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ABSTRACT

This document reports the results of two studies performed to determine the effectiveness of special lessons in facilitating the attainment by children of the basic concept "tree." The first study, which utilized 103 fifth-grade students, also investigated the effects of pretesting. Results showed no significant effects of pretesting and no significant treatment effects. The second study utilized 64 third-grade students divided into a control group and an experimental group. Results showed the experimental group performed better than the control group on tests for the formal level attainment of the basic concept presented. (SL)

TECHNICAL REPORT NO. 372

the effectiveness of experimental lessons in accelerating children's attainment of the concept tree

JANUARY 1976

WISCONSIN RESEARCH
AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

Technical Report No. 372

THE EFFECTIVENESS OF EXPERIMENTAL LESSONS IN ACCELERATING CHILDREN'S ATTAINMENT OF THE CONCEPT TREE

by

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Report from the Project on
Conditions of School Learning and Instructional Strategies

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CENTER FOR COGNITIVE LEARNING

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ABSTRACT

Two studies were performed to determine the effectiveness of experimental lessons in accelerating children's attainment of the concept _tree_. In the first study a variation of the Solomon Four-Group design was used to determine, in addition, whether there were effects of pretesting. Subjects were 103 fifth grade children randomly assigned to experimental or control groups. A two-way analysis of variance showed that there were no significant effects of pretesting and no significant treatment effects. This was attributed to the fact that prior to instruction the subjects were already at a high level of attainment of the concept _tree_.

A replication of the study was performed using 64 third grade children as subjects. The lessons from the first study were revised to be appropriate for third grade children. Since no effects of pretesting were found in the first study, two groups were used in the second study: one experimental and one control. The instructional design and experimental procedures were the same as for the first study. An analysis of covariance showed that the experimental group performed significantly better than the control group on tests for the overall formal level and on three subtests of the formal level. Also, the percentages of experimental children passing the formal level were .03 and .68, respectively, for pretest and posttest; the same percentages for the control children were .03 and .14, respectively.

I

INTRODUCTION

Children spend a major portion of their school life attaining concepts, principles, and problem-solving skills in various subject fields. These outcomes of learning are essential for understanding and dealing with the physical and social worlds. Therefore, research to discover and validate more effective ways to facilitate concept learning is needed if children are to master the growing amounts of subject matter in the school's curriculum and to deal effectively with their physical and social worlds.

PURPOSE OF THE STUDIES

Two experiments were conducted to determine the extent to which specially constructed lessons would facilitate children's attainment of the concept tree. These studies followed a methodology similar to that in an earlier study dealing with the concept equilateral triangle (McMurray, Bernard, & Klausmeier, 1974). In that study, written lessons were used to teach the concept equilateral triangle. The lessons incorporated variables which had been shown by earlier research to facilitate concept attainment. The lessons proved highly effective in that a substantial percent of the children attained the concept to the formal level upon completing the lessons. Moreover, the children who received the equilateral triangle lessons performed about as well after a two month time lapse as they had immediately following the lessons. The control group children who had not received the lesson also functioned at about the same level as they had at the end of the experiment, not improving in their performance during the two-month period.

The experiment using the concept equilateral triangle and the experiment described in this report using the concept tree are based upon a model of conceptual learning and development (Klausmeier, Ghatala, & Frayer, 1974). In this chapter, the model of conceptual learning and development (CLD model) is described. In Chapter II, the first experiment dealing with the concept tree is reported, and in Chapter III a replication study is reported.

THE NATURE OF CONCEPTS

The word concept is used by Klausmeier, Ghatala, and Frayer (1974) to designate mental constructs of individuals and also identifiable public entities that comprise part of the substance of the various disciplines. Thus, concept is used appropriately in two different contexts just as many other English words are. A concept is defined as ordered information about the properties of one or more things--objects, events, or processes--that enables any particular thing or class of things to be differentiated from, and also related to, other things or classes of things.

In regard to concepts as mental constructs, it is noted that maturing individuals attain concepts according to their unique learning experiences and maturational patterns. In turn, the concepts that are attained are used in the individual's thinking about the physical and social world.

Concepts as public entities are defined as organized information corresponding to the meaning of words. Carroll (1964) related concepts, words, and word meanings in the following way. Words in a language can be thought of as a series of spoken or written entities. There are meanings for words that can be thought of as standards of communicative behavior shared by those who speak a language. Finally, there are concepts--that is, the classes of experiences formed in individuals either independently of language processes or in close dependence on language processes. Putting the three together, Carroll stated: "A 'meaning' of a word is, therefore, a societally standardized concept, and when we say that a word stands for or names a concept it is understood that we are speaking of concepts that are shared among members of a speech community [1964, p. 187]."

At the inception of a large programmatic research effort dealing with concept learning and instruction, Klausmeier, Davis, Ramsay, Fredrick, and Davies (1965) formulated a conception of concept in terms of defining attributes common to many concepts from various disciplines. Klausmeier, Ghatala, and Frayer (1974) further refined the definition by specifying eight attributes of concepts: learnability, usability, validity, generality, power, structure, instance numerousness, and instance perceptibility. Other researchers and subject-matter specialists are also treating concepts in terms of defining attributes. For example, Flavell (1970) indicated that a formal definition of concept in terms of its defining attributes is useful in specifying what concepts are and what they are not and also in identifying the great variability among concepts. Markle and Tiemann (1969) and Tennyson and Boutwell (1971) have shown that the external conditions of concept learning can be delineated through research that starts with a systematic identification of the defining attributes of the particular concepts used in the research. Scholars at the Wisconsin Research and Development Center demonstrated that analysis of concepts in terms of their defining and variable attributes is useful in clarifying the meanings of the concepts drawn from four disciplines: language arts--Golub, Fredrick, Nelson, and Frayer (1971); mathematics--Romberg, Steitz, and Frayer (1971); science--Voelker, Sorenson, and Frayer (1971); and social studies--Tabachnick, Weibble, and Frayer (1970).

The CLD model deals primarily with concepts represented by words that can be defined in terms of attributes. However, some concepts are defined on other bases, including synonyms and antonyms. Further, not all words potentially definable in terms of attributes are so defined, even in unabridged dictionaries. Therefore, the researcher and also the developer of curriculum materials must ascertain the defining attributes independently or cooperatively with scholars from the various disciplines.

AN OVERVIEW OF THE CONCEPTUAL LEARNING AND DEVELOPMENT MODEL

Figure 1 shows the structure of the CLD model. Four successively higher levels in the attainment of a given concept are outlined. The four levels are concrete, identity, classificatory, and formal. As a concept is attained by an individual at the successive levels, it becomes increasingly usable and valid, as defined earlier.

A second part of Figure 1 shows the ways in which concepts may be extended and used. Concepts acquired at only the concrete and identity levels can be used to solve simple problems that require only the relating of obvious sensory perceptions. For example, to save time or for some other reason, children may walk diagonally across a rectangular block rather than remaining on the sidewalk and walking around a corner of the block. They need not have attained the concepts of _distance_, _angle_, _diagonal_, or _straight line_ at the classificatory level.

Concepts acquired at the classificatory and formal levels may be generalized to newly encountered instances, related to other concepts, and used in problem-solving situations. Here we are concerned with both transfer of learning and the use of concepts in thinking.

Figure 1 also shows the operations involved in attaining a concept at each level. Attending to and discriminating objects and then remembering what was discriminated are involved in attaining a concept at the concrete level. The same operations are also involved at each subsequent level and are supplemented with the higher-level operations of generalizing, hypothesizing, and evaluating.

Although some of the same operations are postulated to occur at various levels, what is operated on and remembered changes with the attainment of the successively higher levels. That is, the operations are carried out on more sharply differentiated and abstracted stimulus properties at the four successive levels.

By focusing on the attainment of successively higher levels of the same concept, we are able to clarify the short-term learning conditions at each level and to describe conceptual development over long time intervals. Thus, the model provides a basis for organizing knowledge and carrying out research related to both the external and internal conditions of learning at each of the four levels.

The fourth part of the model shows that acquiring and remembering the name of the concept may come at any of the four levels. The solid line indicates that being able to name the concept and its relevant attributes is essential to attaining the concept at the formal level. The broken lines indicate that an individual may acquire the name at about the same time he first attains the concept at the lower levels, but that this is not requisite. For example, a young child might attain a concept at all three lower levels but not have acquired the concept name. The younger the children are when they attain the concept, the less likely they are to have the name for it.

