THE PROCESS CURRICULUM

Cognitive Competence

Classification

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NOTES

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DEFINITION

Classification is the process by which an individual identifies and abstracts (differentiates) a common property (or properties) from an array of actions, events, feelings, objects or ideas and integrates these properties into a group or category which can be extended (generalized) to include all other experiences possessing those properties. It is important to recognize that classification as defined here presupposes the development of perceptual capacities of sufficient complexity to enable the child to make objective reference to his environment. These capacities gradually emerge from the child's repeated interaction with the environment, especially the actions he performs upon it.

DESCRIPTION

An individual's interactions with his environment become meaningful when he differentiates the many elements which comprise the environment and organizes them in a pattern congruent with his own psychological needs and make-up. One means by which an individual achieves this is to reduce the complexities of experience to manageable proportions by categorizing or grouping experiences with respect to some shared quality. This process of grouping objects or events by identifying and abstracting shared qualitative and quantitative attributes is the first function of classification.

Such an organization of objects or events is achieved generally by three means. The first is primarily perceptual and involves sorting based on the recognized similarities or differences of physical attributes such as color, shape, size, pitch or texture. The second is conceptual. In this case, objects are grouped mainly on the basis of function which is largely determined by the social knowledge the individual has derived from his particular cultural setting; e.g., things that can be eaten and not eaten, things that one can ride on, things that can be worn, objects that one sits on, etc. The third mode involves organizing stimuli on the basis of an abstract concept and requires logical thought.

Because the forms of classification developed by the first two processes are more or less the result of perception, they tend to be rigid and unchanged by subsequent experience, while the third process results in the development of categories which are more flexible and accommodative since they are formed and reformed on the basis of logical processes (Piaget, cited in Lavatelli, 1961). This is, in essence, the basis of higher order classification because the individual must not only take in the information, but also reorganize it at a relatively high level of complexity. Most children up to the age of about six, make judgements on the basis of how things look to them. With the development of more

advanced cognitive activities such as reversing the thought process, making logical comparisons, and knowing conditions under which things are the same as well as conditions under which they are different, the child's judgement can transcend the limitations imposed by immediate perception.

When a class is formed by grouping together all circular objects in an array of different colored geometrical figures, circularity becomes the defining property or the critical attribute of the class. This attribute is called the intension of the class. Extending this criteria of circularity to include all other circular objects that are added to the original array is called extension. The defining property of a class is used to determine those objects to be included. In other words, intension and extension are mutually dependent.

The mechanism of classification, according to Piaget (Inhelder and Piaget, 1964), is the coordination of the intensive and extensive properties of a group of objects. Intensive properties can be defined as these properties that are common to all members of a class and distinguish one class from another. These are the qualitative aspects of classification, i.e., the criteria such as color, shape or size, used to group the objects. Extensive properties, in contrast, refer to the quantitative aspect of classification, e.g., the notions of all, some, one or none, and whether there are more red circles or more circles. The ability to coordinate these two properties occurs very slowly in children and the stages involved in the development of this ability will be discussed later in this specification.

Any curriculum for fostering cognitive growth should elicit from students those mental processes and logical operations involved in classification as they appear developmentally in early childhood. To date, our knowledge of the step-by-step development in this area of cognitive growth comes mainly from the research of Inhelder and Piaget (1964). They have identified the following stages:

1. Simple sorting: Grouping of objects according to a single property perceptually apparent like color, shape, size, texture or pitch.

2. True classification: Abstracting a common property in a group of objects and finding the same property in other objects in the group.

3. Multiplicative classification: Classifying on the basis of more than one property and recognizing that an object can belong to several classes at the same time.

4. All-some relation: Distinguishing classes on the basis of a

property belonging to all members of a class and a property belonging to some members of a class. (e.g., in a display of RED squares, RED trianglesa and RED circles, to recognize that all shapes are RED and only some are squares and some are triangles.)

5. Class inclusion relation: Forming sub-classes of objects and including the sub-class in a larger class. (e.g., in a bag containing wooden beads of red and yellow color, there is a class of red beads and a class of yellow beads and both belong to the class of wooden beads.)

In the first of the above processes (or stages) the subject takes the information from the object (or experience), while in the subsequent steps he transforms that information or does something to it by means of an abstract mental operation which results in cognitive growth.

