Piaget's Theory of Intellectual Development

Learning, Development, and Education

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LEARNING AND DEVELOPMENT

We have now described the major periods of intellectual development— sensorimotor, preoperational, concrete operational, and formal operational—and the stages within them. We have postponed until now consideration of the *transition mechanisms.* Why is it that the preoperational child's thought advances to a higher level? Why does the adolescent develop formal operations? In short, what factors produce the transition from one stage to the next? Piaget feels that mental growth involves two processes: *learning in the narrow sense* and *learning in the broad sense,* or *development.* The first of these, *learning in the narrow sense,* is provoked by external events and limited to certain situations; the second, *development,* is a much wider phenomenon, with broad implications. We will begin by discussing learning and development and then turn to the four factors underlying the process of development.

The Nature of Learning and Development

For Piaget, the term "learning" may be used in two senses. *Learning in the narrow sense* involves the acquisition of new information or new responses restricted to a specific situation. (Note the parallel with *memory in the specific sense.)* For example, in school geography, the child learns the names and locations of the states and their capitols. This kind of learning is obviously specific to particular cultured contexts and is of little generality. By virtue of an accident of birth, the American child learns about the fifty states; if transported to Canada, the child would then have to learn the names of the provinces and their capitols. Learning of this type, then, is important—but it is specific and cannot be generalized.

By contrast, *learning in the broad sense,* or *development,* involves the acquisition of general thought structures which apply to many situations. (Note the parallel with *memory in the wider sense.)* For example, the child acquires some general ways of thinking about the states and their capitols. Learning in the wider sense is involved when the child develops such notions as that a state cannot be in two locations at the same time or that the United States must be larger than any individual state (class inclusion). Learning of this type involves structures which are general and which can be transferred from one situation to another. They are not taught through specific instruction.

To take another example, if the young child observes that a ball of clay repeatedly weighs the same despite changes in shape, he may learn that the weight of this particular clay ball remains constant (conservation of weight). The child may even predict that the weight will continue to be the same for any new change in the same ball. In other words, as a result of repeated empirical observations or external reinforcements, the child will have learned a law for a particular situation. This does not necessarily mean, however, that he has understood why the weight remains constant. Also, the child may be unable to generalize the law to other situations with other objects. It is only when the child develops the structures of concrete operational thought that he understands the reasons for the conservation of weight and can generalize to new situations. To summarize, specific learning may enable the child to deal with a particular problem involving weight, but learning in the wider sense, or development, is necessary for him to acquire thought structures capable of generalization. We see, then, that there are important differences between learning in the specific sense and development.

Piaget proposes that, of the two processes, development (learning in the wider sense) is the more fundamental. First, as we have already seen, development results in the acquisition of general cognitive structures as opposed to specific information or responses. Second, development makes possible meaningful learning in the specific sense. The child can appreciate the meaning of an external reinforcement or of new experiences in general only when his structures have reached a certain stage of development through the process of equilibration. The child can profit from external information—for example, reinforcement or an adult’s explanation— only when his cognitive structure is sufficiently prepared to assimilate it.

Thus, information concerning the states and their capitols will only be a rote recitation unless the child understands what a capitol is and how a state relates to the country of which it is a part. Similarly, the spoken number words “one, two three ...” are only meaningless sounds unless the child possesses some general structures of thought enabling him to understand that “one” is less than “two,” and so on. Genuine learning occurs when the child has available the necessary mental equipment to make use of new experiences. When the requisite cognitive structure is present, he can learn from the world and come to understand reality; when the structure is absent, new experience has only superficial effects. If there is too great a disparity between the type of experience presented to the child and his current level of cognitive structure, one of two things is likely to happen. Either the child transforms the experience into a form which he can readily assimilate and consequently does not learn what is intended; or else he merely learns a specific response which has no strength or stability, cannot be generalized, and probably will soon disappear. It is for this reason that the child's learning, in school or out, cannot be accelerated indefinitely. There are some things he is not ready to learn because the necessary cognitive structure is not yet present. If forced to deal with such material, the child does not achieve genuine learning.

Finally, Piaget maintains that learning in the specific sense cannot account for development. As we shall see, the general cognitive structures develop through a complex process involving four factors—maturation, experience (physical and logicomathematical), social transmission, and equilibration—and consists of far more than the mechanical acquisition of new information or responses. For Piaget, learning in the specific sense cannot explain development. Instead, development explains learning.

Piaget and his colleagues in Geneva (Inhelder, Sinclair, and Bovet, 1974) have conducted a number of studies into children's learning in the broad sense and the possibility of accelerating the acquisition of various logical structures. The findings shed some light on the processes of development. The general plan of these studies was first to administer a diagnostic pretest to determine each child's developmental level. After this, the children went through a series of training sessions which presented a range of problems, each of which was designed to elicit a different cognitive operation. The aim was "to arouse a conflict in the child's mind" so that he might attempt a coordination among the various operations and thereby achieve a higher level of development. The investigators carefully observed and questioned children in conflict situations to see whether and how learning occurred. Sometime later, the children were given two diagnostic post-tests, the second about four to six weeks after the first to identify the effects of training and determine whether the changes observed were long-lasting and stable.

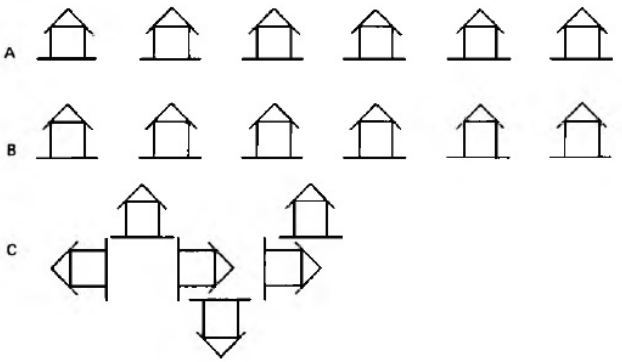

FIGURE 16
Sticks and houses.

Consider one of the Genevan studies. Children were presented with two straight lines of sticks with small houses glued onto each (see Figure 16). The lines (A and B) were identical in length and had the same number. Each child easily recognized that length and number were the same. Then as the child watched, line B was rearranged into configuration C, which obviously looks much different. The experimenter then asked a series of questions concerning both length and number: ' 'Are there the same number of houses here as there? Is this road just as long as the other?" The aim was to place the child in conflict with respect to different aspects of the problem; the child might realize, for example, that number does not change when the configuration is transformed, but at the same time he may fail to conserve the length. If such a conflict is produced, how does the child deed with competing schemes? Does the conflict produce learning?

Through studies like these, Inhelder, Sinclair, and Bovet were able to discover fine distinctions in the learning process. In particular it appears that the learning process involves four steps. In the first, the child keeps the two modes of reasoning separate and does not realize that a conflict is involved. He says that there is the same number of houses in A and C but that A is much longer. Repeated questioning does not help the child to see the contradiction. In the second phase, the child begins to appreciate the conflict. He sees that the two roads, A and C, which he thinks are of different lengths, nevertheless have the same number of sticks in each; now the child understands that this presents something of a problem. Once the child perceives a discrepancy, he tries to reconcile it in some way. The third step involves “compromise solutions.” Here, the child uses an inappropriate method to resolve the conflict. For example, he may break a stick in half so that the longer row in fact has more sticks as well! The fourth step involves a legitimate coordination of the two schemes. In the situation cited, the child sees that he must perform certain compensations; he sees, for example, that although the end points of row A go beyond those of row C, row C has more zigzags than does A and that these compensate for the overlap of A.

Inhelder, Sinclair, and Bovet make several general points about their findings. One is that the child’s ability to profit from training depends on his initial developmental level. These investigators found that children in stage 1 generally progressed very little or not at all in response to training; while those at a transitional level showed considerable progress. The reason for the discrepancy is that the stage 1 children could not perceive the conflict which the training was intended to induce, while the transitional children were able to see it. According to this view, the child will not experience conflict unless his schemes are sufficiently developed. If they are not, then no amount of questioning the child or demonstrating different arrangements of objects will produce conflict and hence intellectual development. Conflict (and the resulting learning) can be provoked only when the child is ready for it. This perspective has important implications for education and we shall return to it later.

A second point is that a major form of conflict occurs when different cognitive subsystems—for example, length and number—operate simultaneously and when one of these schemes has reached a more advanced state than the other.

Third, the studies highlight the central role of the child’s activity and initiative. In particular, the phenomenon of compromise solutions shows that strategies are not simply imposed on the child; rather he plays a major role in inventing them.

Fourth, the investigators summarize their findings as follows:

> [At first there is] . . . an application of existing schemes to an increasing variety of situations. Sooner or later, this generalization encounters resistance, mainly from the simultaneous application of another scheme; this results in two different answers to one problem and stimulates the subject seeking a certain coherence to adjust both schemes or to limit each to a particular application, thereby establishing their differences and likenesses. The situations most likely to elicit progress are those where the subject is encouraged to compare modes of reasoning which vary considerably, both in nature and complexity, but which all, individually, are

> already familiar to him. (Inhelder, Sinclair, and Bovet, 1974, p. 265)

We see, then, that development involves a conflict among existing schemes, the child's assimilation of new problems into those schemes, and a self-regulated adjustment or progression of the current modes of thought. Piaget refers to this as *equilibration,* which constitutes one of the four factors of development that we shall now discuss.

Factors Underlying Development

Maturation. As you will recall, Piaget's theory proposes that specific heredity equips the child with various physical structures which affect intellectual development. Some of these physical structures result in automatic behavioral reactions. For example, when the lips are stimulated, the baby sucks; this occurs because the appropriate reflex is activated through a "prewired" physical mechanism. The automatic behavioral reaction is a kind of "innate knowledge"; because of heredity, which reflects the evolution of the race, the baby implicitly "knows what to do" in the feeding situation. Reflexes, however, play a minor role in intellectual development. In human beings, physical structures given by specific heredity typically exert *indirect* effects on intellect. Thus, the baby is born with eyes that permit him to see only certain frequencies of light, to perceive depth, and to detect objects in front of the body but not behind. The eyes do not provide the baby with a previously written encyclopedia of knowledge— with a stock of innate ideas. Instead, they give the baby ways of knowing; they both set limits on and provide opportunities for intellectual functioning. In brief, the physical structures provided by specific heredity are organs of knowing which determine the rough outlines of intellectual growth but do not specify its content.

Consider now how maturation enters the picture. The physical structures, including the central nervous system, take time to reach their highest level of development. The brain of the newborn, for example, is smaller and lighter than that of the adolescent. It is obvious that immature physical systems often contribute to deficits in cognitive functioning. The simplest example involves motor coordination. The newborn's muscles and other structures are not sufficiently developed to permit walking. Since he cannot get around in the world, the newborn obviously can know very little about it. Other examples abound. One of the factors underlying the newborn's inability to speak is undoubtedly an underdeveloped articulatory apparatus. One of the variables producing his weakness at abstract reasoning is in all probability an insufficiently mature brain. It is clear, then, that immature physical systems can retard development.

It is also obvious that the healthy growth of physical systems contributes, at least indirectly, to intellectual advance, although the details of the process are largely unknown. When leg muscles develop, the baby becomes mobile and can learn about previously inaccessible things and events. Also in infancy, “the coordination between grasping and vision seems to be clearly the result of the myelinization of certain new nerve paths in the pyramidal tract” (Piaget, “Problems in Equilibration,” 1977b, p. 7). In the most general sense, as the brain and the central nervous system mature, they make it possible for the child to use thought and language. In Piaget’s view, the question is not *whether* maturation has an effect, but how *important* the role of maturation is and *how* it operates. Some years ago Gesell proposed that maturation is the chief factor explaining development. According to this hypothesis, the process of physical maturation is the most important and direct influence on all aspects of psychological functioning. Piaget feels that this position is too extreme for several reasons.

One is our lack of understanding of the maturation of the central nervous system. How can one base a theory on maturation when so little is known about it? Second, it is clear that maturation does not explain everything. For example, children in Martinique reach the concrete operational stage about four years later than do children in Switzerland. It would seem unlikely that Swiss children’s brains are four years more mature than those of the children in Martinique. A much more likely explanation is that cultural factors contribute heavily to the differences in development. In Piaget’s view, then, physiological maturation undoubtedly affects cognitive development—often in ways we do not understand—but it is not the only factor.[1]

Experience. A second influence on development is contact with the environment. To acquire the notion of object permanence, the infant must obviously experience things disappearing and reappearing. To classify objects, the child must first perceive them. To speak a language, the infant must hear people talking. Piaget feels that contact with the environment leads to two types of knowledge: *physical* and *logicomathematical.* On the one hand, *physical experience* leads to the knowledge of *observables.* Observables refers to the properties and characteristics of objects, such as shape, color, size, and so on, that are perceived by a person. Physical knowledge of observables is obtained by a process of *empirical abstraction* (called *simple abstraction* in Piaget's early works). The child encounters an apple and, through perceptual activity, "pulls out" or abstracts some of its properties. Now the child "knows" that it is round and that it is red. Or he lifts a block, and in the process discovers that it is heavy. If, however, he lifts two blocks and notes that one is heavier than the other, this would no longer be purely physical knowledge. By comparing the two blocks, he has created a relationship of "more" or "less" heavy that is not given directly in the blocks themselves. This second type of knowledge is *logicomathematical.* In physical experience, then, a child uses empirical abstraction to extract directly from the objects themselves a knowledge of their physical properties.