At this time, we shall delimit the substantive domain that we are treating. The model in its totality describes the four levels of concept attainment and uses of the same concept rather than each of four kinds of

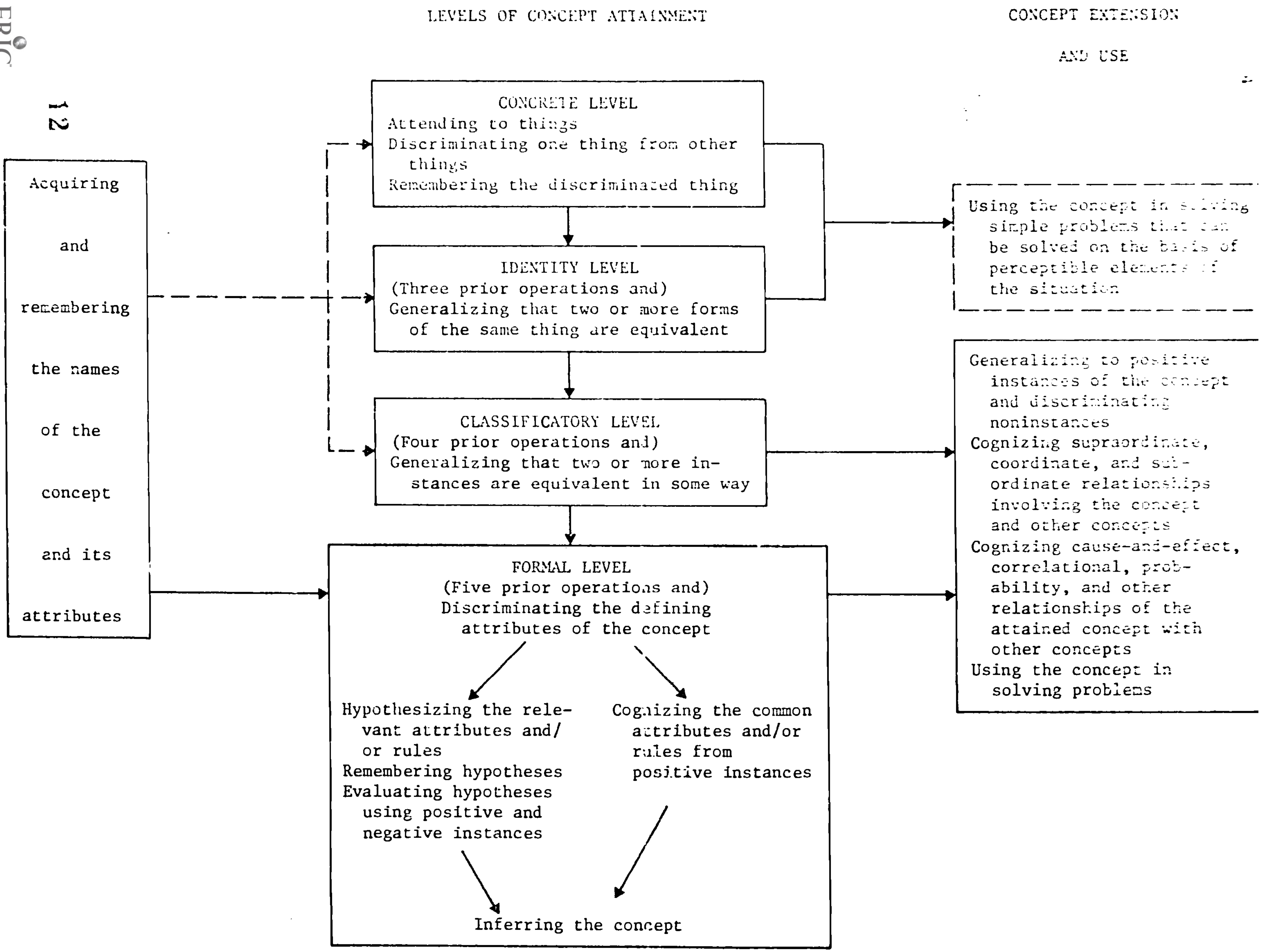

Figure 1. Cognitive operations and concept learning

concepts. The four levels apply to the many concepts that are or can be defined in terms of attributes and which have actual perceptible instances or readily constructed representations of instances. We have already cited a few examples of this kind, including all the concepts comprising the plant kingdom and the animal kingdom. However, the operations at each level are intended to be applicable also to different kinds of concepts, some of which, because of their nature, are not attainable at all four levels. We can specify these kinds of concepts and the levels at which they can be attained.

There are some concepts for which there is only one instance, such as the earth's moon and Abraham Lincoln, and some that have many identical instances, for example, inch and pound. Related to Figure 1, such single-instance or identical-instance concepts which have defining attributes can be attained at the concrete, identity, and formal levels, but not at the classificatory level. By our definition of classificatory level, there must be at least two nonidentical instances that can be placed in the same class. Therefore, some concepts cannot be attained at the classificatory level.

Other concepts are of such low validity that there may not be agreement as to their defining attributes, for example, beauty and morality. Concepts such as these might be learned at the three lower levels but not at the formal level.

Finally, there are concepts with no perceptible instances, such as infinity and atom. These cannot be learned at the three lower levels but might be learned at the formal level.

Returning to the four levels given in Figure 1, we postulate that attaining a concept at the four successively higher levels is the normative pattern for large numbers of individuals under two conditions. First, the concept is of the kind for which there are actual perceptible instances or readily constructed representations; and second, the individual has experiences with the instances or representations starting in early childhood. Furthermore, in order to proceed to the formal level, individuals must acquire labels for the concept and for its attributes. For example, the individual will have successively attained the concrete, identity, and classificatory levels of the concept plant before he describes and treats plant formally in terms of its defining attributes.

Children have direct experiences during preschool years with many things and attain concepts of these things at the first two levels. They also attain many concepts at the beginning classificatory level and learn the societally accepted names for the concepts and their attributes through formal and informal instruction.

Earlier we indicated that some individuals, because of environmental conditions, may not encounter actual instances of a concept; rather, they experience instances only in verbal form. Thus, these individuals may attain a concept at either the classificatory or the formal level at the outset. It is also noted that the mature person, although capable of attaining a concept at the formal level, may stop at a lower level of attainment because of the way in which the perceptible instances are encountered or other conditions of learning.

OPERATIONS RELATED TO LEVELS OF CONCEPT ATTAINMENT

Having considered the overall features of the model, we may take up the operations in more detail, starting with those pertaining to the concr level.

Concrete Level

Attainment of a concept at the concrete level is inferred when the individual cognizes an object that he or she has encountered on a prior occasion. We use the term "operations" as Guilford (1967) does. Guilford has defined the operations of cognition, memory, productive thinking, and evaluation in terms of test performances. He stated that cognition must be related to the products cognized and he formally defined cognition as follows:

> Cognition is awareness, immediate discovery or rediscovery, or recognition of information in various forms: comprehension or understanding. . . . The most general term, awareness, emphasizes having active information at the moment or in the present. . . . The term, recognition, is applied to knowing the same particular on a second encounter. . . . If cognition is practically instantaneous, call it recognition; if it comes with a slight delay, call it "immediate discovery" [pp. 203-204].

The first step in attaining this level is attending to an object and representing it internally. Woodruff (1961) pointed out that:

> All learning begins with some form of personal contact with actual objects, events, or circumstances. . . . The individual gives attention to some object. . . . Through a light wave, or a sound wave, or some form of direct contact with a sensory organ in the body, an impression is picked up and lodged in the mind [p. 66].

Gagné (1970) indicated that as individuals attend to an object, they discriminate it from other objects. Woodruff (1961) called the outcome of these attending and discriminating operations a concrete concept, a mental image of some real object experienced directly by the sense organs. The infant, for example, attends to a large red ball and a white plastic bottle, discriminates each one, maintains a mental image of each, and cognizes each of the objects when experienced later.

The discrimination of objects involves attending to distinctive features that serve to distinguish the objects from one another. Thus, children learn very early to respond to gross differences in such features of objects as size, shape, color, and texture. As children mature, they become capable of making finer discriminations involving these and other features.

Attainment of a concept at the concrete level thus requires attending to the distinctive features of an object and forming a memory image which represents the object as a unique bundle of features. The concept at this level may or may not be associated with the concept label, depending on whether the label has been learned and remembered, and whether it has been associated with the concept.

The preceding analysis of the operations in attaining concepts at the concrete level is sufficiently comprehensive to include motoric experiencing of objects. That is, an object may be manipulated physically and represented enactively, as well as explored visually and represented iconically, to use Bruner's (1964) terminology. The model postulates that attending, discriminating, and remembering are involved in sensorimotor experiencing, to use the terms of Piaget (1970), as well as in the visual perception of objects.

Identity Level

Attainment of a concept at the identity level is inferred when the individual cognizes an object as the same one previously encountered when observed from a different perspective or sensed in a different modality. For example, making the same response to the family poodle when seen from straight ahead, from the side, and from various angles is evidence of the child's having attained the concept of poodle at the identity level. Whereas concept attainment at the concrete level involves only the discrimination of an object from other objects, attainment at the identity level involves both discriminating various forms of the same object from other objects and also generalizing the forms as equivalent. Generalizing is the new operation postulated to emerge as a result of learning and maturation that makes attainment at the identity level possible.

As noted earlier, there are some valid and powerful concepts, such as the English alphabet, for which there is only one instance but which can be represented in different ways, e.g., aurally and in printed form. These concepts are typically learned at the concrete and identity levels but not at the classificatory level. Therefore, individuals proceed directly from the identity to the formal level with this kind of concept.

Bruner, Goodnow, and Austin (1956) have pointed out that identity responses occur very early in life and that the capability to recognize identity may be innate and merely extended to new events through learning. Vernon (1970) indicates that infants have to learn by experience that objects and events in the environment are permanent even though they may change their appearance from time to time as their distance and orientation changes. Clearly, the capacity to recognize identity, indeed the expectation of the continuity of objects and events in the environment, is well developed in the perception of adults.

Recognition of object identity is central to Piaget's formulations. According to Elkind (1969), Piaget's conception of concept emphasizes the variability that occurs within things--changes in state, form, and appearance which can occur to any entity.

Elkind pointed out further that American psychologists have tended to ignore this within-instance variability of concepts and have emphasized the discriminative response aspect of concept attainment by which positive instances are cognized and discriminated from noninstances. Elkind summarized the two points of view thus:

> From the discriminative response point of view, the major function of the concept is the recognition or classification of examples. The Piagetian conception, however, assumes that a major function of the concept is the discrimination between the apparent and the real. This discrimination, in turn, can be reduced to the differentiation of between- and within-things types of variability. Here again, a comprehensive conception of a concept must include both functions because, in fact, every concept does serve both purposes [1969, p. 187].

