THE PROCESS CURRICULUM

Cognitive Competence

Conservation

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DEFINITION

Conservation denotes the intellectual operation by which the qualitative and quantitative invariances of an object, situation or event are abstracted and understood to be invariant while certain of its attributes undergo change or transformation. These invariances include such primary qualities as weight, volume, area or number which remain the same despite changes in appearance.

DESCRIPTION

Current research has revolved around two distinct meanings of conservation. They are:

1. The process of apprehending a stable identity as such despite changes or distortions in appearance, i.e., the penny seen through a magnifying glass is judged to be the same penny the child placed upon the table a moment ago. This is a non-quantitative judgement. (Piaget, 1965)

2. The mental act of maintaining quantitative constancy across certain kinds of perceptual reconfigurations. (DeVries, 1969)

Every act of conservation relies on establishing an equality between the data before and after transformation. For example, a well known observation task devised by Piaget and his associates utilizes two clay balls of equal size and shape. The experimenter then remolds one of the clay balls into a different form such as a cylinder. Although the shape has been changed, the amount is the same; the quantity has been conserved. Being able to conserve is important because it helps to bring order and constancy amid an ever-changing world, thereby reducing the complexity of experience to manageable proportions.

Conservation includes both differentiative and integrative functions. The child differentiates that which remains invariant from the flux of systematically varying superficial relations. In the case of the clay-to-ball-to-clay cylinder change it is the amount of clay that remains identical. Although to an adult this may appear obvious, a child of less than six years is often unable to grasp that the amount of clay can remain invariant across changes in apparent shape or distribution. The reason for this difficulty becomes clear when we recognize that the concept of quantity, presupposed in understanding conservation, is a high-level abstraction which is inferred from immediate experience rather than directly perceived. In this case, constancy can be inferred by coordinating (integrating) simultaneously the inverse relation between length and width. The non-conserving child cannot make this integration of independent dimensions and instead focuses only upon the variance within a single dimension, i.e., height or width.

Research suggests that children who are successful conservers employ several different kinds of mental strategies which differ according to the kinds of attributes which are conserved. These strategies include qualitative versus quantitative constancy, identity versus equivalence, and first-order versus second-order conservation. The following sections will treat these matters in detail and present examples of each strategy to illustrate diagnostic procedures.

Before discussing these specific issues it should be emphasized that conservation like all other operations (e.g., classification and seriation) presuppose being able to reverse a mental act, to retrace a series of transformations back to their point of departure. There are basically two types of reversals: the first is inversion or negation, the cancellation of an operation by combining the original operation with its opposite, and the second is reciprocity which involves equalizing an operation by introducing an off-setting factor to compensate for the original change. The difference between the two can be demonstrated using the familiar experiment in which water is transferred from one large container to four smaller containers (See Figure 1). To invert the

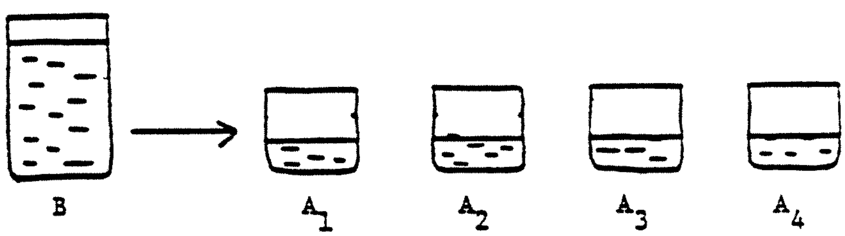

Figure 1

operation one would simply pour the water from the four beakers back into the large beaker. Raising this example to the level of abstract reasoning, we can see that B can be differentiated into parts A_1, A_2, A_3, and A_4 which when added together (integration) equal B. Alternately, a reciprocal operation coordinates opposing relations in different dimensions to establish a compensating system of equilibrium. For instance, when water is poured from the large container into the smaller ones, there is an increase in the spatial distribution of the water yielding an impression that the amount of water has increased. However, within each smaller container, the water level is lower than in the larger container suggesting conversely that the amount of water has decreased. If the child synthesizes these two estimates so that the increase in surface area is contrasted with the decrease in height, he will have established a system of compensating relations which will permit conservational reasoning.

Qualitative and Quantitative Invariants

The distinction between qualitative and quantitative invariants concerns both the attributes of the objects being conserved and the nature of the transformation which these attributes undergo. Qualitative invariants include properties which are typically not quantified, such as color and shape. Qualitative conservation developmentally precedes quantitative conservation and in its most primitive form is expressed as object permanence, the process by which the continued exsistence of physical objects or persons is recognized even when the entity has been removed from the perceptual field. Another aspect of such primitive qualitative conservation is the ability to apprehend the constant identity of a changing organism whose appearance may vary considerably over the passsage of time (for example, a tree whose leaves appear, change color and are shed with the changing seasons).

Quantitative invariants include those attributes that differentiate grades of value or intensity present with a particular qualitative dimension and are typically identified in terms of measureable quantities such as length, number, weight, and volume. A common example of quantitative invariance can be seen in those systems where there is no change in the physical appearance of a substance but no change in its amount, as in the case when water is transferred from a tall glass into four smaller containers (Figure 1A). The number of smaller containers

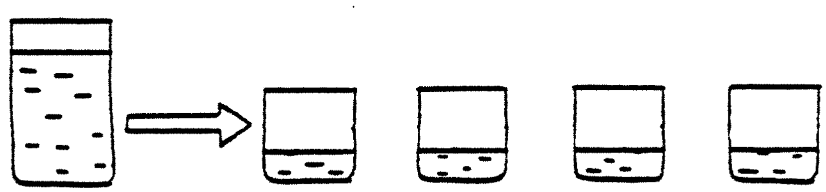

Figure 1A

gives the appearance that there is more water in the four glasses combined than in the one original glass, when, in fact, the quantities of water in both configurations remain the same. As was mentioned earlier, different mental processes are required for quantitative and qualitative conservation. apprehending qualitative invariance is by far the more primitive mode since it does not involve quantitative measurement. At this stage, the mode of reversibility, mentioned above, i.e., inversion and reciprocity, are not functional. Instead, the child uses a simpler process, differentiating certain key attributes of the objects before and after the transformation. If these attributes remain unchanged, then the child reasons that the quality has been conserved. With the advent of reversible thought patterns, the child has intellectual structures sufficiently complex to apprehend quantitative conservation.

