2 | COGNITIVE DEVELOPMENT

TEACHERS' CASEBOOK

WHAT WOULD YOU DO? SYMBOLS AND CYMBALS

The district curriculum guide calls for a unit on poetry, including lessons on *symbolism* in poems. You are concerned that many of your fourth-grade students may not be ready to understand this abstract concept. To test the waters, you ask a few students what a *symbol* is.

"It's sorta like a big metal thing that you bang together." Tracy waves her hands like a drum major.

"Yeah," Sean adds, "My sister plays one in the high school band."

You realize they are on the wrong track here, so you try again. "I was thinking of a different kind of symbol, like a ring as a symbol of marriage or a heart as a symbol of love, or. . . ."

You are met with blank stares.

Trevor ventures, "You mean like the Olympic torch?"

"And what does that symbolize, Trevor?" you ask.

"Like I said, a torch." Trevor wonders how you could be so dense.

CRITICAL THINKING

- What do these students' reactions tell you about children's thinking?
- How would you approach this unit?
- What more would you do to "listen" to your students' thinking so you could match your teaching to their level of thinking?
- How would you give your students concrete experiences with symbolism?
- How will you decide if the students are not developmentally ready for this material?


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OVERVIEW AND OBJECTIVES

What is going on with Trevor? In this chapter, you will find out. We begin with a definition of *development* and examine three questions about development that psychologists have debated for many years: nature versus nurture, continuity versus discontinuity, and critical versus sensitive periods for development. Next we look at general principles of human development that most psychologists affirm. To understand cognitive development, we begin by studying how the brain works and then explore the ideas of two of the most influential cognitive developmental theorists, Jean Piaget and Lev Vygotsky. Piaget's ideas have implications for teachers about how their students think and what they can learn. We will consider criticisms of his ideas as well. The work of Lev Vygotsky, a Russian psychologist, highlights the important role teachers and parents play in the cognitive development of the child. Vygotsky's theory is becoming more and more influential in the field of child development. By the time you have completed this chapter, you should be able to:

Objective 2.1 Provide a definition of development that takes into account three agreed-upon principles and describe three continuing debates about development, along with current consensus on these questions.

Objective 2.2 Summarize some current research on the physical development of the brain and possible implications for teaching.

Objective 2.3 Explain the principles and stages presented in Piaget's theory of cognitive development.

Objective 2.4 Explain the principles presented in Vygotsky's theory of development.

Objective 2.5 Discuss how the ideas of Piaget and Vygotsky influence current educational research and practice.

OUTLINE

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Teachers' Casebook—Symbols and Cymbals: What Would They Do?

A DEFINITION OF DEVELOPMENT

In the next few chapters, as we explore how children develop, we will encounter some surprising situations.

- Leah, a 5-year-old, is certain that rolling out a ball of clay into a snake creates more clay.
- A 9-year-old child in Geneva, Switzerland, firmly insists that it is impossible to be Swiss and Genevan at the same time: "I'm already Swiss. I can't also be Genevan."
- Jamal, a very bright elementary school student, cannot answer the question, "How would life be different if people did not sleep?" because he insists, "People HAVE TO SLEEP!"
- A young girl who once said her *feet* hurt suddenly begins to refer to her *foots,* and then describes her *footses,* before she finally returns to talking about her *feet.*
- A 2-year-old brings his own mother to comfort a friend who is crying, even though the friend's mother is available, too.

What explains these interesting events? You will soon find out, because you are entering the world of child and adolescent development.

The term **development** in its most general psychological sense refers to certain changes that occur in human beings (or animals) between conception and death. The term is not applied to all changes, but rather to those that appear in orderly ways and remain for a reasonably long period of time. A temporary change caused by a brief illness, for example, is not considered a part of development. Human development can be divided into a number of different aspects. **Physical development**, as you might guess, deals with changes in the body. **Personal development** is the term generally used for changes in an individual's personality. **Social development** refers to changes in the way an individual relates to others. And **cognitive development** refers to changes in thinking, reasoning, and decision making.

Many changes during development are simply matters of growth and maturation. **Maturation** refers to changes that occur naturally and spontaneously and that are, to a large extent, genetically programmed. Such changes emerge over time and are relatively unaffected by environment, except in cases of malnutrition or severe illness. Much of a person's physical development falls into this category. Other changes are brought about through learning, as individuals interact with their environment. Such changes make up a large part of a person's social development. But what about the development of thinking and personality? Most psychologists agree that in these areas, both maturation and interaction with the environment (or *nature* and *nurture,* as they are sometimes called) are important, but they disagree about the amount of emphasis to place on each one. Nature versus nurture is one of three continuing discussions in theories of development.

Three Questions Across the Theories

Because there are many different approaches to research and theory, there are some continuing debates about key questions surrounding development.

WHAT IS THE SOURCE OF DEVELOPMENT? NATURE VERSUS NURTURE. Which is more important in development, the "nature" of an individual (heredity, genes, biological processes, maturation, etc.) or the "nurture" of environmental contexts (education, parenting, culture, social policies, etc.)? This debate has raged for at least 2,000 years and has accumulated many labels along the way, including "heredity versus environment," "biology versus culture," "maturation versus learning," and "innate versus acquired abilities." In earlier centuries, philosophers, poets, religious leaders, and politicians argued the question. Today scientists bring new tools to the discussion as they can map genes or trace the effects of drugs on brain activity, for example (Gottlieb, Wahlsten, & Lickliter, 2006). Even in scientific explanations, the pendulum has swung back and forth between nature and nurture (Cairns & Cairns, 2006; Overton, 2006).

Today the environment is seen as critical to development, but so are biological factors and individual differences. In fact, some psychologists assert that behaviors are determined 100% by biology and 100% by environment—they can't be separated (P. H. Miller, 2011). Current views emphasize complex **coactions** (joint actions) of nature and nurture. For example, a child born with a very easygoing, calm disposition will likely elicit different reactions from parents, playmates, and teachers than a child who is often upset and difficult to soothe; this shows that individuals are active in constructing their own environments. But environments shape individuals as well—if not, what good would education be? So today, the *either/or* debates about nature and nurture are of less interest to educational and developmental psychologists. As a pioneering developmental psychologist said over 100 years ago, the more exciting questions involve understanding how "both causes work together" (Baldwin, 1895, p. 77).

WHAT IS THE SHAPE OF DEVELOPMENT? CONTINUITY VERSUS DISCONTINUITY. Is human development a continuous process of increasing abilities, or are there leaps to new stages when abilities actually change? A continuous process would be like gradual improvement in your running endurance through systematic exercise. A discontinuous change (also called *qualitative*) would be like many of the changes in humans during puberty, such as the ability to reproduce—an entirely different ability. Qualitative changes are contrasted with purely quantitative change, such as the adolescent growing taller.

You can think of continuous or quantitative change like walking up a ramp to go higher and higher: Progress is steady. A discontinuous or qualitative change is more like walking up stairs: There are level periods, and then you ascend the next step all at once. Piaget's theory of cognitive development, described in the next section, is an example of *qualitative,* discontinuous change in children's thinking abilities. But other explanations of cognitive development based on learning theories emphasize gradual, continuous, *quantitative* change.

TIMING: IS IT TOO LATE? CRITICAL VERSUS SENSITIVE PERIODS. Are there critical periods during which certain abilities, such as language, need to develop? If those opportunities are missed, can the child still "catch up"? These are questions about timing and development. Many earlier psychologists, particularly those influenced by Freud, believed that early childhood experiences were critical, especially for emotional/social and cognitive development. But does early toilet training really set all of us on a particular life path? Probably not. More recent research shows that later experiences are powerful, too, and can change the direction of development (J. Kagan & Herschkowitz, 2005). Most psychologists today talk about **sensitive periods**—not critical periods. There are times when a person is especially ready for or responsive to certain experiences.

BEWARE OF EITHER/OR. As you might imagine, these debates about development proved too complicated to be settled by splitting alternatives into either/or possibilities (Griffins & Gray, 2005). Today, most psychologists view human development, learning, and motivation as a set of interacting and coacting contexts, from the inner biological structures and processes that influence development such as genes, cells, nutrition, and disease, to the external factors of families, neighborhoods, social relationships, educational and health institutions, public policies, time periods, historical events, and so on. So the effects of a childhood disease on the cognitive development of a child born in the 16th century to a poor family and treated by bloodletting or leeches will be quite different than the effect of the same disease on a child born in 2016 to a wealthy family and given the best treatment available for that time period. Throughout the rest of this book, we will try to make sense of development, learning, motivation, and teaching without falling into the *either/or trap.*

General Principles of Development

Although there is disagreement about exactly how development takes place, there are a few general principles almost all theorists would support.