The present model proposes that a concept is attained at the identity level temporally before it is attained at the classificatory level. Stated differently, persons must be able to cognize various forms of the same objects as equivalent before they are able to generalize that two or more different objects belong to the same class.

Classificatory Level

The lowest level of mastery at the classificatory level is inferred when individuals respond to at least two different instances of the same class as equivalent, even though they may not be able to describe the basis for their response. For example, when children treat the family's toy poodle and the neighbor's miniature poodle as poodles, although they may not name the attributes of poodles, they have attained the concept at the classificatory level.

While generalizing that at least two different instances are equivalent in some way is the lower limit of this level of concept learning, persons are still at the classificatory level of concept learning when they can correctly classify a larger number of instances as examples and nonexamples, but cannot accurately describe the basis for their grouping in terms of the defining attributes. Henley (cited in Deese, 1967), like many other researchers, has observed this phenomenon. Many of her subjects were able to sort cards correctly into examples and nonexamples of the concepts being learned, yet gave totally erroneous definitions of the concepts.

Formal Level

A concept at the formal level is inferred when the individual can give the name of the concept, can discriminate and name its intrinsic or societally accepted defining attributes, can accurately designate instances as belonging or not belonging to the set, and can state the basis for their inclusion or exclusion in terms of the defining attributes. For example, maturing children demonstrate a concept of dog at the formal level if, when shown dogs, foxes, and wolves of various sizes and colors, they properly designate the dogs as such, call them "dogs," and name the attributes that differentiate the dogs from the foxes and wolves. The distinctive aspect of this level of concept mastery is the learner's ability to specify and name the defining attributes and to differentiate among newly encountered instances and noninstances on the basis of the presence or absence of the defining attributes.

As noted in Figure 1, the labels for the concept and the defining attributes may be learned at any of the three lower levels, but are not essential at those levels. Similarly, the discrimination of the defining attributes may occur prior to the formal level, but this is not essential. Thus, discrimination of things on their global and diffuse stimulus properties which is essential at the concrete level changes to discrimination of more specific and abstract properties at the identity and classificatory levels. However, at the formal level the individual must be able to discriminate and label all the defining attributes of the concept.

The operations involved in the learning of concepts at the formal level are also shown in Figure 1. The first operation given at the formal level is that of discriminating the attributes. As already noted, for some concepts with obvious attributes such as color and form, the discriminations may have occurred at earlier levels. However, making the discriminations and having the labels for the attributes are both essential at the formal level. This is true whether the individual infers the concept by hypothesizing and evaluating relevant attributes or cognizing the attributes common to positive instances, as shown in Figure 1.

Individuals differ in their ability to analyze stimulus configurations into abstract dimensions or attributes. There is evidence (Gibson, 1969) that this ability develops with age. Retarded children may have difficulty with simple concept learning tasks because of the difficulty in learning to select out and attend to specific dimensions (Zeaman & House, 1963). Even among children of adequate intelligence, there are those who characteristically analyze the stimulus field and apply labels to attributes while others tend to categorize on the basis of a relatively undifferentiated stimulus (Kagan, Moss, & Sigel, 1963).

Orienting instructions may be given to make explicit the attributes of the stimuli (Klausmeier & Meinke, 1968). These instructions facilitate the learning of concepts at the formal level by assuring that the learner knows all of the attributes that may be relevant to the concept.

Having discriminated and named the attributes, an individual may infer the formal level of a concept inductively in either of the two ways shown in Figure 1. One way involves formulating and evaluating hypotheses and the other involves cognizing the common attributes in positive instances. Which strategy a learner uses depends on the instructions he has been given, his age, and the kind of concept instances he experiences.

Levine (1963) defined a hypothesis as the subject's prediction of the correct basis for responding. In the hypothesis-testing approach, learners guess a possible defining attribute or combination of attributes. They then compare this guess with verified examples and nonexamples of the concept to see whether it is compatible with them. If the guess is not compatible, they make another guess and evaluate it against further examples and nonexamples. Eventually, they combine the information they have obtained from testing their hypotheses so as to infer all the defining attributes and thereby the concept.

Essential to the hypothesis-testing approach are the operations of remembering and evaluating hypotheses. There is support (Levine, 1963; Williams, 1971) for the idea that the subject formulates and remembers a population of hypotheses, remembers the hypotheses that were rejected, and also remembers the last one accepted as correct. In connection with evaluating hypotheses, Bruner et al. (1956) indicated that individuals determine whether or not their hypothesized concepts are valid by recourse to an ultimate criterion, test by consistency, test by consensus, or test by affective congruence. Inherent in all four procedures is establishing a criterion for judging the correctness of a hypothesis. In the present model, the validity of an individual's concept may be assessed in terms of how nearly it corresponds to expert agreement concerning the concept. Our experiments have shown that instructions to subjects which include a decision rule for evaluating hypotheses facilitate concept attainment.

The operations involved in the hypothesis-testing approach to inferring concepts appear to characterize individuals who cognize the information available to them in laboratory and classroom settings from both positive instances (examples) and negative instances (nonexamples). These individuals apparently reason like this: Instance 1 has land surrounded by water. It is a member of the class. Instance 2 has land but it is not surrounded by water. It is not a member of the class. Therefore, lands surrounded by water belong to the class and lands not surrounded by water do not. Surrounded by water is a defining attribute of the concept. This individual has attained a partial but accurate definition of the concept based on experiences with only one positive and one negative instance.

A second inductive way of inferring the concept is by noting the commonalities in examples of the concept. The commonality approach is used more often than the hypothesizing approach by children, apparently because they are either incapable of getting information from nonexamples or because they cannot carry out the hypothesizing and evaluating operations (Tagatz, 1967). The commonality strategy is the only one possible when only positive instances of the concept are available.

Our model is considered appropriate for learning concepts at the formal level by a didactic method of information presentation as well as an inductive one. That is, concepts may also be learned at the formal level deductively.[1] Many upper elementary, high school, and college students are given the names of concepts and their attributes, verbal definitions, verbal examples, and verbal nonexamples but not actual instances of the concepts. To learn the concept initially they must assimilate this information, remember it, and be able to use it in evaluating examples and nonexamples of the concept as shown in Figure 2. When learners have attained a concept initially through this kind of didactic instruction, they are able to use the concept to identify new examples and nonexamples with which they have had no prior experience. The basic operations entailed in this identification of newly encountered instances are hypothesizing whether the instance does or does not belong to the concept and evaluating the hypothesis in terms of the defining attributes that were given in the definition. Prerequisite to these two operations are discriminating the attributes of the concept and knowing their labels. All of these are listed in Figure 1 as part of the inductive strategy. Thus, when didactic instruction is used, the learner must hypothesize and evaluate regarding examples and nonexamples in order to use the newly learned concepts.

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[1]In explaining the model earlier, Klausmeier, Ghatala, and Frayer (1974) subsumed the deductive operations under cognizing the common attributes.

