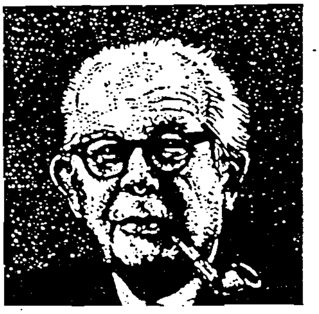
Woolfolk, A. E., Winne, P. H., & Perry, N. E. (2000). Piaget's theory of cognitive development. In *Educational Psychology*, pp. 27-42. New York, NY: Prentice Hall.

Piaget's Theory of Cognitive Development

During the past half-century, the Swiss psychologist Jean Piaget devised a model describing how humans go about making sense of their world by gathering and organizing information (Piaget, 1954, 1963, 1970a, b). We will examine Piaget's ideas closely, because they provide an explanation of the development of thinking from infancy to adulthood.

According to Piaget (1954), certain ways of thinking that are quite simple for an adult are not so simple for a child. Sometimes all you need to do to teach a new concept is to give a student a few basic facts as background. At other times, however, all the background facts in the world are useless. The student simply is not ready to learn the concept. With some students, you can discuss the general causes of wars and then ask why they think the Second World War broke out in 1939. But suppose the students respond with "When is 1939?" Obviously their concepts of time are different from your own. They may think, for example, that they will some day catch up to a sibling in age, or they may confuse the past and the future.



Jean Piaget was a Swiss psychologist whose insightful descriptions of children's thinking changed the way we understand cognitive development.

Influences on Development

As you can see, cognitive development is much more than the addition of new facts and ideas to an existing store of information. According to Piaget, our thinking processes change radically, though slowly, from birth to maturity because we constantly strive to make sense of the world. How do we do this? Piaget identified four factors—biological maturation, activity, social experiences, and equilibration—that interact to influence changes in thinking (Piaget, 1970a). Let's briefly examine the first three factors. We'll return to a discussion of equilibration in the next section.

One of the most important influences on the way we make sense of the world is *maturation*, the unfolding of the biological changes that are genetically programmed in each human being at conception. Parents and teachers have little impact on this aspect of cognitive development, except to be sure that children get the nourishment and care they need to be healthy.

Activity is another influence. With physical maturation comes the increasing ability to act on the environment and learn from it. When a young child's coordination is reasonably developed, for example, the child may discover principles about balance by experimenting with a seesaw. So as we act on the environment—as we explore, test, observe, and eventually organize information—we are likely to alter our thinking processes at the same time.

As we develop, we are also interacting with the people around us. According to Piaget, our cognitive development is influenced by *social transmission*, or learning from others. Without social transmission, we would need to reinvent all the knowledge already offered by our culture. The amount people can learn from social transmission varies according to their stage of cognitive development.

Maturation, activity, and social transmission all work together to influence cognitive development. How do we respond to these influences?

Basic Tendencies in Thinking

As a result of his early research in biology, Piaget concluded that all species inherit two basic tendencies, or "invariant functions." The first of these tendencies is toward **organization**—the combining, arranging, recombining, and rearranging of behaviours and thoughts into coherent systems. The second tendency is toward **adaptation**, or adjusting to the environment.

Organization Ongoing process of arranging information and experience into mental systems or categories.

Adaptation Adjustment to the environment.

Caption and new photo to come

Organization. People are born with a tendency to organize their thinking processes into psychological structures. These psychological structures are our systems for understanding and interacting with the world. Simple structures are continually combined and coordinated to become more sophisticated and thus more effective. Very young infants, for example, can either look at an object or grasp it when it comes in contact with their hands. They cannot coordinate looking and grasping at the same time. As they develop, however, infants organize these two separate behavioural structures into a coordinated higher-level structure of looking at, reaching for, and grasping the object. They can, of course, still use each structure separately (Ginsburg & Opper, 1988).

Piaget gave a special name to these structures. In his theory, they are called schemes. Schemes are the basic building blocks of thinking. They are organized systems of actions or thought that allow us to mentally represent or "think about" the objects and events in our world. Schemes may be very small and specific, for example, the sucking-through-a-straw scheme or the recognizing-a-rose scheme. Or they may be larger and more general—the drinking scheme or the categorizing-plants scheme. As a person's thinking processes become more organized and new schemes develop, behaviour also becomes more sophisticated and better suited to the environment.

Adaptation. In addition to the tendency to organize their psychological structures, people also inherit the tendency to adapt to their environment. Two basic processes are involved in adaptation: assimilation and accommodation.

Assimilation takes place when people use their existing schemes to make sense of events in their world. Assimilation involves trying to understand something new by fitting it into what we already know. At times, we may have to distort the new information to make it fit. For example, the first time many children see a skunk, they call it a "kitty." They try to match the new experience with an existing scheme for identifying animals.

Accommodation occurs when a person must change existing schemes to respond to a new situation. If data cannot be made to fit any existing schemes, then more appropriate structures must be developed. We adjust our thinking to fit the new information, instead of adjusting the information to fit our thinking. Children demonstrate accommodation when they add the scheme for recognizing skunks to their other systems for identifying animals.

People adapt to their increasingly complex environments by using existing schemes whenever these schemes work (assimilation) and by modifying and adding to their schemes when something new is needed (accommodation). In fact, both processes are required most of the time. Even using an established pattern like sucking through a straw may require some accommodation if the straw is of a different size or length than the type you are used to. If you have tried drinking juice from box packages, you know that you have to add a new skill to your sucking scheme—don't squeeze the box or you will shoot juice through the straw, straight up into the air and into your lap. Whenever new experiences are assimilated into an existing scheme, the scheme is enlarged and changed somewhat, so assimilation involves some accommodation.