THEORETICAL JUSTIFICATION: ANISA

Forming and utilizing categories represents one of the most elementary forms of cognition which man uses to organize his environment. Bruner (1956) contends that all cognitive activity depends upon having previously learned to group events according to their class. Classification, then, may be viewed both as an aspect of a "discovery of reality" as well as an indication of the level of concept attainment. A growing child progressively internalizes the criteria of the classification system around him and establishes a kind of order as he assimilates and accommodates the experiences encountered. The child's first categories are largely undifferentiated, unstable and all-inclusive, and his discovery of order in the universe rests primarily upon a progressive differentiation and integration of sensory impressions.

"The formation of entities called classes" (Flavell, 1970) can be regarded as an essential ingredient of the thinking process itself. According to Piaget, one of the corner-stones of logical thought is the ability to think in terms of a class. He describes how classification is rooted in infancy and develops into the ability to conduct scientific inquiry in adolescence. Classification logic is a good example of a basic cognitive tool that is necessary in all school subjects at all levels. The arithmetical operations of addition, subtraction, multiplication and division, as well as elementary measurements of continuous quantities, are examples of concrete operations involving the use of class inclusion. In the stage of formal operations, class inclusion develops into the ability to grasp not only the actual but also the possible. The quantification of probabilities and the hypothetico-deductive thinking of scientific inquiry involve class inclusion at the level of formal operations and requires the

coordination of what is hypothetical or possible (Kamii, 1971).

Realization of the fact that objects have many attributes depending on the level of analysis is an important step in the process of classification and, therefore, in managing the complexity of the environment. Stereotyped thinking arises when classifications are based on a limited number of attributes. When the child preceives objects, persons or events as possessing many attributes, he learns that no one member is fixed in any particular class but can be party to any number of classes depending upon the criterial attributes selected. Children should be involved at an early age to experiences that broaden their powers of categorization and increase their awareness of the polydimensional nature of reality. This will facilitate their thinking in more original ways, thereby fostering creativity. On a practical level, developing sound classification logic in children is crucial to career success in fields of scientific inquiry.

As Elkind (1969) points out, classification responses help to maintain the psychic economy by eliminating the need for fresh adaptation every time a new experience is encountered. Montessori, in fact, placed so much importance on classification that she even ventured to identify intelligence with the faculty of classification; "...to be able to distinguish, classify and catalogue on the basis of a secure order established in the mind, this is at once intelligence and culture." (Quoted in Kohlberg, 1968).

DEVELOPMENTAL CONSIDERATIONS

One of the fundamental postulations of Piaget's theory of cognitive growth is that there is an invariant order of intellectual development and that this order is determined by the child's ability to use increasingly more complex logical operations. Of all the research undertaken in developmental psychology to prove or disprove the above theory, the studies of "classification behavior" of children from infancy to adolescence have by far contributed the greatest bulk of supporting evidence. Extensive investigations carried out by the Genevan School delineate four major stages of development. The description of the first three stages constitutes the major section of the treatise by Inhelder and Piaget—The Early Growth of Logic in the Child. The fourth is described with examples in Inhelder and Piaget (1958).

Inhelder and Piaget (1964) have traced the development of classification starting with its origin in infancy. Even during the first few months of life, evidence has been found that the infant is building schemes or structures to use in classifying new phenomena. Classification here is at a sensori-motor level. The first stage which is known as graphic collection lasts from approximately two and a half to five years.

The second stage, called the stage of non-graphic collection, occurs from about four or five to seven or eight years of age. The third stage marks the attainment of true classification. This stage is one aspect of the period of concrete operations during which a dramatic number of other abilities emerge (e.g., conservation, operational seriation, spatial operations, etc.). The fourth and the final stage belongs to the period of formal operations, which is reached around the age of twelve.

Stage I - Graphic Collections

During this stage, the child characteristically is involved in making pictorial patterns. He uses the proximity of elements as the guiding principle in grouping those elements together. He is perceptually oriented and uses only one variable, and without exception this variable stands out "visually". When asked to put things together that go together, he will arrange objects in a spatial pattern with little regard for objective similarities between them. Toward the end of this stage, a child begins to coordinate more than one element. Without any preliminary plan, he consciously tries to arrange objects on the basis of similarities. An example of the emerging coordination is given in Figure 1. Here, we can infer from the slow, step-by-step process which the child uses to order the shapes when asked to arrange them in a linear fashion, that there is a lack of overall coordination of the intensive and extensive properties.