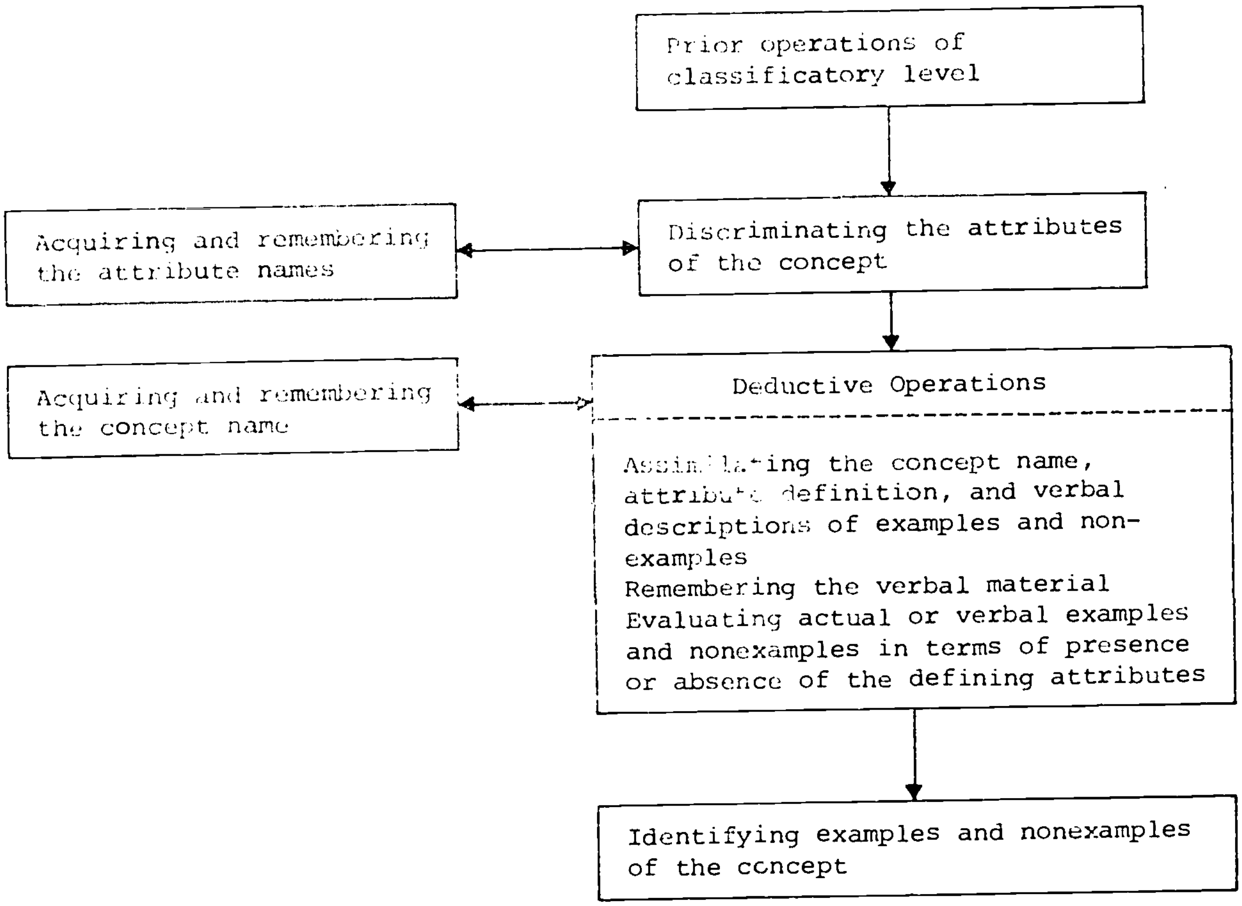

Fig. 2. Cognitive operations and deductive strategies of concept attainment at the formal level.

ACQUIRING APPROPRIATE LABELS

The importance of language in concept learning is widely acknowledged by American (Bruner, 1964) and Russian (Vygotsky, 1962) psychologists. Having the labels of concepts enables individuals to think in symbols rather than in images and to attain other concepts through language experiences in the absence of perceptible instances. Carroll (1964), as noted earlier, has outlined the close relationships among concepts, meanings, and words. However, the purpose here is not to deal with the relationships between language and concept learning, but to show at what points labels may be learned and associated with the various levels of concepts.

Figure 1 indicates that a concept label may be associated with an instance of the concept at any of the four levels--concrete, identity, classificatory, or formal. For example, Billy might manifest a sequence like this: Billy first encounters a dog. Billy's mother points to the dog and says "dog." Billy then says "dog," and associates the name with his concrete concept of the dog. Next, Billy develops the concept of the same dog at the identity level through experiencing it in different locations and situations. His mother repeats the name at various times in the presence of the dog; Billy says the word repeatedly. The word "dog" now comes to represent Billy's concept of the dog at the identity level. Subsequently, Billy encounters other dogs and observes that they, too, are called "dogs." He generalizes the different dogs as equivalent in some way and associates the name "dog" with whatever similarities he has noted. The word thus comes to represent his class of things called "dogs." At the formal level, with greater maturity, Billy discriminates and learns the societally accepted attributes of the class of things called "dogs" and also learns the names of the attributes. Now Billy's concept of dog approaches or becomes identical to the societally accepted definition of the word "dog." As Carroll (1964) pointed out, the concepts held by individuals and the meanings of the words representing the concepts are the same for mature individuals who share similar cultural experiences and the same language.

In connection with language and concept attainment, we recognize that deaf individuals and others who lack normal speech development may attain concepts at the formal level. By our definition, the individual must know the defining attributes of the concept and must be able to communicate this knowledge. Verbalizing is normally used in this kind of communication. Other types of symbolic communication, for example, sign language, may also be employed. Speech, per se, is not necessary for the attainment of concepts, but some means for symbolizing and communicating the concept in the absence of examples is necessary at the formal level.

CONCEPT EXTENSION AND UTILIZATION

The individual who has formed a concept may extend and use it as shown in Figure 1. As noted earlier, a concept attained only to the concrete or identity level may be used in solving simple perceptually-based problems. Concepts learned at the classificatory and formal levels can be used in generalizing to new instances, cognizing supraordinate-subordinate relations, cognizing cause-and-effect and other relations among concepts, and in solving problems.

Ausubel (1963) and Gagné (1970) have theorized concerning the use and extension of attained concepts; however, very little empirical research has been done. In this regard Ausubel (1963) formulated the constructs of cognitive structure, advance organizer, correlative subsumption, and derivative subsumption to show how previously attained and newly encountered concepts are related, while Gagné has indicated that attained concepts are prerequisite to the learning of rules.

Generalizing to New Instances and Discriminating Noninstances

The attainment of concepts at the classificatory and formal levels reduces the need for additional learning and relearning, primarily because the individual is able to generalize to new instances of a concept and to discriminate noninstances. Having a concept also provides individuals with expectations which help them deal effectively with new instances of it. Once persons identify a plant as poison ivy, they treat it gingerly. One test of concept attainment in our experiments is the individual's ability to properly categorize instances not previously encountered as instances or noninstances of the particular concept. We find that both school children and college-age students generalize to new instances readily. Furthermore, the use of instances and noninstances in instructional materials to teach concepts can be manipulated so that errors of overgeneralization and undergeneralization can be reduced (Feldman, 1972; Swanson, 1972).

Not only does having a concept enable learners to identify new instances and act appropriately toward them, but direct and verbal experiences with the new instances possibly increase the validity and power of the concept for the individual. For example, the Canadian visiting Kenya during January, when it is summer there, may attain more valid and powerful concepts of flower and plant. Similarly, by being told that a whale is a mammal, an individual comes to realize that mammals can live in the water as well as on land. Hence, the individual's concept of mammal has greater validity.

Cognizing Supraordinate-Subordinate Relationships

Besides generalizing to new instances, individuals can also use their concepts attained at the formal level, and possibly at the classificatory level, in cognizing coordinate, supraordinate, and subordinate relationships among classes of things. The lowest level of cognizing these relationships is inferred when persons, according to verbal instructions, put instances of concepts in their proper groups. For example, upon request persons put all instances of red and blue equilateral triangles and of right triangles in a grouping of triangles, and all instances of triangles and of rectangles in a grouping of polygons. Furthermore, they justify each group formed on the basis of the defining attributes of the group. For example, they state that equilateral triangles include all the triangles that have three equal sides, triangles include all the polygons that have three sides, and polygons include all the closed, planar figures that have three or more sides. More precise terminology might be required such as "an equilateral triangle is a simple, plane, closed figure with three sides of equal length."

Possible higher levels of attaining the supraordinate-coordinate-subordinate relationships include what Kofsky (1966) designated as the "whole is the sum of the parts" and "some but not all." Again, merely being able to group a few instances properly according to verbal instructions is not a sufficient test of cognizing the sets of relationships; an adequate justification for the actions is required. According to Kofsky (1966), knowledge concerning supraordinate-subordinate relationships increases with age.

The understanding of supraordinate-subordinate relationships increases the validity and usability of the individual's concepts. For example, knowing the attributes of acid and also knowing that vinegar is an acid leads to the inference that vinegar has the attributes of all acids, as well as the attributes peculiar to vinegar. Thus all of the things known about acids--for example, how they react with bases--are true for vinegar also. In this way, learning that acid is a concept supraordinate to vinegar increases the validity and usability of the concept of vinegar for the individual.

Cognizing Other Relationships

There are other statements of relations between or among concepts that are different from relations among supraordinate and subordinate concepts. These additional statements, often termed principles, have been classified by Klausmeier, Ghatala, and Frayer (1974) according to the type of relation that is stated:

1. Cause and effect relationships are statements that may also be expressed in terms of an "if-then" relationship. For example, "tuberculosis is caused by the organism Myobacterium tuberculosis"; "contact with a hot stove produces a blister."

2. Probability statements are principles that express numerically the likelihood of an event's occurrence. For example, "the probability of giving birth to a boy during any given pregnancy is .52"; "provided the coin is fair, the probability of getting a head on only one toss of the coin is .50."

3. Correlational statements describe a relation, often expressed numerically, between two or more objects or events. For example, "if height and weight are measured for a large number of people, the resulting correlation between the two measures is around .50"; "the incidence of lung cancer in women is increasing and the number of women smoking cigarettes is increasing."

4. Axiomatic statements, the most inclusive type of principle, are universally accepted, self-evident truths. Five subclasses have been identified by Bernard (1975): (a) fundamentals, or principles essential to a science, religion, philosophy, or art; (b) laws, or statements of relationship of phenomena that always hold true; (c) rules, or principles in various subject matter domains that prescribe usage, procedure, or conduct; and (d) theorems and (e) axioms, both of which are usually mathematical statements of a relation to be proved or already proved.

Marx (1970) has referred to cause-and-effect, probability, and correlational statements as laws. Gagné (1970) has called these same types of statements principles or rules. In discussing rule learning, Gagné proposed two schemes for classifying rules. The first, based on rule content, divides rules according to those in which the rule relates concepts and designates ideas in contrast to those in which the content functions to guide the individual's response in a specific situation. The second scheme of classification for rules is based on rule structure--either simple or complex. The most simple rules consist of two concepts, arranged in a chain, in the form "if A, then B." Complex rules consist of a larger number of concepts which are often abstract and require subtle discriminations.

Although the various types of statements that express relations among concepts have been classified in slightly different ways by different experts, it is agreed that understanding these statements is critical to thinking and reasoning. Understanding statements of cause and effect or probability, for example, enables the individual to predict consequences from known conditions and to explain newly encountered phenomena. Bruner et al. (1956) have pointed out that understanding lawful relationships between or among concepts permits classes of things, rather than isolated, individual things, to be related. Gagné (1970) has suggested that the structurally simple rule "round things roll" is the kind of rule young children learn very early because it consists of concrete concepts having clearly perceptible instances. Once learned, this rule enables the child to predict what will happen to all spherical objects under certain conditions. Or, consider the more complex relationship: "When two substances at different temperatures come into contact, the temperatures of the substances tend to equalize." This relationship permits us to infer what will happen in such diverse situations as putting ice cubes in warm soda pop or being lost in a snowstorm.