Piaget makes several points about physical knowledge.[2] One is that it is a major influence on development: there is a "vast category of knowledge acquired by means of the experience of external objects" *(Biology and Knowledge, BK,* p. 335). A good part of intellectual development is learning what things are really like.

Second, the process of obtaining physical knowledge involves more than just empirical abstraction. Piaget maintains that "It is impossible for there to be direct and immediate contact between subject and objects. . . . Any kind of knowledge about an object is always an assimilation into schemes" (*BK,* p. 335). The data of experience are always interpreted in terms of a larger intellectual framework of schemes, concepts, and relationships. The child does not simply perceive the properties of a particular apple in isolation. Rather, he perceives and understands them in relation to all the other apples he has known. A particular apple is perceived as "red" as a result of its assimilation to the conceptual scheme of apples, of which redness is one characteristic. Implicit comparisons with other (more or less red) apples experienced in the past give meaning to the redness of this particular apple. But the action of comparing similarities and differences between a present object and a scheme that has been constructed on the basis of past experiences calls for more than empirical abstraction alone.

> The abstraction of any information from an object. . . requires the use of tools of assimilation of a mathematical nature: relationships, one or several classes (or action "schemes" at the sensorimotor level, which are already a type of practical concept), correspondences, functions, identities, equivalences, differences, etc. . . . Clearly, these tools . . . are not extracted from the objects. They are therefore due to the person's own activities. (*Adaptation Vitale et Psychologie de L'Intelligence, AV*, p. 82, trans. by the authors)

In brief, physical knowledge, or the knowledge of observables, is essential to development, but can only be built up within a larger framework because it requires certain mental tools which have been created by means of previous logicomathematical experience.

Logicomathematical experience involves knowledge acquired from reflection on one's own actions, not from the objects themselves. The concept of logicomathematical experience is a difficult one, and we shall now try to explain it by means of an example.

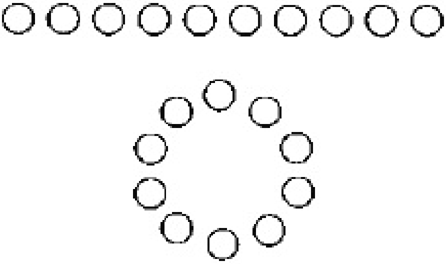

FIGURE 17
Two sets.

Suppose that a child encounters two sets of objects, as in Figure 17. Set A is arranged in a straight line and set B in a circle. The child examines the sets, accurately perceiving that each element is a square, that one set is arranged in a line, and the other in a circle. This is the child's *physical experience* of the sets, and it yields accurate knowledge concerning certain properties of shape, form, and layout. But, while essential, physical knowledge alone does not tell the child something very crucial about the sets: regardless of surface appearance, they have the same number. To gain this knowledge, the child requires a different kind of experience, *logicomathematical experience,* in which knowledge is not a direct result of perceiving objects, but of reflecting upon actions performed on objects. To illustrate the logicomathematical factor, Piaget cites a friend's childhood experience. At the age of about 4 or 5 years,

> he was seated on the ground in his garden and he was counting pebbles. Now to count these pebbles he put them in a row and he counted them one, two, three up to 10. Then he finished counting them and started to count them in the other direction. He began by the end and once again found he had 10. He found this marvelous. … So he put them in a circle and counted them that way and found 10 once again. (Piaget, 1964, p. 12)

Through repetitions of counting and recounting, of arranging and rearranging, the child grasped an important property of number: it stays the same despite different orders of counting and despite differing physical arrangements.

How did this learning take place How did the child come to know something about the equivalence of number? Piaget maintains that empirical abstraction was not sufficient to produce this knowledge. In a sense, the child learned nothing about pebbles: he already knew that they are small, dark, smooth objects. The physical properties of the pebbles were known, and they did not "say" anything to the child about number.

In Piaget's view, the child learned about number not through direct physical experience with the pebbles themselves, but by considering his

own actions. A process of *reflective abstraction* (as opposed to *empirical abstraction)* is involved. The child first notices one of his own actions. In this case, he sees that he has counted the row in one direction, getting 10, and that he has counted the row in the opposite direction, also getting 10. This perception of his own actions interests the child; it surprises him. Next, "the action noted has to be 'reflected' (in the physical sense of the term) by being projected onto another plane—for example, the plane of thought as opposed to that of practical action" (*BK,* p. 320). The child reflects (transposes) his action of counting to the plane of thought. This is one way that the process is reflective.

It is reflective in another way too. Reflecting an action onto another level calls for a reorganization of mental structures to integrate the new action with those already existing at this level. This process of reorganization establishes new relationships and new meanings not found at the lower level. For example, the child has to relate the counting of the pebbles to the action of increasing quantity. Counting to 10 always gives more objects than counting to 9. He has to relate the counting to the concept of sequencing: 5 is always counted after 4 and before 6. Counting must also be related to the notion of invariance of number. He sees that if he can count the objects in various ways and always get the same result, they must be the same number. In a sense, the child defines numerical equivalence in terms of his own actions. In reorganizing his actions of counting, he reflects on them, or contemplates his own actions, and comes to appreciate their wider implications and significance. In sum, reflective abstraction is “reflected” in two ways. The first consists of a projection, or reflection, of actions onto a higher level, and the second consists of a reflection upon and reorganization, or reworking, of both the projected and previous actions into a new and broader understanding.

In his later work, Piaget introduces a third type of abstraction, *pseudoempirical abstraction.* Pseudoempirical abstraction is found during the initial stages of the formation of logicomathematical knowledge, when the young child needs to use concrete objects as a support for such knowledge. The counting of pebbles is an example of pseudoempirical abstraction. Here the knowledge is not abstracted from the pebbles, and thus is not physical experience, but is attributed to them. The child could just as well have gained the understanding of number conservation from another set of objects, although some type of object is necessary at this beginning level. Later, when the child has gained sufficient mastery of counting, he will not need the pebbles, or his fingers, or any other objects as a support, and the abstraction will become truly reflective. Pseudoempirical abstraction is, therefore, a primitive form of reflective abstraction that occurs during the early part of the concrete operational period.

There are several notable aspects of logicomathematical experience. First, it relies on physical experience, although it goes beyond it. In the example cited, a child could not have discovered numerical equivalence if he had not accurately perceived the pebbles. Yet perception of the pebbles—physical experience—in itself was not sufficient, and had to be supplemented by reflection of and on the actions of counting. Second, logicomathematical experience results in harmony with the environment. As the child’s physical knowledge becomes more accurate, his actions, and hence his logicomathematical knowledge, construct an increasingly objective interpretation of the real world. While the richness “of the subject’s thought processes depends on the internal resources of the organism, the efficacy of these processes depends on the fact that the organism is not independent of the environment, but can only live, act, or think in interaction with it” (*BK,* p. 345).

Although different in nature, physical and logicomathematical knowledge are closely intertwined, particularly during the early years. In physical knowledge, the source of knowledge is exogenous or external to the person. It is in the object, or at least those aspects of the object that are perceived by the person. Piaget calls these aspects the *observables.* Observables, such as shape, color, or size, form the *content* of physical knowledge. However, this type of knowledge is extracted within a framework of mental instruments—schemes, concepts, and so on—that have been created by an endogenous or internal source, that of reflective abstraction. These instruments constitute the *form* of physical knowledge. In logicomathematical knowledge, the source of knowledge is endogenous and is found in the coordinations of the person's own actions, although at first the objects of the external world serve as the basis for this knowledge, as in the process of pseudoempirical abstraction. With development, logicomathematical knowledge becomes more and more removed from reality, as reflective abstraction continually leads to the construction of new operations, and of operations upon operations. The formal theories of logic, mathematics, or physics are examples of logicomathematical knowledge as it functions in a "pure" state. But, at the same time as becoming more detached from physical reality, logicomathematical knowledge provides conceptual tools which are able to grasp a deeper and more profound understanding of the physical environment.

Both physical and logicomathematical experience are important, but Piaget feels that they are not sufficient to explain development. One reason is because they omit social factors.

Social transmission. A third factor influencing cognitive development is *social transmission.* This phrase is used in a very broad sense to refer to the influence of the culture on the child's thought. Social transmission may refer to a parent explaining some problem to a child, or to a child's obtaining information by reading a book, or to a teacher giving instruction in a class, or to a child discussing a question with a peer, or to a child's imitation of a model. Certainly, the social transmission of knowledge promotes cognitive development. The accumulated wisdom of a culture passes down from generation to generation, and enables the child to learn through the experience of others. Because of social transmission, the child need not completely reinvent everything for himself. The culture provides him with extraordinary cognitive tools—the counting numbers, a language, an alphabet. These tools enable him to do mathematics, to speak, to write—in sum, to participate in higher intellectual activities, particularly those of a literate nature.

But social transmission itself is not sufficient. Unless the child is prepared to understand the cultural wisdom, social transmission will not be effective. In other words, to appreciate the knowledge passed on by other individuals, the child must possess cognitive structures which can assimilate it. The 5-year-old cannot learn the calculus, however well it is transmitted, because he does not have the prerequisite structures.

Some American and Russian psychologists have proposed that one specific type of social factor, namely, the child’s own language, is vital for the development of behavior and thought. In very general terms, their thesis is that at about the age of 4 or 5 years the child uses internal speech to control and organize his activities. Language “mediates” between external events and the child’s response. Without an internal linguistic system, the child’s responses are directly contingent upon external events; but with such a system the child can represent external events, delay responding to them, and can thereby control his own behavior.

Piaget’s view, very different from the foregoing, attributes a lesser role to language. Piaget does not accept the proposition that language is the sole or primary device by which the child forms mental representations of external events. Representation takes many forms—mental imagery, symbolic play, drawing—in addition to language. Thus, mental images are often nonverbal. At 18 months of age, the infant has images of things and events even though he can hardly speak. According to Piaget, the infant’s images and other representations derive from imitating persons and things and not from language. In brief, the representational function, and generally, the figurative aspect of thought, need not involve or depend on language.[3]

Piaget believes that the operative aspect of thought also need not involve language. In the case of classification, we have seen that the preoperational child in stage 1 cannot produce a hierarchical arrangement of objects and does not understand inclusion relations. This is so despite the fact that the child can use all of the relevant words involved. He can say “blue triangles,” or “red circles,” or “more of these,” or “some of these.” Even though the language is available, the preoperational child cannot classify. This is not, however, to assert that language plays no role in the development of classification or other mental operations. For example, the presence of nouns in the language may stimulate the child to think in terms of discrete classes. Also, the ability to verbalize a thought structure, like class inclusion, may help to consolidate and generalize it. Nevertheless, for Piaget, thought involves more than language and is not dependent upon it.

This proposition is reinforced by the research of Sinclair (reported in Inhelder, Sinclair, and Bovet, 1974). She began by examining the language of two separate groups of young children, some of whom were unable to solve conservation problems and some of whom were successful. She found a correlation between the ability to conserve and the ability to talk about it. The conserving children used phrases comparing the variables, saying, for example, that one glass of water is “tall and thin,” while the other is “short and fat.” The nonconserving children, on the other hand, used “undifferentiated terms” to describe the situation; they said, for example, that one glass of water is “big” and the other is “fat.” It would appear then—perhaps contrary to Piaget’s views—that conservers and nonconservers are characterized by different types of linguistic ability.

But does the use of complex language cause the ability to conserve? To discover the answer to this question, Sinclair taught the nonconserving children to use the language of the conservers in describing the various problems. If language is crucial for conservation, these children should then have been able to conserve. Yet the results showed that they could not: the benefits of language training were quite limited. It appears, then, that language does not enable the child to conserve. In fact, the opposite seems true: the development of the thought structures underlying conservation enables the child to employ sophisticated forms of language to describe what he does and understands.

