

Is this area an example of a prairie?

Why or why not?

3. Across a large area of central Africa, grass grows to a height of three feet. Trees grow along the river banks and elsewhere. This area receives as much as 60 inches of rainfall each year. Temperatures are in the 70 degree to 80 degree range all year.

Is this area an example of a prairie?

Why or why not?

4. In Yugoslavia and Hungary on the continent of Europe, there is an area which is covered with grass one to two feet tall. Trees grow along the river banks. This area receives 20 to 40 inches of rain each year. The climate is cool. Winter temperatures are 10 degrees to 20 degrees. Summer temperatures are 60 degrees to 70 degrees.

Is this area an example of a prairie?

Why or why not?

5. Along the northern edge of Australia is a small area where native grass grows two to three feet tall. Trees grow along the river banks. This area receives 20 to 40 inches of rain each year. It is hot most of the year, 80 degrees in the summer and 70 degrees to 80 degrees in the winter.

Is this area an example of a prairie?

Why or why not?

6. An area in southern Oklahoma is covered with bluestem grass, which grows about two feet tall. This area receives 30 to 40 inches of rain each year. There are a few trees, mostly along the river banks. The temperature in the winter is 40 degrees to 50 degrees. Summer temperatures are around 80 degrees.

Is this area an example of a prairie?

Why or why not?

7. Much of France, in Europe, is covered with different kinds of trees. The area receives about 40 inches of rain each year. In the winter, the normal temperature is 40 degrees. The normal summer temperature is from 70 degrees to 80 degrees.

Is this area an example of a prairie?

Why or why not?

8. In eastern Wyoming, grama grass grows to a height of three or four inches. No trees grow in the area. This part of Wyoming receives 10 to 20 inches of rain each year. The average winter temperature is between 20 degrees and 30 degrees. The average summer temperature is between 70 degrees and 80 degrees.

Is this area of Wyoming an example of a prairie?

Why or why not?

APPENDIX B

PRETEST ON THE CONCEPT OF "INTERDEPENDENCE"

Name____________________

Date____________________

Period__________________

1. A hospital ship, staffed by volunteer doctors and nurses, sails to many nations where people need medical care. When the ship docks, it becomes a medical clinic, providing care for those who need it.

Is this an example of interdependence?

Why or why not?

2. Several nations joined together in an organization. They each agreed that if any member of the organization was attacked, they would all help the attacked nation defend itself.

Is this situation an example of interdependence?

Why or why not?

3. Before Europeans started to settle in the area that is now Nebraska, several groups of native Americans lived here. Each group provided completely for its own needs of food, clothing, and shelter, depending on the resources of the land.

Is the situation that existed among the groups of native Americans one of interdependence?

Why or why not?

4. Japan buys most of its food from other countries, because it has little farmland. Japan sells manufactured items such as cars and electronic equipment, to the countries from which they buy food.

Is this situation an example of interdependence?

Why or why not?

5. A number of countries refuse to buy and sell with Rhodesia. Rhodesia produces much chrome, which these countries could use, but they will not buy it from Rhodesia. Rhodesia needs manufactured items which the other countries make, but they will not sell to Rhodesia.

Is this situation an example of interdependence?

Why or why not?

6. A few weeks ago, there were severe floods in India. Volunteers from many countries went to India to help in many ways. Many countries sent food and medicine to India.

Is this situation an example of interdependence?

7. The United States and the Soviet Union signed an agreement limiting the number of atomic explosion tests each country would make. Atomic explosions pollute the air. Many times, a test made by one country will cause air pollution over other countries.

Is the agreement between the United States and the Soviet Union an example of interdependence?

Why or why not?

8. In some societies in Africa, certain families raise or hunt animals for meat. Other families grow grains and vegetables. On market days all the families gather to trade, so that each family has meat, vegetables and grain.

Is this situation an example of interdependence?

Why or why not?

APPENDIX C

EXAMPLES AND NON-EXAMPLES OF THE CONCEPT "PRAIRIE"

Prairie--Any area of the world which is covered with native grass, growing to a height of one to three feet, which has trees growing along rivers or streams, and which receives 20 to 40 inches of rainfall annually.