Identity and Equivalence Conservation

Elkind (1970) has identified two stages in a typical conservation task which can be demonstrated in the following experiment (See Figure 2).

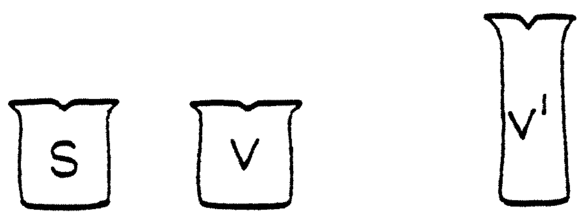

Figure 2

Two beakers of water, equal in size and shape, are presented to the child. He is allowed to adjust the level of water until he is satisfied that the amount of water in each is equal, so that the standard (s) = the variable (v). The experimenter then pours the water from v into a tall cylinder (v') and then asks the child to compare the amounts of water in s and v'. Elkind has termed such a comparison equivalence conservation. He labels the comparison of the liquid when it was in v, with itself as it appears later in v', identity conservation because it contrasts the amount of liquid in the graduated cylinder (v') with the same liquid when it was in v.

Many studies have aimed at determining which type of conservation occurs first, but the results of these investigations are in conflict. Elkind (1967), Hooper (1969), and McManis (1969), have evidence which supports the priority of identity over equivalence conservation. On the other hand, Piaget (1952), Inhelder and Piaget (1963), and Northman (1970) contend that the two concepts occur simultaneously. While these studies have not resolved the matter, it is important to be aware of the separate steps of identity and equivalence since the different comparisons can be used in diagnosing students who experience difficulty with the concept of conservation.

It should be mentioned briefly that Bruner (1966) has found that preschool children at very young ages (3-4 years) believe that the quality of water changes during transformation. For example, when a toy duck in water was transferred into a different container, some children believed that the water was not the same, that it was "different water". Bruner sees this confusion as a negative instance of what he calls object "identity", an expression which denotes something different from Elkind's use of the term. Whereas for Elkind, identity and equivalence issue from reversible operations and embody quantitative aspects, Bruner's notion of identity is concerned only with qualitative invariance.

First-Order and Second-Order Conservation

The essential difference between first-order and second-order conservation centers around the types of reversibility and the degree of abstraction which are required for the operation. First-order conservation, which encompasses parameters like weight, area, continuous quantity, number, etc., can be understood either by the use of inversion or reciprocity, and is rather easily demonstrated by concrete objects in the physical world. Second-order conservation, among which are included concepts like volume, density, uniformly accelerated motion, etc., necessitates the use of inversion and reciprocity simultaneously (correlation). Since it is based on notions which are inherently more abstract, second-order conservation is much more difficult to demonstrate in forms of concrete changes. Consequently, second-order conservation does not emerge until the stage of formal operations (age 11-13).

TYPES OF CONSERVATION

In order to assist the teacher in understanding the pervasive nature of conservation as a generic process through which the child understands the physical world, some of the common conservation tasks are described below. All normative data will be given in the section on development.

Conservation of Substance (Mass)

This type of conservation can be demonstrated with two clay or plasticene balls of equal size and weight (E and F, Figure 3). The child is permitted to add or subtract clay until he is satisfies that the amount of clay in E is the same as that in F. Then, one of the balls (F) is

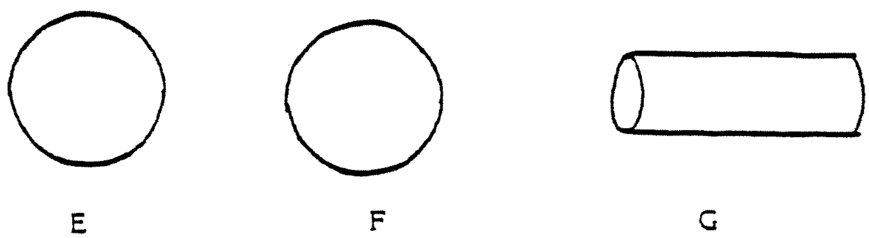

Figure 3

molded into a different shape, e.g., a sausage (G, in Figure 3), or a pancake. Then he is asked to compare the amount of clay in F and G. Certain types of shapes lead to specific intuitive answers depending on the individual child. For instance, a pancake may appear to have lost substance, while a cylinder may give the impression that the amount of clay has increased. If the child is to achieve conservation in such tasks he must learn to avoid judgements based on such superficial impressions. More precisely, he must acquire perceptual strategies which enable him to differentiate and integrate attributes which more adequately describe the transformation.

Conservation of Weight

This task proceeds in exactly the same manner as conservation of substance, except that a scale is introduced to determine the weight. There is less reliance om intuitive reasoning as the basis of verification with this task because the scale can be the final proof that weight is conserved (Brainerd and Allen, 1971).

Conservation of Length

One variation of this task is to arrange two parallel rows of 10 match sticks so that their ends are perfectly aligned and the equality of length between row A and B is obvious (See Figure 4). Then (See Figure 5) the sticks can be arranged in a slant (B_1) or a zigzag pattern (B_2), or moved so that the ends of A and B are no longer aligned (A and B_3). With each such alteration, the child is queried about the equality of each transformation with respect to the standard, (row A). This question might be phrased, "If you were travelling on one of these roads, on which road would you have to travel the farthest.