Further evidence supporting this proposition derives from Opper’s (1979) research in Thailand. The Thai language contains certain built-in terms called “classifiers,” which signify that an object is part of a higher-order class. Thus the word for *lotus* specifies both that the object is that particular flower known as a lotus *and* that it belongs to the larger class of flowers. The language itself virtually announces class inclusion. The question then becomes whether children exposed to such a language acquire class inclusion at a younger age than usual. Opper found that they did not. Despite the presence of linguistic mechanisms which would supposedly facilitate this development, Opper’s work showed that Thai children did not acquire class inclusion earlier than Swiss children, whose mother tongue does not contain such mechanisms. This evidence also seems to support Piaget’s proposition that thought involves more than language and that the former is not fully shaped by the latter.[4]

Consider now the role of formal schooling: Is this kind of social transmission crucial for intellectual development? Some psychologists believe that it is. Some years ago, on the basis of research in West Africa, Greenfield (1966) proposed that the Western style of schooling is necessary for the development of the stages of thought as described by Piaget. The main evidence for this assertion was the discovery that school children in Senegal did achieve the period of concrete operations, as judged from a test of conservation, whereas those children not in school remained at a lower level of thought. While this is an intriguing finding, the evidence in this area is by no means clear-cut. Some studies are directly contradictory, showing that schooling is not necessary for the development of concrete operations (Ashton, 1975; Dasen, 1972). At the present time, the weight of the evidence seems to support the Piagetian view that schooling, like other forms of social transmission, may accelerate intellectual development but is not necessary for it. Apparently, individuals growing up in “primitive” societies without schools nevertheless develop the basic thought structures described by Piaget. Perhaps the failure of some researchers to obtain this finding can be attributed to problems of measurement in strange cultures, where Western testing techniques and testing materials are often inappropriate. In any event, Piaget’s view is that schooling and other forms of social transmission can contribute to intellectual growth but do not fully determine it.

Equilibration. A fourth factor affecting development is *equilibration*,[5] which in a way integrates the effects of the other three factors, none of which is sufficient in itself to explain mental development. Equilibration refers to the child’s self-regulatory processes, by which he progressively attains higher levels of equilibrium throughout development. The equilibration process is the backbone of mental growth.

Let us begin by reviewing the concept of equilibrium. Piaget has borrowed this notion from physics and biology and has modified it to apply to human intelligence. The concept of equilibrium, which is not novel in psychology, refers to a state of balance or harmony between at least two elements which have previously been in a state of disequilibrium. Freud, for example, makes use of a similar principle when he states that a person tends toward a release of tension. For Piaget (unlike Freud) equilibrium does not have the connotation of a static state of repose between a closed system and its environment. Rather, equilibrium, when applied to intellectual processes, implies an active balance or harmony. It involves a system of exchanges between an open system and its surroundings. The child is always active, and does not merely receive information from his environment like a sponge soaking up water. Rather, the child attempts to understand things, to structure experience, and to bring coherence and stability to the world. A cognitive system is never at rest, it continually interacts with the environment. The system attempts to deal with environmental events in terms of its structures (assimilation), and it can modify itself in line with environmental demands (accommodation). When in equilibrium, the cognitive system need not distort events to assimilate them, nor does it need to change very much to accommodate to new events.

Although the concept of equilibrium was taken from physics, Piaget stresses that physical and cognitive equilibrium are very different. Physical equilibrium seeks to maintain the stability of the system without change. Disequilibrium is overcome by a movement in the opposite direction which restores the original state of equilibrium. A thermostat, for example, maintains equilibrium by compensating for increases or decreases in heat with actions that restore the system to the original temperature. With intellectual development, however, there is both stability and change. Cognitive systems, as they progress, preserve past intellectual achievements but at the same time create new actions and novel responses which allow the person to gain more understanding. Equilibrium results from regulations that tend toward better forms of knowledge. There is an increase in knowledge rather than a return to an original state, and this requires a dynamic model of equilibrium. “It would not do, then, to conceive of equilibration as a simple process toward equilibrium since it always involves construction oriented toward *better* equilibrium” *(Equilibration of Cognitive Structures, ECS,* p. 26).

For Piaget, cognitive development consists of a succession of alternating equilibria and disequilibria. Each successive level of equilibrium reaches a better form of knowledge through the addition and reorganization of cognitive elements. These quantitative and qualitative changes result in new relationships, new understandings, and the solving of certain problems, but also open up the possibility of new questions and problems, of new imbalances and disequilibria. To reconcile both the stability and the changes that occur in cognitive development and to emphasize the dynamic aspect of this process, Piaget refers to it as *optimizing equilibration (équilibration majorante).* Optimizing equilibration is the process that leads to the successive improvements in equilibrium that occur with development. Each new equilibrium becomes more powerful in its ability to comprehend the physical characteristics and relationships of the objects in the environment, and also to attribute causal, logical, and mathematical properties to them.

Piaget describes three types of equilibrium, all of which contribute toward achieving a balance between the person and his environment. The first is the equilibrium between a person and an object or event of the environment. Here the person encounters an object, assimilates it to a scheme, and accommodates the scheme to the particular object. If the scheme is appropriate, there is equilibrium; if not, there will be disequilibrium. A child who only has schemes for apple and oranges would have no trouble when encountering instances of these fruits, but would be in disequilibrium when presented with her first experience of a pineapple. This type of equilibrium depends upon the interaction between a person and the environment, that is, between assimilation and accommodation.

Another type of equilibrium is between the various cognitive subsystems. Here, the equilibrium is internal rather than external. Examples of this can be found in the research by Inhelder and colleagues into learning, discussed in the previous section, which indicated that very often the lack of understanding of a problem is caused by an imbalance due to differences in the speed of acquisition of different cognitive subsystems. For example, at a certain stage of development the child's acquisition of the subsystem of number is in advance of that of length and this creates a disequilibrium. Only when the two subsystems reach the same level and are in equilibrium is the child able to understand conservation of length problems. Assimilation and accommodation are also involved in this second type of equilibrium, but they are carried out internally by means of reciprocal assimilation and accommodation of the various cognitive subsystems.

A third type of equilibrium is between an overall cognitive system and its component subsystems, that is, between the whole and its parts. The overall system, by integrating the various elements, assumes various properties of its own which are not found in the individual subsystems. These subsystems do not cease to exist by virtue of being integrated, but continue to retain their own specific characteristics and thus be differentiated from each other. One example is the hierarchical class inclusion of animals. The category of animals integrates the various subcategories of lions, tigers, cats, dogs, and so forth. It incorporates certain characteristics of each of these, but has a broader application than any of them. The subcategories are clearly differentiated from each other even though they may have certain characteristics in common. The intension and extension of the class of animals does not duplicate entirely those of any of the subclasses, just as the intension and extension of each of these is distinct from those of any other subclass. Another example is the coordination at the level of formal operations of the two earlier types of reversibility, negation and reciprocity, within the overall INRC system. The INRC group provides more possibilities than either of the two types of reversibility encountered earlier in development although these continue to exist as distinct processes even when they have become integrated into the INRC system. This third type of equilibrium is between the processes of integration and differentiation, but also involves assimilation and accommodation. Integration is accomplished by assimilation, whereas accommodation is responsible for differentiation.

One fundamental question regarding the dynamics of this process of optimizing equilibration is this: What are the transition mechanisms that enable the progression from one level of equilibrium to another more powerful type of cognitive structure? Piaget believes that a major factor is reflective abstraction in its dual forms of projection and reorganization. Piaget also proposes some more specific principles to explain conceptual development: *differentiation and integration,* the *relativization of concepts,* and the *quantification of relations.*

Differentiation and integration are two complementary processes that play a major role in conceptual development. Differentiation is the process of constructing new schemes or elements on the basis of existing ones so as to meet the requirements of experience. As a result, finer and finer distinctions are made between and within schemes or concepts. Integration is the process of establishing links or connections between these elements so as to maintain their unity.

When faced with a familiar object or experience for which he already has a scheme available, the child uses this scheme to assimilate the familiar experience. If, however, he encounters a novel object or event, for which existing schemes are inadequate, a new scheme will need to be constructed. This new scheme will either be derived from an existing one that bears some similarity to the new experience, or may result from the reciprocal assimilation of two or more schemes that separately contain the characteristics of this experience. The new differentiated schemes that are created do not exist in isolation, but become related to, or integrated with, existing schemes into higher-order ones. By introducing new relationships and characteristics to concepts, differentiation and integration allow for the subsequent assimilation of more varied experiences and hence open up the possibility for further differentiation and integration.

Differentiation and integration are closely related to the intension and extension of concepts. Recall that the intension of a class or concept refers to the characteristics or properties of that class. For Piaget, this means the actions that a person can carry out, or the schemes that a person has available, relating to that class. The intension of an apple refers to the available schemes of red, round, or sweet. Extension refers to the members of the class, its field of application, or the objects to which these schemes apply. In the child, or in an adult for that matter, intension and extension are not static. On the contrary, they are constantly changing as the result of experience, and it is the processes of differentiation and integration that underlie these changes. The first characteristics to be differentiated are the obvious superficial aspects of the physical environment that can be directly perceived. These refer to physical experience. Gradually, as the child reflects on his experiences of these objects, he goes beyond merely apprehending observable characteristics to draw inferences from them. Since inferences are processes of a logicomathematical nature, differentiation and integration now occur within a logicomathematical framework. Thus, knowledge moves from the periphery to the center of objects, from exogenous to endogenous processes. In this way differentiation and integration lead to an increasingly complex and deeper understanding of the world.

The development of the “cat” concept can serve as an illustration. For the very young child, the concept of “cats” initially refers to the actual cats that he encounters at home, in his neighborhood, or even in stories. At this stage his cat scheme is very general, and indeed there is often an overgeneralization of schemes. Its intension might be something with four legs, a tail, and fur, and its extension may even include squirrels, badgers, or other four-legged creatures with a tail and fur. With additional experience of cats of different colors such as ginger, black, or tabby, or with different eye colors, blue, green, or yellow, he will construct or differentiate subschemes of cats to account for these differences. Each subscheme has its own characteristics distinct from the others, but they are all interrelated and integrated within the overall scheme of cats.

Such differentiation and integration could continue indefinitely, depending upon the experiences, interests, and motivation of the person. The child starts with their physical characteristics or the actions that can be taken with cats, such as stroking or feeding. Later, the person considers features such as breed, personality traits, or genes that are not directly observable and require inferences. Thus a judge at a cat show, who needs to go far beyond just a superficial knowledge of the observable characteristics of cats, would have a highly differentiated and integrated concept of cats.

Piaget refers to this increasingly wide network of relations or links that are established between schemes and their elements by means of differentiation and integration as the *relativization of concepts.* The child initially understands objects, situations, or events in terms of a limited number of broad, undifferentiated categories or schemes. As she begins to create additional subschemes or elements to account for new differentiated characteristics, she establishes relationships and interdependencies between these elements. With an increased number of elements comes an increase in the number of compositions, and hence of possible interrelationships between them. These relationships may cover the observable characteristics of actions and objects, their physical features such as shape, size, or color. Or they may cover *coordinations,* that is, inferences drawn from the person's actions that construct spatial, causal, and logicomathematical relationships with other objects in the environment. The relativization of concepts underlies a movement from an initial, superficial, and undifferentiated understanding of an object to a deeper and more varied grasp of its various properties, functions, and relationships.

Consider the seriation of sticks task as an example of relativization. The very young child divides the sticks into the two broad undifferentiated schemes of "large" and "small." Relationships both within and between the schemes are somewhat limited. The slightly older child begins to distinguish more characteristics of length and creates a new scheme of "medium size." Already more relations need to be constructed because of the larger number of schemes. Later the child will be able to seriate the sticks, first, in a tried-and-error fashion, and then more systematically. When the seriation is finally grasped, the child is able to set up relations and interdependencies between every element. Each of the sticks becomes linked or related to every other one in an ordered system of graded lengths ranging from shortest to longest.

One type of relation that the child slowly constructs is quantification. The *quantification of relations* refers to the child's progressive move from an initial focus on the qualitative features of a concept to reasoning on its quantitative aspects. For example, in seriation, the young child first focuses on the qualities of "bigness" or "smallness." All the elements in the "large" category are viewed as being similar to each other, they are all large and different from those in the "small" one. The construction of a third "middle-sized" category is still a qualitative approach, although it is a move toward quantification. The addition of the middle calls for comparisons among the three categories in which the child focuses more specifically on, and becomes more sensitive to, the differences in length between the sticks.

With increasing sensitivity to these differences, the child comes to recognize that, even within each category, the sticks are perhaps not quite as similar as first believed. Indeed, there are differences among the various "large" sticks. Eventually, the child understands that all the sticks are related in a quantifiable manner. Each stick, when compared with the others, is a little more, or less, "long" or "short." They are all now viewed as variations along the single dimension of length. The implication is that the child has now constructed a continuum with unlimited possibilities of including not only actual objects presented, but also any other possible variation along that same continuum. For example, the child could envisage the possibility of including sticks that will never actually be presented but are only mentally conceived.