EXAMPLES:

1. In northern Spain, which is on the continent of Europe, is a small area where grass grows one to two feet tall. There are trees that grow by rivers and streams. The climate is warm. Winter temperatures are 40 degrees to 50 degrees. Summer temperatures range from 80 degrees to 90 degrees. The area receives 20 to 40 inches of rain each year.

2. There is an area in central Illinois which receives 30 to 40 inches of rainfall each year. Bluestem grass grows to a height of two to three feet, and oak and hickory trees grow along the rivers and streams. This area has mild winters, with average temperatures ranging from 40 degrees to 50 degrees. In the summer the average temperature ranges from 70 degrees to 80 degrees.

3. In Ethiopia, on the African continent, there is an area which is covered with grass about two feet tall. There are few trees; those which are there grow along streams. This area receives 20 to 40 inches of rain each year. The temperature in this area of Ethiopia is hot all year, about 80 degrees.

4. An area in the southern part of Africa, known as the Veld, is covered with grass. The grass is one to three feet tall. In the Veld, it rains 20 to 40 inches every year. There are some trees which grow along the river banks. It is always warm in the Veld. In the summer, the average temperature is 80 degrees. In the winter, the average temperature is between 60 degrees and 70 degrees.

NON-EXAMPLES

5. In southern Missouri, bluestem grass grows to a height of three feet. Oak and hickory trees grow everywhere. The average winter temperatures range from 40 to 50 degrees. Summer temperatures average 80 degrees to 90 degrees. The area receives 40 to 50 inches of rainfall each year.

6. In the Soviet Union there is an area which receives 10 to 20 inches of rain each year. The grass is short; it is only a few inches high. A few trees grow along the rivers. Temperatures range from 0 degrees to 10 degrees in the winter and from 70 degrees to 80 degrees in the summer.

7. Across a large section of China, which is on the continent of Asia, short grass grows in patches. In some places, nothing grows. This area receives less than 10 inches of rain each year. There are no trees. The average temperature in the winter is from 20 degrees to 30 degrees. In the summer, the average temperature reaches 90 degrees.

8. Throughout much of southern Africa, there are large areas of trees. Not very much grass grows in this area. The area receives 20 to 40 inches of rain each year. The climate is quite warm. Summer temperatures average 80 degrees; winter temperatures are between 70 degrees and 80 degrees.

NOTE: This information as given to the students did not include the definition, nor were the examples and non-examples identified on the page.

APPENDIX D

EXAMPLES AND NON-EXAMPLES
OF THE CONCEPT OF "INTERDEPENDENCE"

Interdependence--Any situation in which people or groups of people each depend on the other to satisfy important needs.

EXAMPLES:

1. Great Britain buys much of its food from other countries, because it has little farmland. It sells manufactured goods, such as clothing and machinery, to those countries.

2. In a small community, all the families formed a volunteer fire department. They agreed to help fight any fire that developed in the community.

3. People who live on farms in Nebraska grow food, which is needed by people who live in the cities. People who live in the cities help produce things like machinery, fertilizer, fuel, and information which farmers need.

4. The United States buys large amounts of oil, which it needs for many things, such as gasoline, from Saudi Arabia. The United States sells modern equipment, like airplanes for its army, to Saudi Arabia.

NON-EXAMPLES:

5. In many large cities, different communities are inhabited by people from different ethnic backgrounds. In New York, for example, there are Chinese communities, Italian communities and Puerto Rican communities. Within each community are churches, schools, stores, restaurants, and recreation centers. Many people never leave the community.

6. For many years, a group of Eskimos in Alaska lived in complete isolation from other people. They provided their own food, clothing and shelter from the resources available to them, such as snow, fish, and seals. They had no contact with other people in Alaska, or anywhere else.

7. For many years, the United States and the Republic of China did not trade with each other, even though the Republic of China needed to buy grain, such as wheat, and the United States needed to sell grain to more countries.

8. Two years ago, a tornado struck parts of Omaha, causing much damage in many parts of the city. Many people from other cities and towns in Nebraska went to Omaha. They helped the people in Omaha clear away damaged trees and buildings and start to repair their homes. Other

people sent money to provide temporary food and shelter for families who needed it.