In all cases, of course, being able to understand and use a lawful relationship is contingent upon knowing the concepts embedded in the statement. Only then can the rule or axiom or principle be understood and applied to appropriate phenomena.

Using Concepts in Problem-Solving Situations

Problem-solving ability is treated by Klausmeier (in press) as one of the most critical of all outcomes of education; a person who is capable of solving problems can learn independently. A considerable amount of instruction is directed toward teaching students problem-solving skills, and students acquire considerable knowledge through problem solving. Concept learning itself may be regarded as a special case of problem solving.

A situation requiring problem solving is encountered when an individual must respond but does not have immediately available the specific information, concepts, principles, or methods to arrive at a solution. To solve any problem the individual must think adaptively; more specifically, the individual must selectively recall important concepts, principles, and methods needed to solve the problem. Thus, not only may one or more concepts be instrumental in the solution of many kinds of problems, but the more experience an individual has with a given concept, the greater the probability of solving successfully a problem involving that concept.

Much of the organized knowledge concerning the nature of problem solving has been summarized in diverse theories, descriptions of the steps in problem solving, and descriptions of the internal and external conditions of learning. Although varying slightly in their emphases, these theories and descriptions all attest to the importance of problem solving in complex learning and thinking. In turn, theorists have also focused on the role played by concepts in problem solving. For example, Woodruff (1967) has discussed the role of concepts in higher-level mental activities, including problem solving. In accord with his cumulative model of learning, Gagné (1970) has viewed concepts as prerequisite to the learning of rules, and rules as prerequisite to the solving of problems. Gagné has also indicated that one way in which concepts are called into play in solving problems is by the application of principles to the problem-solving situation. For example, principles underlying the concepts of pressure, volume, gravity, and distance can be utilized to determine the height of a mountain by using a barometer.

ADDITIONAL FEATURES OF THE CLD MODEL

The CLD model is more heavily oriented toward learning than toward development in that it implies that all the concepts held by any individual are learned; they do not emerge simply with maturation. In this context it is similar to four theories of concept learning generated by American experimental psychologists and reviewed by Bourne, Ekstrand, and Dominowski (1971): theory of associations (Bourne & Restle, 1959); theory of hypotheses (Levine, 1966; Trabasso & Bower, 1968); theory of mediation (Osgood, 1953); and theory of information processing (Hunt, 1962). Also, in agreement with these theories, the model specifies that the attainment of concepts is potentially explainable in terms of principles of learning. Despite some differences in terminology, the CLD model, like Hunt's, represents an information-processing approach to learning. The CLD model differs from the four theories just mentioned in that it describes different levels in the attainment of the same concept and specifies the operations essential to attaining concepts at the successively higher levels. While some of the operations are postulated to be common to more than one level, these operations at the successively higher levels are carried out on more highly differentiated and abstracted properties of actual concept instances or on verbal descriptions of instances and attributes.

The CLD model is similar to Gagné's (1970) cumulative learning model in that both provide a framework for studying the internal and external conditions of learning. It also differs in two regards. Whereas Gagné describes seven forms of learning, ranging from the simplest learning through rule learning and problem solving, in the CLD model only one form of learning, concept learning, is analyzed according to its several constituent cognitive behaviors at each of four levels. Gagné also postulates a linear vertical learning hierarchy extending from signal learning through problem solving. The CLD model, as shown in Figure 1, indicates that a concept when learned at the classificatory or the formal level may be used in cognizing supraordinate-subordinate relations among the concept and other attained concepts, in understanding relations among concepts such as those incorporated in principles and laws, and in problem solving. Thus, the CLD model departs from the straight linear learning hierarchy postulated by Gagné.

Possibly different from the preceding learning theories and more in agreement with Piaget (1970), the CLD model presumes that the new operations at each successive level involve qualitative changes in operating on instances and attributes of concepts, not merely additions to or modifications of prior operations. Further, the operations that continue from one level to the next are carried out on more highly differentiated and abstracted concept attributes. While the model does not postulate a stage concept associated with age levels as does Piaget, qualitative differences in thinking of the kinds pointed to by Bruner, Olver, Greenfield et al. (1966) and Kagan (1966) are recognized. Also, Bruner's (1964) conceptualization of enactive, iconic, and symbolic representation is accepted as a satisfactory global explanation of how experiences are represented and stored.

The roles of language and directed learning experiences are recognized as being of central importance in attaining concepts at the classificatory and formal levels. The cross-cultural studies of Bruner et al. (1966) support the directed-experiences point of view (cf. Goodnow, 1969). Also, Bruner's (1964) intermediate position that specifies how language facilitates thinking, rather than being essential to thinking (Luria, 1961) or being dependent on thought (Inhelder & Piaget, 1964), appears valid for the present model. Accepting directed experience as critical in concept attainment de-emphasizes a maturational readiness viewpoint, such as that expressed by Gesell (1928, 1945). While it is accepted that certain cognitive operations emerge with educational experience, this conception does not espouse a behaviorist-environmentalist point of view regarding learning to the extent that either Gagné (1970) or Staats (1971) does.

II

THE FIRST EXPERIMENT DEALING WITH TREE

This study was conducted to determine the effectiveness of instruction for accelerating children's attainment of a concept to the formal level. Instructional lessons for the concept tree were prepared and used with fifth grade children.

METHOD

Instructional Design

The instructional design used in this study corresponded to that of the earlier study with the concept equilateral triangle. Eight major activities were carried out: (1) Analysis of the concept in terms of its definition, defining attributes, variable attributes, and position in a taxonomy; (2) determination of the preinstructional characteristics of the sample of students to be taught; (3) identification of the level of attainment desired after instruction, according to the CLD model; (4) assessment of learner's preinstructional level of concept attainment according to the CLD model; (5) design of lessons using methods which have been shown empirically to facilitate concept learning; (6) instruction; (7) assessment of subjects' postinstructional level of concept attainment; and (8) evaluation of the results.

1. Analysis of the concept. The analysis of tree was conducted with assistance from subject matter experts and various printed materials. The defining attributes of tree were identified as: a green plant with (a) roots, (b) seeds, (c) leaves, (d) one main stem, (e) woody stem, and (f) perennial. The definition was given as: "A tree is a kind of plant. It has roots, leaves, and seeds. It has one main stem that is woody. Trees are perennial." The variable attributes of tree were (a) type of leaves--broad or needle; (b) flowers or cones; (c) pattern of branches--alternate, opposite, or whorled; (d) deciduous or coniferous; (e) size; and (f) shape. In a taxonomy, tree is subordinate to the concept plant, coordinate to the concepts herb, shrub, and other plants, and supraordinate to the concepts deciduous tree and coniferous tree.

2. Preinstructional characteristics of the sample of students to be taught. For the purposes of this study an important criterion for subject selection included prior attainment of the concept tree

at the classificatory level. However, no empirical data existed to guide the determination of the grade level most likely to satisfy the criterion. That is, no cross-sectional or longitudinal data pertaining to children's level of attainment of this concept were available when the study was initiated. Data from cross-sectional studies with kindergarten, third, sixth, and ninth grade children concerning their conceptual development had indicated, however, that the majority of children in the third and sixth grades had not yet reached the formal level of attainment of the concepts equilateral triangle and noun (Klausmeier, Sipple, & Allen, 1974). On this basis, it was assumed that children in fifth grade would also not have achieved the formal level of the concept tree.

3. Selection of postinstructional level of concept attainment. Although most concept learning research has been done at the classificatory level (Klausmeier, Ghatala, & Frayer, 1974, p. 183), according to the CLD model it is attainment at the formal level which greatly facilitates the ability of individuals to use a concept. Since no reported research had been done at this attainment level, the formal level was chosen as the desired postinstructional level for the study.

4. Assessment of preinstructional level of concept attainment. Assessment was done using The Conceptual Learning and Development Assessment Series IV: Tree (Klausmeier, Marliave, Katzenmeyer, Sipple, 1974) which contains a set of exercises designed to assess children's concept attainment at the concrete, identity, classificatory, and formal levels. For this study, five subtests from the set were used to assess attainment level of the concept tree prior to instruction. These subtests were the classificatory subtest and the four subtests for the formal level: discriminating attributes; vocabulary; evaluating examples and nonexamples; and definition. Attainment of the overall formal level was determined by performance on the four subtests of the formal level. The subtest assessing the classificatory level consisted of eight items with instructions to mark an "X" on pictures which have certain attributes in common. For instance, one item instructed subjects to place an "X" on each of the pictures among ten which showed plants with woody stems. The next eight items in the classificatory subtest assessed the subjects' ability to determine supraordinate-subordinate relationships among concepts. An example is given below:

Are all of the trees below plants?

a. no, only some of them are plants

b. no, none of them are plants

c. yes, all of them are plants

d. I don't know

In the four subtests assessing the formal level of attainment, ten items tested the subjects' ability to recognize the defining attributes of the concept tree. Fourteen items tested ability to recognize the names or labels for the defining attributes of tree. Fourteen items assessed the ability to determine whether or not an instance was an example or nonexample of the concept tree, and one item determined the ability of the subjects to recognize the correct definition of tree.