1. *People develop at different rates.* In your own classroom, you will have a whole range of examples of different developmental rates. Some students will be larger, better coordinated, or more mature in their thinking and social relationships. Others will be much slower to mature in these areas. Except in rare cases of very rapid or very slow development, such differences are normal and should be expected in any large group of students.
2. *Development is relatively orderly.* People develop abilities in a logical order. In infancy, they sit before they walk, babble before they talk, and see the world through their own eyes before they can begin to imagine how others see it. In school, they will master addition before algebra, Harry Potter before Shakespeare, and so on. But "orderly" does not necessarily mean linear or predictable—people might advance, stay the same for a period of time, or even go backward.
3. *Development takes place gradually.* Very rarely do changes appear overnight. A student who cannot manipulate a pencil or answer a hypothetical question may well develop this ability, but the change is likely to take time.

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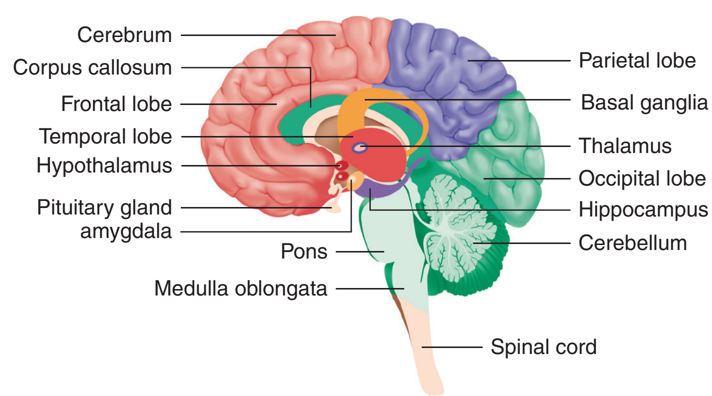
THE BRAIN AND COGNITIVE DEVELOPMENT

If you have taken an introductory psychology class, you have read about the brain and nervous system. You probably remember that there are several different areas of the brain and that certain areas are involved in particular functions. For example, the feathery-looking *cerebellum* coordinates and orchestrates balance and smooth, skilled movements—from the graceful gestures of the dancer to the everyday action of eating without stabbing yourself in the nose with a fork. The cerebellum may also play a role in higher cognitive functions such as learning. The *hippocampus* is critical in recalling new information and recent experiences, while the *amygdala* directs emotions. The *thalamus* is involved in our ability to learn new information, *particularly* if it is verbal. Figure 2.1 shows the various regions of the brain.

Advances in brain imaging techniques have allowed scientists remarkable access to the functioning brain. For example, **functional magnetic resonance imaging (fMRI)** shows how blood flows within the brain when children or adults do different cognitive tasks. **Event-related potential (ERP)**

FIGURE 2.1

REGIONS OF THE BRAIN



measurements assess electrical activity of the brain through the skull or scalp as people perform activities such as reading or learning vocabulary words. **Positron emission tomography (PET)** scans can track brain activity under different conditions.

Let's begin our look at the brain by examining its tiny components: neurons, synapses, and glial cells.

The Developing Brain: Neurons

A newborn baby's brain weighs about 1 pound, barely one third of the weight of an adult brain. But this infant brain has billions of **neurons**, the specialized nerve cells that accumulate and transmit information (in the form of electrical activity) in the brain and other parts of the nervous system. Neurons are a grayish color, so they sometimes are called the *gray matter* of the brain. One neuron has the information processing capacity of a small computer. That means the processing power of one 3-pound human brain is likely greater than all the computers in the world. Of course, computers do many things, like calculate square roots of large numbers, much faster than humans can (J. R. Anderson, 2010). These incredibly important neuron cells are tiny; about 30,000 could fit on the head of a pin (Sprenger, 2010). Scientists once believed that all the neurons a person would ever have were present at birth, but now we know that the production of new neurons, **neurogenesis**, continues into adulthood, especially in the hippocampus region (Koehl & Abrous, 2011).

Neuron cells send out long arm- and branch-like fibers called *axons* and *dendrites* to connect with other neuron cells. The fiber ends from different neurons don't actually touch; there are tiny spaces between them, about one billionth of a meter in length, called **synapses**. Neurons share information by using electrical signals and by releasing chemicals that jump across the synapses. Axons transmit information out to muscles, glands, or other neurons; dendrites receive information and transmit it to the neuron cells themselves. Communication between neurons by these synaptic transmissions is strengthened or weakened, depending on patterns of use. So the strength of these synaptic connections is dynamic—always changing. This is called **synaptic plasticity**, or just **plasticity**, a very important concept for educators, as you will see soon. Connections between neurons become stronger with use or practice and weaker when not used (Dubinsky, Roehrig, & Varma, 2013). Figure 2.2 on the next page shows these components of the neuron system (J. R. Anderson, 2010).

At birth, each of the child's 100 to 200 billion neurons has about 2,500 synapses. However, the fibers that reach out from the neurons and the synapses between the fiber ends increase during the first years of life, perhaps into adolescence or longer. By ages 2 to 3, each neuron has around 15,000 synapses; children this age have many more synapses than they will have as adults. In fact, they are *oversupplied* with the neurons and synapses that they will need to adapt to their environments. However, only those neurons that are used will survive, and unused neurons will be "pruned." This pruning is necessary and supports cognitive development. Researchers have found that some developmental disabilities are associated with a gene defect that interferes with pruning (Bransford, Brown, & Cocking, 2000; J. L. Cook & Cook, 2014).

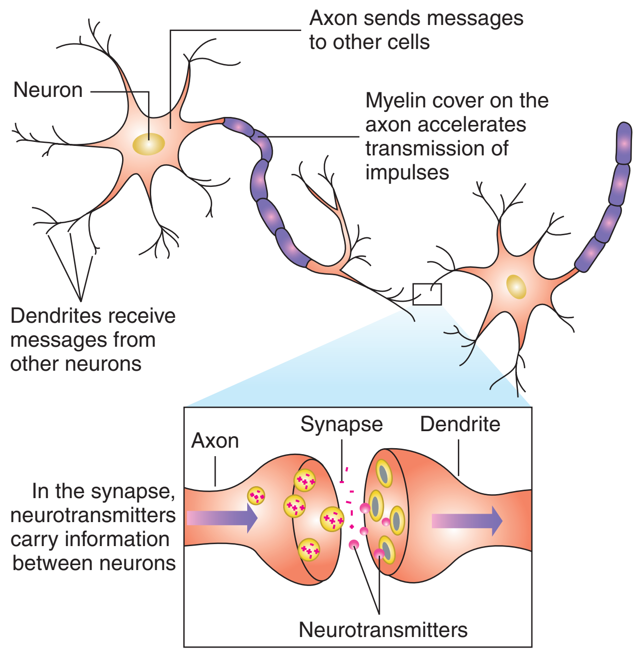
Two kinds of overproduction and pruning processes take place. One is called *experience-expectant* because synapses are overproduced in certain parts of the brain during specific developmental periods, awaiting (expecting) stimulation. For example, during the first months of life, the brain expects visual and auditory stimulation. If a normal range of sights and sounds occurs, then the visual and auditory areas of the brain develop. But children who are born completely deaf receive no auditory stimulation and, as a result, the auditory processing area of their brains becomes devoted to processing visual information. Similarly, the visual processing area of the brain for children blind from birth becomes devoted to auditory processing (C. A. Nelson, 2001; Neville, 2007).

Experience-expectant overproduction and pruning processes are responsible for general development in large areas of the brain and may explain why adults have difficulty with pronunciations that are not part of their native language. For example, the distinction between the sounds of *r* and *l* is important in English but not in Japanese, so by about 10 months, Japanese infants lose the

FIGURE 2.2

A SINGLE NEURON

Each neuron (nerve cell) includes dendrites that bring in messages and an axon that sends out messages. This is a single neuron, but each neuron is in a network with many others.



ability to discriminate between *r* and *1; those neurons are pruned away.* As a result, Japanese adults learning these sounds require intense instruction and practice (Bransford et al., 2000; Hinton, Miyamoto, & Della-Chiesa, 2008).

The second kind of synaptic overproduction and pruning is called *experience-dependent.* Here, synaptic connections are formed based on the individual's experiences. New synapses are formed in response to neural activity in very localized areas of the brain. Examples are learning to ride a bike or use a spreadsheet. The brain does not "expect" these behaviors, so new synapses form stimulated by these experiences. Again, more synapses are produced than will be kept after "pruning." Experience-dependent processes are involved in individual learning, such as mastering unfamiliar sound pronunciations in a second language you are studying.