There are also times when neither assimilation nor accommodation is used. If people encounter something that is too unfamiliar, they may ignore it. Experience is filtered to fit the kind of thinking a person is doing at a given time. For example, if you overhear a conversation in a foreign language, you probably will not try to make sense of the exchange unless you have some knowledge of the language.

Schemes Mental systems or categories of perception and experience.

Assimilation Fitting new information into existing schemes.

Accommodation Altering existing schemes or creating new ones in response to new information.

Equilibration. According to Piaget, organizing, assimilating, and accommodating can be seen as a kind of complex balancing act. In his theory, the actual changes in thinking take place through the process of equilibration—the act of searching for a balance. Piaget assumed that people continually test the adequacy of their thinking processes in order to achieve that balance.

Briefly, the process of equilibration works like this: If we apply a particular scheme to an event or situation and the scheme works, then equilibrium exists. If the scheme does not produce a satisfying result, then disequilibrium exists, and we become uncomfortable. This motivates us to keep searching for a solution through assimilation and accommodation, and thus our thinking changes and moves ahead. In order to maintain a balance between our schemes for understanding the world and the data the world provides, we continually assimilate new information using existing schemes, and we accommodate our thinking whenever unsuccessful attempts to assimilate produce disequilibrium.

Four Stages of Cognitive Development

Now we turn to the actual differences that Piaget hypothesized for children as they grow. Piaget's four stages of cognitive development are called sensorimotor, preoperational, concrete operational, and formal operational. Piaget believed that all people pass through the same four stages in exactly the same order. These stages are generally associated with specific ages, as shown in Table 2.1. When you see ages linked to stages, remember that these are only general guidelines, not labels for all children of a certain age. Piaget was interested in the kinds of thinking abilities people are able to use, not in labelling. Often, people can use one level of thinking to solve one kind of problem and a different level to solve another. Piaget noted that individuals may go through long periods of transition between stages and that a person may show characteristics of one stage in one situation but characteristics of a higher or lower stage in other situations. Therefore, knowing a student's age is never a guarantee that you know how the child will think (Ginsburg & Opper, 1988).

Infancy: The Sensorimotor Stage. The earliest period is called the sensorimotor stage, because the child's thinking involves seeing, hearing, moving, touching, tasting, and so on. During this period, the infant develops object permanence, the understanding that objects in the environment exist whether the baby perceives them or not. As most parents discover, before infants develop object permanence, it is relatively easy to take something away from them. The trick is to distract them and remove the object while they are not looking—"out of sight, out of mind." The older infant who searches for the ball that has rolled out of sight is indicating an understanding that the objects still exist even though they can't be seen.

A second major accomplishment in the sensorimotor period is the beginning of logical, goal-directed actions. Think of the familiar container toy for babies. It is usually plastic, has a lid, and contains several colorful items that can be dumped out and replaced. A six-month-old baby is likely to become frustrated trying to get to the toys inside. An older child who has mastered the basics of the sensorimotor stage will probably be able to deal with the toy in an orderly fashion. Through trial and error the child will slowly build a "container toy" scheme: (1) get the lid off; (2) turn the container upside down; (3) shake if the items jam; (4) watch the items fall. Separate lower-level schemes have been organized into a higher-level scheme to achieve a goal.

The child is soon able to reverse this action by refilling the container. Learning to reverse actions is a basic accomplishment of the sensorimotor stage. As

Equilibration Search for mental balance between cognitive schemes and information from the environment.

Disequilibrium In Piaget's theory, the "out-of-balance" state that occurs when a person realizes that his or her current ways of thinking are not working to solve a problem or understand a situation.

Sensorimotor Involving the senses and motor activity.

Object Permanence The understanding that objects have a separate, permanent existence.

Goal-Directed Actions Deliberate actions toward a goal.

TABLE 2.1 Piaget's Stages of Cognitive Development

Stage	Approximate Age	Characteristics
Sensorimotor	0–2 years	Begins to make use of imitation, memory, and thought.
		Begins to recognize that objects do not cease to exist when they are hidden.
		Moves from reflex actions to goal-directed activity.
Preoperational	2–7 years	Gradually develops use of language and ability to think in symbolic form.
		Able to think operations through logically in one direction.
		Has difficulties seeing another person's point of view.
Concrete operational	7–11 years	Able to solve concrete (hands-on) problems in logical fashion.
		Understands laws of conservation and is able to classify and seriate.
		Understands reversibility.
Formal operational	11–adult	Able to solve abstract problems in logical fashion.
		Becomes more scientific in thinking.
		Develops concerns about social issues, identity.

Source: From *Piaget's Theory of Cognitive and Affective Development,* 4/e by Barry J. Wadsworth. Copyright © 1971, 1979, 1984, 1989. Adapted by permission of Addison-Wesley Educational Publishers Inc.

we will soon see, however, learning to reverse thinking—that is, learning to imagine the reverse of a sequence of actions—takes much longer.

Early Childhood to the Early Elementary Years: The Preoperational Stage. By the end of the sensorimotor stage, the child can use many action schemes. As long as these schemes remain tied to physical actions, however, they are of no use in recalling the past, keeping track of information, or planning. For this, children need what Piaget called operations, or actions that are carried out and reversed mentally rather than physically. The stage after sensorimotor is called preoperational, because the child has not yet mastered these mental operations but is moving toward mastery.