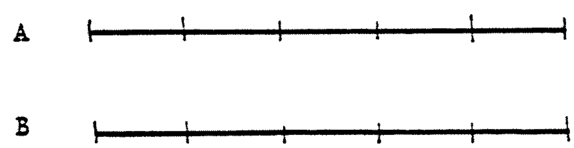

Figure 4

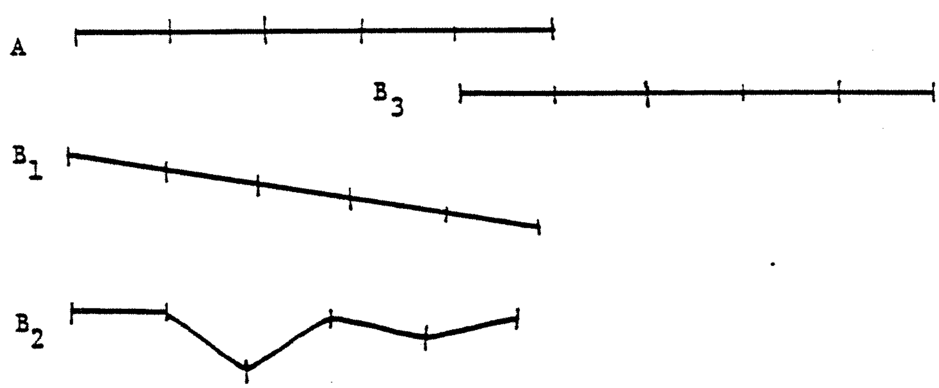

Figure 5

<u>Conservation of Number</u>

Number conservation entails the following procedure:

1. Two rows of objects containing equal numbers of elements are placed before children as illustrated (See Figure 6), and they are asked to confirm their equality;

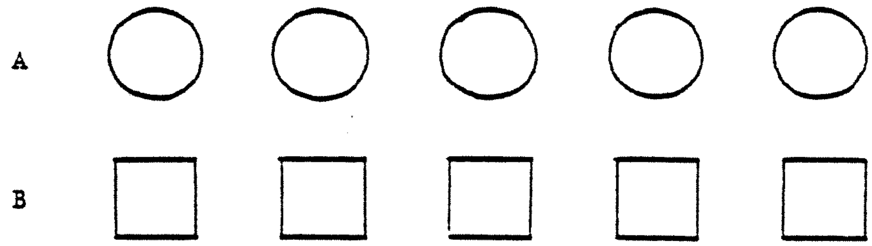

Figure 6

The experimenter then either increases or decreases,

2. The distance between the objects in one row is changed so that the rows are of unequal length (See Figure 7). At this point the child is asked, "Does one row have more objects than the other or are there the same number of objects in each row?"

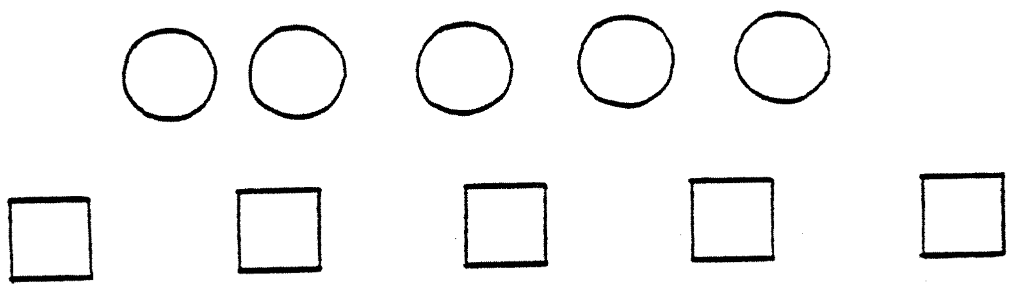

Figure 7

This task involves establishing a one-to-one correspondence, a prerequisite to grasping basic number-relations, particularly the concept of cardinal value (Brainard and Allen, 1971).

Conservation of Continuous Quantity

This exercise was introduced earlier in the experiment where water was transformed from a large container into several smaller ones. An initial comparison is made between water in two containers of the same size, A and B, before the transfer is made to containers C. Other variations (See Figure 8) include transferring the water from container B into: (1) a container which is shorter but wider than the original (D), and (2) a container which is taller but thinner than the original (E).

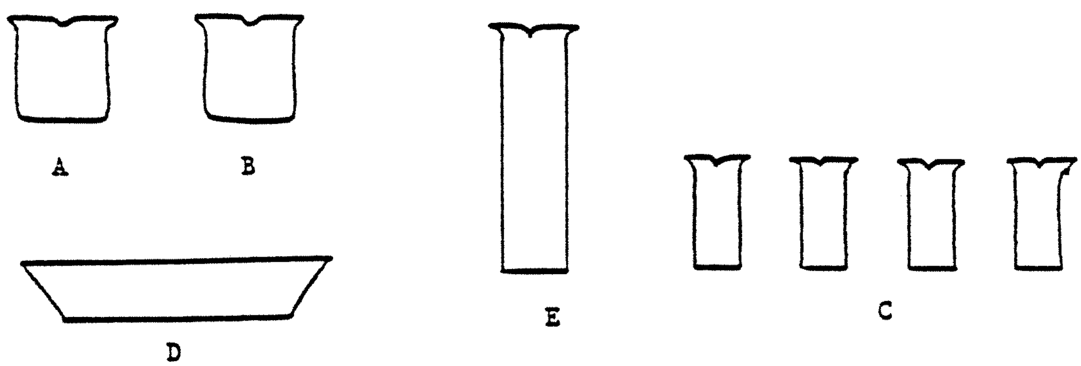

Figure 8

These three variations are presented in sequence and if the child is able to reason that the quantity of liquid remains the same in all cases, this will indicate he has mastered conservation at the level of concrete operations (Ginsburg and Opper, 1969).

<u>Conservation of Discontinuous Quantity</u>

This task is similar to the one before with the exception that beads are used in the place of liquids. Beads can be thought of as discrete discontinuous particles since the total volume of beads can be subdivided into individual units. Quantities based on such determinate particle units introduce the concept of one-to-one correspondence as a factor influencing the attainment of conservation.

The task commences with the child comparing the amount of beads in containers A and B (See Figure 8). Once again the child is encouraged to adjust the heights of each container until he is convinced of their equality. Then, the beads are transferred to containers C, D, and E, and the child is asked whether the necklaces made from the beads in each of these containers would be equal in size.

One-to-one correspondence may be evoked by having the child first count out the same number of beads for jar A and B before going through with the above exercise. Incidently, although research by Piaget indicates that one-to-one correspondence is not sufficient for conservation, he does regard it as an intermediate step (Piaget, 1965).

Conservation of Order

The conservation of order is the ability to hold constant a sequential pattern of data under varying modes of orientation and presentation. The following example will help illustrate. Three balls, each a different color, labelled A, B, and C, are strung on a wire (See Figure 9).