Stimulating environments may help in the pruning process in early life (experience-expectant period) and also may support increased synapse development in adulthood (experience-dependent period) (J. L. Cook & Cook, 2014). In fact, animal studies have shown that rats raised in stimulating environments (with toys, tasks for learning, other rats, and human handling) develop and retain 25% more synapses than rats who are raised with little stimulation. Even though the research with rats may not apply directly to humans, it is clear that extreme deprivation can have negative effects on human brain development. But extra stimulation will not necessarily improve development for young children who are getting adequate or typical amounts (Byrnes & Fox, 1998; Kolb & Whishaw, 1998). So spending money on expensive toys or baby education programs probably offers more stimulation than is necessary. Pots and pans, blocks and books, sand and water all provide excellent stimulation—especially if accompanied by caring conversations with parents or teachers.

Look back at Figure 2.2. It appears that there is nothing between the neurons but air. Actually, this is wrong. The spaces are filled with **glial cells**, the *white matter* of the brain. There are trillions of these cells; they greatly outnumber neurons. Glial cells appear to have many functions, such as fighting infections, controlling blood flow and communication among neurons, and providing the *myelin* coating (see Figure 2.2) around axon fibers (Ormrod, 2012). **Myelination**, the coating of axon neuron fibers with an insulating fatty glial covering, influences thinking and learning. This process is something like coating bare electrical wires with rubber or plastic. This myelin coating makes message transmission faster and more efficient. Myelination happens quickly in the early years but continues gradually into adolescence, with the child's brain doubling in volume in the first year of life and doubling again around puberty (J. R. Anderson, 2010).

The Developing Brain: Cerebral Cortex

Let's move from the neuron level to the brain itself. The outer 1/8-inch-thick covering is the cerebral cortex—the largest area of the brain. It is a thin sheet of neurons, but it is almost 3 square feet in area for adults. To get all that area in your head, the sheet is crumpled together with many folds and wrinkles (J. R. Anderson, 2010). In humans, this area of the brain is much larger than it is in lower animals. The cerebral cortex accounts for about 85% of the brain's weight in adulthood and contains the greatest number of neurons. The cerebral cortex allows the greatest human accomplishments, such as complex problem solving and language.

The cortex is the last part of the brain to develop, so it is believed to be more susceptible to environmental influences than other areas of the brain (Gluck, Mercado, & Myers, 2008; Schacter, Gilbert, & Wenger, 2009). Parts of the cortex mature at different rates. The region of the cortex that controls physical motor movement matures first, then the areas that control complex senses such as vision and hearing, and last, the frontal lobe that controls higher-order thinking processes. The temporal lobes of the cortex that play major roles in emotions, judgment, and language do not develop fully until the high school years and maybe later.

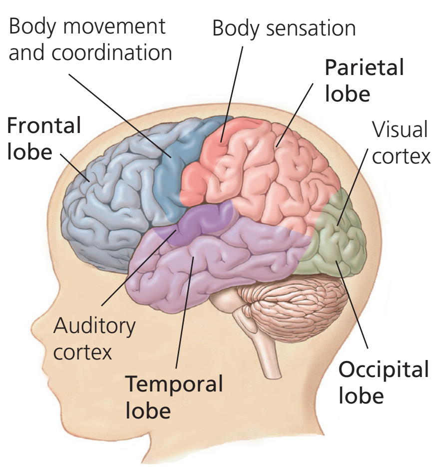
Different areas of the cortex seem to have distinct functions, as shown in Figure 2.3. Even though different functions are found in particular areas of the brain, these specialized functions are quite specific and elementary. To accomplish more complex functions such as speaking or reading, the various areas of the cortex must communicate and work together (J. R. Anderson, 2010; Byrnes & Fox, 1998).

Another aspect of brain functioning that has implications for cognitive development is **lateralization**, or the specialization of the two hemispheres of the brain. We know that each half of the brain controls the opposite side of the body. Damage to the right side of the brain will affect movement of the left side of the body and vice versa. In addition, certain areas of the brain affect

FIGURE 2.3

A VIEW OF THE CEREBRAL CORTEX

This is a simple representation of the left side of the human brain, showing the cerebral cortex. The cortex is divided into different areas, or lobes, each having a variety of regions with different functions. A few of the major functions are indicated here.



particular behaviors. For most of us, the left hemisphere of the brain is a major factor in language processing, and the right hemisphere handles much of our spatial-visual information and emotions (nonverbal information). For some left-handed people, the relationship may be reversed, but for most left-handers, and for females on average, there is less hemispheric specialization altogether (J. R. Anderson, 2010; O'Boyle & Gill, 1998). The brains of young children show more plasticity (adaptability) because they are not as specialized or lateralized as the brains of older children and adults. Young children with damage to the left side of the brain are somewhat able to overcome the damage, which allows language development to proceed. Different areas of the brain take over the functions of the damaged area. But in older children and adults, this compensation is less likely to occur after damage to the left brain hemisphere.

These differences in performance by the brain's hemispheres, however, are more relative than absolute; one hemisphere is just more efficient than the other in performing certain functions. Language is processed "differently, but simultaneously" by the left and right hemispheres (Alferink & Farmer-Dougan, 2010, p. 44). Nearly any task, particularly the complex skills and abilities that concern teachers, requires simultaneous participation of many different areas of the brain in constant communication with each other. For example, the right side of the brain is better at figuring out the meaning of a story, but the left side is where grammar and syntax are understood, so both sides of the brain have to work together in reading. Remember, no mental activity is exclusively the work of a single part of the brain, so there is no such thing as a "right-brained student" unless that individual has had the left hemisphere removed—a rare and radical treatment for some forms of epilepsy.

Adolescent Development and the Brain

The brain continues to develop throughout childhood and adolescence. During adolescence, changes in the brain increase individuals' abilities to control their behavior in both low-stress and high-stress situations, to be more purposeful and organized, and to inhibit impulsive behavior (Wigfield et al., 2006). But these abilities are not fully developed until the early 20s, so adolescents may "seem" like adults, at least in low-stress situations, but their brains are not mature. They often have trouble avoiding risks and controlling impulses. This is why adolescents' brains have been described as "high horse power, poor steering" (Organisation for Economic Co-operation and Development [OECD], 2007, p. 6).

One explanation for this problem with avoiding risks and impulsive behavior looks to differences in the pace of development for two key components of the brain—the limbic system and the prefrontal cortex of the brain (Casey, Getz, & Galvan, 2008). The limbic system develops earlier; it is involved with emotions and reward-seeking/novelty/risk-taking/sensation-seeking behaviors. The prefrontal lobe takes more time to develop; it is involved with judgment and decision making. As the limbic system matures, adolescents become more responsive to pleasure seeking and emotional stimulation. In fact, adolescents appear to need more intense emotional stimulation than either children or adults, so these young people are set up for taking risks and seeking thrills. Risk taking and novelty seeking can be positive factors for adolescent development as young people courageously try new ideas and behaviors—and learning is stimulated (McAnarney, 2008). But their less mature prefrontal lobe is not yet good at saying, "Whoa—that thrill is too risky!" So in emotional situations, thrill seeking wins out over caution, at least until the prefrontal lobe catches up and becomes more integrated with the limbic system toward the end of adolescence. Then risks can be evaluated in terms of long-term consequences, not immediate thrills (Casey et al., 2008; D. G. Smith, Xiao, & Bechara, 2012). In addition, there are individual differences: Some adolescents are more prone than others to engage in risky behaviors.

Teachers can take advantage of their adolescent students' intensity by helping them devote their energy and passion to areas such as politics, the environment, or social causes (L. F. Price, 2005) or by guiding them to explore emotional connections with characters in history or literature. Connections to family, school, community, and positive belief systems help adolescents "put the brakes" on reckless and dangerous behaviors (McAnarney, 2008).

Other changes in the neurological system during adolescence affect sleep; teenagers need about 9 hours of sleep per night, but many students' biological clocks are reset so it is difficult for them to fall asleep before midnight. Yet in many school districts, high school begins by 7:30, so 9 hours of sleep are impossible to get, and students are continually sleep deprived. Classes that keep students in their seats taking notes for the full period may literally "put the students to sleep." With no time for breakfast and little for lunch, these students' nutritional needs are often deprived as well (Sprenger, 2005).