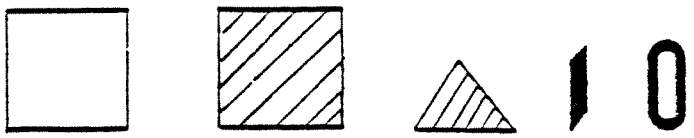


Figure 1

However, within a small group the coordination is perfect. When asked to justify the basis of the arrangement, he explains that shapes 1 and 2 are both squares, shapes 2 and 3 are both blue, shapes 3 and 4 are both small, etc. Piaget theorizes that the reason for the child's inability to coordinate more than two elements is that at this stage his thought is fixed at one level (centration). The child that makes a linear arrangement, as shown in the above figure, can think only of the similarity of successive pairs in a static way. By the time he comes to the third element he "forgets" how he grouped the first two elements. Since he

cannot remember the rule by which he began his classification, he has no stable basis upon which to plan further classification. What Piaget calls "hindsight", or "mobility of thought backward", refers to the child's ability to remember what he just did. The capacity to plan how to group the rest of the items is called "foresight" or "mobility of thought forward". Foresight and hindsight develop hand-in-hand because if a child can remember what he just did, he can also use this knowledge to plan the grouping of other objects. When such an ability to coordinate develops, the child moves into the second stage.

Stage II - Non-graphic Collections

The Stage II child groups things according to their similarities and differences. For him, the "intension" of the class determines the "extension" of the class. If redness is the criterion, for example, he will keep collecting things until all red ones are grouped together. The ability to peform at this level is due to the increased mobility of his thought. He can remember why he grouped the first elements together and use his knowledge to anticipate how to group the following elements. It is this hindsight that enables the child to continue the classification with foresight, thereby giving consistency to the intension. Because the child makes collections which are no longer based on graphic considerations, this stage is referred to as the stage of "non-graphic collections".

Although the child is able to coordinate the intensive and extensive properties to achieve the dichotomies, the ability is not stable enough to permit multiple classification, all-some relations and class inclusion. For example, an array containing red circles and green circles, when the child is asked, "Are there more red circles or more circles," the Stage II child will answer, "More red circles." From the standpoint of intension, the child knows very well that in front of him there are red circles and green circles and that all are circles. From the standpoint of extension, however, the moment he focuses on the "red circles" the group becomes separated from the whole and the whole for him becomes the remaining green circles. The child has not yet achieved a mobility of thought that allows him to see that red circles form only a part of the circles. He is able to think of the parts and the whole consecutively, but not simultaneously.

Stage III - Classification

In this stage the mobility of the child's thought enables him to separate (differentiate) the whole into parts and still maintain the whole (integration) in his mind. For this reason he understands that there are more circles than red circles. According to Piaget, "classification" is not achieved until the extensive properties are thus coordinated hierarchically with intensive properties. Any grouping activity that the child engages in prior to having "class inclusion" is considered to be the

making of collections, not classification (Kamii, 1969). In this stage, the child is not only able to engage in class inclusion but also to shift criteria and engage in multiple classification.

Stage IV - The Period of Formal Operations

The importance of evaluating the child's ability to make dichotomies and to shift criteria, dicussed above in terms of their indispensability for the achievement of class inclusion and multiple classification, are in turn indispensible for the attainment of formal operations in adolescence. The implications of the abilities attained in the previous stages for proper logico-deductive thinking in this fourth stage is worthy of note but is beyond the scope of this document. (For a detailed discussion of this problem, see Inhelder and Piaget, 1958).

Much of the research concerned with classification focuses on three basic questions: How children learn (a) to form one class, (b) to change criteria for classification, and (c) to compare the size and contents of different classes (Bruner and Oliver, 1963; Lovell, Mitchell and Everett, 1962; Vigotsky, 1962; and Dowdell, 1962). These investigations to a large extent confirmed the main theses advanced by the Genevan school. Inhelder and Piaget (1959), using a cross-cultural approach in which groups of children of different ages were given tasks which varied in complexity, have offered a detailed explanation of the steps by which children learn class inclusion. Kofsky (1966), using a scalographic study of classification development, has diagrammatically summarized the theory and given a predicted sequence of skills (See Figure 2).