This continuum is a logicomathematical construction of which the actual sticks presented form only one part. Furthermore, at this point, the child also understands that "more" and "less" are reciprocally related. As the sticks become longer, or "more long," they also become "less short." A move in the positive direction of "more long" implicitly involves a corresponding move in the opposite, negative direction of "less short."

For purposes of simplicity, the present example has concentrated on the quantification of a single property, the "long-short" dimension of length. In real life, of course, the situation is far more complex. Objects vary along a number of dimensions. Apples are never identical. Each individual apple can be quantified along a number of dimensions: size, color, texture, sweetness, to name but the most obvious characteristics. All these differences can be placed along quantifiable continua that do not necessarily develop at the same pace. As quantification proceeds for these various differences, it allows for the possibility of an increasing number of relationships, and in this way not only contributes toward a more objective understanding of reality, but also toward better and better forms of equilibrium.

Inevitably, the study of equilibration and the successive levels of equilibrium along the path of development leads to the reverse of the coin, disequilibrium. As Piaget states, the existence of any positive instance necessarily implies the existence of its negation. Consequently the study of equilibrium leads to the study of disequilibrium. Piaget holds that disequilibrium is of crucial importance in the process of equilibration, since it is the prime motor of intellectual development. Disequilibrium motivates the search for better forms of knowledge, and thus provides the link between one level of equilibrium and the next.

Disequilibrium, or imbalance, occurs when a person encounters an object or event that he is unable to assimilate due to the inadequacy of his cognitive structures. In such situations, there is a discrepancy or a conflict between the child's schemes and the requirements of the experience. This is accompanied by feelings of unease. Piaget refers to this situation as a disturbance, perturbation, or conflict. Generally speaking, a disturbance is anything that prevents the person from assimilating an experience or achieving a goal. Since assimilation is involved in disturbances, and assimilation always occurs relative to an assimilatory scheme, the concept of disturbance is a relative one. What may be a disturbance to one person, because of the nature and type of schemes available, may not be so for another person, either because his schemes are not sufficiently developed for him even to perceive the event as disturbing, or because his schemes are so well organized that a particular event or experience is rapidly assimilated. In the conservation of liquids task, the very young child states with no feeling of unease or conflict that there is more liquid when it is poured into a tall thin container than when it is in a short fat one. For him, the situation is not disturbing. This same situation will, however, produce conflict in the slightly older child, who feels unease at stating that the same water is more, or less, depending upon the shape of the container. The even older child again feels no conflict because he can explain the situation in a logical way.

When faced with a disturbance, the person reacts with responses that attempt to regulate the conflict. These responses, or *regulations,* will differ depending upon what schemes are available. In most of the studies carried out in Geneva, three types of reactions to disturbances have been found, and Piaget calls them *alpha, beta,* and *gamma.*

Alpha reactions are generally found in the very young preoperational child who often, because he does not perceive the event as disturbing, simply ignores it. If he perceives it at all, it would be as a minor disturbance that requires only slight modification of his structures. On the other hand, he may deform the event completely so as to fit his schemes. In both cases, very little change occurs to the cognitive system. Alpha reactions, therefore, either modify the disturbing element so as not to interfere with existing cognitive structures or ignore the conflict altogether. The young child who has only schemes for squares and circles may assimilate a novel shape such as a triangle into the square scheme, thereby completely deforming the experience. Similarly, a child who, during the early stages of language development, refers to all animals as “dogs,” is not disturbed by feelings of unease. She assimilates all four-legged creatures into her underlying scheme of dogs, regardless of the extent to which reality is deformed to do this.

With *beta reactions,* which are usually found during the later preoperational and concrete operational stages, the child seeks to incorporate the conflicting event into his current cognitive system. To do this, he modifies and reorganizes this system so as to take account of the disturbance. The child of this level not only distinguishes circles from squares, but will create new schemes when he encounters triangles, rectangles, and so on. The disturbance introduces variations into the system by causing new schemes to be created that will exist alongside the original ones. The variations are partial because the child is able to create only a limited number of new schemes or subcategories. Beta reactions are nevertheless an improvement on alpha ones because they attempt to adapt the system to disturbances perceived in the environment.

Finally, *gamma reactions* are found at the formal operational level. Here the person constructs a system that allows him to anticipate all possible variations by means of inferences. The system becomes a closed one and the likelihood of disturbance is reduced. The original disturbing element becomes one possible variation within a whole system of possible transformations. The child at this level can anticipate the possibility of all sorts of shapes, both regular and irregular, even before he actually perceives them.

The alpha, beta, and gamma reactions are not necessarily confined to particular stages of development. Piaget believes that the same types of reactions are to be found in any area of knowledge, so that if an adult were exposed to a totally new topic, she too would exhibit the same sequence of alpha, beta, and finally gamma reactions when she masters the relevant knowledge.

In sum, disequilibrium, a major cause of cognitive development, is caused by disturbances, perturbations, or conflicts that occur when there is a discrepancy between the child’s schemes, which determine what she is able to assimilate, and the requirements of certain experiences. Disequilibrium is relative to the child’s developmental level. The child reacts to the conflict by regulations which Piaget categorizes as alpha, beta, or gamma, depending upon the schemes available.

Contradictions. Closely related to cognitive conflict and disequilibrium is the notion of contradiction (see Piaget, *Experiments in Contradiction,* 1981a). One example is the conservation of liquids task, where liquid appears to be more when in a tall thin container than in a short fat one. The person starts to question this contradiction and, to resolve it, tries to discover its reasons or causes. In an attempt to explore the nature of contradiction and relate it to the equilibration process, Piaget and his colleagues have carried out a number of studies in this area.

In one of the tasks, the children were presented with a series of seven disks, referred to as A to G, each of which was imperceptibly larger than the previous one. The disks were attached to a board so that any single one could only be compared with those immediately before and after it. Thus disk A could be compared with B, B with C, and so on. The last and largest disk, G, was not attached, and could be compared with any other disk of the series. Since each disk was only very slightly larger than the previous one, the difference between each of the six attached disks was imperceptible, although it was evident that G was larger than A. The child was asked to explain the contradictory situation of an apparent equality between the first six disks, A = B, B = C, and so on, and the nonequality between G and A.

In this and other studies of the same nature, three stages were found in the child's understanding of contradiction. During an initial stage, the young child is not aware that there might be any contradiction in the situation, in this case of admitting that the first six disks are equal, that F is equal to G, and that G is larger than A. He also appears to feel no unease at stating at one point in the interview that F is the same size as G and later at another point that G is larger than F. Either he forgets his former statement, or he does not relate the two statements together, and thus does not recognize the contradiction. Children who remember their previous statements attempt to reconcile the contradiction but do so with inappropriate actions. Some of them say that G is the same as F, that F is the same as A, and that G is larger than A. As we have seen in the previous section, these are alpha reactions.

At the same time as exhibiting a lack of awareness of many contradictions, the young child of this initial stage provides examples of what Piaget calls *pseudocontradictions,* that is, he interprets as contradictory certain relationships or situations that are not so to the person at a higher level of development. For example, in the seriation task, a young child finds it contradictory that a stick can be simultaneously larger (than previous sticks) and smaller (than the ones to follow) or that a half-filled glass can be half full as well as half empty. He believes that a stick is either large or small, a glass either empty or full, but not both at the same time.

During a second stage, the child begins to be aware of the contradictions in his statements. He will search for solutions, but since he does not yet have the ability to overcome these contradictions, his solutions will be compromise ones. In the earlier disks experiment, he will set up two distinct classes: the "small" disks, A, B, and C, and the "large" ones, E, F, and G, but then he might have trouble deciding whether the boundary disk, D, should be in the "small" or "large" category and will move it back and forth between the two. Some children believe that disk G changes in size, and first say it is the same size as F, but then that it becomes larger when compared with A. Other children in this stage may create three classes, with an intermediate size between the small and large categories. For example, A and B would be small, C, D, and E intermediate, and F and G large. All these different reactions constitute beta behavior, or the creation of variations within the system.

Finally, at around 11 to 12 years, the stage 3 child understands that the disks form a seriation, with imperceptible differences between each successive disk. He has quantified the size relationship. By doing this he has created a new cognitive structure that is able to assimilate the disturbing element. This understanding of the situation resolves the imperceptible differences problem. It allows the child to explain the apparent contradiction and to anticipate the possibility of an unlimited number of disks.

Piaget states that the child's initial unawareness of contradiction occurs because he first concentrates on the observable features of a situation or the results of an action, on *affirmations,* and neglects the nonobservables, or what has been excluded by the action, the *negations.* The common feature of till contradictions is an incomplete compensation between affirmations and negations. For the young child, affirmations predominate over negations. This is because it is easier to apprehend positives than negatives. The perception of an absent object or characteristic involves *expectations* that go beyond the information actually provided by the objects. We can spontaneously think of red objects (affirmations), but we need to construct or infer the category of nonred ones (negations) since they are not given perceptually. Negation requires inference, that is, an internal construction, and the child needs time to build these internal constructions.

Only when the intension and extension of a concept have become sufficiently differentiated to cover negations will the child be able to overcome contradiction. The awareness of contradiction presupposes the ability to draw inferences. In the foregoing task, the young child concentrates on the observables or affirmations that “A is the same as B,” “B is the same as C,” and so on, until “F is the same as G” and “G is larger than A.” To feel contradiction and to overcome it, the child must be able to infer two things. First, he must realize that the relationship “G is larger than A” (affirmation) implies that “A is not equal to G” (negation). Second, and more complex, the child must be able to infer, by using a scheme of transitivity, that “A is the same as F.” Since only adjacent disks can be compared, this cannot be observed directly and is also a negation. It is only at quite an advanced stage of development that the child acquires transitivity and hence becomes capable of constructing this negation.

All this may seem contrived, artificial, and irrelevant to the study of normal intellectual development, but that is not so. On the contrary, Piaget believes that the concepts of affirmation and negation are of tremendous importance to the whole of cognitive development. This is because every action necessarily and implicitly contains both a positive and a negative aspect, both an affirmation and a negation. The class of red objects implies all the objects excluded from this class, or the class of nonred objects. Addition implies subtraction, and so on. Affirmations and negations are found at every level, in perception, sensorimotor actions, and mental operations. Initially, the young child grasps only affirmations. Only slowly and laboriously does he construct negations. His negations are systematically grasped only when the child is able to construct reversible operational structures in which there is a complete compensation of affirmations and negations.

Although Piaget reached these conclusions on affirmations and negations during the latter part of his career, he felt that they were such an important explanatory framework for intellectual development as a whole that he returned to many of his earlier studies, in particular the conservation tasks, in an attempt to explain past findings in terms of the child’s initial primacy of affirmations and his subsequent construction of negations.

To end this section on equilibration, let us look at how Piaget incorporates the concepts of empirical and reflective abstraction, optimizing equilibration, equilibrium, and disequilibrium, into a model of cognitive development which he calls the *spiral of knowing.* This spiral of knowing is symbolized by an inverted cone, as shown in Figure 18. The inner spiral of the cone, A, represents internal constructions in the form of reflective abstraction with its successive projections and reorganizations that are carried out within the optimizing equilibration process. The outer layers, E and E', represent interactions with the environment in the form of empirical abstraction within the framework of previous reflective abstraction. These two processes, A and E/E', are in constant interaction as new projections and reorganizations result from interactions with the environment. Three vectors, a, b, and c, determine the progress of cognition. Vector a represents the hierarchical succession of cognitive structures, starting with reflexes, moving through sensorimotor schemes, preoperational structures, concrete operations, finally to reach prepositional operations. Vector b represents the modifications of the structures and dis-equilibria that result from interactions with the environment. Vector c represents explorations of the environment which lead to partied or complete reorganization of the structures.

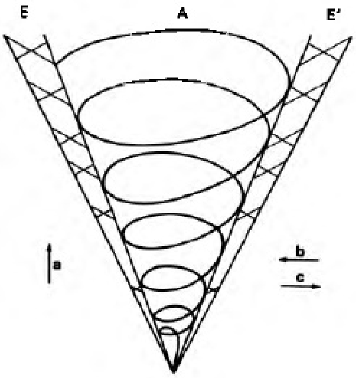

FIGURE 18
The spiral of knowing. From Adaptation Vitale et Psychologie de I'Intelligence: Selection Organique et Phénocopie, by J. Piaget. Copyright 1974 by Hermann, Paris. Reprinted by permission of Hermann, Paris.

The ever-widening but open circles of spiral A represent three major characteristics of equilibrium. First, there is the underlying *power* of the equilibrium. This refers to the number of actions that can be carried out and hence to the number of schemes available, or the *field of application* of the cognitive structures. As the field of application extends and schemes become more differentiated, more actions become possible, and equilibrium becomes more powerful. This increase in schemes, or in the field of application, is reflected in the widening of the circles.