Putting It All Together: How the Brain Works

What is your conception of the brain? Is the brain a culture-free container that holds knowledge the same way for everyone? Is the brain like a library of facts or a computer filled with information? Do you wake up in the morning, download what you need for the day, and then go merrily on your way? Is the brain like a pipe that transfers information from one person to another—a teacher to a student, for example? Kurt Fischer (2009)—a developmental psychologist and Harvard professor—offers a different view, based on neuroscience research. Knowing is actively constructing understandings and actions. Knowledge is based in our activities, and the brain is constantly changing:

> When animals and people do things in their worlds, they shape their behavior. Based on brain research, we know that likewise they literally shape the anatomy and physiology of their brains (and bodies). When we actively control our experience, that experience sculpts the way that our brains work, changing neurons, synapses, and brain activity. (p. 5)

All experiences sculpt the brain—play and deliberate practice, formal and informal learning (Dubinsky et al., 2013). You encountered the term earlier that describes the brain's capacity for constant change in neurons, synapses, and activity—*plasticity.* Cultural differences in brain activity provide examples of how interactions in the world shape the brain through plasticity. For example, in one study, when Chinese speakers added and compared Arabic numbers, they showed brain activity in the motor (movement) areas of their brains, whereas English speakers performing the same tasks had activity in the language areas of their brains (Tang et al., 2006). One explanation is that Chinese children are taught arithmetic using an abacus—a calculation tool that involves movement and spatial positions. As adults, these children retain a kind of visual-motor sense of numbers (Varma, McCandliss, & Schwartz, 2008). There also are cultural differences in how languages affect reading. For example, when they read, native Chinese speakers activate additional parts of their brain associated with spatial information processing, probably because the language characters used in written Chinese are pictures. But Chinese speakers also activate these spatial areas of the brain when they read English, demonstrating that reading proficiency can be reached through different neural pathways (Hinton, Miyamoto, & Della-Chiesa, 2008).

So thanks to plasticity, the brain is ever changing, shaped by activity, culture, and context. We build knowledge as we do things, as we manipulate objects and ideas mentally and physically. As you can imagine, educators have looked for applications of neuroscience research for their instruction. This has led to vigorous debate between the enthusiastic educational advocates of brain-based education and the skeptical neuroscience researchers who caution that studies of the brain do not really address major educational questions. Many publications for parents and teachers have useful ideas about the brain and education, but beware of suggestions that oversimplify. The jury still is out on many of these "brain-based" programs (Beauchamp & Beauchamp, 2013). See the *Point/Counterpoint* on the next page for a slice of this debate.

So what can teachers learn from neuroscience? We turn to this next.

Neuroscience, Learning, and Teaching

First let's be clear about what neuroscience does not tell teachers. There are many popular neuromyths (myths about the brain), as you can see in Table 2.1 on page 42. We have to be careful about what we encounter in the media.

It is *not* a myth that teaching can change the organization and structure of the brain. For example, individuals who are deaf and use sign language have different patterns of electrical activity in their brains than people who are deaf and do not use sign language (Varma, McCandliss, & Schwartz, 2008). What are some other effects of instruction on the brain?

PODCAST 2.1
Listen as textbook author Anita Woolfolk talks about brain-based education. What does this mean? Are there some clear implications for teachers or is it still too early to say?

ENHANCEDetext *podcast*

POINT/COUNTERPOINT

Brain-Based Education

Educators are hearing more and more about brain-based education, the importance of early stimulation for brain development, the "Mozart effect," and right- and left-brain activities. In fact, based on some research findings that listening to 10 minutes of Mozart can briefly improve spatial reasoning (Rauscher & Shaw, 1998; K. M. Steele, Bass, & Crook, 1999), a former governor of Georgia established a program to give a Mozart CD to every newborn. The scientists who had done the work couldn't believe how their research had been "applied" (Katzir & Paré-Blagoev, 2006). In fact, the governor apparently had confused experiments on infant brain development with studies of adults (Pinker, 2002). Are there clear educational implications from the neuroscience research on the brain?

POINT **No, the implications are not clear.** Catherine and Miriam Beauchamp (2013) note that the application of neuroscience to education actually has been plagued by misapplications because the findings have been treated in isolation, without attention to knowledge from other disciplines such as cognitive science or educational psychology that place the findings in context. To further complicate the problem of misapplications, educators and neuroscience researchers have different meanings for "learning" and don't have an appreciation for each others' reality; neuroscientists don't understand schools, and few educators have a background in neurobiology.

John Bruer, president of the James S. McDonnell Foundation, has written articles that are critical of the brain-based education craze (Bruer, 1999, 2002). He notes that many so-called applications of brain research begin with solid science, but then move to unwarranted speculation, and end in a sort of appealing folk tale about the brain and learning. He suggests that for each claim, the educator should ask, "Where does the science end and the speculation begin?" For example, one claim that Bruer questions is the notion of right-brain, left-brain learning.

> "Right brain versus left brain" is one of those popular ideas that will not die. Speculations about the educational significance of brain laterality have been circulating in the education literature for 30 years. Although repeatedly criticized and dismissed by psychologists and brain scientists, the speculation continues. David Sousa devotes a chapter of *How the Brain Learns* to explaining brain laterality and presents classroom strategies that teachers might use to ensure that both hemispheres are involved in learning. . . . Now let's consider the brain sciences and how or whether they offer support for some of the particular teaching strategies Sousa recommends. To involve the right hemisphere in learning, Sousa writes, teachers should encourage students to generate and use mental imagery. . . . What brain scientists currently know about spatial reasoning and mental imagery provides counter examples to such simplistic claims as these. Such claims arise out of a folk theory about brain laterality, not a neuroscientific one. . . . Different brain areas are specialized for different tasks, but that specialization occurs at a finer level of analysis than "using visual imagery." Using visual imagery may be a useful learning strategy, but if it is useful it is not because it involves an otherwise underutilized right hemisphere in learning. (Bruer, 1999, pp. 653–654)

Ten years later, Kurt Fischer (2009), president of the International Mind, Brain, and Education Society, lamented:

> Expectations for neuroscience and genetics to shape educational practice and policy have exploded far beyond what is merited by the state of the emerging field of MBE [mind body education] and the level of knowledge about how brains and genetics function. . . . Many neuromyths "have entered popular discourse—beliefs about how the brain and body work that are widely accepted but blatantly wrong" (OECD, 2007). Most of what is put forward as "brain based education" builds on these scientifically inaccurate myths: The one small way that neuroscience relates to most brain-based education is that the students have brains. There is no grounding for these claims in the young field of neuroscience.

No teacher doubts that the brain is important in learning. As Steven Pinker (2002), professor of psychology at Harvard University, observed, does anyone really think learning takes place somewhere else, like the pancreas? But knowing that learning affects the brain does not tell us how to teach. All learning affects the brain; "this should be obvious, but nowadays any banality about learning can be dressed up in neurospeak and treated like a great revelation of science" (Pinker, 2002, p. 86). Virtually all of the so-called best practices for brain-based education are simple restatements of good teaching based on understandings of how people learn, not how their brain works. For example, we have known for over 100 years that it is more effective to learn in many shorter practice sessions as opposed to one long cramming session. To tie that fact to building more dendrites does not give teachers new strategies (Alferink & Farmer-Dougan, 2010). Finally, Richard Haier and Rex Jung (2008) look to the future: "Someday, we believe that our educational system will be informed by neuroscience knowledge, especially concerning intelligence, but how we get from here to there remains unclear" (p. 177).

COUNTERPOINT Yes, teaching should be brain-based. Articles in popular magazines such as *Newsweek* assert, " . . . it's naive to say that brain discoveries have no consequences for understanding how humans learn" (Begley, 2007). Do scientists agree? In their article on "Applying Cognitive Neuroscience Research to Education" in the *Educational Psychologist,* Tami Katzir and Juliana Paré-Blagoev (2006) concluded, "When applied correctly, brain science may serve as a vehicle for advancing the application of our understanding of learning and development. . . . Brain research can challenge common-sense views about teaching and learning by suggesting additional systems that are involved in particular tasks and activities" (p. 70). If we are to guard against overstating the links between brain research and education, then we should not ask if to teach, but instead "how best to teach neuroscience concepts to pre-service teachers" (Dubinsky et al., 2013, p. 325). A number of universities, including Harvard, Cambridge, Dartmouth, the University of Texas at Arlington, University of Minnesota, University of Southern California, Beijing Normal University, Southeast University in Nanjing, and Johns Hopkins are pioneering this process. They have established training programs for educators in brain-education studies (Dubinsky et al., 2013; K. Fischer, 2009; Wolfe, 2010). Other educational psychologists have called for a new professional specialty—neuro-educators (Beauchamp & Beauchamp, 2013).

Brain research is leading to much better understandings about learning disabilities. For example, neuroscience studies of people with reading disabilities have found that these individuals may have trouble with sounds and sound patterns or with retrieving the names of very familiar letters, so there may be different bases for the reading disabilities (Katzir & Paré-Blagoev, 2006).

There are examples of applying knowledge of brain research to education. A reading improvement product called *FastForword* was developed by two neuroscientists, Dr. Michael Merzenich and Dr. Paula Tallal, and is already in use today in classrooms around the country (see scilearn.com/results/success-stories/index.php). It specifically uses discoveries in neural plasticity to change the brain's ability to read the printed word (Tallal & Miller, 2003).

In his presidential address for the First Conference of the International Mind, Brain, and Education Society, Kurt Fischer noted:

> The primary goal of the emerging field of Mind, Brain, and Education is to join biology, cognitive science, development, and education in order to create a sound grounding of education in research. The growing, worldwide movement needs to avoid the myths and distortions of popular conceptions of brain and genetics and build on the best integration of research with practice, creating a strong infrastructure that joins scientists with educators to study effective learning and teaching in educational settings. (2009, pp. 3–16)

Fischer makes the point that we can go from understanding how the brain works to understanding cognitive processes, and then to developing educational practices. But jumping directly from knowledge about the brain to educational practices probably involves too much speculation.