NOTE: This information as given to the students did not include the definition, nor were the examples and non-examples identified on the page.

APPENDIX E

RETRIEVAL CHART FOR CONCEPT OF "PRAIRIE"

Area Continent/ Hemisphere	Temperature		Annual Precipitation			Grass				Trees			
	Summer	Winter	0-20 in.	20-40 in.	40-80 in.	None	Less Than 1 Ft. Fall	1-3 Feet Tall	Kind	None	Grows Along Rivers and Streams Only	Grows In Many Places	Kind

APPENDIX F

RETRIEVAL CHART FOR CONCEPT OF "INTERDEPENDENCE"

Group 1	Group 2	Does Group 1 depend on Group 2 for something important?	If yes, what is it?	Does Group 2 depend on Group 1 for something important?	If yes, what is it?

APPENDIX G

POSTTEST ON THE CONCEPT OF "PRAIRIE"

Name____________________

Date____________________

Period__________________

1. Along the northern edge of Africa is an area which receives about ten inches of rain each year. Grass grows to a height of two or three inches. There are no trees. In the summer, the average temperature is 80 degrees. In the winter, the normal temperature ranges from 50 degrees to 60 degrees.

Is this area an example of a prairie?

2. An area in Argentina, on the continent of South America, has a mild climate. The summer temperature is between 60 degrees and 70 degrees. The winter temperature is between 40 degrees and 50 degrees. The area in Argentina has a few trees along the river which flows through it. The land is covered with grass one to three feet tall. This area receives 20 to 40 inches of rainfall each year.

Is this area in Argentina an example of a prairie?

Why or why not?

3. In northern Texas, buffalo grass grows three to four inches tall. The area receives 10 to 20 inches of rain each year. Cottonwood and willow trees grow along the streams. The climate is quite warm. Average temperatures in the winter are 50 degrees to 60 degrees. In the summer, the average temperature is 80 degrees.

Is this area an example of a prairie?

Why or why not?

4. Brazil is a country in South America. A large part of it is covered with grass, about three feet tall. Trees grow in many places. Rainfall ranges from 40 to 80 inches per year. Winter temperature is around 70 degrees and summer temperature is 80 degrees to 90 degrees.

Is this area an example of a prairie?

Why or why not?

5. In the country of China, which is on the continent of Asia, there is an area which has hot summers and cold winters. In summer, the temperature is between 70 degrees and 80 degrees. In winter, it is near 0 degrees. This area is covered with grass a little over one foot tall. It receives between 20 and 40 inches of rain each year. There are a few trees in the area, mostly along rivers and streams.

Is this area in China an example of a prairie?

Why or why not?

6. In Manitoba, a province in Canada, there is an area which receives 20 to 40 inches of rainfall each year. The climate is quite cool. Summer temperatures range from 60 degrees to 70 degrees. In the winter, the average temperature is 0 degrees to 10 degrees. The land is covered with bluestem grass, which grows one to two feet tall. There are a few trees which grow along the river banks.

Is this area an example of a prairie?

Why or why not?

7. In southern Michigan, beech and maple trees grow over a large area of land. The area receives 20 to 40 inches of rainfall each year. There is little or no grass. Normal winter temperature is 20 degrees to 30 degrees. The normal summer temperature is 70 degrees to 80 degrees.

Is this area an example of a prairie?

Why or why not?

8. An area in eastern Nebraska is covered with tall grass, about two feet high. There are some trees growing along the river. The temperature is hot, between 80 degrees and 90 degrees, in the summer. It is cold, between 10 degrees and 30 degrees, in the winter. The area receives 20 to 40 inches of rain each year.

Is this area an example of a prairie?

Why or why not?

APPENDIX H

POSTTEST ON THE CONCEPT OF "INTERDEPENDENCE"

Name______________________

Date______________________

Period____________________

1. A few years ago, anthropologists found a group of people living on a small island in the Pacific Ocian. These people had no contact with people anywhere else. They provided for their own needs by making use of what grew on the island.

Is the situation that existed between these people and the people in the rest of the world an example of interdependence?

Why or why not?

2. The United States buys a lot of aluminum from the country of Ghana. Aluminum is used in the manufacturing of many things, from pans to machinery to airplanes. Ghana buys many of these products United States manufacturers make.