The young child's classification system, for instance, would be relatively undifferentiated with few classes and subclasses. With only a few schemes and subschemes available, it would not be possible for him to carry out many actions, or to establish many links or relationships between them. This equilibrium would not be very powerful. For the older child who has already constructed a hierarchical classification system with numerous subclasses, the possibility of links and relationships becomes boundless. The equilibrium is therefore infinitely more powerful.

The power of a particular level of equilibrium is directly related to the degree of relativization and quantification of concepts as well as to differentiation and integration. Understanding becomes increasingly coherent as relationships and connections between schemes increase. Consequently an increase in power of equilibrium is accompanied by a growth in coherence.

Another characteristic of equilibrium is *stability,* which is defined as the capacity to compensate by actions or mental operations for changes in the environment without disturbing the whole structure. When a system is stable, the introduction of new elements does not destroy it. The structure easily incorporates the new elements and does not change. Stability is achieved when any action in one direction (affirmation) can be compensated for or canceled out by an action in an opposite direction (negation). With a stable equilibrium, affirmations are balanced by negations. In seriation, for instance, the young child who is able to construct a series only by trial and error will, when presented with additional sticks to insert, find it necessary to destroy the whole series and start from the beginning again, whereas the child with a mature seriation structure can incorporate an unlimited number of additional sticks without distorting the series. The latter has a more stable equilibrium. Perfect stability is achieved when the person is able to anticipate disturbances or conflict before they are actually encountered.

A third characteristic of equilibrium is its *openness,* which refers to the ability to incorporate new ideas and raise new questions and problems. These will lead to novel actions and responses to solve these problems. This openness is reflected in the upward movement of the spiral. Each successive level of equilibrium in the equilibration process solves previous problems and provides answers to previous questions, but at the same time opens up the possibility of new problems and new questions. It is this openness that ensures that cognition is continually developing. These three characteristics combined—power, stability, and openness—ensure that the equilibration process continually conserves past understanding and constructs new knowledge.

POSSIBILITY

Piaget was greatly concerned with the construction of new knowledge, a problem underlying the equilibration process and the spiral of knowing. How does the child create new responses or actions? What accounts for the openness of the spiral toward new possibilities of disequilibrium and re-equilibration?

In a number of studies designed to investigate the development of the concept of possibility, children were required to come up with as many solutions as possible to certain problems. (See Piaget, *Le Possible et le Necessaire,* 1981b, 1983.) For example, they were asked to indicate all the different ways they could think of to place three dice on a piece of cardboard, to make a toy car go from point A to point B, or to cut up a paper square.

Findings of this type of study showed three main stages in the development of possibilities. The young child of 4 to 5 years comes up with a limited number of possible solutions, one or two at most. These few possibilities are often accompanied by a strong feeling of necessity, which Piaget calls *pseudonecessity.* This is the feeling that it is impossible to change reality or the impression that because this is how things are, this is how they necessarily have to be. Reality, as given in the few solutions suggested, is felt of necessity to be the only possibility.

In the study with the three dice, the very young children of 4 to 6 years were able to come up with only a few suggestions, and these were often generated by a process of analogy. For example, one child placed the three dice in the three angles of the square paper. When asked if there were other ways, he moved one of the dice to the fourth angle, then moved the three dice around the various angles, each time leaving a different angle without a die. Children of this level also believe that the best solutions are those that are similar to the first one proposed.

At the next stage the older children are able to increase the number of possible solutions suggested, and come up with a range of "co-possibles," the number of which increase with age. Children of 7 to 8 years produce four to five possible solutions, whereas by 9 to 10 years they can envisage thirty or more solutions, even though they themselves are not always able to describe all these possibilities. With the dice problem, children of 7 to 10 years suggested numbers ranging from twenty to ten thousand, although when the experimenter suggested ten thousand, one child felt that this number was too high. They realize that these many solutions exist as abstract co-possibles which someone else may be able to describe, even though they themselves cannot think of all of them. At this stage, the best solutions are considered to be those that differ the most from the ones that have already been suggested.

Finally, around 11 to 12 years, children infer more or less immediately that the number of possibilities is unlimited. The child realizes that any solution proposed is only a sample of such a vast number of solutions that it would not be possible to think of them all. At this point, an unlimited number of possibilities is conceptually deduced rather than actually observed.

The idea of an unlimited number of possibilities is obviously not something the child is able to observe in the environment, but is something that he constructs internally by making inferences from what is actually given in a situation. As we have seen, inferences require an internal construction that goes beyond observables. This explains why it takes so long for a child to acquire the concept of possibility.

Piaget maintains that the conquest of possibilities is a crucial mechanism of the equilibration process. Each new possibility opens up a field of virtual or potential new possibilities. As the child solves problems he begins to discover others, and to realize that each problem can generate a host of possible solutions, not all of which he is able to describe. It is this creation and multiplication of possibilities that provides the openness of equilibration, and explains the production of novelty which is one of the basic questions raised by Piaget in his genetic epistemology.

Studies were also conducted into the feeling of necessity in the child. Their results show that necessity follows a parallel development to possibility. Young children start with the feeling of pseudonecessity, which was found in the studies of possibility. Older children produce a small number of co-necessities and grasp the idea that each of the co-possibilities or solutions to a problem is equally necessary. Finally, around 11 to 12 years, the child explains that there are an unlimited number of co-necessities.

In his discussions on the relationship among possibility, necessity, and reality, Piaget states that in the early stages of development, there is a lack of differentiation among these three modalities. The young child, owing to his limited number of schemes, believes that the only possibilities are those that are observable. Moreover, these are conceived of as being necessary, which is in fact a pseudonecessity. As the child’s schemes multiply, and as more connections between them are established, he becomes capable of going beyond observables and of drawing inferences about reality. It is these inferences that lead to the construction of a larger number of co-possibilities. Possibilities are the result of the differentiation of schemes. At the same time, with development, the initial regulations are changed into reversible operations. Operations are accompanied by feelings of necessity. As we have seen in the conservation tasks, necessity is one characteristic of logical reasoning processes which results from the integration of schemes and their transformation into operatory structures. Operations represent a synthesis of the possible and the necessary, as well as a synthesis between integration and differentiation which is characteristic of the third type of equilibrium.

Summary and Conclusion

Piaget distinguishes between development and learning in the narrow sense. Development is influenced by four factors. *Physical structures* both limit certain aspects of cognitive development and make others possible, but maturation in itself is not sufficient to explain mental development, partly because there are obvious cultural effects on cognitive functioning. A second factor is *experience.* Physical experience involves gaining knowledge of objects by observing them directly. Logicomathematical experience involves an internal coordination of the individual’s actions which at the outset are performed on the objects, but later do not require this physical support. However, these two types of experience are not sufficient to explain development, because they omit, among other things, the effects of social influences. A third factor, *social transmission,* refers to the acquisition of knowledge by such techniques as reading or instruction. This factor is also insufficient to explain development, partly because it ignores the role of the cognitive structures which make social influences efficient or inefficient. A fourth factor is *equilibration.* This concept involves the child's self-regulatory processes which lead him through progressively more effective states of equilibrium. The notion of equilibrium refers to a system of exchanges between an open system and its surroundings. It implies a system that is in active balance with its environment. The degree of equilibrium is defined by a system's position on three dimensions: field of application, stability, and openness. The greater the degree of these qualities, the more perfect the equilibrium. Research stresses the central role of internal conflict in promoting equilibration. As equilibration proceeds, the child comes to appreciate the roles of possibility and necessity.

Piaget distinguishes between learning in the narrow sense and learning in the wider sense. The former involves the mere acquisition of specific responses to particular situations. Such learning is superficial: it is unstable, impermanent, and unlikely to generalize. Learning in the wider sense involves the acquisition of general cognitive structures. Indeed, these are used to give meaning to specific learning and often make it possible. Thus, development explains learning. Further, development occurs through a self-regulatory process involving the four factors, not through the acquisition of specific information or responses. Learning therefore cannot explain development.

Piaget's theory makes an enormous contribution in focusing on the processes of *self-regulated* development. Piaget continually stresses the child's contribution to the developmental process. It is the child who tries to assimilate the conservation problem into already available structures, and it is the child who feels a subjective lack of certainty about his solution. The child does not simply react to external events, but takes an active part in his own development. Piaget's notion of self-regulation is extremely valuable. It seems to capture a good part of the reality of children's development. It also serves as an alternative to human engineering views which stress the external shaping of responses and the modification of behavior.

EDUCATION

In the present section, we will consider some implications which Piaget's views hold for education.

While Piaget has devoted relatively little attention to problems in this area, his work can make three types of contributions to educational practice. First, Piaget's theory provides some general principles for the conduct of education. Second, Piaget's studies of the development of specific logical, mathematical, and physical concepts in the child can assist the development of curricula and teaching practices in these areas. Third, Piaget's clinical interviewing technique can prove a valuable diagnostic and evaluative tool for the teacher. This section therefore will describe Piaget's thoughts with respect to education and will discuss these three types of potential contributions. The section closes by considering possible future directions for a Piagetian approach.

It should be emphasized at the outset that our intention is not to propose particular curricula or instructional practices on the basis of Piaget's work. As Sinclair (1976, p. 11) puts it,

> I'm not sure that much can be done with application of Piaget's theory in a detailed way by the Piagetian psychologist. . . . There are absolutely no [direct] practical indications in the work of Piaget with respect to education. . . . Piaget has very little to say with respect to specific problems such as how to teach reading and writing, and various other educational techniques.

Hence, we will be concerned with the major guiding principles which emerge from Piaget's work. Like Piaget, we feel that the implementation of these principles requires the special skills of the educator, who understands the distinctive conditions of the school setting, rather than the psychologist.

A Child-Centered Approach

One of Piaget's most significant contributions is his notion that the young child is quite different from the adult in several ways: in methods of approaching reality, in the ensuing views of the world, and in the uses of language. Piaget's investigations concerning matters such as the concept of number and verbal communication have enabled him to produce a change—indeed, one might almost say a metamorphosis—in our ways of understanding children. As a result of his work we have become increasingly aware that the child is not just a miniature although less wise adult, but a being with a distinctive mental structure that is qualitatively different from the adult's. The child views the world from a unique perspective. For example, the child below the age of 7 years truly believes that water, when poured from one container to another, gains or losses in quantity, depending on the shape of the second container. Or in the case of number, the young child, although able to count to 20 or more, has no conception of certain fundamental mathematical ideas. He may think, for example, that a set of five elements is larger than a set of eight elements if the physical arrangement of the sets takes on certain forms.

These and many other unexpected discoveries lead to the surprising recognition that the child's world is in many ways qualitatively different from that of the adult. One reason for the child's distinctive view of reality is a distinctive mental structure. The young child (below about 7 or 8 years of age) centers his attention on limited amounts of information; he attends to states rather than transformations; he is egocentric, failing to take into account other points of view; his concepts are relatively undifferentiated; and he is incapable of forms of thought, such as reversibility, which allow symbolic manipulation of the data of experience. Even the older child (between 7 and 11 years) is strongly tied to concrete situations although he is capable of fairly subtle mental operations. The child reasons best about immediately present objects and fails to appreciate the contradictions or possibilities inherent in a situation.

One result of the child's cognitive structure is a view of reality which to the adult seems chaotic and unnatural. Another consequence is that the young child's use of language is different from that of the adult. That is, the words that the child uses do not hold the same meaning for him as they do for the adult. Adults often overlook this point. We usually assume that if a child uses a particular word, it automatically conveys the same meaning that it does when an adult uses that word. Adults often believe that once a child has learned the linguistic label for an object, he has available the underlying concept. But Piaget has shown that this often is not the case. The child does learn his words from the adult, but assimilates them into his own mental structure, which is quite different from the adult's. The words "same amount to drink," for example, are interpreted in one way by the 4-year-old, and in another way by the adult. Only after a period of cognitive development does the child use these words and understand them in the same way as the more mature person.

The implication of this very general proposition—that the young child's thought and language are qualitatively different from the adult's— is also very general: the educator must make a special effort to understand the unique properties of the child's experience and ways of thinking. The educator must try to adopt a child-centered point of view, and cannot assume that the child's experience or modes of learning are the same as his own. For example, while the educator himself may learn a great deal by reading a book or listening to a lecture, similar experiences may be far less useful for the young child. The educator may profit from an orderly sequence of material, but perhaps the child does not. While the educator may feel that a given idea is simple and indeed self-evident, the child may find it difficult. In short, it is not safe to generalize from the adult's experience to that of the child. The educator's assumptions, stemming as they do from an adult perspective, may not apply to children. The educator needs to improve his own capacity to watch and listen, and to place himself in the distinctive perspective of the child. Since the meaning expressed by the child's language is often idiosyncratic, the adult must try to understand the child's world by observing his actions closely. There are no easy rules or procedures to use to understand the child. What *is* necessary is considerable sensitivity—a willingness to learn from the child, to look closely at the child's actions, and to avoid the assumption that what is true or customary for the adult is also true for the child. The educator needs to interact with the child in a flexible way to gain insight into the latter's current level of functioning. With this attitude—a willingness to observe the child and to learn from him the educator can begin to understand the child and to tailor the educational experience to the child's needs. Education must stem from a child-centered perspective.