According to Piaget, the first step from action to thinking is the internalization of action, performing an action mentally rather than physically. The first type of thinking that is separate from action involves making action schemes symbolic. The ability to form and use symbols—words, gestures, signs, images, and so on—is thus a major accomplishment of the preoperational period and moves children closer to mastering the mental operations of the next stage. This ability to work with symbols, such as using the word "bicycle" or a picture of a bicycle to stand for a real bicycle that is not actually present, is called the semiotic function.

Operations Actions a person carries out by thinking them through instead of literally performing the actions.

Preoperational The stage before a child masters logical mental operations.

Semiotic Function The ability to use symbols—language, pictures, signs, or gestures—to represent actions or objects mentally.

The child's earliest use of symbols is in pretending or miming. Children who are not yet able to talk will often use action symbols—pretending to drink from an empty cup or touching a comb to their hair, showing that they know what each object is for. This behaviour also shows that their schemes are becoming more general and less tied to specific actions. The eating scheme, for example, may be used in playing house. During the preoperational stage, we also see the rapid development of that very important symbol system, language. Between the ages of 2 and 4, most children enlarge their vocabulary from about 200 to 2,000 words.

As the child moves through the preoperational stage, the developing ability to think about objects in symbolic form remains somewhat limited to thinking in one direction only, or using *one-way logic*. It is very difficult for the child to "think backwards," or imagine how to reverse the steps in a task.

Reversible thinking is involved in many tasks that are difficult for the preoperational child, such as the conservation of matter. Conservation is the principle that the amount or number of something remains the same even if the arrangement or appearance is changed, as long as nothing is added and nothing is taken away. You know that if you tear a piece of paper into several pieces, you will still have the same amount of paper. To prove this, you know that you can reverse the process by taping the pieces back together.

A classic example of difficulty with conservation is found in the preoperational child's response to the following Piagetian task. Leah, a five-year-old, is shown two identical glasses, both short and wide in shape. Both have exactly the same amount of coloured water in them. The experimenter asks Leah if each glass has the same amount of water, and she answers, "Yes." The experimenter then pours the water from one of the glasses into a tall, narrow glass and asks Leah again if each glass has the same amount of water. Now she is likely to insist that there is more water in the tall, narrow glass, because the water level is higher. Notice, by the way, that Leah shows a basic understanding of identity (it's the same water) but not an understanding that the *amounts* are identical (Ginsburg & Opper, 1988).

Piaget's explanation for Leah's answer is that she is focusing, or centring, attention on the dimension of height. She has difficulty considering more than one aspect of the situation at a time, or decentring. The preoperational child cannot understand that increased diameter compensates for decreased height, since this would require taking into account two dimensions at once. Thus, children at the preoperational stage have trouble freeing themselves from their own perceptions of how the world appears.

This brings us to another important characteristic of the preoperational stage. Preoperational children, according to Piaget, are very egocentric; they tend to see the world and the experiences of others from their own viewpoint. Egocentric, as Piaget intended it, does not mean selfish; it simply means children often assume that everyone else shares their feelings, reactions, and perspectives. For example, if a little boy at this stage is afraid of dogs, he may assume that all children share this fear. Very young children centre on their own perceptions and on the way the situation appears to them. This is one reason it is difficult for these children to understand that your right hand is not on the same side as theirs when you are facing them.

Egocentrism is also evident in the child's language. You may have seen young children happily talking about what they are doing even though no one is listening. This can happen when the child is alone or, even more often, in a group of children—each child talks enthusiastically, without any real interaction or conversation. Piaget called this the collective monologue.

Recent research has shown that young children are not totally egocentric in every situation, however. Children as young as age four change the way they talk to two-year-olds by speaking in simpler sentences, and even before age

Being able to manipulate concrete objects helps children understand abstract relationships such as the connection between symbols and quantity.

Reversible Thinking Thinking backward, from the end to the beginning.

Conservation Principle that some characteristics of an object remain the same despite changes in appearance.

Decentring Focusing on more than one aspect at a time.

Egocentric Assuming that others experience the world the way you do.

Collective Monologue Form of speech in which children in a group talk but do not really interact or communicate.

two children show toys to adults by turning the front of the toy to face the other person. So young children do seem quite able to take the needs and different perspectives of others into account, at least in certain situations (Gelman, 1979; Gelman & Ebeling, 1989). The Guidelines give ideas for working with preoperational thinkers.

Guidelines

Teaching the Preoperational Child

Use concrete props and visual aids whenever possible.

Examples

1. When you discuss concepts such as "part," "whole," or "one-half," use shapes on a felt board or cardboard "pizzas" to demonstrate.
2. Let children add and subtract with sticks, rocks, or coloured chips.

Make instructions relatively short, using actions as well as words.

Examples

1. When giving instructions about how to enter the room after recess and prepare for social studies, ask a child to demonstrate the procedure for the rest of the class by walking in quietly, going straight to his or her seat, and placing the text, paper, and a pencil on his or her desk.
2. Explain a game by acting out one of the parts.
3. Show children what their finished papers should look like. Use an overhead projector or display examples where students can see them easily.

Don't expect the students to be consistent in their ability to see the world from someone else's point of view.

Examples

1. Avoid social studies lessons about worlds too far removed from the child's experience.
2. Avoid long lectures on sharing. Be clear about rules for sharing or use of materials, but avoid long explanations of the rationales for the rules.