BEWARE OF EITHER/OR

Schools should not be run on curricula based solely on the biology of the brain. However, to ignore what we do know about the brain would be equally irresponsible. Brain-based learning offers some direction for educators who want more purposeful, informed teaching. At the very least, the neuroscience research is helping us to understand why effective teaching strategies, such as distributed practice, work.

Resources: Podcast on understanding the brain: http://www.oecd.org/edu/ceri/understandingthebrainthebirthofalearningscience.htm

INSTRUCTION AND BRAIN DEVELOPMENT. Several studies have shown differences in brain activity associated with instruction. For example, the intensive instruction and practice provided to rehabilitate stroke victims can help them regain functioning by forming new connections and using new areas of the brain (Bransford, Brown, & Cocking, 2000; McKinley, 2011). In another example, Margarete Delazer and her colleagues (2005) compared students' brain activity as they learned new arithmetic operations, either by just memorizing the answers or by learning an algorithm strategy. Using fMRI, the researchers found that students who simply memorized answers showed greater activity in the area of the brain that specializes in retrieving verbal information, whereas the students who used a strategy showed greater activity in the visual-spatial processing portion of the brain.

TABLE 2.1 • **Myths About the Brain**

COMMON MYTHS	TRUTH
1. You use only 10% of your brain.	1. You use all your brain. That is why strokes are so devastating.
2. Listening to Mozart will make children smarter.	2. Listening won't, but learning to play a musical instrument is associated with increased cognitive achievement.
3. Some people are more "right brained," and others are more "left brained."	3. It takes both sides of your brain to do most things.
4. A young child's brain can only manage to learn one language at a time.	4. Children all over the world can and do learn two languages at once.
5. You can't change your brain.	5. Our brains are changing all the time.
6. Damage to the brain is permanent.	6. Most people recover well from minor brain injuries.
7. Playing games like Sudoku keeps your brain from aging.	7. Playing Sudoku makes you better at playing Sudoku and similar games. Physical exercise is a better bet to prevent decline.
8. The human brain is the biggest brain.	8. Sperm whales have brains five times heavier than those of humans.
9. Alcoholic beverages kill brain cells.	9. Heavy drinking does not kill brain cells, but it can damage the nerve ends called dendrites, and this causes problems with communicating messages in the brain. This damage is mostly reversible.
10. The adolescent's brain is the same as that of an adult.	10. There are critical differences between adolescents' and adults' brains: Adolescents' brains have "high horsepower, but poor steering" (K. Fischer, 2009).

Source: Based on Aamodt & Wang (2008); K. W. Fischer (2009); Freeman (2011); OECD (2007).

In another dramatic example of how teaching can affect brain development, K. W. Fischer (2009) describes two children who each had one brain hemisphere removed as a treatment for severe epilepsy. Nico's right hemisphere was removed when he was 3, and his parents were told he would never have good visual-spatial skills. With strong and constant support and teaching, Nico grew up to be a skilled artist! Brooke's left hemisphere was removed when he was 11. His parents were told he would lose his ability to talk. Again, with strong support, he regained enough speaking and reading ability to finish high school and attend community college.

THE BRAIN AND LEARNING TO READ. Brain imaging research is revealing interesting differences among skilled and less-skilled readers as they learn new vocabulary. For example, one imaging study showed that less-skilled readers had trouble establishing high-quality representations of new vocabulary words in their brains, as indicated by ERP measurements of electrical activity of the brain. When they encountered the new word later, less-skilled readers' brains often didn't recognize that they had seen the word before, even though they had learned the words in an earlier lesson. If words you have learned seem unfamiliar later, you can see how it would be hard to understand what you read (Balass, Nelson, & Perfetti, 2010).

In another study, Bennett Shaywitz and his colleagues (2004) studied 28 children ages 6 to 9 who were good readers and 49 children who were poor readers. Differences in the brain activity of the two groups showed on fMRIs. The poor readers underused parts of their brains' left hemisphere and sometimes overused their right hemispheres. After over 100 hours of intensive instruction in letter–sound combinations, reading ability improved; the brains of the poor readers started to function more like those of the good readers and continued this functioning a year later. Poor readers who received the standard school remediation did not show the brain function changes.

> Reading is not innate or automatic—every brain has to be taught to read (Frey & Fisher, 2010). Reading is a complex integration of the systems in the brain that recognize sounds, written symbols, meanings, and sequences, and then connect with what the reader already knows. This has to happen quickly and automatically (Wolf et al., 2009).

> Will brain research help us teach reading more effectively? Judith Willis (2009), a neurobiologist who became a science teacher, cautions that "Neuroimaging and the other brain monitoring systems used for reading research offer *suggestive* rather than completely empirical links between how the brain learns and metabolizes oxygen or glucose, conducts electricity, or changes its cellular density." (p. 333)

Although the strategies for teaching reading that are consistent with brain research are not completely new, the research may help us understand *why* these strategies work. What are some strategies suggested? Use multiple approaches that teach sounds, spelling, meanings, sequencing, and vocabulary through reading, writing, discussing, explaining, drawing, and modeling. Different students may learn in different ways, but all need practice in literacy.

EMOTIONS, LEARNING, AND THE BRAIN. Finally, another clear connection between the brain and classroom learning is in the area of emotions and stress. Let's step inside a high school math classroom described by Hinton, Miyamoto, and Della-Chiesa (2008, p. 91) for an example:

> Patricia, a high school student, struggles with mathematics. The last few times she answered a mathematics question she got it wrong and felt terribly embarrassed, which formed an association between mathematics . . . and negative emotions. . . . Her teacher had just asked her to come to the blackboard to solve a problem. This caused an immediate transfer of this emotionally-charged association to the amygdala, which elicits fear. Meanwhile, a slower, cortically-driven cognitive appraisal of the situation is occurring: she remembers her difficulty completing her mathematics homework last night, notices the problem on the board contains complicated graphs, and realizes that the boy she has a crush on is watching her from a front-row seat. These various thoughts converge to a cognitive confirmation that this is a threatening situation, which reinforces her progressing fear response and disrupts her ability to concentrate on solving the mathematics problem.

In Chapter 7 you will learn about how emotions can become paired with particular situations; and in Chapter 12, you will see that anxiety interferes with learning, whereas challenge, interest, and curiosity can support learning. If students feel unsafe and anxious, they are not likely to be able to focus attention on academics (Sylvester, 2003). But if students are not challenged or interested, learning suffers too. Keeping the level of challenge and support "just right" is a challenge for teachers. And helping students learn to regulate their own emotions and motivation is an important goal for education (see Chapter 11). Simply put, learning will be more effective "if educators help to minimize stress and fear at school, teach students emotional regulation strategies, and provide a positive learning environment that is motivating to students" (Hinton, Miyamoto, & Della-Chiesa, 2008).

STOP & THINK As a teacher, you don't want to fall for overly simplistic "brain-based" teaching slogans. But obviously, the brain and learning are intimately related—this is not a surprise. So how can you be a savvy, "neuroscientific" teacher (Murphy & Benton, 2010)? •

Lessons for Teachers: General Principles

What can we learn from neuroscience? One overarching idea is that teachers and students should transform the notion of learning from "using your brain" to "changing your brain"—embrace the amazing plasticity of the brain (Dubinsky et al., 2013). Here are some general teaching implications drawn from Driscoll (2005), Dubinsky and colleagues (2013), Murphy and Benton (2010), Sprenger (2010), and Wolfe (2010):

1. Human capabilities—intelligence, communication, problem solving, and so on—emerge from each person's unique synaptic activity overlaid on his or her genetically endowed brain anatomy; nature and nurture are in constant activity together. The brain can place some limits on learning in the form of genetic brain anomalies in neural wiring or structure, but learning can occur through alternate pathways in the brain (as Nico and Brooke demonstrate). So, there are multiple ways both to teach and to learn a skill, depending on the student.