Activity

The concept that children—or individuals of any age—learn best from self-initiated activity is vital for the guidance of education. Throughout this book we have seen that Piaget places major emphasis on the role of activity—both physical and mental—in intellectual development. In Piaget's view, "to know an object, is to act on it" (Piaget, "Development and Learning," 1964, p. 8). Almost from birth, the infant touches objects, manipulates them, turns them around, looks at them, and through such activities gains an increasing understanding of their properties. It is through action, not passive observation, that he develops an understanding of the world. Indeed, there is a sense in which the child constructs reality. For the older child, too, the essence of knowledge is activity. Thus, when the preoperational child attempts to remember (retain his knowledge over time), he actively organizes the material by assimilating it to available schemes. Often, the child's understanding is not on a verbal level, which in fact usually takes a long time to develop. The adolescent's knowledge also involves activity: in trying to understand physical phenomena, he actively generates combinations of hypothetical possibilities and transforms them in thought. He does not simply respond to the immediate present. To summarize, in all cases—whether behavioral schemes, concrete operations, or formal structures are involved—the essence of knowledge is activity.

To promote genuine understanding, the teacher should therefore encourage the child's activity. When the teacher attempts to bypass this process in various ways—for example, by lecturing at a class of young children—the result is often superficial learning. Perhaps this is one reason why so much of what is taught in school is immediately forgotten after the school year ends. By contrast, genuinely active learning can lead to a more solid and long-lasting understanding.

A word of caution is needed in connection with this emphasis on activity. Sometimes teachers take it to refer solely to physical activity; they believe that the manipulation of objects automatically leads to learning. This may be true in some situations, but it is not always the case. Take, for example, a preschooler who is actively engaged in playing with the toys provided at school—swinging on the swings, or building castles in the sandpit. This child will probably learn something about the properties of toys, swings, or sand, and about his own relationships to these objects. This is important knowledge for the child at this stage. Take, on the other hand, the case of a high school student following a science lesson. First, the teacher carefully demonstrates a particular experiment to the class. The teacher then asks the pupils to carry out the same experiment, for which the procedure is given step by step on a certain page of the textbook. Is the pupil who carries out the correct physical actions as described in the book really learning? Not necessarily so, or at least he is not always learning the things that the teacher intended him to learn. If the pupil's physical actions are not accompanied by parallel mental activity, such as thinking of alternative types of results and their meaning, it is unlikely that much real and lasting learning will occur. At this stage, simply tarrying out physical manipulations will not produce much learning.

As Piaget *(Science of Education and the Psychology of the Child,* 1970c) put it, "although the child's activity at certain levels necessarily entails the manipulation of objects, ... at other levels the most authentic research activity may take place in the spheres of reflection, of the most advanced abstraction, and of verbal manipulation (provided they are spontaneous and not imposed on the child)" (p. 68).

Acceptance of the principle of active learning requires a considerable reorientation of beliefs concerning education. Teachers (and the public at large) usually consider that the aim of education is to impart existing knowledge, often of a factual type, as efficiently as possible to the pupil, who will then absorb it in the form presented. In this view, if students were allowed to design and conduct experiments, there would not only be chaos in the classroom, but there would also be no learning. According to Piaget's theory, these beliefs and attitudes are erroneous for several reasons. Teachers can in fact impose very little knowledge. It is true that they can convince the child to *say* certain things, but these verbalizations often indicate little in the way of real understanding. Moreover, it is seldom legitimate to conceive of knowledge as a *thing* which can be transmitted. Certainly the child needs to learn some facts, and these may be considered *things.* Sometimes, drill or programmed instruction may assist in learning of this type. But often the child does not learn even facts when imposed; the student may have to discover them himself.

In addition, facts are but a small portion of real knowledge. True understanding involves action, on both the motoric and conceptual levels. Consider for example the understanding of class properties. A traditional view might propose that the child can simply be taught some facts about classification, for instance, that a square is a geometric form. Piaget's view, on the other hand, argues that understanding of classification consists of a sequence of activities. First, the child physically sorts or otherwise manipulates objects. He feels various forms and in this way (among others), perceives the differences among them. He may put different forms in different places. Later, he can sort the objects solely on a mental level; now the child does not need to separate things physically. Later still, he can perform inclusion operations on imagined classes of objects and can consider that a hypothetical class includes and is "larger than" its constituent subclass. Thus, knowledge of classification does not merely involve facts but actions as well: physical sorting, mental sorting, mental inclusion operations. Furthermore, most of these actions are nonverbal.

Since learning occurs through the child's activity, structured teaching methods, such as programmed learning or audiovisual aids, should be deemphasized in favor of more "active" methods. Instead of attempting to impart truths, teachers should set up situations which will lead the child to question, to experiment, and to discover facts and relationships. Children need to be encouraged in their exploratory frame of mind. This occurs naturally in the very young child, who is constantly experimenting with objects, language, and situations to understand more about the world. Yet once he starts going to school, he seems to cease being an experimenter. What has happened to extinguish this desire for discovery? In school, exploration is often discouraged entirely. And when it does take place, the teacher—not the child—is usually the experimenter. Under these circumstances, the child learns very little, becomes disinterested, and loses motivation. Teachers should therefore present the child with materials and situations that encourage the design of his own experiments. This will in turn lead to a deeper and more long-lasting knowledge than will a rote memorization of facts presented by teachers or in textbooks.

We have seen that Piaget's theory stresses the role of activity in education. It should be clear that Piaget's intention is not to glorify activity for its own sake. Instead, it is to point out that activity, when channeled in certain directions, leads to the goal of genuine learning. As we shall see next, the notion of reinvention provides an understanding of the goal, genuine learning.

Reinvention

Suppose that the child has been encouraged to engage in active exploration and that the educator has taken pains to guide the process of equilibration in a manner sensitive to the child's cognitive abilities and needs. The goad of all this activity is to produce genuine understanding. As we have seen, this does not involve the mere repetition of simple facts. *Genuine understanding is instead a process of reinvention.* As Piaget puts it, "read comprehension of a notion or theory implies the reinvention of this theory by the subject" (Piaget, "Comments on Mathematical Education," 1977a, p. 731).

Piaget describes the reinvention process as follows. At first, the child engages in concrete activities involving a notion like cardinal number. For example, he may spontaneously count a line of objects first from left to right and then from right to left. Activities such as these, spontaneously generated by the child, lead to the understanding of key principles. He finds, for example, that if you count a set from right to left, you get the same number as when you count from left to right.

In the Piagetian view, we can say that the child has *reinvented* a key aspect of the principle of cardinality. The notion of reinvention is used since the concept was not simply transmitted from teacher to child; instead, the child was put in a position where his own spontaneous activity led to the creation of the concept. Thus, when the child gets the same number regardless of the direction of counting, he concludes *on his own* that directionality makes no difference for counting. This "concluding on his own" is the essence of reinvention.

The understanding which results from reinvention, Piaget maintains, is more genuine and powerful than is that provided through structured teaching and passive learning. One indication of the reinvented concept's power is that the child spontaneously uses it in new situations, as if he is testing its generality. The child who receives the concept in a passive fashion is less likely to engage in active generalization of this type.

At the same time, Piaget points out a key limitation to the child's reinvented understanding: "the pupil will be far more capable of doing and understanding in actions than of expressing himself verbally ... a large part of the structures the child uses when he sets out actively to solve a problem are unconscious" (Piaget, 1977a, p. 731). So the child's reinvention leads to a genuine understanding, but one that is not yet capable of expression on a conscious, verbal level.

The achievement of a higher level of understanding should be delayed until a later time. As Piaget put it, "formalization [in mathematics] should be kept for a later moment as a type of systematization of the notions already acquired. This certainly means the use of intuitions before axiomatization" (in Piaget, 1977a, p. 732). In other words, formalization should be introduced only after the child has become comfortable with his "informal notions" and only with much assistance on the part of the teacher. Indeed, one of the teacher's main responsibilities is to help the child achieve an explicit consciousness, expression, and formalization of his "intuitive knowledge." In a later section (on curriculum), we shall explore the process of helping the child to make a transition between these different levels of understanding.

Individualized Learning

Piaget's theory stresses that current cognitive structures and new experiences interact to arouse interest and stimulate the subsequent development of understanding. Interest and learning are best facilitated if the experience presented to the child bears some relevance to what he already knows, but is at the same time sufficiently novel to present incongruities and conflicts. In other words, Piaget proposes that the child’s interest is aroused when an experience is moderately novel (recall the discussion of the moderate novelty principle during infancy). This means that the experience is not so radically novel that the child cannot assimilate it into current cognitive structures, and it is not so familiar as to be immediately and effortlessly assimilated, and thus of little interest. The principle is relativistic: by itself an event does not possess some degree of interest. Rather, interest is derived from the interaction between the state of the child’s mind and the properties of the thing to be known. At the same time, moderately novel experiences present the child with cognitive conflict. And according to the theory of equilibration, these conflicts serve as the basis for reorganization of cognitive structures and subsequent development.

The situation with regard to interest and conflict is complicated by the fact that there is considerable variation among children of the same age in their rate of development. We have seen that some children within a given culture acquire conservation, for example, at age 5 and others not until 8. Consequently, in any class of thirty to fifty children, there are wide differences among children in levels of cognitive functioning. Because these levels vary, the children’s interests, which are determined by an interaction between the current level of cognitive functioning and experience, will also vary. The teacher is therefore inevitably faced with a wide variation among students in both cognitive level and interest.

To deal with this, there must be extensive changes in classroom practice. First, teachers should be aware of the child’s current level of functioning. To some extent the teacher can rely on Piaget’s discoveries for this information. But Piaget’s work covers only a limited number of those topics usually studied in school. Therefore, the teacher himself must make an assessment of his students’ capabilities. Once obtained, this knowledge will help the teacher to create situations intended to provoke the child to question and experiment. The teacher may also select suitable counterarguments which will encourage the child to clarify his thinking. Knowledge of students’ functioning will also help the teacher to present the conflict situations that, as we have seen from the training research carried out in Geneva, are one important mechanism of conceptual growth.

The assessment of intellectual level is not an easy task. The evaluation must be different from the usual standard achievement tests which often measure only surface knowledge, rote memory, and other superficial aspects of learning. The teacher will have to evaluate not only the products of thought—correct or incorrect answers—but the process of students' thinking as well. The teacher will need to observe the children carefully and attempt to discover both their competencies and their weaknesses in any area. Without such evaluation, the teacher will find it difficult to judge between what is moderately novel and thus likely to arouse interest, between what is already known or too advanced for the pupil at this stage of development, and between what is or is not a conflict situation for each individual student. Once the teacher recognizes the child's current level of functioning he can create experiences which will promote interest, arouse conflict, and facilitate development for the student.

Second, teaching should be oriented more toward the individual student than the overall group. Since there are great individual differences in almost all areas of cognitive development, it is unlikely that any one task or lesson will arouse the interest of or promote learning in all members of the class. For some children, a specific task may be too easily assimilated into current mental structures, while for other students the same problem may require too great a degree of accommodation for them at their present stage of development. The result is boredom for the first group and confusion for the second. Third, children must also be given considerable control over their own learning. Some may need more time than others to deal with the same material; similarly, children may approach the same problem in different ways.

To promote interest and learning, then, the teacher should tailor the curriculum to the learner and try to individualize teaching as much as possible. This means that the large group should effectively be disbanded as the sole classroom unit, that children should often work on individual projects, and that they should be allowed a degree of freedom in their own learning. Several objections are usually raised to this sort of a proposal. Under an individual learning arrangement, would not children waste their time or engage in mere play? One may counter this argument by noting that the teacher may depend on a certain amount of spontaneous intellectual motivation in children, particularly younger ones. Piaget has shown that the child is quite active in acquiring knowledge, and that he learns about important aspects of reality quite apart from instruction in the schools. In the first two years of life, for example, the infant acquires a primitive understanding of causality, of the nature of objects, of relations, of language and of many other things—largely without the benefit of formal instruction or adult "teaching." One need only watch an infant for a short period of time to know that he is curious, interested in the world surrounding him, and eager to learn. The same can also be said of older children and is supported by the fact that some schools manage to operate individualized programs with a good dead of success. In addition, one must remember that individualized instruction does not require the abrogation of responsibility on the part of the teacher. Indeed, the more individualized the learning, the heavier the burden on the teacher. The teacher must assess the student's level, assign relevant learning experiences, and generally supervise the entire learning process. Getting children to work "on their own" requires a considerable contribution on the part of the teacher.