PROTOTYPICAL LEARNING EXPERIENCES

Basic Guidelines

The play activities characteristic of most preschool programs provide a wide variety of opportunities for cognitive growth. Yet teachers are not always fully aware of how to intervene in a way that enables the child to gain the most mileage from those experiences. Therefore, training is necessary if teachers are to recognize and exploit the rich, cognitive content latent in most child activities.

The first step is to establish a coherent and adequate theoretical framework that will, in turn, serve as a base from which teachers can begin to identify, structure, and evaluate experiences fostering development. This theoretical framework should focus on the developmental aspects of each concept the child is expected to obtain. An example of this can be found in the developmental stages of classification (see preceding section). On the basis of this information the teacher can diagnose a

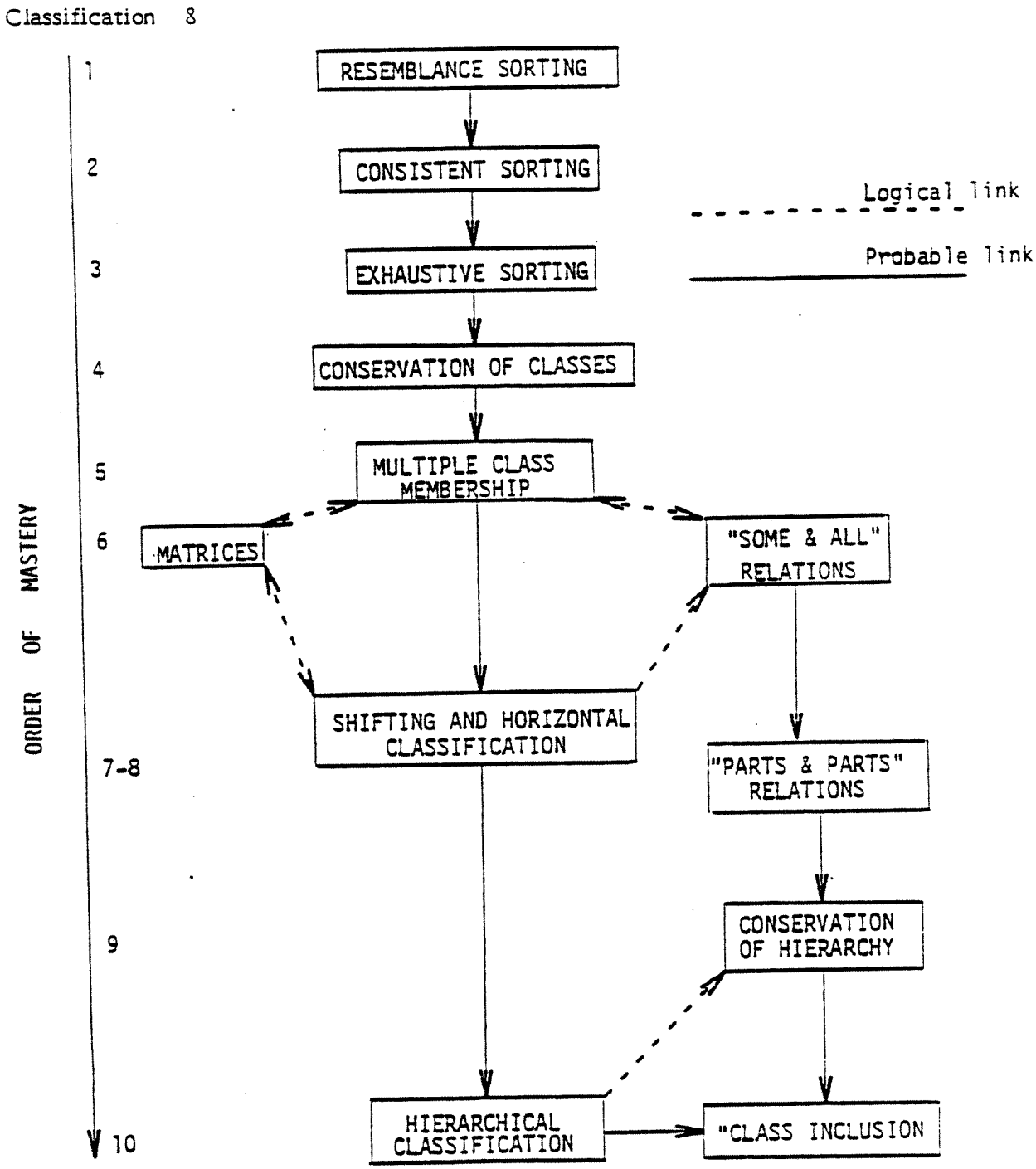


Figure 2

Predicted Sequence of Development of Classificatory Skills
(adopted with modifications from Kofsky, 1966)

child's level of functioning and build a curriculum geared to his unique needs. Through prescription or intervention, a teacher can arrange the environment in such a way that provides him with the prerequisite experiences and guide the child's interaction with that environment in such a way that provides him with the prerequisite experiences to achieve class inclusion, normally reached between seven and nine years of age. Although this scalogram modle may not be the most accurate picture of the developmental sequence, it may still prove useful, providing one keeps in mind that (a) there is no way to locate an individual child on the continuum in a manner which precisely differentiates the skills he has mastered from those which he is unable to perform, and (b) a child is capable of a broad range of behavior at any given time.

In order for a child to begin the processes of classification, he must be exposed to activities which require him to engage in a mental operation. Thus, the classroom should be a medium for performing the mental operation concerned. Learning activities should be arranged in the order of difficulty to match as closely as possible the developmental characteristics of the child. Although age norms described in Piaget's work are only approximate, the sequence of development seems to be invariant. Classification structures are by no means completed by the age of seven or eight, but there is strong evidence to suggest that the groundwork should be laid during the preschool and primary school years.