2. Many cognitive functions are differentiated; they are associated with different parts of the brain. So, learners are likely to have preferred modes of processing (e.g., visual or verbal) as well as varying capabilities in these modes. Using a range of modalities for instruction and activities that draw on different senses may support learning—for example, using maps and songs to teach geography. Assessment should be differentiated, too.
3. The brain is relatively plastic, so enriched, active environments and flexible instructional strategies are likely to support cognitive development in young children and learning in adults.
4. Some learning disorders may have a neurological basis; neurological testing may assist in diagnosing and treating these disorders, as well as in evaluating the effects of various treatments.
5. The brain can change, but it takes time, so teachers must be consistent, patient, and compassionate in teaching and reteaching in different ways, as Nico's and Brooke's parents and teachers could tell you.
6. Learning from real-life problems and concrete experiences helps students construct knowledge and also gives them multiple pathways for learning and retrieving information.
7. The brain seeks meaningful patterns and connections with existing networks, so teachers should tie new information to what students already understand and help them form new connections. Information that is not linked to existing knowledge will be easily forgotten.
8. It takes a long time to build and consolidate knowledge. Numerous visits in different contexts over time (not all at once) help to form strong, multiple connections.
9. Large, general concepts should be emphasized over small specific facts so students can build enduring, useful knowledge categories and associations that are not constantly changing.
10. Stories should be used in teaching. Stories engage many areas of the brain—memories, experiences, feelings, and beliefs. Stories also are organized and have a sequence—beginning, middle, end—so they are easier to remember than unrelated or unorganized information.
11. Helping students understand how activity (practice, problem solving, making connections, inquiry, etc.) changes their brain and how emotions and stress affect attention and memory can be motivating, leading to greater self-efficacy and self-regulated learning (we talk more about this in Chapter 11). One important message to students is that they are responsible for doing what it takes to change their own brains; you have to work (and play) to learn.

For the rest of the chapter, we turn from the brain and cognitive development to examine several major theories of cognitive development, the first offered by a biologist turned psychologist, Jean Piaget.

ENHANCEDetext *self-check*

PIAGET'S THEORY OF COGNITIVE DEVELOPMENT

Swiss psychologist Jean Piaget was a real prodigy. In fact, in his teens, he published so many scientific papers on mollusks (marine animals such as oysters, clams, octopuses, snails, and squid) that he was offered a job as the curator of the mollusk collection at the Museum of Natural History in Geneva. He told the museum officials that he wanted to finish high school first. For a while, Piaget worked in Alfred Binet's laboratory in Paris developing intelligence tests for children. The reasons children gave for their wrong answers fascinated him, and this prompted him to study the thinking behind their answers. This question intrigued him for the rest of his life (Green & Piel, 2010). He continued to write until his death at the age of 84 (P. H. Miller, 2011).

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

STOP & THINK Can you be in Pittsburgh, Pennsylvania, and the United States all at the same time? Is this a difficult question for you? How long did it take you to answer? •

According to Piaget (1954), certain ways of thinking that are quite simple for an adult, such as the Pittsburgh question in *Stop & Think*, are not so simple for a child. For example, do you remember the 9-year-old child at the beginning of the chapter who was asked if he could be a Genevan? He answered, *"No, that's not possible. I'm already Swiss. I can't also be Genevan"* (Piaget, 1965/1995, p. 252). Imagine teaching this student geography. The student has trouble with classifying one concept (Geneva) as a subset of another (Switzerland). There are other differences between adult and child thinking. Children's concepts of time may be 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. Let's examine why.

Influences on Development

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. 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. 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 can discover principles about balance by experimenting with a seesaw. Thus, 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 behaviors and thoughts into coherent systems. The second tendency is toward **adaptation**, or adjusting to the environment.

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 behavioral 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 (Flavell, Miller, & Miller, 2002; P. H. Miller, 2011).

Piaget gave a special name to these structures: **schemes**. In his theory, 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 can be very small and specific, for example, the sucking-through-a-straw scheme or the recognizing-a-rose scheme.

Or they can be larger and more general, for example, the drinking scheme or the gardening scheme. As a person's thinking processes become more organized and new schemes develop, behavior also becomes more sophisticated and better suited to the environment.

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

Video 2.1
The children in this video are learning something new about growth by observing a tadpole as it changes from day to day. They can assimilate the idea that the tadpole grows legs, but they need to accommodate their concept of growth to understand why the tadpole's tail gets smaller.

ENHANCEDetext *video example*

Assimilation takes place when we use our existing schemes to make sense of events in our 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 raccoon, they call it a "kitty." They try to match the new experience with an existing scheme for identifying animals.

Accommodation occurs when we must change existing schemes to respond to a new situation. If we cannot make new data fit any existing schemes, then we must develop more appropriate structures. 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 raccoons 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 such as sucking through a straw requires 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-through-a-straw 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 (Mascolo & Fischer, 2005).

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.

EQUILIBRATION. According to Piaget, organizing, assimilating, and accommodating can be viewed 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. Of course, the level of disequilibrium must be just right or optimal—too little and we aren't interested in changing, too much and we may be discouraged or anxious and not change.

Four Stages of Cognitive Development

Now we turn to the actual differences that Piaget hypothesized for children as they grow. Piaget believed that all people pass through the same four stages in exactly the same order. The stages are generally associated with specific ages, as shown in Table 2.2, but these are only general guidelines, not labels for all children of a certain age. 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 traits of a higher or lower stage in other situations. Therefore, remember that knowing a student's age is never a guarantee you will know how the child thinks (Orlando & Machado, 1996).

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.

TABLE 2.2 • **Piaget's Stages of Cognitive Development**

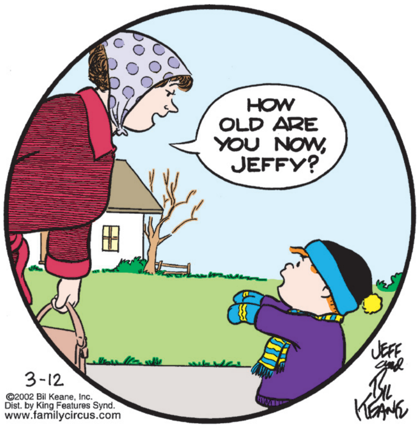
STAGE	APPROXIMATE AGE	CHARACTERISTICS
Sensorimotor	0–2 years	Learns through reflexes, senses, and movement—actions on the environment. Begins to imitate others and remember events; shifts to symbolic thinking. Comes to understand that objects do not cease to exist when they are out of sight—object permanence. Moves from reflexive actions to intentional activity.
Preoperational	Begins about the time the child starts talking, to about 7 years old	Develops language and begins to use symbols to represent objects. Has difficulty with past and future—thinks in the present. Can think through operations logically in one direction. Has difficulties understanding the point of view of another person.
Concrete Operational	Begins about first grade, to early adolescence, around 11 years old	Can think logically about concrete (hands-on) problems. Understands conservation and organizes things into categories and in series. Can reverse thinking to mentally "undo" actions. Understands past, present, and future.
Formal Operational	Adolescence to adulthood	Can think hypothetically and deductively. Thinking becomes more scientific. Solves abstract problems in logical fashion. Can consider multiple perspectives and develops concerns about social issues, personal identity, and justice.

During this period, infants develop **object permanence**, the understanding that objects exist in the environment whether they perceive them or not. This is the beginning of the important ability to construct a mental representation. 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 objects still exist even when they are not in view (M. K. Moore & Meltzoff, 2004). Some researchers suggest that infants as young as 3 to 4 months may know that an object still exists, but they do not have either the memory skills to "hold on" to the location of the object or the motor skills to coordinate a search (Baillargeon, 1999; Flavell et al., 2002).

A second major accomplishment in the sensorimotor period is the beginning of logical, **goal-directed actions**. Think of the familiar clear plastic container baby toy with a lid and several colorful items inside that can be dumped out and replaced. A 6-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 by building a "container toy" scheme: (1) get the lid off, (2) turn the container upside down, (3) shake if the items jam, and (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 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. However, as long as these schemes remain tied to physical actions, they are of no use in recalling the past,



"I can't tell you 'cause I'm wearin' my mittens."

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. At the **preoperational** stage the child is moving toward mastery, but has not yet mastered these mental operations (so thinking is *pre*operational).

According to Piaget, 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 to represent an object that is not present, such as using the word *horse* or a picture of a horse or even pretending to ride a broomstick horse, is called the **semiotic function**. In fact, the child's earliest use of symbols is in pretending. 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 behavior also shows that their schemes are becoming more general and less tied to specific actions. The eating scheme, for example, can be used in playing house. During the preoperational stage, there is also 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 backward," 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.

Video 2.2
In this video, children participate in tasks that show their understanding of conservation of volume and conservation of number. Compare the responses, and identify each child's stage of cognitive development, according to Piaget's theory.

ENHANCEDetext *video example*

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, but a child using preoperational thinking can't think that way. Here is a classic example of difficulty with conservation. Leah, a 5-year-old, is shown two identical glasses, both short and wide in shape. Both have exactly the same amount of colored water in them. She agrees that the amounts are "the same." The experimenter then pours the water from one of the glasses into a taller, narrower glass and asks, "Now, does one glass have more water, or are they the same?" Leah responds that the tall glass has more because "It goes up more here" (she points to higher level on taller glass).