Be sensitive to the possibility that children may have different meanings for the same word or different words for the same meaning. Children may also expect everyone to understand words they have invented.

Examples

1. If a child protests, "I won't take a nap. I'll just rest!," be aware that a nap may mean something like "changing into pajamas and being in my bed at home."
2. Ask children to explain the meanings of their invented words.

Give children a great deal of hands-on practice with the skills that serve as building blocks for more complex skills like reading comprehension.

Examples

1. Provide cut-out letters to build words.
2. Supplement paper-and-pencil tasks in arithmetic with activities that require measuring and simple calculations—cooking, building a display area for class work, dividing a batch of popcorn equally.

Provide a wide range of experiences in order to build a foundation for concept learning and language.

Examples

1. Take field trips to zoos, gardens, theatres, and concerts; invite storytellers to the class.
2. Give children words to describe what they are doing, hearing, seeing, touching, tasting, and smelling.

Later Elementary to the Middle School Years: The Concrete-Operational Stage. Piaget coined the term concrete operations to describe this stage of "hands-on" thinking. The basic characteristics of the stage are the recognition of the logical stability of the physical world, the realization that elements can be changed or transformed and still conserve many of their original characteristics, and the understanding that these changes can be reversed.

Figure 2.2 shows examples of the different tasks given to children to assess conservation and the approximate age ranges when most children can solve these problems. According to Piaget, a student's ability to solve conservation problems depends on an understanding of three basic aspects of reasoning: identity, compensation, and reversibility. With a complete mastery of identity, the student knows that if nothing is added or taken away, the material remains the same. With an understanding of compensation, the student knows that an apparent change in one direction can be compensated for by a change in another direction. That is, if the liquid rises higher in the glass, the glass must be narrower. And with an understanding of reversibility, the student can mentally cancel out the change that has been made.

Concrete Operations Mental tasks tied to concrete objects and situations.

Identity Principle that a person or object remains the same over time.

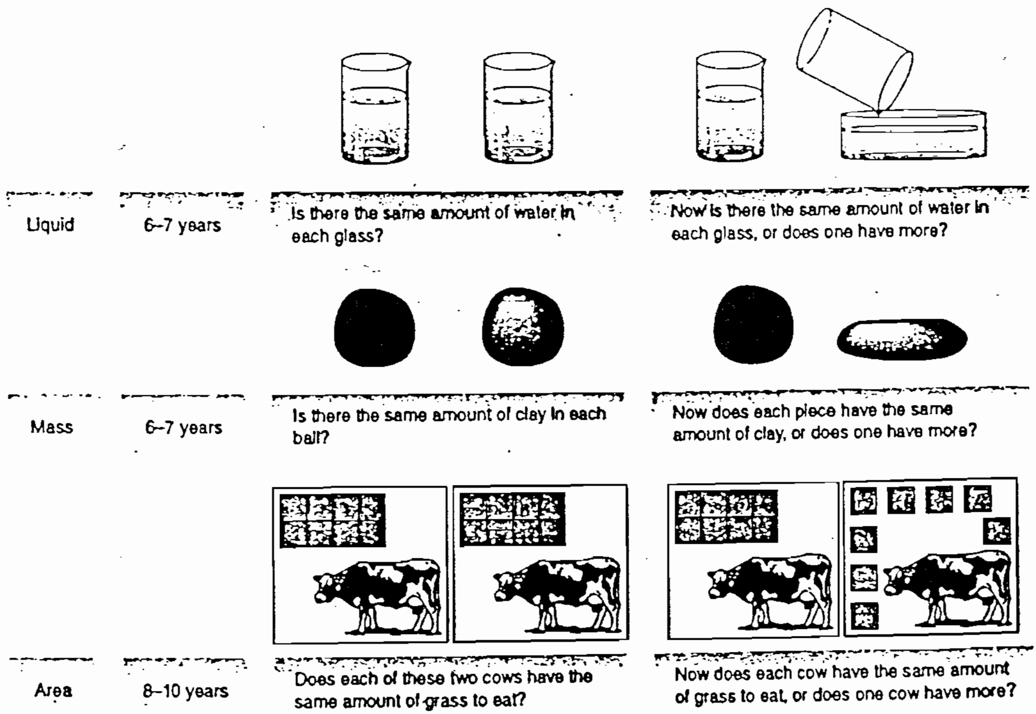
Compensation The principle that changes in one dimension can be offset by changes in another.

Reversibility A characteristic of Piagetian logical operations—the ability to think through a series of steps, then mentally reverse the steps and return to the starting point; also called reversible thinking.

FIGURE 2.2

Some Piagetian Conservation Tasks

In addition to the tasks shown here, other tasks involve the conservation of number, length, weight, and volume. These tasks are all achieved over the concrete-operational period.



Source: From Laura E. Berk, *Child Development*, 4/e. Copyright © 1997. All rights reserved. Adapted by permission of Allyn & Bacon.

Classification Grouping objects into categories.

Seriation Arranging objects in sequential order according to one aspect, such as size, weight, or volume.

Another important operation mastered at this stage is classification. Classification depends on a student's abilities to focus on a single characteristic of objects in a set and group the objects according to that characteristic. Given 12 objects of assorted colours and shapes, the concrete-operational student can invariably pick out the ones that are round.

More advanced classification at this stage involves recognizing that one class fits into another. A city can be in a particular state or province and also in a particular country. As children apply this advanced classification to locations, they often become fascinated with "complete" addresses such as Lee Jary, 5116 Forest Hill Drive, Richmond Hill, Ontario, Canada, North America, Northern Hemisphere, Earth, Solar System, Milky Way, Universe.