5. Design of lessons. Methods which had been shown empirically to facilitate concept learning were used in the lessons in the study dealing with the concept equilateral triangle and also in this study on the concept tree. These methods, as reported by McMurray et al. (1974) were (1) use of a definition; (2) empirical selection of concept examples through an instance probability analysis; (3) use of rational sets of examples and nonexamples; (4) pairing of examples with nonexamples; (5) emphasis of defining attributes; (6) teaching of a strategy; (7) feedback; (8) active involvement by the student.

All of these methods were included in the instructional materials used to teach the concept tree to the formal level. It was hypothesized that since these methods had been effective when used sinly in past concept learning experiments, in combination they would prove effective in bringing children to the formal level of concept attainment.

6. Instruction. The written lessons, including instructions to get started, were used to teach the concepts in a manner designed to parallel the regular instruction of the children.

7. Assessment of postinstructional level of attainment. The Conceptual Learning and Development Assessment Series IV: Tree (Klausmeier, Marliave, Katzenmeyer, & Sipple, 1974) was again used for assessment of subjects' postinstructional level of concept attainment. In this way, pre- and postinstructional levels of attainment could be compared to determine the effectiveness of the lessons.

8. Evaluation of results. The objective for the experimental lessons was to bring children to the formal level of attainment of the concept tree. The data were examined statistically to determine whether the experimental lessons, in comparison with placebo lessons, facilitated attainment of the formal level.

Materials

The instructional materials consisted of two lessons. The first lesson, TR I, consisted of 33 pages and contained an introduction and a presentation of each of the defining attributes of the concept <u>tree</u>. Questions were asked following the presentation of each attribute and subjects were asked to respond by circling the correct answer or filling in a blank. The children were given immediate feedback as to the correctness of their responses. Immediate feedback has been found to facilitate concept learning (Clark, 1971). The subjects drew pictures of the defining attributes as each was presented. The questions and drawings involved the subjects actively in learning, another method found to facilitate concept learning (Piaget, 1964). Emphasis of defining attributes (Frayer, 1970; Rasmussen & Archer, 1961) was achieved through the use of position of picture or label of attribute on the page, boxes, arrows, and verbal cues.

In the second lesson, TR II, the definition of <u>tree</u> and a rational set of examples and nonexamples of <u>tree</u> were presented. Use of a definition which lists defining attributes had been used in several studies and had been found to facilitate concept attainment (Anderson & Kulhavy, 1972; Feldman, 1972; Feldman & Klausmeier, 1974; Merrill & Tennyson, 1971). The examples and nonexamples in the lesson had been selected empirically in an instance difficulty survey conducted prior to the study. In that survey, fifth grade children were asked to correctly classify instances as examples or nonexamples of <u>tree</u>. The difficulty rating for each example and nonexample referred to the percentage of survey subjects correctly classifying each item (Tennyson, Woolley, & Merrill, 1972).

In the rational set, examples were matched with nonexamples which differed from the examples in as few as possible defining attributes. Matching examples and nonexamples had first been suggested by Markle and Tiemann, 1969) and found to facilitate concept learning by Feldman (1972), Swanson (1972), and Tennyson et al. (1972). The rational set includes enough examples to vary each irrelevant attribute and enough nonexamples to exclude each defining attribute (Markle & Tiemann, 1969).

In the second lesson (TR II), subjects were also taught a strategy for evaluating whether an instance was an example or a nonexample of the concept <u>tree</u>. Strategies for inferring concepts have beer described by Bruner et al. (1956). A description of the series of questions concept learners ask themselves and decisions they make in evaluating instances as examples or nonexamples of a concept is given by Trabasso, Rollins, and Shaughnessy (1971). The strategy taught in lesson TR II makes use of this sequence of decisions assumed to be made internally by a learner given a concept definition and concept examples and nonexamples to evaluate. The definition of <u>tree</u> was provided and subjects were also given a decision rule regarding each attribute of the concept. That is, they were instructed to ask a series of questions, one for each attribute (Klausmeier, Ghatala, & Frayer, 1974, p. 117). For example, given a description of something, the subject asks six questions, one for each attribute. A "no" answer for any one of the six questions would classify the instance as a nonexample of <u>tree</u>. Two "riddles" from lesson TR II demonstrating this strategy follow.

Riddle 1. This living thing has long roots and many needle leaves. Its seeds grow inside cones. It has one main stem called a trunk that is very thick and woody. It has been living for 50 years.

Now answer these questions:

1. Does it have roots?	YES	NO
2. Does it have leaves?	YES	NO
3. Does it have seeds?	YES	NO
4. Does it have one main stem?	YES	NO
5. Is the stem woody?	YES	NO
6. Is it perennial?	YES	NO
7. Is it a tree?	YES	NO

Riddle 2. This living thing loves to fly. It has big wings. It eats seeds and sometimes tiny leaves. It lives inside an old barn. It is five years old.

1. Does it have roots?	YES	NO
2. Does it have leaves?	YES	NO
3. Does it have seeds?	YES	NO
4. Does it have one main stem?	YES	NO
5. Is the stem woody?	YES	NO
6. Is it perennial?	YES	NO
7. Is it a tree?	YES	NO

Eight riddles in which subjects were asked to evaluate examples and nonexamples were included in the lesson, four for examples and four for nonexamples. On the page following the riddles the subjects could check whether their responses were correct.

The Dale-Chall Formula for Predictability (Dale & Chall, 1948) was used to determine whether the reading level of the lessons was appropriate for the fifth grade level. A pilot was conducted with a small group of fifth grade children selected across ability levels to determine the readability of the materials and whether they held the children's interest. Minor changes were made as a result of the pilot. Placebo lessons, PL I and PL II, were developed for use with control subjects. These placebo lessons were concerned with number systems and the mathematical concept curves and were equal in length to the treatment lessons.

Experimental Design

A variation of the Solomon Four-Group design (Campbell & Stanley, 1963) was used to determine the effects of the experimental lessons and to control for possible pretest effects. The subjects were randomly assigned to one of four groups: group 1 received a pretest, treatment lessons, and posttest; group 2 received a pretest, placebo lessons, and posttest; group 3 received a placebo pretest, treatment lessons, and posttest; group 4 received a placebo pretest, placebo lessons, and posttest. This experimental design ensures that effects of pretesting can be separated from the main treatment effects.

Subjects

The subjects were 103 fifth grade students in two elementary schools of two small rural communities in Wisconsin. Fifth graders were selected because the written lessons required a reading level which could be expected of fifth year elementary school children. Also, as mentioned previously, it was assumed that fifth graders would not yet have attained the formal level of the concept.

Procedure

Four fifty-minute sessions were held with each group of subjects over 4 consecutive days. In order to control intergroup communication, the subjects were asked not to talk to one another about the lessons during the four-day period. Teachers were also told not to talk to the children regarding the study. All questions during the lessons were handled individually. On the first day, pretests were administered to one treatment group and one control group and placebo pretests were administered to one treatment group and one control group. General instructions for both the pretest and the placebo pretest were read aloud to the children by the experimenter. Then each item was read aloud and sufficient time allowed for the subjects to respond in the test booklet.

On the second day, a booklet containing lesson TR I was given to each of the treatment subjects and a booklet containing lesson PL I was given to each of the control subjects. General instructions were read aloud to both groups and a list of potentially unfamiliar words from both lessons was read aloud by both experimenter and subjects. The children were told to raise their hands if they encountered a word in the lesson they could not pronounce or directions they did not understand and that the experimenter would help them individually. They were informed that the experimenter could not explain the meanings of words to them and that they must work by themselves. The subjects then read the lesson to themselves and responded to the various questions and activities in the lesson. When they were finished the children read a book or did schoolwork while waiting for the rest of the group to finish. Booklets were collected at the end of the session.

On the third day a similar procedure was followed with lessons TR II and PL II. The posttest was administered to all subjects, experimental and control, on the fourth day. General instructions and each item were again read aloud.

Results

Dependent measures in this study were the mean number of correct responses on tests for the classificatory and formal levels and for the subtests of the formal level. For each of the pretest groups (1 and 2), the mean number of correct responses on the pretest for the classificatory and formal levels and for the subtests of the formal level was determined. For each of the posttest groups (1, 2, 3, and 4) the mean number of correct responses on the posttest for the classificatory and formal levels and for the subtests of the formal level was determined. These mean scores are given in Table 1.

TABLE 1

MEAN NUMBER OF CORRECT RESPONSES ON PRETEST AND POSTTEST
FOR CLASSIFICATORY AND FORMAL LEVELS:
FIRST STUDY WITH THE CONCEPT TREE

Pretest

Test	Treatment Group	
	Experimental (1) n = 22	Control (2) n = 31
Classificatory	7.77	7.83
Formal (overall)	27.08	28.43
Discriminating attributes	9.50	9.54
Vocabulary	9.36	10.23
Evaluating	7.40	7.83
Definition	.82	.83

Posttest

Test	Treatment Group			
	Experimental (1) n = 22	Control (2) n = 31	Experimental (3) n = 26	Control (4) n = 24
Classificatory	7.77	7.74	7.73	8.25
Formal (overall)	29.99	30.09	30.65	29.18
Discriminating attributes	9.77	9.68	9.65	9.75
Vocabulary	11.36	11.16	12.19	10.63
Evaluating	7.95	8.25	8.00	7.92
Definition	.91	1.00	.81	.88

A two-way analysis of variance was performed for each dependent measure to assess the effects of treatment, the effects of pretest, and the effects of treatment and pretest interaction. These data are summarized in Table 2.