Before administering the Piagetian tasks for classification, the teacher must work closely with each child to ascertain his level of perceptual discrimination and assess the vocabulary associated with the relevant attributes. The latter is especially important since the role played by language is greater for classification than for seriation (Piaget and Inhelder, 1964), and the teacher must constantly bear in mind that the child may be incapable of articulating the concept he has recently mastered.

Prototypical Learning Experiences

Experience 1 - Stage I

Objective:

> Resemblance Sorting. To enable the child to classify on the basis of similarities; to extract at least one attribute and group two objects which share that attribute (intension).

Materials:

3 triangles of different colors and sizes
3 circles of different colors and sizes
3 balls of different size and color

3 squares of different color and sizes

Activity:

The child is asked to put things together that are alike, or, the child is shown a figure, and asked to comment on its qualities and then encouraged to find another one like the original.

Experience 2 - Stage I

Objective:

Consistent Sorting To enable the child to classify at least three objects together with similar attributes (intension and extension).
Materials and activities may be the same as in Experience 1, but the child is encouraged to find more objects like those already grouped.

Experience 3 - Stage II

Objective:

Exhaustive Sorting: Hindsight and foresight To group objects on the basis of an attribute and complete the classification until all objects that possess the critical attribute are included in the group (coordinated intension and extension).

Materials:

A collection of blocks (preferably three dimensional) including a red and a blue circle, one green and a blue square, two red and two green triangles.

Activity:

The child selects a block, puts it in a separate box and then he is asked to put in all other blocks that are alike. After the first box is filled, the procedure should be repeated with the remaining blocks in another box until all the blocks have been accounted for.

Experience 4 - Stage II

Objective:

Conservation of Classes To enable the child to grasp that a

class is not destroyed when some objects are taken away.

Materials:

A collection of objects from which he can make a class.

Activity:

The child is asked to classify objects, after which a few objects are removed from the classifying array.
The child is then asked if the group still exists. The same question is asked after making a pattern out of the grouped array.

Experience 5 - Stage III

Objective:

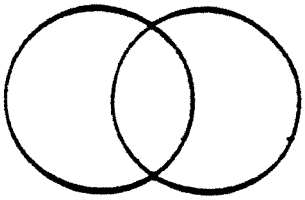
Multiple class membership To enable the child to know that an object classified on the basis of one attribute may belong to other classes at the same time (intersection), and/or to enable a child to classify objects on the basis of two attributes (matrices).