Indeed, the burden is so heavy that teachers often feel that the provision of individualized instruction in large classes (between twenty to fifty children) is an entirely unrealistic and impractical solution. It is true that in large classes no single teacher can effectively tailor a curriculum to meet the specific cognitive needs of every pupil at every moment of the teaching day. And from another point of view, it might not even be a good idea to have twenty, thirty, or fifty individual learners, all "doing their own thing' ' since some of the advantages of group learning would be lost in the process. Yet, when covering topics where there are obvious differences among children in their understanding of the material, teachers can divide the class into small groups of children at approximately the same level. For other topics, all children can work individually at their own level, while for still other topics the entire class can be joined together. The essential point is that teaching needs to be flexible; the teacher can employ a combination of group and individual instruction.

What the student needs, then, are opportunities to learn in a rich environment which contains many potentially interesting elements. The students' needs a teacher who is sensitive to his affective and cognitive needs; who can judge what materials will challenge him at a given point in time; who is able to evaluate his level of functioning and present new ideas at a level consistent with the student's intellectual and linguistic development; who can present this knowledge in a way that arouses the child's interest and activity; and who can help the students when necessary and who has faith in the child's capacity to learn.

Social Interaction

In Piaget's view, physical experience and concrete manipulation are not the only influences on learning. Another factor that leads to the development of knowledge is social experience or interaction with other persons. While Piaget has not written extensively on this topic, his work contains a number of important implications concerning the role of peers in the educational process.

The effects of social experience, although almost negligible during the first few months of life, become increasingly important as the child grows older. We have pointed out earlier that one of the prime deterrents to an objective understanding of reality is the child’s egocentric thought. At first, the child cannot view people, objects, or events in the surrounding world objectively because he can only perceive them as they relate to himself. The very young child assimilates external events directly into his own action schemes. Objects or events are only relevant to the extent that they concern the child’s own private preoccupations. He cannot view objects or events from any perspective except his own, and this egocentrism of course prevents him from gaining an objective view of objects or of persons. Gradually, as the child becomes capable of decentering his attention, as he begins to focus simultaneously on various aspects of reality, and as he comes to understand another person’s point of view, then he gains a more objective knowledge of reality.

One method which promotes the relinquishment of egocentrism is social interaction. When one child talks to another, he comes to realize that his way of viewing things is not the only perspective. The child sees that other people do not necessarily share his opinions. Social interaction inevitably leads to arguments and discussion: the child’s views are questioned, and he must defend and justify his opinions. This action forces the child to clarify his thoughts, for if he wants to convince others of the validity of his own views, the child must present them clearly and logically. In addition, other people may not be as tolerant of his inconsistencies as is the child himself, and they do not hesitate to point them out. Thus social interaction helps the child to recognize the shortcomings in his thinking and forces him to see other points of view which may conflict with his own. Such conflicts in schemes or ideas are one of the mechanisms of progress. Therefore, we see that, in addition to the more commonly stressed affective side of social interaction—the need to get along with other people— there is also an important cognitive component. Social experience not only helps people to adjust to others at an emotional level, but it also serves to clarify a person’s thinking and ultimately helps him to become more coherent and logical.

It should be made clear that social experience is not independent of physical experience. Verbal exchange of opinions, for example, is not feasible on certain subjects until the child has the experience of manipulating objects. During the early stages of development, physical experience is especially crucial. Yet once the child has acted on an object or a situation, language can then serve as a major tool to internalize the experience into a compact category. The child can also use language to communicate an understanding of experience to others. Indeed, the very attempt to communicate permits the child to make explicit certain aspects of experience which were at first understood only at the level of action. The child's activity and experience are of paramount importance during the early stages of development; later verbal communication and social interaction help to define and conceptualize this experience.

The implication of Piaget's view, therefore, is that social interaction should play a significant role in the classroom. Children should converse, share experiences and argue, for these are all major tools in the acquisition of knowledge.

Curriculum

In the preceding sections, we have reviewed various educational principles. Most refer to general aspects of the learning process and in themselves do not represent a completely novel approach to education. Many of these points have already been emphasized by educational philosophers. The role of activity in learning was discussed by Rousseau and Dewey, and the principle of individualized learning has some commonality with Skinner's concepts of programmed instruction. Piaget's research adds new empirical data in support of these principles, but the educational principles themselves are not new. The uniqueness of Piaget's contribution to education lies in other areas, particularly in his detailed description of the development of numerous physical, logical, and mathematical concepts in children, and in his account of the general development of thinking. This type of knowledge was not available to other educational theorists such as Rousseau or Dewey. A number of the concepts which Piaget has investigated are particularly relevant to education, since they are taught either directly or indirectly in schools. For example, while conservation of length is not usually taught in schools, it is a prerequisite for the understanding of measurement, which is taught. Knowledge of the child's cognitive level and of the child's understanding of particular concepts can be used to facilitate education in several ways.

Limits. On the one hand, research concerning the child's cognitive level demonstrates that there are limitations on what the child can learn. The child’s thought develops through a series of stages, each showing both strengths and weaknesses. Any one stage is characterized by the ability to perform certain actions and, on the other hand, by the propensity to commit particular errors. One implication of the stage theory is in a way “pessimistic.” Since intellectual development seems to follow an ordered sequence—a sequence which, until proof to the contrary, appears to be universal—the young child is incapable of learning certain kinds of concepts. It would serve no purpose, for instance, to try to teach a child of the preoperational period the principle of inertia, or any other abstract notion which requires the existence of reasoning at a formal operational level. Some things cannot be taught at any level, regardless of the method adopted. It is of course possible to accelerate some types of learning through the use of suitable environmental stimuli. For instance, if a child of the preoperational period is fairly close to achieving the structure of concrete operations, suitable physical experience may expedite the process, with the result that the structure may be acquired somewhat earlier than if no such experience had been presented. But as we have seen, such acceleration is possible only if the child is in a transitional stage.

Given these limitations on children’s learning, the educator can respond in several ways. One strategy is to delay the teaching of certain subjects until children are presumed “ready” to understand them. To some extent, this strategy is obviously reasonable: it makes no sense to teach calculus to the 5-year-old. On the other hand, this approach can be applied in an overly-zealous manner. Thus, one might propose that since elementary school children cannot employ formal operations, science should not be taught until adolescence, when it is possible to reason in a hypothetico-deductive manner. Such a practice would be unfortunate because even young children can understand something of science on a level appropriate to their own cognitive abilities. For the concrete operational child, science could involve a good deal of physical experience which might lead to formal operational thought. Similarly, in mathematics, while preoperational children cannot fully understand equivalence, they can profit from considerable experience in the counting of concrete objects. Often such concrete activity is a prerequisite for more abstract understanding. In brief, while limitations in children’s cognitive abilities prevent them from learning certain concepts, one should not forget that preparatory work, usually of a concrete nature, is often desirable and even necessary for later understanding. Hence, despite the limits, one should not give up on young children’s learning of certain concepts, but should search out appropriate ways for them to engage in preparatory activities.[6]

Strengths. At the same time, there is a more “optimistic” side to Piaget’s theory. At each stage of development, the child is capable of certain forms of thought, of specific concepts. For example, Piaget has found that concepts of topological geometry (distinctions between closed versus open figures, etc.) develop in the child before those of Euclidean geometry (measurement of angles, distances, etc.) and projective geometry (measurement of perspectives, coordinates, etc.). Understanding of topological notions appears fairly early in life, whereas the child only begins to understand the notions of Euclidean and projective geometry at around 7 years of age. Thus, while the 5-year-old may be incapable of learning projective concepts, he has already developed an intuitive understanding of topological notions. Each stage of development is characterized by strengths as well as weaknesses. Knowledge of the strengths as well as of the limitations can be used to improve education in several ways. One possible improvement is a detailed evaluation and modification of existing curricula. This type of work is being carried out more and more extensively in several countries. For example, Shayer (1972; 1974) has worked with a number of science courses (chemistry, physics, biology) commonly given in the United Kingdom. He has tried, for each topic covered, to assess the minimum conceptual level required for a pupil to be interested in and to grasp the particular concept involved. Shayer attempts to determine how suitable the courses and specific concepts are in relation to the developmental levels of the students. As a result of these investigations, he suggests that many learning problems may be due to a mismatch between the conceptual level of the majority of pupils and the concepts being presented. Such work—assessing students’ strengths and weaknesses in relation to the material taught—can eventually lead to the development of new and more effective curricula.

Knowledge of students’ intellectual strengths can lead to the improvement of education in other ways, too. In particular, it can produce an optimistic view concerning students’ potential and the creation of new learning opportunities. Piaget’s theory shows that by the age of 5 or 6, when they are simultaneously entering school and the period of concrete operations, most children have developed remarkably sophisticated intellectual processes. By this age, most children already possess the intellectual prerequisites for understanding a good deal of what is taught in elementary school. For example, children’s spontaneous concept of number is such that they should have no particular difficulty with the most notorious of school subjects, namely, arithmetic. As a result of natural development, they understand ideas of one-to-one correspondence, equivalence, additivity—that is, the concepts forming the foundation for a good deal of school arithmetic. In other words, Piaget's theory suggests that virtually all children possess the cognitive equipment for doing standard academic work. What is taught in school should easily be assimilated into the existing cognitive framework. Piaget feels that it is difficult to understand how students "who are well endowed when it comes to the elaboration and utilization of the spontaneous [patterns] of intelligence can find themselves handicapped in the comprehension" of academic subjects (Piaget,

Science of Education, 1970c, p. 4). The teacher should therefore seriously consider the notion that the education of children can rely on some already existing intellectual assets. Problems in learning are not likely to stem from fundamental intellectual deficits in the child. Given this notion, the educator can devise curricula which attempt to exploit the child's strengths. If, for example, the preoperational child is capable of understanding "functions," then the educator may elaborate on this concept. If the concrete operational child can deal with complex forms of equivalence, then the educator may try to exploit this informal knowledge. The natural course of development—the spontaneous appearance of intellectual capabilities—provides important opportunities for the fostering of academic knowledge and should therefore exert a strong influence on the nature of curriculum. The educator should also expect that children will have little difficulty in mastering school work because of their natural intellectual strengths.

Intuition and consciousness. We all know that despite children's intellectual strengths, the teaching of certain subjects does not go as smoothly as it might. Arithmetic is a prime example. Although children already possess spontaneous notions of basic mathematical ideas, they usually have a terrible time learning school arithmetic. Why should this be so? There are, of course, many different kinds of reasons, but perhaps Piaget's notion of different levels of understanding can shed some light on the issue.

The first of these levels is *motoric* or *practical* understanding. This is the level of action. The child can act directly on objects and manipulate them correctly, making the objects do what they are supposed to do. All this indicates that the child has "understood" objects at the level of motor responses. This knowledge is preserved in the form of schemes, which allow the actions to be repeated in identical situations and generalized to new ones. Another level of understanding is *conceptualization.* Here the child reconstructs internally the actions that were previously performed directly on objects, and at the same time adds new characteristics to these actions. He organizes the mental activities and provides logical connections. At the same time, much of the child's intellectual work remains unconscious. As we saw in reviewing Piaget's work on consciousness, the child is often capable of mental operations that he is not aware of and cannot express. A third level of knowledge involves *consciousness* and *verbalizations.* Now the child can deal with concepts on an abstract level and can express his mental operations in words. The child can reflect on his own thought.

At all stages of intellectual development, children find it easier to act—either behaviorally or mentally—than to achieve consciousness of their actions. Consciousness and verbalization are relatively late developments, and their emergence may depend on prior understanding at the lower levels.

The existence of different levels of understanding—practical, conceptual, and conscious—has important implications for education. We have already seen that at every stage of cognitive development the child possesses basic intellectual strengths. Usually these involve understanding at the unconscious levels, that is, motoric and conceptual understanding. By contrast, school learning typically operates at an exclusively verbal and formalized level. The child's spontaneous mathematics is informal and unconscious; the arithmetic taught in school is formal and highly verbalized. For Piaget, then, one of the key problems of education involves "finding the most adequate method for bridging the transition between these natural but nonreflective structures [that is, understanding of the first two types] to conscious reflection upon such structures and to a theoretical formulation of them" *(Science of Education,* 1970c, p. 47). Piaget recommends gradually building on what the child already knows—on the child's actions or unverbalized "intuitions"—to achieve a subsequent formalization.