As can be seen from Table 2, there were no significant effects of treatment, pretest, or interaction for any of the subtests at the classificatory or formal levels.

DISCUSSION

No significant differences were found between the posttest performances of the treatment group and the control group on any of the classificatory and formal subtests. These results were unexpected because the first intervention study, using the concept equilateral triangle (McMurray et al., 1974), found significantly superior performances by the treatment groups on all subtests at the classificatory and formal levels.

Closer examination of the present pretest data, however, revealed the probable explanation for the lack of significant differences between experimental and control groups. Unlike the pretest scores for the concept equilateral triangle, pretest scores for the concept tree were already at a very high level before any experimental treatment began. The pretest scores, maximum number of correct responses possible, and percentage of correct responses are presented in Table 3. Inspection of this table shows that on the pretest the mean number of correct responses for all subtests approached the maximum number of correct responses possible.

The conflicting results of the present and the earlier study on equilateral triangle suggest interesting and useful information about these two different concepts. One of the principles of the conceptual learning and development model is that various concepts are attained by the same children at different rates (Klausmeier, in preparation). Reasons for differential rates of attainment for different concepts are examined by Klausmeier, Ghatala, and Frayer (1974). They pose the question: What determines the individual's level of mastery of a given concept at a particular point in time (p. 183)? and they propose three factors which enter into this determination: (a) characteristics of the learner; (b) characteristics of the instructional situation; and (c) characteristics of the concept.

Subjects, instructional materials, and procedures were comparable in the equilateral triangle study and in the tree study. It is reasonable, therefore, to turn to factor (c), "characteristics of the concept," as a probable source of the different results from the two studies. One of the characteristics of a concept which influences the rate at which it is learned is the "abstractness" of the concept. According to Klausmeier, Ghatala, and Frayer (1974), abstractness pertains to the degree to which the common attributes of a concept are perceptible (p. 212).

One implication of a concept having perceptible referents is that the learner generally has had more experience with such a concept and has had it from an earlier age. Concepts with few or

TABLE 2

SOURCE TABLE FOR A TWO-WAY ANALYSIS OF VARIANCE ON EACH OF FIVE DEPENDENT VARIABLES: FIRST STUDY WITH THE CONCEPT TREE

Test	df	MS	F	
Source: Treatment	1			
Classificatory		.078	.177	NS
Formal (overall)		14.640	1.046	NS
Discriminating attributes		.000	.000	NS
Vocabulary		16.748	3.141	NS
Evaluating		.016	.005	NS
Source: Pretest	1			
Classificatory		.066	.151	NS
Formal (overall)		1.584	.113	NS
Discriminating attributes		.007	.029	NS
Vocabulary		.731	.137	NS
Evaluating		2.110	.653	NS
Source: Interaction	1			
Classificatory		.194	.441	NS
Formal (overall)		8.915	.637	NS
Discriminating attributes		.232	.919	NS
Vocabulary		9.741	1.827	NS
Evaluating		.082	.026	NS
Source: Error	99			
Classificatory		.440		
Formal (overall)		13.999		
Discriminating attributes		.253		
Vocabulary		5.331		
Evaluating		3.299		

TABLE 3

PRETEST SCORES SHOWING MEAN NUMBERS OF CORRECT RESPONSES, NUMBERS OF CORRECT RESPONSES POSSIBLE, AND PERCENT OR RESPONSES CORRECT: FIRST STUDY WITH THE CONCEPT TREE

Test	Pretest Scores	Number of Correct Responses Possible	Percent of Items Correct on Pretest
Classificatory	7.71	8	.96
Formal (overall)	27.84	35	.80
Discriminating attributes	9.51	10	.95
Vocabulary	9.86	13	.76
Evaluating	7.65	10	.77
Definition	.82	1	.82

no perceptible instances are not experienced as early in life, as frequently, nor as concretely as those with many perceptible instances which are abundantly present in the child's environment. The concept tree has many perceptible instances and examples of this concept are experienced early and often in the life of virtually every child. Therefore, it is reasonable to assume prior knowledge of the concept and of the defining attributes of the concept.

Examination of the criterion instrument also reveals that many of the items could be answered by fifth grade children in the absence of instruction. For instance, knowledge of the definition of tree was tested by a multiple choice item consisting of a stem and five choices. The correct definition was easily recognizable among the distractors.

A shortcoming of this study with tree was that the appropriate grade level selected for the study could not be determined accurately on the basis of existing empirical data. As a result, a majority of these fifth grade children had already achieved the formal level of the concept tree before the experiment began. Ideally, of course, preliminary data should have been gathered to determine fifth grade children's present level of attainment of the concept tree. A replication of this study was performed, but using third grade children as subjects.

III

SECOND EXPERIMENT DEALING WITH TREE

In the discussion of the first experiment, the nonsignificant results obtained were attributed to formal level attainment of tree by many fifth graders prior to the experiment; consequently the dependent measures employed in the study were inappropriate for assessing effects of instruction. Prior to this experiment, a pilot study was run with a small group of third grade children and it was found that most of them had not acquired the concept at the formal level.

METHOD

Instructional Design

A replication of the preceding study was conducted with 64 third grade children attending an elementary school in a small community in Wisconsin. The method used in this study was the same as that used in the original study: (1) the concept analysis was the same as that in the original study; (2) the characteristics of the students to be taught were determined--the children should have attained the concept tree at the classificatory but not the formal level and should have the necessary ability to read the lessons; (3) the level of attainment desired after instruction was identified as the formal level; (4) the instructional materials were designed using the same methods as in the first study (use of definition, empirical selection of concept examples through an instance probability survey, use of rational sets of examples and nonexamples, pairing of examples with nonexamples, emphasis of defining attributes, teaching of a strategy, feedback to the students as to the correctness of their responses, and active involvement of the student in learning).

Materials

After the first study, the instructional lessons (TR I and TR II) were rewritten to be appropriate for third grade children. Drafts of lessons were reviewed by a third grade teacher and administered to a group of sixteen third grade children to determine whether the reading level and vocabulary were comprehensible to children at that level. Modifications in the materials were made after that review. Aside from the modifications to make the materials appropriate for third graders, the lessons had the same format as those used for Study 1.

The assessment measures used for this study were identical to those used in the first study with the exception of the definition item. This item was determined to be nondiscriminative in the pretest for Study 1. It can be seen in Table 1 that a majority of children passed this item on the pretest. It was revised to discriminate between those children who had received the treatment and those children who had not received the treatment.

Experimental Design

This study included a treatment and a control group. The subjects were assigned randomly to one of the two groups: Group 1 received the pretest, the treatment lessons, and the posttest. Group 2 received the pretest, placebo lessons on mathematical curves and equilateral triangles, and the posttest.

Subjects

Third grade children were chosen as subjects for two reasons: (1) since in the original study, pretest scores indicated that the fifth grade children had considerable preinstructional knowledge of the concept tree, performing the study with younger children was seen as a way of minimizing the possibility of preinstructional formal level concept attainment of tree; (2) third grade was considered the lowest grade level at which the children could still read the written lessons independently. Independent reading of the lessons was considered necessary to make the replication as nearly like the original study as possible.

Procedure

The procedure followed the one used in the first study. The study was conducted in four fifty-minute sessions. One session was held on each of four consecutive days. As in the first study, the children were asked not to talk to one another about the lessons during the four-day period. This was done in order to control intergroup communication. Teachers were again instructed not to discuss the study with the children. Since this study used only two groups of subjects, treatment and control, as opposed to the four groups used in the first study, pretests were administered to all subjects on Day 1. Instructions for the pretest were read aloud by the experimenter. Then each item was read aloud and sufficient time was allowed for the subjects to respond in the test booklet.

On the second day, a booklet containing lesson TR I was given to each of the treatment subjects and a booklet containing PL I to each of the control subjects. General instructions were read aloud to both groups and a list of potentially unfamiliar words from both lessons were read aloud by the experimenter and subjects. Children then read the lesson independently and questions concerning vocabulary or procedure were answered for the children individually by the experimenter. On the third day a similar procedure was followed with lessons TR II and PL II. On the fourth day, the posttest was administered to all of the children in both the experimental and the control groups. General instructions and each test item were again read aloud for the subjects.

Results

Dependent measures in the replication were the number of items correct on the classificatory and formal subtests and on each component of the formal subtest. The mean pretest scores for the experimental and the control groups on the test for the classificatory level, each subtest for the formal level, and the total formal level are given in Table 4. Because the pretest mean scores on both the classificatory and formal level tests for the control groups are somewhat lower than for the experimental group, the data were submitted to an analysis of covariance with the pretest used as the covariate.

Table 4 shows that the mean posttest scores of the experimental and control groups were almost identical at the classificatory level (the highest score possible on the posttest was 8). Thus, both before the experiment started, and at its conclusion, the majority of the children in both the experimental and control groups had attained the concept at the classificatory level.

A substantial difference between the experimental group and the control group was found on the posttest mean scores at the formal level. The total number of items in the formal test was 35. The mean score of the experimental group (31.71) approached this ceiling.