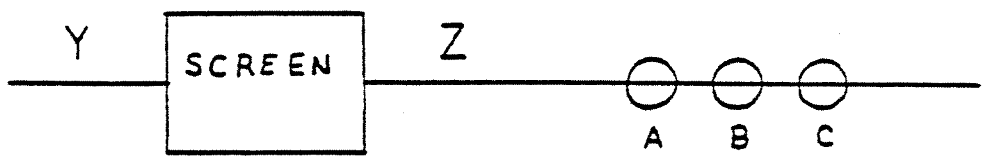

Figure 9

These objects are passed in order, A—B—C, behind a screen and then emerge at the opposite end, Y. The child is then posed the problem of predicting:

1. In what order will the balls emerge from end Y? and,

2. In what order will the objects reappear if they travel through the tunnel in the reverse direction, emerging at end Z?

The child then moves to the other side of the screen (in back of it) in a variation of the original exercise. The three balls are placed in the experimenter's hand and while in full view of the child they are rotated 180 degrees so that ball C is in the position where ball A is in the diagram above and vice versa. Another option is to repeat the above, rotating the balls 360 degrees but leaving the other end unchanged. The major focus of the task is to discover whether children recognize that the order of the balls remains unchanged when emerging from the tunnel at side Y and that the order is reversed when the balls emerge from side Z.

Conservation of Area

This task involves the comparison of two equal areas of space, each divided into smaller segments and distributed differently. In the typical exercise the child is asked to consider the area as a patch of grass available for a toy cow to eat. The grass is simulated by equal rectangular sheets of green cardboard or blotter paper (See Figure 10), and the experiment proceeds by introducing identical wooden blocks, which represent barns, one at a time into areas A_1 and A_2. The blocks in

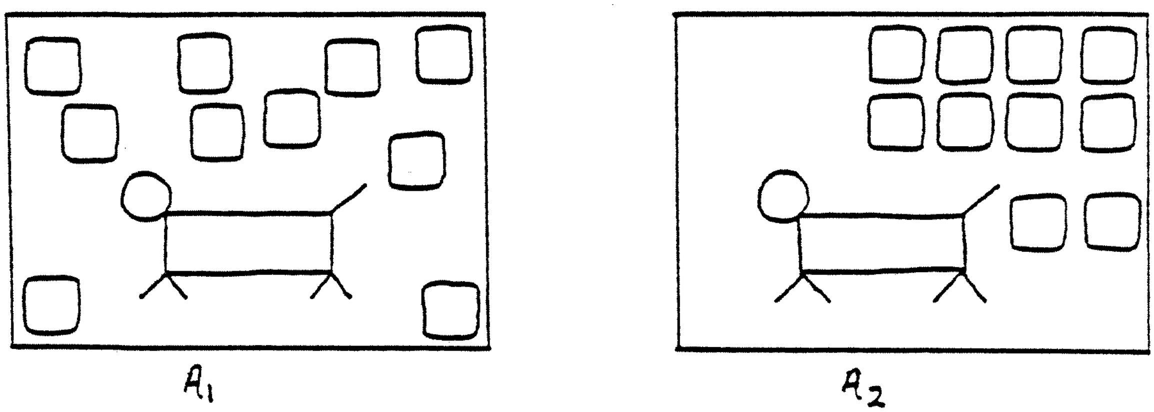

Figure 10

A_1 are placed next to one another while the blocks in A_2 are spread apart. As each block is placed into the areas, the child is asked to determine which cow has more grass to eat.

THEORETICAL JUSTIFICATION: ANISA

Earlier it was mentioned that if a child is to be a competent conserver he must differentiate parameters that remain constant during transformations. Because of its wide-ranging differentiative function, conservation is a key process underlying learning competence.

Piaget views conservation "...as a necessary condition of all experience and all reasoning". He claims that the process of reasoning which is achieved through building a system of abstract concepts "requires a certain permanence in their definitions" which the process of conservation fulfills.

Piaget and others speak of conservation as forming the basis of mathematics and the resultant systems of measurements. Piaget has written that "...a number is only intelligible if it remains identical with itself, whatever the distribution of units of which it is composed..." and the "set", another fundamental concept in number systems, "...is only conceivable if it remains unchanged irrespective of the changes occurring in the relationship between the elements." (Piaget, 1965). Regarding systems of measurement, Lovell and Ogilvie (1960) state that "...the notion of invariance is essential to any kind of measurement in the physical world."

Conservation is one of the fundamental processes underlying rational thought and hence, lies at the root of scientific inquiry. Piaget points out that conservation of rectilinear and uniform motion made possible the development of modern physics, while conservation of matter and energy made modern chemistry possible (Piaget, 1965).

It is important to note that the process of conservation extends to other categories of human potential besides cognition albeit in less formalized and quantitative modes. For example, a child must learn that he can be loved by mother, though the expression of that love may vary greatly depending upon the nature of the occasion. The behavior of a loving parent can range from the warm reassurance during times of stress to firm guidance in periods of discipline. One might say that the expression of love is conserved in this transformation and that although the outward behaviors are perceptually different, the inward concern of parent for child (love) is the same. This ability to discern conservation and maintain constancy in the deeper structure of one's emotional experience is just as important for a child's development as is conservation of the physical world.

DEVELOPMENTAL CONSIDERATIONS

This section will trace the development of first-order conservation through the sensorimotor, pre-operational, and concrete operational stages of growth. The sensorimotor and the early part of the pre-operational stages mainly involve qualitative invariance while quantitative concepts are developed in the later preschool ages, but are not mastered until the concrete operational stage.

Sensorimotor Growth (0-2 years)

The genetic antecedents of conservation can be found in the child's mastery of object permanence, the belief that an object exists even though it is no longer present to the senses. Object permanence can be regarded as an early form of conservation because the object undergoes a transformation of being removed or hidden from one's senses, yet it still exists as the original object. Without the conviction of permanence in the physical world, the children will not have mastered the prerequisite to handle more complicated transformations which accompany advanced forms of conservation.

Pre-operational Growth (3-7 years)

One can view the development of conservation during this period in terms of two sub-processes: the conservation of qualitative constancies, and later, the conservation of quantitative invariants. Bruner (1966) has found that children between the ages of 4-5 years demonstrate an ability to conserve the qualitative identity of a substance across simple transformations (See Figure 11). That is, a child will conclude after watching water poured from container A to container B, that the water in B is the same water that was previously in A (this does not imply that the child has conserved the amount of water across the transfer).