Classification is also related to reversibility. The ability to reverse a process mentally now allows the concrete-operational student to see that there is more than one way to classify a group of objects. The student understands, for example, that buttons can be classified by colour, then reclassified by size or by the number of holes.

Seriation is the process of making an orderly arrangement from large to small or vice versa. This understanding of sequential relationships permits a student to construct a logical series in which $A < B < C$ (A is less than B is less than C) and so on. Unlike the preoperational child, the concrete-operational child can grasp the notion that B can be larger than A but smaller than C.

With the abilities to handle operations like conservation, classification, and seriation, the student at the concrete-operational stage has finally developed a complete and very logical system of thinking. This system of thinking, however, is still tied to physical reality. The logic is based on concrete situations that can be organized, classified, or manipulated. Thus, children at this stage can imagine several different arrangements for the furniture in their rooms before they act. They do not have to solve the problem strictly through trial and error by actually making the arrangements. But the concrete-operational child is not yet able to reason about hypothetical, abstract problems that involve the coordination of many factors at once. This kind of coordination is part of Piaget's next and final stage of cognitive development.

In any grade you teach, a knowledge of concrete-operational thinking will be helpful. In the early grades, the students are moving toward this logical system of thought. In the middle grades, it is in full flower, ready to be applied and extended by your teaching. In the high school years, it is often used by students whose thinking may not have fully developed to the next stage—the stage of formal operations. The Guidelines on page xx should give you ideas for teaching children who can apply concrete operations.

Guidelines

Teaching the Concrete-Operational Child

Continue to use concrete props and visual aids, especially when dealing with sophisticated material.

Examples

1. Use time lines in history and three-dimensional models in science.
2. Use diagrams to illustrate hierarchical relationships like branches of government and the agencies under each branch.

Continue to give students a chance to manipulate and test objects.

Examples

1. Set up simple scientific experiments like the following involving the relationship between fire and oxygen. What happens to a flame when you blow

on it from a distance? (If you don't blow it out, the flame gets larger briefly, because it has more oxygen to burn.) What happens when you cover the flame with a jar?

2. Have students make candles by dipping wicks in wax, weave cloth on a simple loom, bake bread, set type by hand, or do other craft work that illustrates the daily occupations of people in the pioneer period.

Make sure presentations and readings are brief and well organized.

Examples

1. Assign stories or books with short, logical chapters, moving to longer reading assignments only when students are ready.
2. Break up a presentation with a chance to practise the first steps before introducing the next.

Use familiar examples to explain more complex ideas.

Examples

1. Compare students' lives with those of characters in a story. After reading *Island of the Blue Dolphins* (the true story of a girl who grew up alone on a deserted island), ask "Have you ever had to stay alone for a long time? How did you feel?"
2. Teach the concept of area by having students measure two rooms in the school that are different sizes.

Give opportunities to classify and group objects and ideas on increasingly complex levels.

Examples

1. Give students slips of paper with individual sentences written on each paper and ask the students to group the sentences into paragraphs.
2. Compare the systems of the human body to other kinds of systems: the brain to a computer, the heart to a pump. Break down stories into components, from the broad to the specific: author; story; characters, plot, theme; place, time; dialogue, description, actions.

Present problems that require logical, analytical thinking.

Examples

1. Use mind twisters, brain teasers, Master Mind, and riddles.
2. Discuss open-ended questions that stimulate thinking: "Are the brain and the mind the same thing?" "How should the city deal with stray animals?" "What is the largest number?"

Junior and Senior High: Formal Operations. Some students remain at the concrete-operational stage throughout their school years, even throughout life. However, new experiences, usually those that take place in school, eventually present most students with problems that they cannot solve using concrete operations. What happens when a number of variables interact, as in a laboratory experiment? Then a mental system for controlling sets of variables and working through a set of possibilities is needed. These are the abilities Piaget called **formal operations.**

At the level of formal operations, all the earlier operations and abilities continue in force; that is, formal thinking is reversible, internal, and organized in a system of interdependent elements. The focus of thinking shifts, however, from what *is* to what ***might be.*** Situations do not have to be experienced to be imagined. Ask a young child how life would be different if people did not sleep, and the child might say, "People have to sleep!" In contrast, the adolescent

Formal Operations Mental tasks involving abstract thinking and coordination of a number of variables.

who has mastered formal operations can consider contrary-to-fact questions. In answering, the adolescent demonstrates the hallmark of formal operations—**hypothetico-deductive** reasoning. The formal thinker can consider a hypothetical situation (people do not sleep) and reason deductively (from the general assumption to specific implications, such as longer workdays, more money spent on lighting, or new entertainment industries). Formal operations also include inductive reasoning, or using specific observations to identify general principles. For example, the economist observes many specific changes in the stock market and attempts to identify general principles about economic cycles. Formal-operational thinkers can form hypotheses, set up mental experiments to test them, and isolate or control variables in order to complete a valid test of the hypotheses.

The ability to consider abstract possibilities is critical for much of mathematics and science. After elementary school, most math is concerned with hypothetical situations, assumptions, and givens: "Let $x = 10$," or "Assume $x^2 + y^2 = z^2$," or "Given two sides and an adjacent angle . . . ." Young children cannot reason based on symbols and abstractions, but this kind of reasoning is expected in the later grades (Bjorklund, 1989). Work in social studies and literature requires abstract thinking, too: "What did Woodrow Wilson mean when he called World War I the 'war to end all wars'?" "What are some metaphors for hope and despair in Shakespeare's sonnets?" "What symbols of old age does T. S. Eliot use in *The Waste Land*?" "How do animals symbolize human character traits in Aesop's fables?"