Is this situation an example of interdependence?

Why or why not?

3. On an island in the Pacific, there are two groups of people. Those people who live in the center of the island grow many kinds of vegetables. The people who live on the edge of the island catch fish. Once a month, the two groups meet to trade their produce. The people who catch fish also need vegetables, and the people who grow vegetables need fish.

Is this situation an example of interdependence?

Why or why not?

4. Cuba and the United States do not buy and sell products from each other, even though Cuba has sugar the United States could use and the United States has manufactured items Cuba could use.

Is this an example of interdependence?

Why or why not?

5. The United States buys a large amount of iron ore from Venezuela. The iron ore is used in a variety of manufactured items. Venezuela buys wheat and corn from the United States.

Is this situation an example of interdependence?

Why or why not?

6. Two cities have made an agreement. City A will not dump untreated waste in the river. This means the water in the river will still be clean for City B. City B will use new equipment in its electrical plant, so pollutants are not put in the air. This means clouds of air pollution will not float over City A.

Is this an example of interdependence?

Why or why not?

7. After the Revolutionary War, the United States stopped all trade with Great Britain, The two nations had no formal contact for several years, even though each had needs the other could have satisfied.

Is this situation an example of interdependence?

Why or why not?

8. In many cities, there are agencies which provide food and shelter for people who have no other means of support.

Is this situation an example of interdependence?

Why or why not?

APPENDIX I

FORMAL OPERATIONS TEST

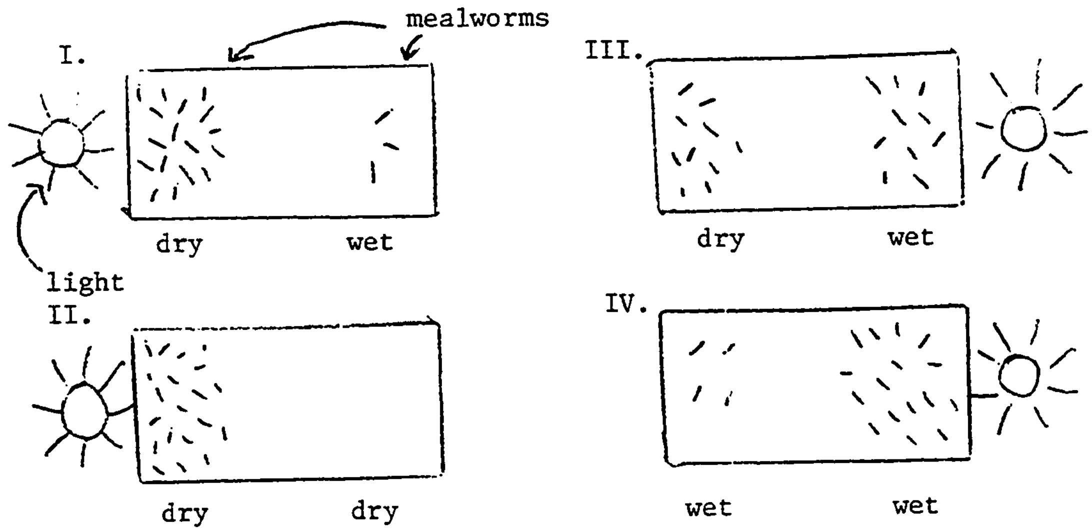
PUZZLES

In the next few pages are some puzzles which different people solve in different ways. If we know how *you* solve them, we can teach you better. You can help by writing down how you solved each problem.

Name ______________________ Date ________________

THE MEALWORM PUZZLE

A scientist wanted to figure out whether mealworms like or dislike light and whether they like or dislike wetness. To find this out he set up four (4) boxes as shown in the picture below. He used lamps for light sources and constantly-watered pieces of paper in the box for wetness. He put 20 mealworms in the center of the box. After one (1) day he came back and counted the number of mealworms at each end of the boxes.