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

This brings us to another important characteristic of the preoperational stage. Preoperational children, according to Piaget, have a tendency to be **egocentric**, to see the world and the experiences of others from their own viewpoint. The concept of egocentrism, 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. The 2-year-old at the beginning of this chapter who brought his own mother to comfort a distressed friend—even though the friend's mother was available—was simply seeing the situation through his own eyes. Very young children center on their own perceptions and on the way the situation appears to them. This is one reason it is difficult for preoperational children to understand that *your* right hand is not on the same side as theirs when you are facing them.

Research has shown that young children are not totally egocentric in every situation, however. Children as young as 2 describe more details about a situation to a parent who was not present than they provide to a parent who experienced the situation with them. So young children do seem quite able to take the needs and different perspectives of others into account, at least in certain situations (Flavell et al., 2002). And in fairness to young children, even adults can make assumptions that others feel or think like they do—think about all the politicians who believe "the people agree with

GUIDELINES
Family and Community Partnerships

Helping Families Care for Preoperational Children

Encourage families to use concrete props and visual aids whenever possible.

Examples
1. When family members use words such as *part, whole,* or *one half,* encourage them to demonstrate using objects in the house such as cutting an apple or pizza into parts.
2. Let children add and subtract with sticks, rocks, or colored chips. This technique also is helpful for early concrete-operational students.

Make instructions relatively short—not too many steps at once. Use actions as well as words.

Examples
1. When giving instructions such as how to feed a pet, first model the process, then ask the child to try it.
2. Explain a game by acting out one of the parts.

Help children develop their ability to see the world from someone else's point of view.

Examples
1. Ask children to imagine "how your sister felt when you broke her toy."
2. Be clear about rules for sharing or use of material. Help children understand the value of the rules, and help them develop empathy by asking them to think about how they would like to be treated. Avoid long lectures on "sharing" or being "nice."

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

Examples
1. Provide cut-out letters or letter magnets for the refrigerator to build words.
2. Do activities that require measuring and simple calculations—cooking, 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 trips to zoos, gardens, theaters, and concerts; encourage storytelling.
2. Give children words to describe what they are doing, hearing, seeing, touching, tasting, and smelling.

me!" The *Guidelines: Family and Community Partnerships* gives ideas for working with preoperational thinkers and for guiding families in supporting the cognitive development of their children.

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.

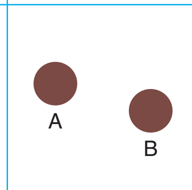
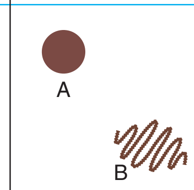
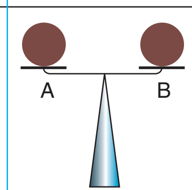
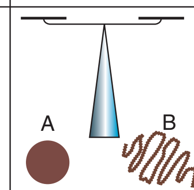
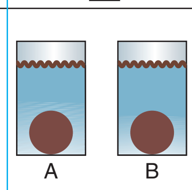
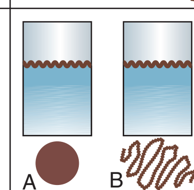
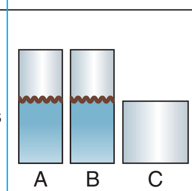
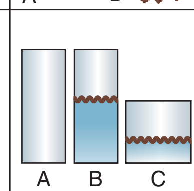
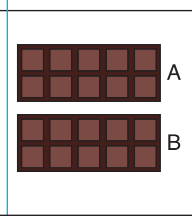
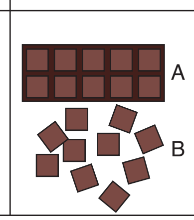
Look at Figure 2.4 on the next page to see examples of the different tasks given to children to assess conservation and the approximate age ranges when most children can solve these problems. According to Piaget, the ability to solve conservation problems depends on having an understanding of three basic 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 glass is narrower, the liquid will rise higher in the glass. And with an understanding of **reversibility**, the student can mentally cancel out the change that has been made. Leah apparently knew it was the same water (identity), but she lacked compensation and reversibility, so she was still moving toward conservation.

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 (e.g., color) and group the objects according to that characteristic. 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 you probably knew when I asked you earlier about Pittsburgh, Pennsylvania, USA. 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.

FIGURE 2.4

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.

	Suppose you start with this	→	Then you change the situation to this	→	The question you would ask a child is
(a) conservation of mass		Roll out clay ball B			Which is bigger, A or B?
(b) conservation of weight		Roll out clay ball B			Which will weigh more, A or B?
(c) conservation of volume		Take clay ball out of water and roll out clay ball B			When I put the clay back into the water beakers, in which beaker will the water be higher?
(d) conservation of continuous quantity		Pour water in beaker A into beaker C			Which beaker has more liquid, B or C?
(e) conservation of number		Break candy bar B into pieces			Which is more candy? A or B

Source: Woolfolk, A., & Perry, N. E., Child Development (2nd ed.),

Classification is also related to reversibility. The ability to reverse a process mentally 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 color, and 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 still smaller than C.

With the abilities to handle operations such as conservation, classification, and seriation, the student at the concrete-operational stage has finally developed a complete and very logical system of thinking. However, this system of thinking 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. They do not have to solve the problem strictly through trial and error by actually moving the furniture. However, 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, knowledge of concrete-operational thinking will be helpful (see *Guidelines: Teaching the Concrete-Operational Child*). 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. Students in high school and even adults still commonly use concrete-operational thinking, especially in areas that are new or unfamiliar.

HIGH SCHOOL AND COLLEGE: 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.

STOP & THINK You are packing for a long trip, but want to pack light. How many different three-piece outfits (slacks, shirt, jacket) will you have if you include three shirts, three slacks, and three jackets (assuming of course that they all go together in fashion perfection)? Time yourself to see how long it takes to arrive at the answer. •

GUIDELINES
Teaching the Concrete-Operational Child

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

Examples

1. Use timelines in history and three-dimensional models in science.
2. Use diagrams to illustrate hierarchical relationships such as 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 such as 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 colonial 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, giving students an opportunity to practice the first steps before introducing the next steps.

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 schoolrooms 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.

Present problems that require logical, analytical thinking.

Examples

1. 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?"
2. Use sports photos or pictures of crisis situations (Red Cross helping in disasters, victims of poverty or war, senior citizens who need assistance) to stimulate problem-solving discussions.

What happens when a number of variables interact, as in a laboratory experiment or the question in *Stop & Think?* 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, the focus of thinking can shift from what is to what might be. Situations do not have to be experienced to be imagined. You met Jamal at the beginning of this chapter. Even though he is a bright elementary school student, he could not answer the question, "How would life be different if people did not have to sleep?" because he insisted, "People HAVE TO SLEEP!" In contrast, the adolescent 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-operational 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 energy and lighting, smaller houses without bedrooms, 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 from this information.

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Reasoning (II, A1)
Be able to distinguish between inductive and deductive reasoning. Explain the role that each plays in the learning of concepts.

Using formal operations is a new way of reasoning that involves "thinking about thinking" or "mental operations on mental operations" (Inhelder & Piaget, 1958). For example, the child using concrete operations can categorize animals by their physical characteristics or by their habitats, but a child using formal operations can perform "second-order" operations on these category operations to *infer relationships between* habitat and physical characteristics—such as understanding that the physical characteristic of thick fur on animals is related to their arctic habitats (Kuhn & Franklin, 2006). Abstract formal-operational thinking is necessary for success in many advanced high school and college courses. For example, most math is concerned with hypothetical situations, assumptions, and givens: "Let $x = 10$," or "Assume $x2 + y2 = z2$," or "Given two sides and an adjacent angle. . . ." Work in social studies and literature requires abstract thinking, too: "What did 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 asked, "How many different shirt/slacks/jacket outfits can you make using three of each kind of clothing?" the child using formal operations can systematically identify the 27 possible combinations. (Did you get it right?) A concrete-operational thinker might name just a few combinations, using each piece of clothing only once. The underlying system of combinations is not yet available.

Another characteristic of this stage is **adolescent egocentrism**. Unlike egocentric young children, adolescents do not deny that other people may have different perceptions and beliefs; the adolescents just become very focused on their own ideas. They spend much time examining their own beliefs and attitudes. This leads to what Elkind (1981) calls the sense of an *imaginary audience*—the feeling that everyone is watching. Thus, adolescents believe that others are analyzing them: "Everyone noticed that I wore this shirt twice this week." "The whole class thought my answer was dumb!" You can see that social blunders or imperfections in appearance can be devastating if "everybody is watching." Luckily, this feeling of being "on stage" seems to peak in early adolescence by age 14 or 15, although in unfamiliar situations we all may feel our mistakes are being noticed.

The ability to think hypothetically, consider alternatives, identify all possible combinations, and analyze their own thinking has some interesting consequences for adolescents. Because 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 also can imagine many possible futures for themselves and may try to decide which is best. Feelings about any of these ideals may be strong.