Figure 11

Another type of conservation acquired at this stage is the ability to comprehend the identity of a living oganism through changes in appearance, a process known as generic identity (DeVries, 1969). DeVries placed masks of different animals on household pets and presented them to children to test their grasp of generic identity. Although her study has been criticized as inconclusive on the basis of her methodology, the experiment deals with the important capacity to conserve the identity of living things something critical for understanding the growth process over time. For example, the contrasting appearance of a plant two months after planting does not alter the identity of the plant.

As qualities are differentiated, the child begins to compare differences with a given dimension in very primitive global terms, e.g., big ball, little ball. Such activity marks the beginning of quantification which is, of course, an essential prerequisite for the achievement of quantitative conservation. It will be recalled that conservation entails the systematic integration of these quantitative differences. Between the ages of three to five, children are unable to conserve quantity and frequently judge that solids and liquids vary in quantity when their apparent shape is altered. Thus, when the water is poured from container A to container B (See Figure 11 again) the child sees no inconsistency in expecting the amount of water to change because one level is lower than the other. At this stage, quantification is based on estimates derived from simplistic perceptions, and the child does not understand the inverse relationship between a decrease in height and in increase in width (as can be seen in container B). Moreover, these perceptual estimates are not characterized by combination. This prevents the child from understanding the additive relationship between the whole and the sum of its parts. When a young child sees a liquid being poured from container A into several smaller containers, it is perfectly consistent with his level of thought to assume that there is more water in the four containers, because they present a perceptually overwhelming arrangement (See Figure 12).

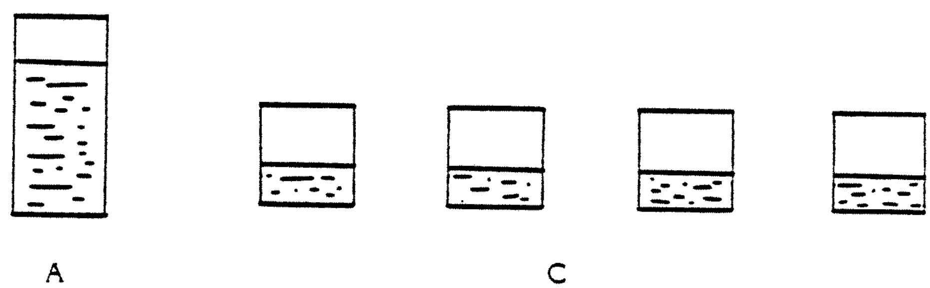

Figure 12

Once again he has not grasped the fact that a liquid can be partitioned into smaller and equal units while remaining quantitatively the same (Piaget, 1965).

In stage 2, that of intermediary reactions, the child can apprehend constancy across transformations as long as the perceptual disparity between the beginning point and end points is not too great. For example, he could coordinate the changes in the height and breadth that occur when water is transferred between beakers A and B or A and C (See Figure 13) and succeed when the transformation is slight. However, he cannot conserve when the discrepancy between before and after is large, as would be the case when water is poured from A to D.

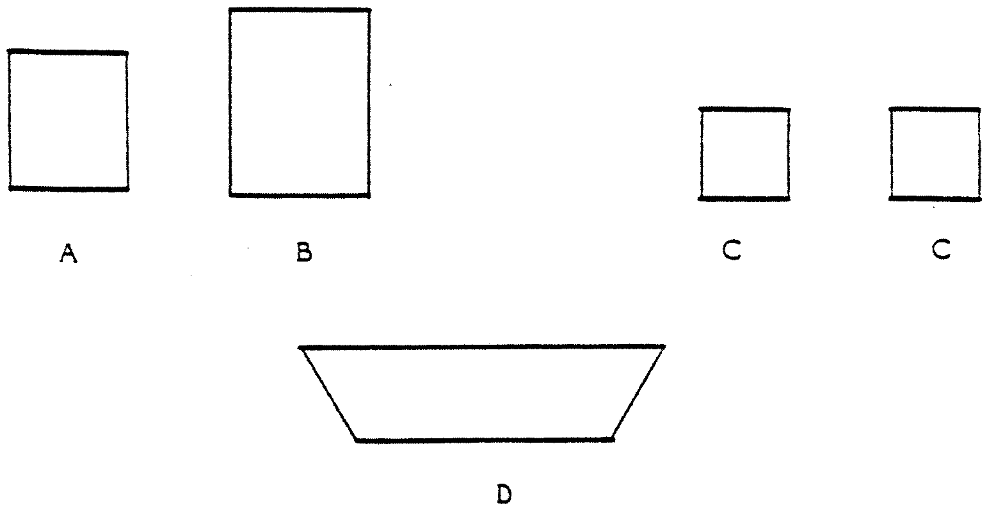

Figure 13

A parallel situation exists with containers A and C. As long as only two C containers are used, children comprehend the invariance because they understand that a whole remains identical with itself when it is subdivided into two halves. However, when three of four containers are used, perceptual influences become predominent, and the ability to conserve is impaired. Piaget reports one child as saying that the more a given quantity is subdivided, the more there will be of it (Piaget, 1965).

Concrete Operations (7-11 years)

During this period of growth, the level of necessary conservation is mastered. Now the child's answers indicate a consistent grasp of conservation irrespective of the number and nature of the changes made. Such consistency is attainable only because the child can comprehend (1) what Piaget terms the logical multiplication of relations, and (2) simple proportions involving numerical partitions. Logical multiplication of relations is a form of inference which enables the child to discern a quantitative change in a higher order dimension. Thus he can correctly compare the change in amount of liquids transferred between two containers as long as: (1) the two relationships vary in the same direction, (2) one remains constant while the other varies or (3) both remain constant. As a case in point, containers A and D (See Figure 14) exemplify two relationships varying in the same direction, since container D is both taller and wider than container A; containers A and B illustrate the case where one relationship is constant, the height, while the width varies, and containers A and C illustrate the case where both height and width remain the same. However, logical multiplication alone does not allow the child to decipher an increase, decrease, or invariance of quantities when relationships vary in two opposite directions simultaneoulsy, e.g., when container B is shorter in height, but wider than container A (See Figure 15).