Table 5 shows the percent of the control and experimental groups who had attained the formal level at the time of the pretest and at the time of the posttest. The number of experimental subjects passing the formal level increased from 1 on the pretest (3 percent) to 21 on the posttest (68 percent). There was no increase in the number or percent of experimental subjects passing the test for the classificatory level or the subtest for discriminating attributes; the numbers of subjects passing these tests on the pretest already approached the maximum number possible (29 of 31) for the classificatory test, and had reached the maximum number possible (31 of 31) for the discriminating attributes subtest. On the remaining subtests of the formal level, increases in the numbers and percent of experimental subjects passing on pretest and posttest were as follows: Vocabulary, 5 to 26 (.16 to .84); evaluating, 19 to 26 (.61 to .84); and definition, 11 to 17 (.35 to .87).

Table 5 also reveals that there was an increase in number and percent of control subjects passing the test for overall formal level (1 to 5, .03 to .14) and the subtests for discriminating attributes (31 to 33, .94 to 1.00); vocabulary (6 to 10, .18 to .30); evaluating (14 to 20, .42 to .61); and definition (11 to 17, .33 to

TABLE 4

MEAN NUMBER OF CORRECT RESPONSES ON PRETEST AND POSTTEST FOR CLASSIFICATION AND FORMAL LEVELS: SECOND STUDY WITH THE CONCEPT TREE

Pretest

Test	Treatment Group	
	Experimental (1) n = 31	Control (2) n = 33
Classificatory	7.84	7.65
Formal (overall)	26.77	24.77
Discriminating attributes	9.32	9.00
Vocabulary	9.68	8.90
Evaluating	7.42	6.55
Definition	.35	.32

Posttest

Test	Treatment Group	
	Experimental (1) n = 31	Control (2) n = 33
Classificatory	7.74	7.71
Formal (overall)	31.71	27.26
Discriminating attributes	9.65	9.32
Vocabulary	12.81	10.36
Evaluating	8.39	7.10
Definition	.87	.48

TABLE 5

NUMBER AND PERCENT OF SUBJECTS PASSING THE CLASSIFICATORY AND FORMAL LEVELS ON THE PRETEST AND POSTTEST: SECOND STUDY WITH THE CONCEPT <u>TREE</u>

Pretest

Test	Treatment Group	
	Experimental (1) n = 31	Control (2) n = 33
Classificatory	29(.94)	31(.94)
Formal (overall)	1(.03)	1(.03)
Discriminating attributes	31(1.00)	31(.94)
Vocabulary	5(.61)	6(.18)
Evaluating	19(.61)	14(.42)
Definition	11(.35)	11(.33)

Posttest

Test	Treatment Group	
	Experimental (1) n = 31	Control (2) n = 33
Classificatory	29(.94)	31(.94)
Formal (overall)	21(.68)	5(.14)
Discriminating attributes	31(1.00)	33(1.00)
Vocabulary	26(.84)	10(.30)
Evaluating	26(.84)	20(.61)
Definition	27(.87)	17(.52)

.52). However, these numbers and percents did not approach the performance increments of the experimental subjects, except for the evaluating subtest where the number of control subjects passing on the pretest already approached the maximum number possible.

Table 6 presents the results of the analysis of covariance for each of the six dependent measures. As would be expected from the high mean scores for both groups at the classificatory level the difference between the means was not significant. The difference between the experimental and control groups means on the formal test was significant. The differences between the mean scores for the two groups of children on each of the three subtests

Table 6

SOURCE TABLE FOR AN ANALYSIS OF COVARIANCE ON EACH OF SIX DEPENDENT VARIABLES WITH PRETEST SCORES AS COVARIATE: SECOND STUDY WITH THE CONCEPT TREE

Test	df	SS	MS	F	
Source: Treatment	1				
Classificatory		.025	.025	.070	(NS)
Formal (overall)		151.000	151.000	28.440	$p < .01$
Discriminating attributes		.708	.708	2.309	(NS)
Vocabulary		70.140	70.140	35.509	$p < .01$
Evaluating		8.809	8.809	3.611	$p < .05$
Definition		1.960	1.960	11.119	$p < .01$
Source: Error	60				
Classificatory		21.730	.356		
Formal (overall)		323.800	5.308		
Discriminating attributes		18.700	.307		
Vocabulary		120.500	1.975		
Evaluating		148.800	2.439		
Definition		13.750	1.676		

at the formal level (vocabulary, evaluating examples and nonexamples of the concept, and the definition of the concept) were also significant. Referring back to Table 4, the reader will observe that mean scores of the two groups on the pretest for discriminating attributes were 9.32 and 9.00 respectively. The total number of items for this test was 10, thus the majority of students in both groups scored very high on this particular test and no significant difference was found.

DISCUSSION

The results of this study parallel those of the earlier study by McMurray et al. (1974). Both studies show unequivocally that lessons can be prepared which markedly facilitate children's attainment of concepts. The differences between the control and experimental groups were smaller in this study dealing with tree than they were in the study dealing with equilateral triangle. The smaller difference is interpreted as resulting from the difference in the levels at which the children in the two studies began the experiments. Table 7 shows the number and percent of experimental and control subjects in the study with equilateral triangle who passed the classificatory and formal levels on the posttest. Since

TABLE 7

NUMBER AND PERCENT OF SUBJECTS PASSING THE CLASSIFICATORY AND FORMAL LEVELS ON THE POSTTEST: STUDY WITH THE CONCEPT EQUILATERAL TRIANGLE

Test	Treatment Group			
	Exp. 1 n = 32	Control 1 n = 30	Exp. 2 n = 28	Control 2 n = 28
Classificatory	30(.94)	22(.73)	26(.93)	18(.64)
Formal (overall)	19(.60)	2(.07)	18(.64)	3(.11)
Discriminating attributes	31(.91)	22(.73)	26(.93)	16(.57)
Vocabulary	24(.75)	5(.17)	23(.82)	3(.11)
Evaluating	20(.62)	7(.23)	22(.79)	3(.11)
Definition	21(.66)	4(.13)	20(.71)	4(.14)

there were no significant effects of pretest, the number and percent of control subjects passing the classificatory and formal levels on the posttest may be seen as representing the preinstructional level of concept attainment of equilateral triangle for children in the study. As can be seen from Tables 5 and 7, the fourth graders were at a lower level of preinstructional attainment of the concept equilateral triangle than were the third graders in their attainment of the concept tree. Most of the third graders had attained the concept of tree at the classificatory level whereas many of the fourth graders had not attained the concept equilateral triangle at the classificatory level. Further, not many children attained the concept equilateral triangle to a higher level during the two-month period between the end of the experiment and the retention test. Table 8 shows the number and percent of subjects passing the classificatory and formal levels on the two-month retention test in the study with equilateral triangle. In this second study, however, the control children continued to move toward attainment of tree at the formal level without instruction. It is possible that

TABLE 8

NUMBER AND PERCENT OF SUBJECTS PASSING THE CLASSIFICATORY AND FORMAL LEVELS ON THE TWO-MONTH RETENTION TEST: STUDY WITH THE CONCEPT EQUILATERAL TRIANGLE

	Treatment Group			
	Exp. 1	Control 1	Exp. 2	Control 2
Test	n = 28	n = 29	n = 25	n = 26
Classificatory	26(.93)	22(.76)	24(.96)	16(.62)
Formal (overall)	13(.46)	2(.07)	13(.52)	2(.08)
Discriminating attributes	27(.96)	23(.79)	24(.96)	16(.62)
Vocabulary	19(.67)	7(.24)	18(.72)	4(.15)
Evaluating	15(.54)	4(.14)	16(.64)	2(.08)
Definition	20(.71)	6(.21)	19(.76)	6(.23)

this improvement resulted from interactions between the experimental and control children during the four days in which the experiment was carried out.

The most important conclusion that can be drawn from the statistically significant results of the experiments with tree and equilateral triangle is that knowledge about concept learning can be incorporated in lessons that greatly facilitate children's learning of concepts. Therefore, each of the following guidelines merits careful attention in preparing printed materials to teach concepts.

1. Identify the key vocabulary and teach the children to read these key terms prior to study of a lesson.
2. Teach the children the defining attributes of the concept as well as the key terms by which the attributes are represented. Line drawings are particularly useful for depicting the attributes.
3. Present the definition of the concept in terms of its defining attributes. In addition to giving the definition, emphasize or point out the defining attributes.
4. Present a sufficient number of rational sets of examples and nonexamples so that errors of overgeneralization, undergeneralization, and misconception are prevented.
5. Provide exercises whereby the children can evaluate instances as being examples or nonexamples of the concept.
6. Simultaneously with the five above, teach a strategy for identifying examples and nonexamples of the particular concept.
7. Insert questions to which the children respond and, immediately after responding to a set of questions, provide feedback in the form of the correct answers.
8. Provide for active involvement of the children. This is accomplished primarily by including exercises in which the children either complete or make line drawings, or supply missing words, phrases, or sentences.

While other variables may be incorporated in lessons such as providing an advance organizer and raising questions within the lessons (Bernard, 1975), it appears that none of the preceding eight should be omitted.

We consider the knowledge gained from the experiments described in this paper as being sufficient to warrent using such lessons and procedures, either in experiments or in actual school instruction, to facilitate children's attainment of concepts. We do not propose, however, that the lessons be used alone. The younger the children are and the fewer experiences the students have had with examples of particular concepts (regardless of their age), the greater is the need to provide actual examples rather than pictorial or verbal representations. Also, other procedures may be required to sustain a high level of motivation. The authors strongly recommend that educating children to attain concepts, as well as for other outcomes of learning, should involve a warm interaction between teachers and children. Lessons such as these, then, may be used either as the primary instructional means for teaching certain kinds of concepts within certain instructional situations or as a supplement to the live instruction carried out by the teachers.

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