Perhaps there is a paradox here: to foster true abstraction and consciousness, one must first encourage the concrete and unconscious. Of course, this does not mean that all learning must always involve the manipulation of concrete objects. The adolescent in the stage of formal operations may profit from verbal or written material, provided that in the course of development he has already acquired a good deal of motoric and conceptual knowledge corresponding to the abstraction in question. If, however, the formal operational learner encounters highly abstract material with which he has had no relevant previous experience, then for him (like the younger child) lower levels of understanding may help to serve as a foundation for consciousness. For most of us, truly abstract understanding can be achieved only through immersion in the concrete. In brief, one of the chief tasks of education is the elimination of the gap between the child's informed modes of understanding, which Piaget has described in some detail, and the formalities taught in school.

A caution. A word of caution is necessary with regard to the use of actual Piagetian tasks or experiments in the school curriculum. Since conservation is an indicator that the child has reached a certain stage of development or has acquired a certain cognitive structure, some educators believe that the direct teaching of conservation will automatically promote the development of the child's underlying cognitive structure. Piaget's tasks are therefore being used as teaching devices, as basic subject matter in the curriculum. This seems to make little sense. Learning the correct responses to certain specific tasks does not mean that a child will reach the same intellectual level as another child who spontaneously gives the correct responses to the same task. The only result of instruction in Piagetian concepts is generally that the child acquires some very localized learning in the narrow sense, which does not promote general progress in other areas of cognition. Such instruction is therefore of rather limited value, especially since the cognitive structures normally develop in a spontaneous fashion, quite without the "benefit" of education.

Clinical Method

As we have seen in Chapter 1, it was very early in his career that Piaget rejected standard tests as a useful tool for the study of cognitive development. Such tests, he felt, fail to give a good indication of underlying cognitive processes. Piaget now feels that standard tests are not particularly useful for educational purposes, either. Indeed, he considers the tests to be a "veritable plague on education" (quoted by Elkind, 1976, p. 192). For Piaget the preferred method is the clinical interview. This technique is not merely preliminary, nor is it sloppy or unscientific. It is instead the most useful and "valid" method currently available for the study of thinking. The clinical method has an important role to play in education, too, particularly in the areas of assessment and diagnosis. By the use of suitable probing questions that attempt to reveal the underlying reasons for a child's initial statement or judgment, by presenting countersuggestions to the child's arguments, and by providing conflict situations, the teacher who employs this method can discover a great deal about a child's cognitive functioning. In the clinical method, the interviewer must observe and listen to the child carefully and must adapt both the pace and the level of the questioning to the individual child who is interviewed. Standardization must be avoided. It is not the purpose of the interview to find out only whether a child is able to answer a certain question correctly or not, but to uncover underlying cognitive processes. Incorrect answers in particular provide the interviewer with an indication of the child's current state of knowledge.

The clinical method need not be restricted to Piagetian tasks, like conservation or seriation. The method can be used in any situation in which the objective is the exploration of the child's thought processes. Hence, it is quite appropriate, and we think very useful, to employ the method to examine the child's understanding of academic subject matter. For example, clinical interviewing has proved successful in the investigation of elementary school children's problems in learning arithmetic (Ginsburg, 1982). Teachers attempting to assess their pupils' functioning might therefore find the method a useful diagnostic tool in many areas of classroom learning. The technique is particularly valuable in identifying the intellectual difficulties which underlie learning problems.

Another and more indirect use of the method might be made in programs which attempt to train prospective teachers in questioning skills for use in teaching situations. There are many similarities between the clinical interview and the "Socratic" questioning technique in the classroom. For instance, in a group or individual setting, a skillful teacher does not simply ask questions which require the recall of correct answers; even more important, he asks provocative questions that stimulate the pupil to think, and to become aware of underlying causes. This requires questions that probe into the "whys" of situations. In addition, teachers need to adapt the level and pace of their questions to the understanding of pupils; teachers need to be able to listen and observe to understand the meaning of a response. These skills of questioning, sensitivity, and interpretation are all stressed in the clinical interview.

These, then, are two ways in which Piaget's clinical method can be used in education: first, as a means of assessment different from standard tests in both its flexible procedure and its aim of assessing cognitive structure, and, second, as a means of developing in the prospective teacher a sensitivity toward learners and the questioning skills essential for instruction.

Future Directions

During the period from 1960 to 1980, psychological and educational researchers carried out numerous studies based on the structural aspects of Piaget’s theory, that is, the stages of cognitive development, concepts of conservation, classification, or seriation. Educators in particular believed that an overall theory of human intellectual development should be able to provide insights that would help them in their teaching in the classroom. These studies have resulted in a certain amount of perhaps predictable disenchantment and disappointment. Expectations were too high. It is difficult to see how a theory that emphasizes four broad stages of development could provide useful insights for a teacher who teaches children over the relatively short period of one year, just as it is difficult to imagine how the study of conservation, which is not a concept taught in school, could be of any direct benefit to the teacher. Piaget’s later work into the processes of cognitive development and the mechanisms of learning offers more scope for both cognitive psychology and education. This later functional approach to cognitive development, however, like the early structural work, does not have *direct* applications to education. Before it can help the teacher in the classroom setting, a great deal of research is needed. But it provides a framework for the study and analysis of the processes by which learners acquire what it is teachers are trying to teach and could result in insights into classroom teaching and learning. Three main areas of this later work have potential applications to education.

The first is related to Piaget’s distinction among three types of knowledge: social, physical, and logicomathematical. The different nature of each type calls for different types of teaching methods. Social knowledge calls for didactic methods; physical knowledge is best promoted through the manipulation, exploration, and discovery of objects; and logicomathematical knowledge requires construction, reinvention, and reflection on actions and coordinations. At present, teachers have a tendency not only to treat all knowledge as if it were of the same type, but in many cases to treat it as if it were social knowledge and best promoted through errorless learning. While this type of learning may be appropriate for social knowledge, it may not necessarily be suitable for the other two types. If, as Piaget claims, it is disequilibrium, disturbance, or conflict that motivates the search for better forms of knowledge, then the learning of physical and logicomathematical knowledge would call for situations with some element of conflict.

If a particular subject matter could be analyzed in terms of these three types of knowledge, and the kinds of conflict likely to lead to learning, then teaching appropriate to each type could be designed. This might result in more varied, interesting, and effective teaching methods than those currently adopted.

Another area of Piaget’s theory with indirect application to education is that of the alpha, beta, and gamma reactions to disturbances. Here again, specific subject matters could be analyzed with these concepts in mind and appropriate teaching methods and situations designed for each level. Alpha reactions would require situations which enable the learner to become more aware of disturbing elements. Learners at the beta level need situations that help them to explore and construct variations and compromise solutions, whereas learners at the gamma level need to be helped to integrate their more mature understanding of one particular area of knowledge with other areas.

The third area in which Piaget’s work can provide a heuristic framework for educational research covers specific principles of the equilibration process, such as differentiation and integration, and the relativization and quantification of concepts. For any specific area of academic learning, researchers could identify the processes involved, such as the type of differentiations and integrations that occur, the sequence and nature of relativizations, the characteristics that are quantified for any particular concept, the interrelationships between these quantifications, and so on. Understanding of the dynamics of these processes for an academic subject could then help educators to set up appropriate teaching-learning situations.

This approach to teaching and learning would be a radical change from past practices. If adopted, the educator, rather than looking at teaching from the point of view of the academic subject to be learned or at what has proved successful in the past, would approach the teaching-learning situation from the point of view of the learner and how this learner spontaneously acquires knowledge. We believe that this constructivist, genetic epistemological approach to the classroom setting, based on the functional aspects of Piaget’s theory, could prove to be an extremely fruitful method of collaboration between psychology and education and could lead to important curriculum developments in the future.

Summary and Conclusions

We have reviewed some of the major implications of Piaget’s views for educational practice. While Piaget has not been mainly concerned with schools, one can derive from his theory a number of general principles which may guide educational procedures. The first of these is that the child’s language and thought are different from the adult’s. The teacher must be cognizant of this and must therefore observe children very closely in an attempt to discover their unique perspectives. Second, children need to act on things to learn. Formed verbal instruction is generally ineffective, especially for young children. Activity constitutes a major portion of genuine knowledge; the mere passive reception of facts or concepts is only a minor part of real understanding. Third, children are most interested and learn best when experience is moderately novel. When a new event is both familiar enough so that it may be assimilated without distortion into current cognitive structure, and novel enough so that it produces some degree of conflict, then interest and learning are promoted. Since at a given age level children’s cognitive structures differ, all children will not find the same new event interesting, nor will they learn from it. This implies that successful group instruction is almost impossible. Children should work individually, with freedom, at tasks of their own choosing. Piaget finds, too, that an important aspect of learning is self-regulation. Before entering school, and without adult instruction, the child learns in many ways. Fourth, children should have the opportunity to talk with one another in school, to argue and debate. Social interaction, particularly when it is centered on relevant physical experience, promotes intellectual growth.

Fifth, one of Piaget’s major contributions to education lies in the provision of extensive data on the development in children of basic mathematical, logical, and scientific concepts, and thus on the general development of thinking. This information can be used to determine the limits on children’s ability to learn, to evaluate curricula, to develop new learning experiences, and to eliminate the gaps between intuition and consciousness. Sixth, Piaget’s clinical method can be used as an effective aid in diagnosis and assessment, and in helping teachers acquire the questioning skills useful for promoting genuine learning in the classroom. Finally, Piaget’s theory of equilibration has implications for the conduct of teaching.

It should be clear that these views are at variance with many of the assumptions of traditional education. According to Piaget’s evidence and theory, students of a given age level do not and cannot learn essentially the same material; they learn only in a minor way through verbal explanation or written exposition (concrete experience must come first); they can and do exert control over their own learning; and they should talk to one another. It should also be clear that these ideas are not particularly new. The "progressive" education movement has proposed similar principles for many years. Piaget's contribution is not in developing new educational ideas, but in providing a vast body of data and theory which provide a sound basis for a "progressive" approach to the schools.

We would also like to point out that these educational ideas are not only "idealistic," but practical as well. Many primary schools in Great Britain and in the United States have been approaching education in line with the principles described above, and have drawn directly on Piaget's work for their inspiration. These schools represent a very promising experiment in educational innovation and have already achieved a good measure of success.

We will close this section on education, and this book, with a quotation from Piaget, stating his educational goals and at the same time describing his own accomplishment.

> The principal goal of education is to create men who are capable of doing new things, not simply of repeating what other generations have done— men who are creative, inventive, and discoverers. The second goal of education is to form minds which can be critical, can verify, and not accept everything they are offered. The great danger today is of slogans, collective opinions, ready-made trends of thought. We have to be able to resist individually, to criticize, to distinguish between what is proven and what is not. So we need pupils who are active, who learn early to find out by themselves, partly by their own spontaneous activity and partly through material we set up for them; who learn early to tell what is verifiable and what is simply the first idea to come to them. (Piaget, "Development and Learning, 1964, p. 5)

Notes

1 Lenneberg has proposed a sophisticated theory of maturation to explain the development of language. This theory, which is far superior to Gesell's, is in many respects congruent with Piaget's and deserves to be taken seriously indeed. See E. H. Lenneberg, *Biological Foundations of Language* (New York: John Wiley & Sons, Inc., 1967).

2 Piaget himself has given relatively little attention to physical experience, despite his estimate of its importance. In developmental psychology, this topic is usually treated under the rubric of perceptual development, and the most important theory in the area is E. J. Gibson's. See E. J. Gibson, *Principles of Perceptual Learning and Development* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1969).

3 Today, many psychologists are coming to agree with Piaget's thesis that thought shapes language far more than language shapes thought. See, for example, J. McNamara, "Cognitive Basis of Language Learning in Infants,'' *Psychological Review*, Vol. 79 (1972), pp. 1-13.

[4] These assertions concerning the role of language have not gone unchallenged. Beilin (1977) in particular has demonstrated that training in verbal rules can accelerate the pace of conservation, and in an address ("Language and Thought: Thistles Among the Sedums," Piaget Society, 1977) has elaborated on the role of language in the development of thinking.

[5] Piaget revised his concept of equilibration on several occasions. The present description is based on his last revision contained in works written between 1970 to 1980 and in particular in *The Equilibration of Cognitive Structures* (1985).

[6] One important issue regards the teaching of reading to the young child. On the basis of Piaget's theory, what can one conclude concerning the desirability of teaching 4- or 5-year-olds to read? We believe that the theory has little if anything to say about reading, since Piaget has not studied it directly and since it is not clear how the intellectual skills which he has studied relate to reading. Our own experience is that there is no cognitive limitation which would prevent preoperational children from learning to read if they are motivated to do so.