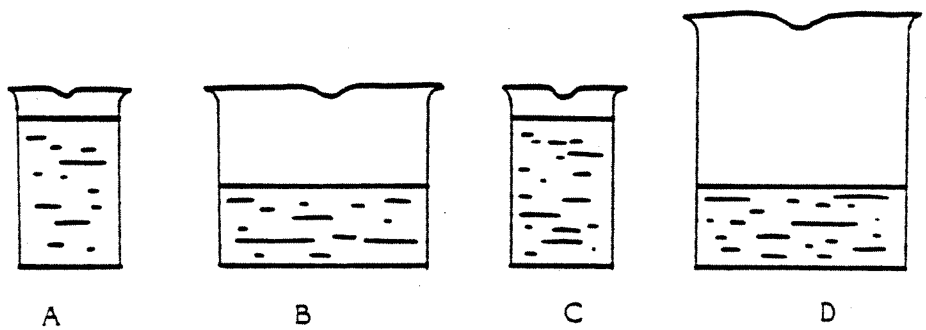

Figure 14

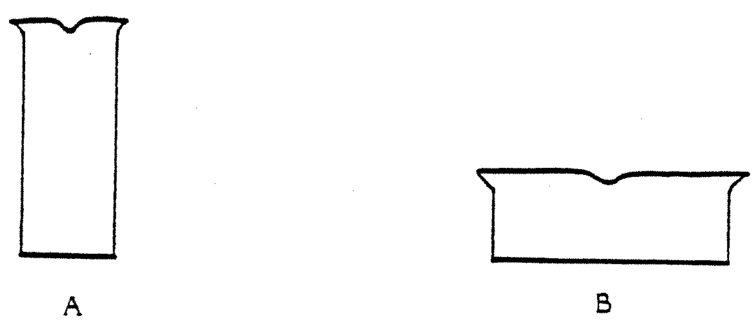

Figure 15

Simple proportionality allows the coordination of at least two relationships that vary in opposite directions, e.g., a container that increases in height while at the same time decreases in width, or a quantity of liquid that decreases in level while the width of the container increases. Children can eventually coordinate such relationships because with the schema of proportions or numerical partitions, asymmetrical relationships of differences can be equated. For example, at this stage, children can understand that a difference in height can be compensated or equated with a change in width.

Moreover, proportionality implies the differentiation of a complex whole and a systematic coordination of the relations between these differentiated components such that the whole becomes defined in terms of the systematic interrelation among its parts. The whole is no longer viewed as an undifferentiated totality whose value changes with the shape of the container. At this stage, children can comprehend the constant quantity of a liquid when it is poured from container C into containers D (See Figure 16). Numerical partition is then an act of summating or equating the different levels in the D containers which are shorter in height, narrower in width, and lower in level with the whole amount of liquid in C, which is taller in height, wider, and higher in level. $C = D_1 + D_2 + D_3 + D_4 + D_5$.

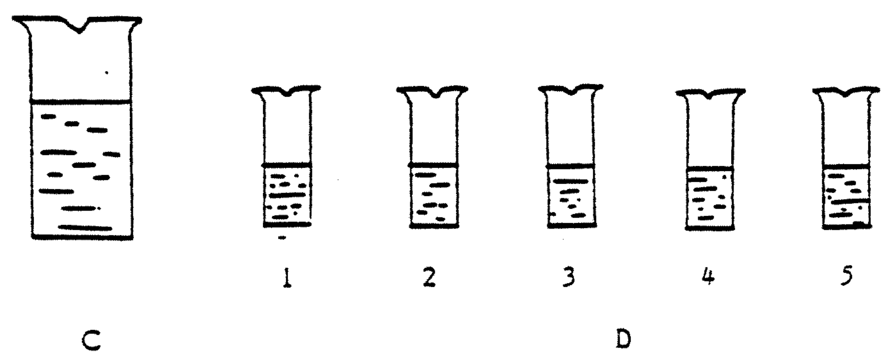

Figure 16

Developmental research demonstrates that an understanding of conservation on one type of task does not insure that the conservation of other types will also be understood. Until the stage of formal operations the child who may be able to conserve in one medium, e.g., clay, cannot transfer the process to different media, e.g., liquids. Transference is successful only with substances which are very similar to those used in the original task, i.e., solids like mud, wet sand, or rubber. Moreover, the pre-operational child seems unable to generalize conservation across qualitatively different dimensions. For example, there is no spontaneous transference from the conservation of matter to the conservation of area since the latter requires a familiarity with spatial forms. Rather, there is a horizontal staggering at which each of the concepts are understood; for example, the conservation of number and area are generally not achieved at the same time. Such studies indicate that we must be cautious in assigning age norms for different conservation tasks since children proceed in their development at different rates. Thus, all age norms assigned to the stages of growth are only approximate and not specific.

Referring to specific conservation tasks, the conservation of number appears to be the first process mastered. Brainerd (1971) and Piaget (1965) found that children achieved competence in this area between the ages of 5-7 years. In addition, training studies by Wallach and Sprott (1964) report that conservation of number was successfully taught to first grade children between the ages of 6 1/2 and 7 1/2 years.

There are three conservation tasks which can be discussed together since they involve children's concepts of space, namely, the conservation of length, of area, and of order. Conservation of length, which might be considered the conservation of space in one dimension, was found by Brainerd (1971) to occur between 5-7 years and by Murray (1965) between 7-8 years, although Murray's experiment could be discounted because it was not the traditional Piagetian one. Conservation of area, which demands coordination of spatial relationships in two dimensions, seems to occur sometime after 7 years of age (Beilen and Franklin, 1962). Finally, the conservation of order is achieved at different times, depending on the complexity of the task. For instance, simple order is mastered at 4 years; reverse order is contemplated between 5-6 years; and the two tasks together with the rotation (See "Conservation of Order") is understood at about 7-8 years (Piaget, 1970).