The organized, scientific thinking of formal operations requires that students systematically generate different possibilities for a given situation. For example, if a child capable of formal operations is asked, "How many different meat/vegetable/salad meals can you make using three meats, three vegetables, and three salads?" the child can systematically identify the 27 possible combinations. A concrete thinker might name just a few meals, focusing on favourite foods or using each food only once. The underlying system of combinations is not yet available.

The ability to think hypothetically, consider alternatives, identify all possible combinations, and analyze one's own thinking has some interesting consequences for adolescents. Since they can think about worlds that do not exist, they often become interested in science fiction. Because they can reason from general principles to specific actions, they often are critical of people whose actions seem to contradict their principles. Adolescents can deduce the set of "best" possibilities and imagine ideal worlds (or ideal parents and teachers, for that matter). This explains why many students at this age develop interests in utopias, political causes, and social issues. They want to design better worlds, and their thinking allows them to do so. Adolescents can also imagine many possible futures for themselves and may try to decide which is best. Feelings about any of these ideals may be strong.

Another characteristic of this stage is **adolescent egocentrism**. Elkind (1967) coined this concept to describe the self-centredness often associated with individuals as they make the transition from childhood to adulthood. According to Elkind, adolescent egocentrism is manifested in two ways. The first involves the construction of an imaginary audience—the sense teenagers have that everyone is watching and analyzing them. The second is related to the first and involves the construction of a personal fable—the belief that, if everyone is so concerned with me, I must be "special," which may be perceived as good or bad. In fact, Schonert-Reichl at the University of British Columbia (1994) has linked adolescent egocentrism with adolescent depression. In particular, she found that girls from high socioeconomic status (SES) families tended to be overly self-con-

Hypothetico-Deductive Reasoning A formal-operations problem-solving strategy in which an individual begins by identifying all the factors that might affect a problem and then deduces and systematically evaluates specific solutions.

Adolescent Egocentrism Assumption that everyone else shares one's thoughts, feelings, and concerns.

scious, and more at risk for depression. In contrast, boys from high SES families reported a heightened sense of omnipotence, uniqueness, and invulnerability.

Focus on...

Piaget's Theory

- What is a scheme?
- Distinguish between assimilation and accommodation.
- As children move from sensorimotor to formal-operational thinking, what are the major changes?
- What are the characteristics of concrete-operational thinking? Is Trevor's thinking concrete (p. xx)?

Do We All Reach the Fourth Stage? As we have just seen, most psychologists agree that there is a level of thinking more sophisticated than concrete operations. But the question of how universal formal-operational thinking actually is, even among adults, is a matter of debate. According to Neimark (1975), the first three stages of Piaget's theory are forced on most people by physical realities. Objects really are permanent. The amount of water doesn't change when it is poured into another glass. Formal operations, however, are not so closely tied to the physical environment. They may be the product of experience and of practice in solving hypothetical problems and using formal scientific reasoning. These abilities tend to be valued and taught in literate cultures, particularly in colleges and universities.

Piaget himself (1974) suggested that most adults may be able to use formal-operational thought in only a few areas where they have the greatest experience or interest. So do not expect every student in your junior high or high school class to be able to think hypothetically about all the problems you present. Students who have not learned to go beyond the information given to them are likely to fall by the wayside. Sometimes students find shortcuts for dealing with problems that are beyond their grasp; they may memorize formulas or lists of steps. These systems may be helpful for passing tests, but real understanding will take place only if students are able to go beyond this superficial use of memorization—only, in other words, if they learn to use formal-operational thinking. The Guidelines may help you support the development of formal operations with your students.

Guidelines

Helping Students to Use Formal Operations

Continue to use concrete-operational teaching strategies and materials.

Examples

1. Use visual aids such as charts and illustrations as well as somewhat more sophisticated graphs and diagrams.
2. Compare the experiences of characters in stories to students' experiences.

Give students the opportunity to explore many hypothetical questions.

Examples

1. Have students write position papers, then exchange these papers with the opposing side and have debates about topical social issues—the environment, the economy, national unity.
2. Ask students to write about their personal vision of a utopia; write a description of a universe that has no sex differences; write a description of Earth after humans are extinct.

Give students opportunities to solve problems and reason scientifically.

Examples

1. Set up group discussions in which students design experiments to answer questions.

(continued)

2. Ask students to justify two different positions on animal rights, with logical arguments for each position.

Whenever possible, teach broad concepts, not just facts, using materials and ideas relevant to the students' lives.

Examples

1. When discussing Native land claims consider other issues that have divided the Canadians (e.g., Quebec separation).
2. Use lyrics from popular songs to teach poetic devices, to reflect on social problems, and to stimulate discussion on the place of popular music in our culture.

Implications of Piaget's Theory for Teachers

Piaget has taught us that we can learn a great deal about how children think by listening carefully, by paying close attention to their ways of solving problems. If we understand children's thinking, we will be better able to match teaching methods to children's abilities.

Understanding Students' Thinking

The students in any class will vary greatly both in their level of cognitive development and in their academic knowledge. As a teacher, how can you determine whether students are having trouble because they lack the necessary thinking abilities or because they simply have not learned the basic facts? To do this, Robbie Case, at the University of Toronto (1985b) suggests you observe your students carefully as they try to solve the problems you have presented. What kind of logic do they use? Do they focus on only one aspect of the situation? Are they fooled by appearances? Do they suggest solutions systematically or by guessing and forgetting what they have already tried? Ask your students how they tried to solve the problem. Listen to their strategies. What kind of thinking is behind repeated mistakes or problems? The students are the best sources of information about their own thinking abilities (Confrey, 1990a).