Materials:

(For intersection).
Four red triangles and four green triangles. Four red squares and four yellow squares.
Four red rectangles and four black rectangles.
Two large brass rings of sufficient diameter to include all objects when placed on a flat surface.

Activity:

The child is instructed to place the rings on the table near one another and then asked to place inside a ring all triangles and then place all remaining red objects inside the other so that the first ring can have only triangles. The second ring can have only red objects. On the basis of this rule, which objects can he place in the intersection if the rings are placed as shown in Fig. 3 ? The objective is achieved if the final arrangement appears as shown in Fig. 3a.



Intersection

Figure 3

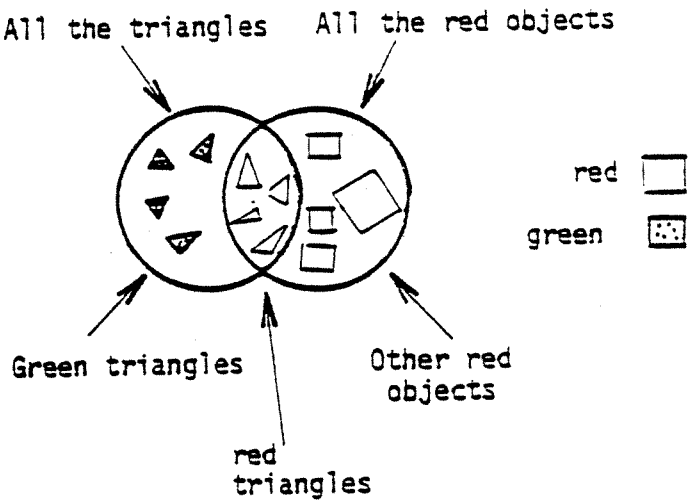


Figure 3a

Experience 6 - Stage III

Objective:

Hierarchical classification To enable a child to form groups and sub-groups within a group.

Materials:

An array of geometrical figures consisting of circles that are red and blue, and squares that are yellow and green.

Activity:

Ask the child to classify the objects on the basis of one attribute. The first classification should result in two groups, one of circles and the other of squares. Then ask the child to further classify each group. If the child has understood hieracrhical classification, he should produce the arrangement in Figure 4.

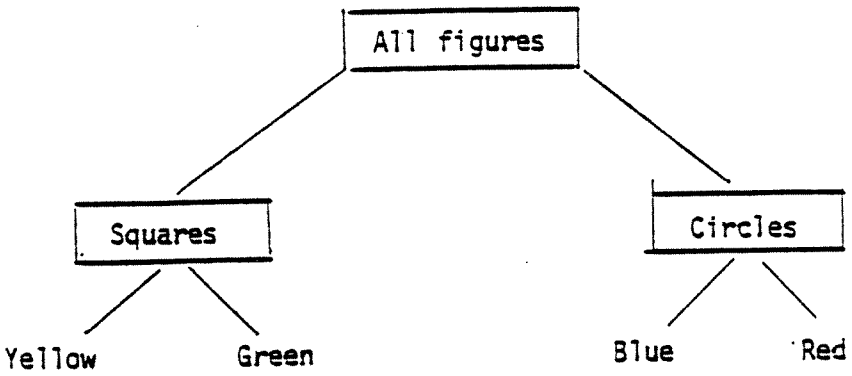


Figure 4

Experience 7 - Stage III

Objective:

"Some" and "All" relations To enable the child to understand the relation between the whole and the elements of a class.

Materials:

Nine blocks differing in color and shape—six of these are blue figures made up of two triangles and four squares, the remaining figures are red triangles.

Activity:

Ask the child first to identify the reds, blues, triangles and squares and then:

1. Are all reds triangles? Why? (The answer should be "yes" since every red is a triangle.)

2. Are all the triangles red? Why? (The answer should be "no" since some are blue.)

3. Are all the squares blue? Why? (The answer should be "yes" since every square is blue.)

4. Are all blues squares? Why? (The answer should be "no" since there are some blue triangles.)

The above tests can be performed with flowers of different kinds and colors.