The pictures show that mealworms like

A) light but not wetness

B) wetness but not light

C) both wetness and light

D) neither light nor wetness

Why do you think so?____

____

Would you do another box to test your idea? Yes_____ No_____

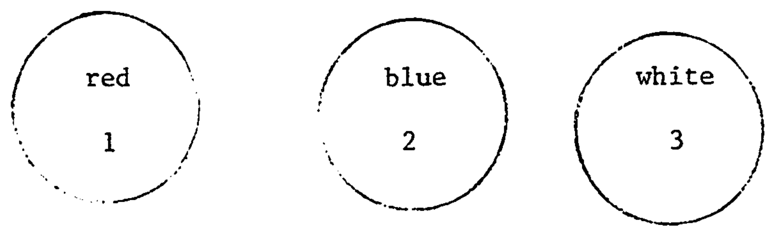
If so, what would it look like?

If not, why not?____

____

THE POKER CHIP PUZZLE

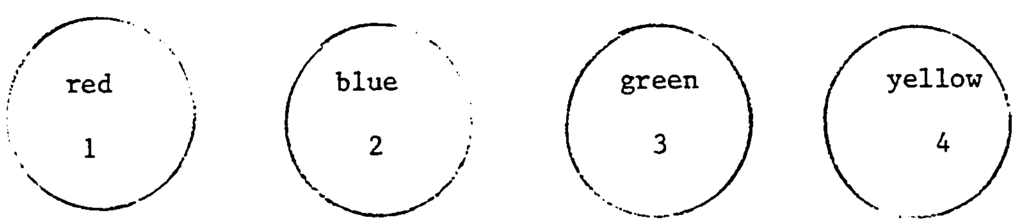
If you had three poker chips red, white, and blue, and you wanted to put them together in all the different ways that were possible, you would have the following possibilities:



1, 2, 3
1, 2
2, 3
1, 3
1
2
3

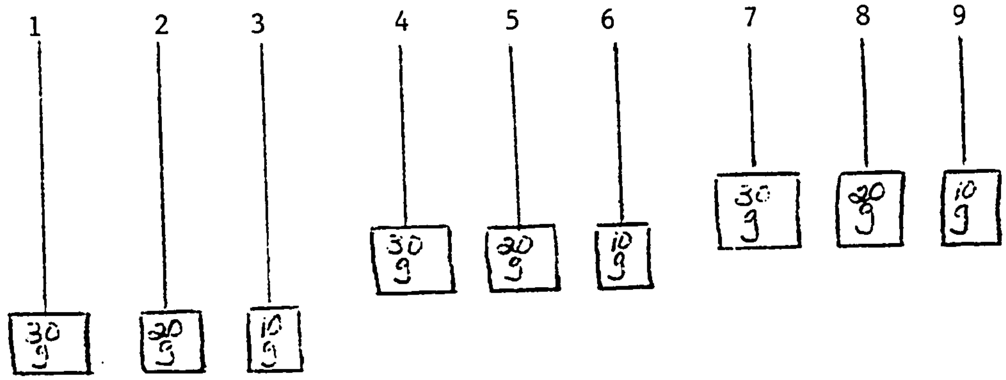
Notice that the order of the way they are put together makes no difference and that you don't have to use all of the chips every time.

Using the example, how many different ways can four chips be put together? Write down all the ways you can think of.



THE PENDULUM PUZZLE

You are working with a pendulum problem. You have all of the pendulums diagrammed below. They have different lengths of string and different weights. You want to find out if string length and/or weight affect how fast a pendulum swings back and forth.



1. Which pendulums can you compare to find out if short strings swing faster than long strings? Why did you choose those pendulums to compare?

2. Could you compare pendulums 5 and 9 to find out if short strings swing faster than long strings? Why or why not?

3. Which pendulums can you compare to find out if heavy weights swing faster than light weights? Why did you choose those pendulums to compare?

4. Could you compare pendulums 3 and 7 to find out if heavy weights swing faster than light weights? Why or why not?

THE WAHOO PUZZLE

When the State of Nebraska converts its highway signs to a dual English-Metric system, you might see a sign as you drive toward Grand Island which looks like this:

Grand Island
94 Miles
152 Kilometers

As you drive toward Wahoo you might see the following sign:

Wahoo
_____ Miles
380 Kilometers

Can you figure out what number should go in the blank from the information given on this page?

Yes_____ No_______

If yes, explain how you would figure it out and do the calculation.

If no, explain why not.