Matching Strategies to Abilities

An important implication of Piaget's theory for teaching is what Hunt years ago (1961) called "the problem of the match." Students must be neither bored by work that is too simple nor left behind by teaching they cannot understand. According to Hunt, disequilibrium must be kept "just right" to encourage growth. Setting up situations that lead to errors can help create an appropriate level of disequilibrium. When students experience some conflict between what they think should happen (a piece of wood should sink because it is big) and what actually happens (it floats!), they may rethink their understanding, and new knowledge may develop.

It is worth pointing out, too, that many materials and lessons can be understood at several levels and can be "just right" for a range of cognitive abilities. Classics such as *Alice in Wonderland*, myths, and fairy tales can be enjoyed at both concrete and symbolic levels. It is also possible for students to be introduced to a topic together, then work individually on follow-up activities matched to their level. Tom Good and Jere Brophy (1994) describe activity cards for three or four ability levels. These cards provide different readings and assignments, but all are directed toward the overall class objectives. One of the cards should be a good "match" for each student.

Constructing Knowledge

Piaget's fundamental insight was that individuals *construct* their own understanding; learning is a constructive process. At every level of cognitive development, you will also want to see that students are actively engaged in the learning process. They must be able to incorporate the information you present into their own schemes. To do this, they must act on the information in some way. Schooling must give the students a chance to experience the world. This active experience, even at the earliest school levels, should not be limited to the physical manipulation of objects. It should also include mental manipulation of ideas that arise out of class projects or experiments (Ginsburg & Opper, 1988). For example, after a social studies lesson on different jobs, a primary-grade teacher might show the students a picture of a woman and ask, "What could this person be?" After answers such as "teacher," "doctor," "secretary," "lawyer," "saleswoman," and so on, the teacher could suggest, "How about a daughter?" Answers such as "sister," "mother," "aunt," and "granddaughter" may follow. This should help the children switch dimensions in their classification and centre on another aspect of the situation. Next, the teacher might suggest "American," "jogger," or "blonde." With older children, hierarchical classification might be involved: it is a picture of a woman, who is a human being; a human being is a primate, which is a mammal, which is an animal, which is a life form.

All students need to interact with teachers and peers in order to test their thinking, to be challenged, to receive feedback, and to watch how others work out problems. Disequilibrium is often set in motion quite naturally when the teacher or another student suggests a new way of thinking about something. As a general rule, students should act, manipulate, observe, and then talk and/or write (to the teacher and each other) about what they have experienced. Concrete experiences provide the raw materials for thinking. Communicating with others makes students use, test, and sometimes change their thinking abilities. Discussions about the implications of Piaget's theory often centre on the question of whether cognitive development can be accelerated, as you can see in the Point/Counterpoint on page xx.

Some Limitations of Piaget's Theory

Piaget's influence on developmental psychology and education has been enormous, even though recent research has not supported all his ideas. Although most psychologists agree with Piaget's insightful descriptions of how children think, many disagree with his explanations of why thinking develops as it does.

The Trouble with Stages. Some psychologists have questioned the existence of four separate stages of thinking, even though they agree that children do go through the changes that Piaget described (Case, 1993; Gelman & Baillargeon, 1983). One problem with the stage model is the lack of consistency in children's thinking. Psychologists reason that if there are separate stages, and if the child's thinking at each stage is based on a particular set of operations, then once the child has mastered the operations, he or she should be somewhat consistent in solving all problems requiring those operations. In other words, once you can conserve, you ought to know that the number of blocks does not change when they are rearranged (conservation of number) and that the weight of a ball of clay does not change when you flatten it (conservation of weight). But it doesn't happen this way. Children can conserve

POINT COUNTERPOINT

Can Cognitive Development Be Accelerated?

Ever since Piaget described his stages of cognitive development, some people have asked if progress through the stages could be accelerated. More recently, the question has focused on whether we should accelerate learning for preschoolers and young children at risk of academic failure. Can learning be accelerated, and if so, is this a good idea?

POINT Every child deserves a head start.

Some of the strongest arguments in favour of "speeding up" cognitive development are based on the results of cross-cultural studies of children (studies that compare children growing up in different cultures). These results suggest that certain cognitive abilities are indeed influenced by the environment and education. Children of pottery-making families in one area of Mexico, for example, learn conservation of substance earlier than their peers in families who do not make pottery (Ashton, 1978). Furthermore, children in non-Western cultures appear to acquire conservation operations later than children in Western cultures. It seems likely that factors in the environment contribute to the rate of cognitive development.

But even if cognitive development can be accelerated, is this a good idea? Two of the most vocal (and heavily criticized) advocates of early academic training are Siegfried and Therese Engelmann (1981). In their book, *Give Your Child a Superior Mind,* they suggest that children who learn academic skills as preschoolers will be smarter throughout their school years, are less likely to fail, and are more likely to enjoy school. They contend:

> Children respond to the environment. Their capacity to learn and what they learn depends on what the environment teaches. . . . Instead of relying on the traditional environment that is rich in learning opportunities for the child, we can take the environment a step further and mold it into a purposeful instrument that teaches and that guarantees your child will have a superior mind. (p. 10)

COUNTERPOINT Acceleration is ineffective and may be harmful.