Experience 8 - Stage III

Objective:

Relation between parts To understand that the whole is equal to the sum of its parts.

Materials:
Two blue wooden squares and an array of six red squares.

Activity:

Ask if all of these figures are squares? If the red ones are squares. If the blues are squares.
Tell a story:
Mary and Joan wanted to build a tower with these figures. Mary said they could make the highest tower if they took all the red blocks and all the blue blocks and put them together. Joan said that they could make the highest tower if they took all the blocks and put them together.
Who is correct, Mary or Joan? Who will have the tallest tower and why?
The same task can be performed with different colored wooden beads. The child is asked to string a necklace out of the beads and then compare the lengths.

Experience 9 - Stage III

Objective:

To understand the conservation of hierarchy

Materials:

Same as in the previous task.

Activity:
The opening question is also the same.
If I took away all the reds, are there just blues left or squares left? Why?
If I took away all the reds, would there be more blues or squares

left, or as many blues as squares?
Two correct answers are needed to understand conservation of the hierarchy. When these two questions are answered correctly, the child understands that taking away "blueness" or "redness" does not destroy "squareness".

Experience 10 - Stage III

Objective:

Class inclusion

Materials:

(Same as in experience 7).
Nine blocks differing in color and shape—six of these are blue figures made up of two triangles and four squares, the remaining figures are red triangles.

Activity:

The following questions are asked:

1. Are there more blues or squares? Count them. (Answer: More blues since there are six blues and four squares.)

2. Are there more reds or triangles? Count them. (Answer: More triangles, since there are five triangles; 2 blues and all 3 reds, and only 3 red figures.)

The same task can be administered with flowers of different color and kind, and also with wooden beads of different colors. The questions should be asked very carefully, making sure that the child correctly understands the problem.

REFERENCES

Bruner, J., Goodnow, J. J. and Austin, G. G. A study of thinking. New York: John Wiley & Sons, 1956.

Bruner, J. and Oliver, R. R. Development of equivalence transformation in children. Monograph of Society for Research in Child Development, 1963, 28, (No. 2), 125-40.

Dodwell, P. C. Relation between the understanding of the logic of classes and of cardinal number in children. Canadian Journal of Psychology, 1962, 16, 152-60.

Elkind, D. Conservation and concept formation. In Elkind, D. and Flavell, J. H. (Eds.), Studies in cognitive development: Essays in honor of Piaget, New York: Oxford University Press, 1969, 152-60.

Flavell, J. H. Concept development. In Musson, D. (Ed.), Carmichel's manual of child psychology. New York: John Wiley & Sons, 1970, (Vol. 1, Part III), 983-1060.

Inhelder, B. and Piaget, J. The growth of logical thinking from childhood to adolescence. New York: Basic Books, 1958.

Inhelder, B. and Piaget, J. La genese des structures logiques elementaires. Neuchatel: Delachaux et Niestle, 1959.

Inhelder, B. and Piaget, J. The early growth of logic in the child. New York: W. W. Norton & Co., Inc., 1964.

Kamii, C. A Piagetian method of evaluating pre-school children's development in classification. ED 039 013 Office of Education, ERIC Files, 1969.

Kamii, C. Evaluation of learning in pre-school education: Socioemotional, perceptual-motor, and cognitive development. In Bloom, B., Hastings, J. T. and Madans, G. (Eds.), Handbook on formative and summative evaluation of student learning. New York: McGraw-Hill, 1971.

Kofsky, E. A scalogram of classificatory development. Child Development, 1966, 191-204.

Kohlberg, L. Early education: A cognitive developmental view. Child Development, 1968, 39, 1013-62.

Lavatelli, C. S. Piaget's theory applied to an early childhood curriculum. American Science and Engineering, Inc., Boston, 1970.

Lovell, K., Mitchell, B. and Everett, I. R. An experimental study of the growth of some logical structures. British Journal of Psychology, 1962, 53, 175-88.

Siegal, I. E., Anderson, L. M. and Shapiro, H. Categorization behavior of lower and middle class Negro preschool children: Differences in dealing with representation of familiar objects. Journal of Negro Education, 1966, 35, 218-29.

Vygotsky, L. S. Language and thought. Cambridge, Mass.: M. I. T. Press, 1962.