With regard to the conservation of solids and liquids, Elkind (1961) found that conservation of substance was understood at 7-8 years. He also found that the age range for the conservation of weight to be around 9-10 years. This norm conflicts with Furth's (1964) finding that 6 1/2 year old, normal subjects were able to conserve weight while deaf children succeeded at 8 years. Finally, both conservation of continuous and discontinuous quantities occur after the conservation of substance, since the shape of the containers which hold the liquid offers an added perceptual distraction to the task.

PROTOTYPICAL LEARNING EXPERIENCES

General

To differentiate and integrate the qualitative and quantitative dimensions of a changing physical or biological system such that its invariant qualities are apprehended.

Specific

Sensorimotor Conservation (0-2 years)

Object Permanence. To give indication that an object still exists even when it has disappeared from one's perceptual field.

Pre-operational Conservation (3-6 years)

Generic Identity. To discern the invariant identity of a living being across any transformation, e.g., to recognize a cat is still a cat even when wearing a mask resembling a wolf's head.

Inanimate Object Identity. To recognize the constancy of a physical substance across some transformations, e.g., to recognize that by pouring water from a large beaker into three smaller ones, the physical quality of the water is not changed; it is still the same water.

Order Identity. To identify the proper order of a sequence of three objects which disappear from view and then reappear.

Concrete Operational Conservation (6-10 years)

Conservation. To maintain cognitively the invariance across transformations in the following physical systems.

Age of Initial Appearance in Years	Physical System
5 - 7	1. Number
5 - 7	2. Length
7	3. Substance (mass)
7	4. Continuous Quantity (liquids)
7	5. Discontinuous Quantity
7	6. Area
7 - 8	7. Order (with transformation)
9 - 10	8. Weight

Guidelines for Writing Prototypical Learning Experiences

A fundamental point which Piaget and his colleagues have stressed continually is that the capacity for learning is limited by the child's particular developmental level. The distinction between development, especially psychological development, and learning may at first seem puzzling since it would appear to be enormously difficult to separate these factors. Nevertheless, Piaget contends we must somehow account for the fact that children, on the whole, show consistent differences in their ability to understand and perform certain logical processes.

The matter of controversy is whether the normative limits are based upon the child's lack of certain kinds of experiences or whether they are innately determined. Piaget seems to think the latter while a number of American psychologists, notably Bruner, argue that it is possible to teach any concept to a child regardless of age providing appropriate symbolic representation is used (Bruner, 1961). This controversy has spawned numerous attempts to teach conservation to children in the pre-operational stage of development. Most of these attempts have been unsuccessful, thus lending credence to Piaget's claim. However, positive results were reported by Smedslund (1961).

Of interest is the method he used which relies on the introduction of cognitive conflict in the training procedure. The theoretical basis of such a method is that if the child is faced with two juxtaposed competing judgements, he will be forced to reflect rather than to respond on the basis of what he already knows. Such an approach is basically congruent with Piaget's thesis that intellectual development is impelled by a condition of disequilibrium produced when incongruous judgements of a situation arise from inadequate representations of reality. In order to restore equilibrium, the child must accommodate and refine his intellectual modes of representation.

On the issue of designing educational experiences, Piaget is at pains to point out that any cognitive operation can be "taught" only by providing those experiences that facilitate a process of assimilation, accommodation, and equilibrium between a child and his environment, within his present developmental level.

In addition, other considerations include:

1. At the intuitive or perceptual level, children are unable to follow the transformations of more than one property of an object or situation at any given moment.

2. A child able to conserve in one task may be unable to conserve with different materials or tasks.

3. Children tend to revert to the intuitive or perceptual level when the demands of the environment are too removed from concrete content.

4. Experiences should elicit active involvement on the part of the child and be accompanied by speech (Smart, 1970).

There are a cluster of studies that have investigated which of three training methods were most effective in inducing weight conservation in 6-8 year old children. The training procedures used in these studies were (1) reinforced practice (R.P.), (2) addition/subtraction methods (A.S.), and (3) verbal rule instruction (V.R.I.).

The procedure for reinforced practice begins with 1 or 2 objects of equal weight being deformed, following which the child is asked whether the weight has remained constant. The objects are then weighed on a scale and with no comment the teacher proceeds to repeat the transformation.

The addition/subtraction method involves a deformation followed by the teacher either adding or removing a piece of the substance in full view of the child. The teacher then asks the child to compare and judge the amounts after which the results are verified on a scale or balance.

The verbal rule intstruction method also includes the deformation of one of the objects followed by the standard conservation question. If the child answers incorrectly, the teacher gives a verbal statement of the principle of conservation of weight and then reverses the transformation.

Smith (1968) reports in his study a comparison of the three methods mentioned above with non-conservers and transitional conservers. With the non-conservers he found no significant difference betwen A.S., R.P., and the control. However, he did find that the V.R.I. method produced a highly significant difference. For the transitional conservers, there was a significant improvement with the R. P. and V.R.I. methods, although here again the V.R.I. method showed the greatest gain.

Smedslund (1961) studied the changes in the types of answers children give in a conservation task, using both the R.P. and A.S. methodology. He classified their answers as either symbolic or perceptual. Symbolic answers required explanations which directly or indirectly referred to previous events in the test sequence, while perceptual answers included explanations that could be directly perceived at the moment of explanation. Presumably, the symbolic answers indicate a greater reliance on logical thought processes and therefore reflect a higher level of functioning than a perceptual response. Smedslund found that the two methodologies, A.S. and R.P., produced no significant difference in their ability to produce an increase in the amount of symbolic anwsers a child would use during an experiment. However, it should be noted that the R.P. method had slightly greater effects than the A.S. sequence.

Brainerd and Allen (1971) conclude that the most effective methods of training conservation are those which incorporate the demonstration of reversibility into the training method or prototypical experience. In fact, there are a number of studies which use the inversion-negation form of reversibility (Wallach, Wall, and Anderson, 1967; Smith, 1968; Gelman, 1969; and Beilin, 1965). These studies tend to be the most successful in inducing conservation in non-conservers.

The ANISA concept of isolating relevant processes, arranging the environment of the learner, and then guiding children's interaction with that environment support Brainerd and Allen's conclusion. Among the experiences outlined below, numbers 2, 3, 4, and 5 incorporate the use of reversals. In experience 5, an attempt is made to use the "reciprocity" form of reversibility.