The position of Piagetian psychologists who attempt to apply his theory to education is that development should not be speeded up. This traditional view has been well summarized by Wadsworth (1978):

> The function of the teacher is not to accelerate the development of the child or speed up the rate of movement from stage to stage. The function of the teacher is to insure that development within each stage is thoroughly integrated and complete. (p. 117)

According to Piaget, cognitive development is based on the self-selected actions and thoughts of the student, not on the teacher's action. If you try to teach a student something the student is not ready to learn, he or she may learn to give the "correct" answer. But this will not really affect the way the student thinks about this problem. Therefore, why spend a long time teaching something at one stage when students will learn it by themselves much more rapidly and thoroughly at another stage?

Today the pressure is on parents and preschool teachers to create "superkids," three-year-olds who read, write, and speak a second language. David Elkind (1991) asserts that pushing children can be harmful. Elkind believes that preschool children who are given formal instruction in academic subjects often show signs of stress such as headaches. These children may become dependent on adults for guidance. Early focus on "right" and "wrong" answers can lead to competition and loss of self-esteem. Elkind asserts:

> The miseducation of young children, so prevalent in the United States today, ignores well-founded and noncontroversial differences between early education and formal education. As educators, our first task is to reassert this difference and insist on its importance. (p. 31)

number a year or two before they can conserve *weight.* Piagetian theorists have tried to deal with these inconsistencies, but not all psychologists are convinced by their explanations (Siegler, 1991).

Some psychologists have pointed to research on the brain to support Piaget's stage model. Epstein observed changes in rates of growth in brain weight and skull size and changes in the electrical activity of the brain between infancy and adolescence. These growth spurts occur at about the same time as transitions between the stages described by Piaget (Epstein, 1978, 1980). Evidence from animal studies indicates that infant rhesus monkeys show dramatic increases in synaptic (nerve) connections throughout the brain cortex at the same time that they master the kinds of sensorimotor problems described by Piaget (Berk, 1997). This may be true in human infants as well. Transition to the higher cognitive states in humans has also been related to changes in the brain, such as production of additional synaptic connections.

Underestimating Children's Abilities. It now appears that Piaget underestimated the cognitive abilities of children, particularly younger ones. The problems he gave young children may have been too difficult and the directions too confusing. His subjects may have understood more than they could show on these problems. For example, work by Gelman and her colleagues (Gelman, Meck, & Merkin, 1986; Miller & Gelman, 1983) shows that preschool children know much more about the concept of number than Piaget thought, even if they sometimes make mistakes or get confused. As long as preschoolers work with only three or four objects at a time, they can tell that the number remains the same, even if the objects are spread far apart or clumped close together. Similarly, Keenan, at the Ontario Institute for Studies in Education (Keenan, Ruffman, & Olson, 1994), found that making important task information salient helped four- and five-year-old children make inferences about what a story character knew. In other words, we may be born with a greater store of cognitive tools than Piaget suggested. Some basic understandings, like the sense of number or understanding what other people know, may be part of our evolutionary equipment, ready for use in our cognitive development.

Piaget's theory does not explain how even young children can perform at an advanced level in certain areas where they have highly developed knowledge and expertise. For example, Porath, at the University of British Columbia, found the drawings of artistically gifted children and the story plots of verbally gifted children to be far more elaborate than those of children in a same-age control group (1997; 1996). In fact, she found that the story plots of verbally gifted six year olds typified those of eight-year-old children. As John Flavell (1985) noted, "the expert [child] looks very, very smart—very 'cognitively mature'—when functioning in her area of expertise" (p. 83).

Cognitive Development and Information Processing. As you will see in Chapter 7, there are alternative explanations for why children have trouble with conservation and other Piagetian tasks. These explanations focus on the child's developing information processing skills such as attention, memory capacity, and learning strategies. Siegler (1991) proposes that, as children grow older, they develop better and better rules for solving problems and for thinking logically. Teachers can help students develop their capacities for formal thinking by putting the students in situations that challenge their thinking and reveal the shortcomings of their logic. Seigler's approach is called *rule assessment* because it focuses on understanding, challenging, and changing the rules that students use for thinking. This approach assumes specific experiences, teaching, and other outside influences play a greater role in children's cognitive development.

Cognitive Development and Culture. A final criticism of Piaget's theory is that it overlooks the important effects of the child's cultural and social group. Children in Western cultures may master scientific thinking and formal

Focus on...

Implications of Piaget's Theory

- How can teachers get a sense of the kind of thinking (preoperational, concrete, or formal) their students use to solve problems?
- What is the "problem of the match" described by Hunt?
- What is active learning? Why is Piaget's theory of cognitive development consistent with active learning?
- How would you teach an abstract concept to students like Trevor (p. xx)?

operations because this is the kind of thinking required in Western schools (Artman & Cahan, 1993; Berk, 1996). Even basic concrete operations such as classification may not be so basic to people of other cultures. For example, when African subjects from among the Kpelle people were asked to sort 20 objects, they created groups that made sense to them—a hoe with a potato, a knife with an orange. The experimenter could not get the Kpelle to change their categories; they said this is how a wise man would do it. Finally the experimenter asked in desperation, "Well, how would a fool do it?" The subjects promptly created the four neat classification piles the experimenter had expected—food, tools, and so on (Rogoff & Morelli, 1989).

There is an increasingly influential view of cognitive development. Proposed years ago by Lev Vygotsky and recently rediscovered, this theory ties cognitive development to culture.