Prerequisites. Sub-processes necessary for the development of conservation include: identity, object permanence, perceptual constancy, inversion-negation, reciprocity, structuring and synthesis, and an understanding of causality. Several of the sensorimotor processes, particularly perceptual constancy and object permanence, seem to be especially important. "Perceptual constancy is comparable at the sensorimotor level with various ideas of conservation," (Piaget, 1966) and "the permanence of the object...is not only the product of intelligence, but constitutes the very first of those fundamental ideas of conservation which we see developing within the thought process (Piaget, 1966).

Identity, inversion-negation, and reciprocity have already been discussed in the previous sections so they need only be mentioned here as prerequisites. Structuring and synthesis refer to a whole and its subsequent division into parts. These sub-processes refer to the ability to synthesize the parts into the whole, and the ability to recognize the equivalence between the whole and its parts. Finally, conservation demands that the child be able to direct his perceptual search to those attributes of the transformation that serve as relevant to quantitative invariance.

Prototypical Learning Experiences

Experience 1

Objective: To recognize, using psychomotor cues, the permanence of an object when it has disappeared from one's view.

Process: Object permanence.

Level: Sensorimotor.

Materials: Teething ring, rattle.

Activity: Introduce object (teething ring) to child so that he begins to play with it. After a period of 3 minutes, withdraw the ring so that he cannot see it. Observe his facial expressions.

Repeat with rattle, but when you withdraw the rattle, shake it so the infant can hear the sound while it is out of sight.

Evaluation: If the infant seeks the object after it has disappeared, he has achieved a degree of object permanence. Intermediate stages are present when you observe the infant staring at the spot where the object disappeared, instead of playing with some unrelated object. Also, the infant begins to use his eyes to follow object's disappearance (Ginsburg andd Opper, 1969).

Experience 2

Objective: To conserve water (and like substance) across changes in shape.

Process: Object identity.

Level: Pre-operational.

Materials: Water, pans (different shapes), play dough.

Activity: Pour water into one pan and let child play with it a while. Question him as to the difference in height, appearance (e.g., round vs. square), etc. Ask him if it is still the same water.

Repeat using play dough (DeVries, 1969).

Experience 3

Objective: To understand that two rows of objects contain the same number of items if there is a one-to-one correspondence between these objects, regardless of the physical appearance of the rows (i.e., differences in distances between objects in a given row).

Process: Conservation of mass.

Level: Concrete operational.

Materials: Two balls, 3" in diameter, made out of play dough.

Activity: 1. Place 2 balls on the floor or table.

2. Ask child if the 2 balls contain the same amount of play dough. If the child thinks they contain different amounts, allow him to take away or add play dough from one ball until he claims they are equal.

3. Take one ball and roll it into a cylinder.

4. Roll the cylinder back into the original ball.

5. Ask the child if the 2 balls are equal. If he agrees that they are, proceed to step 6. If he thinks they are not, return to step 2.

6. Pick up one ball and roll it into a cylinder. Ask if the amount of clay in the ball and cylinder are equal.

7. Evaluate whether the child use inversion as a reason for believing that there is no change in the amount of play dough.

<u>Experience 5</u>

Objective: To understand that 2 objects, initially determined to be equal in the amount of matter, maintain that equality when one undergoes a change in shape <u>because</u> the changes in appearance compensate for one another (reciprocity).

Materials: Two balls, 3" in diameter, made out of play dough.

Level: Concrete operational (5-8 years).

Activity: 1. and 2. Repeat first two steps of Experience 4.

3. Take one ball and roll it into a cylinder. Extend thumb and index finger the length of the cylinder. Extend the fingers the length of the diameter.

4. Roll the cylinder back into a ball. Ask the child about the amounts of play dough in the two balls. If he agrees the 2 balls are equal in amount, go on to step 5. If he does not, return to step 1, described in Experience 4.

5. Repeat step 3.

6. Ask child to compare the amounts of play dough in the cylinder and the ball.

7. Evaluate whether child uses reciprocity as a reason for believing that there is no change. This can be assessed by analyzing his comments for evidence of compensatory reasoning, i.e., the cylinder is longer than the ball but narrower, thus cancelling the possibility of any overall change.

Experience 6

Conservation of love. As mentioned previously, the process of conservation appies to other potentialities besides cognitive. This learning experience introduces the use of the process of conservation to promote affective competence, and specifically involves the emotion of love. Love is a very powerful emotion, yet it can be expressed in many ways. The behaviors which are characteristic of the love between parents and children can vary from the warm reasurrance of parents during times of stress to firm guidance during periods of discipline. One might say that the quality of love is conserved in this transformation although the outward behaviors are perceptually different. This type of conservation is of quality not quantity, since it is impossible to measure the quantity of love. In this way conservation of love is similar to identity conservation.

Objective: To understand that parental love is manifested in all types of behavior and that a change in behavior does not mean that one's parents do not love one.

Materials: Four 5" X 8" file cards with pictures pasted on them showing a parent or parents: (1) kissing their children, (2) talking sternly to their children, (3) shouting at their children, and (4) spanking their children.

Environment: 1. Have child sit on platform, chair, or carpeted floor.

2. Child, age 3-5 years old.

Activity: 1. Place one of the pictures on the floor or table. Ask child to make up a story explaining the picture.

2. Repeat for each of the remaining 3 pictures.

3. Ask the child to indicate which pictures show a parent loving the child. Select the picture from 2, or 4, that children relate to best in terms of representing punishment. Use the appropriate picture in step 4.

4. Create a story about pictures 1 and 2, 3, or 4, as follows: One day Otis (the child) and his parents decided to go on a picnic. They awoke early in the morning when Otis jumped on his parents' bed and his parents kissed him (picture 1). However, later in the day, Otis told his parents a lie about brushing his teeth when he really didn't, so his parents punished him (picture 2). Which picture shows that Otis' parents loved him: How could they love him here (picture 1) and not here (pictures 2, 3, or 4)? Would you want parents who didn't punish you at all?

5. If the child does not understand, discuss with him that parents show love in different ways depending on how their children behave. If one is unkind, dishonest, or violent he may be punished for his actions, but this doesn't mean that parents do not love their children. Punishment is one way of teaching a person that unfair actions bring unpleasant consequences and prepares him to be a better and wiser human being.

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