DO WE ALL REACH THE FOURTH STAGE? Most psychologists agree that there is a level of thinking more sophisticated than concrete operations. But there is a debate about how universal formal-operational thinking actually is, even among adults. 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. Being able to use formal operations may be the result of practice in solving hypothetical problems and using formal scientific reasoning—abilities that are valued and taught in literate cultures, particularly in college. Even so, not all high school students can perform Piaget's formal-operational tasks (Shayer, 2003). The *Guidelines: Helping Students to Use Formal Operations* will help you support the development of formal operations in your students.

Piaget himself (1974) suggested that most adults might only be able to use formal-operational thought in a few areas where they have the greatest experience or interest. Taking a college class fosters formal-operational abilities in that subject, but not necessarily in others (Lehman & Nisbett, 1990). Expect many students in your middle school or high school classes to have trouble thinking hypothetically, especially when they are learning something new. Students sometimes 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 can go beyond this superficial use of memorization.

Information Processing, Neo-Piagetian, and Neuroscience Views of Cognitive Development

As you will see in Chapter 8, there are explanations for why children have trouble with conservation and other Piagetian tasks. These explanations focus on the development of information processing skills, such as attention, memory capacity, and learning strategies. As children mature and their brains develop, they are better able to focus their attention, process information more quickly, hold more information in memory, and use thinking strategies more easily and flexibly (Siegler, 2000, 2004). One critical development is improvement in executive functioning. **Executive functioning** involves all those processes that we use to organize, coordinate, and perform goal-directed, intentional actions. Executive functioning skills include focusing attention, inhibiting impulsive responses,

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, especially when the material is new.
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 debate topical social issues such as the environment, the economy, and national health insurance.
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.
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 (Delpit, 1995).

Examples

1. When discussing the Civil War, consider racism or other issues that have divided the United States since then.
2. When teaching about poetry, let students find lyrics from popular songs that illustrate poetic devices, and talk about how these devices do or don't work well to communicate the meanings and feelings the songwriters intended.

making and changing plans, and using memory to hold and manipulate information (Best & Miller, 2010; Raj & Bell, 2010). As children develop more sophisticated and effective executive functioning skills, they are active in advancing their own development; they are constructing, organizing, and improving their own knowledge and strategies (Siegler & Alibali, 2005). For example, one classic Piagetian task is to show children 10 daisies and 2 roses, then ask if there are more daisies or more flowers. Young children see more daisies and jump to the answer, "daisies." As they mature, children are better at resisting (inhibiting) that first response based on appearances and can answer based on the fact that both daisies and roses are flowers. But even adults have to take a fraction of a second to resist the obvious, so inhibiting impulsive responses is important for developing complex knowledge throughout life (Borst, Poirel, Pineau, Cassotti, & Houdé, 2013).

Some developmental psychologists have formulated **neo-Piagetian theories** that retain Piaget's insights about children's construction of knowledge and the general trends in children's thinking but add findings from information processing theories about the role of attention, memory, and strategies (Croker, 2012). Perhaps the best-known neo-Piagetian theory was developed by Robbie Case (1992, 1998). He devised an explanation of cognitive development suggesting that children develop in stages within specific domains such as numerical concepts, spatial concepts, social tasks, storytelling, reasoning about physical objects, and motor development. As children practice using the schemes in a particular domain (e.g., using counting schemes in the number concept area), accomplishing the schemes requires less attention. The schemes become more automatic because the child does not have to "think so hard." This frees up mental resources and memory to do more, so the child can combine simple schemes into more complex ones and invent new schemes when needed (assimilation and accommodation in action).

Kurt Fischer (2009) connected cognitive development in different domains to research on the brain. He also examined development in different domains such as reading or math. You may remember Nico and Brooke, the remarkable children we met earlier in the chapter who each had one side of their brain removed to treat severe epilepsy, yet both still developed other pathways in their brains to recover lost spatial and verbal abilities. We have seen that one of the implications of research on the brain is that there are multiple pathways for learning.

Fischer (2009) has found, however, that even though their brains follow different pathways as they master skills in speaking, reading, and mathematics, children's growth patterns show a similar series of spurts and they go through predictable levels of development. When learning a new skill, children move through three tiers—from *actions* to *representations* to *abstractions.* Within each tier, the pattern is moving from accomplishing a single action to mapping or coordinating two actions together, such as coordinating addition and multiplication in math, to creating whole systems of understanding. At the level of abstractions, children finally move to constructing explanatory principles. This may remind you of sensorimotor, concrete operations, and formal operations in Piaget's theory. Look at Table 2.3, which shows the movement through the tiers of *actions* to *representations* to *abstractions.*

For each skill level, the brain reorganizes itself, too. Table 2.3 shows this progression between birth and 45 years. Notice the column that says "Age of Emergence of Optimal Level." This column shows the ages at which the skills will develop if the individuals have *quality support and the chance to practice.* The age the skill emerges without support and practice is shown in the last column. Support and practice are keys in another explanation of cognitive development we will discuss soon—Vygotsky's theory.

Some Limitations of Piaget's Theory

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 (Mascolo & Fischer, 2005; P. H. Miller, 2011). One problem with the stage model is the lack of consistency in children's thinking. For example, children can conserve number (the

TABLE 2.3 • A Pattern of Cognitive Development over 45 Years

As children develop skills in speaking, reading, and mathematics, their growth patterns show a similar series of spurts. In learning a new skill, children move from *actions* to *representations* to *abstractions.*

TIERS	LEVELS	AGE OF EMERGENCE OF OPTIMAL LEVEL	AGE OF FUNCTIONAL LEVEL
Abstraction	Ab4. Principles	23–25 years	30–45 years
	Ab3. Systems	18–20 years	23–40 years
	Ab2. Mappings	14–16 years	17–30 years
	Rp4./Ab1. Single Abstraction	10–12 years	13–20 years
Representations	Rp3 Systems	6–7 years	7–12 years
	Rp2 Mappings	3½–4½ years	4–8 years
	Sm4./Rp1. Single Representations	2 years	2–5 years
Actions	Sm3. Systems	11–13 months	11–24 months
	Sm2. Mappings	7–8 months	7–13 months
	Sm1. Single Actions	3–4 months	3–9 months

Source: Reprinted with permission from Fischer, K. W. (2009). Mind, brain, and education: Building a scientific groundwork for learning and teaching. Mind, Brain, and Education, 3, *p. 10.*

number of blocks does not change when they are rearranged) a year or two before they can conserve weight (a ball of clay does not change when you flatten it). Why can't they use conservation consistently in every situation? In fairness, we should note that in his later work, even Piaget put less emphasis on stages of cognitive development and gave more attention to how thinking *changes* through equilibration (P. H. Miller, 2011).

Another problem with the idea of separate stages is that the processes may be more continuous than they seem. Changes may seem like discontinuous, qualitative leaps when we look across longer time periods. The 3-year-old persistently searching for a lost toy seems qualitatively different from the infant who doesn't miss a toy or search when the toy rolls under a sofa. But if we watched a developing child very closely and observed moment-to-moment or hour-to-hour changes, we might see that indeed there are gradual, continuous changes. Rather than appearing all at once, the knowledge that a hidden toy still exists may be a product of the older child's more fully developed memory: He knows that the toy is under the sofa because he remembers seeing it roll there, whereas the infant can't hold on to that memory. The longer you require children to wait before searching—the longer you make them remember the object—the older they have to be to succeed (Siegler & Alibali, 2005).

Change can be both continuous and discontinuous, as described by a branch of mathematics called *catastrophe theory.* Changes that appear suddenly, like the collapse of a bridge, are preceded by many slowly developing changes such as gradual, continuous corrosion of the metal structures. Similarly, gradually developing changes in children can lead to large changes in abilities that seem abrupt (Dawson-Tunik, Fischer, & Stein, 2004; Siegler & Alibali, 2005).

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 demonstrate when solving these problems. For example, work by Gelman and her colleagues (Gelman, 2000; Gelman & Cordes, 2001) 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 3 or 4 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. Mirjam Ebersbach (2009) demonstrated that most of the German kindergartners in her study considered all three dimensions—width, height, and length—when they estimated the volume of a wooden block (actually, how many small cubes it would take to make bigger blocks of different sizes). In other words, we may be born with a greater store of cognitive tools than Piaget suggested. Some basic understandings or core knowledge, such as the permanence of objects or the sense of number, may be part of our evolutionary equipment, ready for use in our cognitive development (Geary & Bjorklund, 2000; Woodward & Needham, 2009).

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. An expert 9-year-old chess player may think abstractly about chess moves, whereas a novice 20-year-old player may have to resort to more concrete strategies to plan and remember moves (Siegler, 1998).

Finally, Piaget argued that the development of cognitive operations such as conservation or abstract thinking cannot be accelerated. He believed that children had to be developmentally ready to learn. Quite a bit of research, however, has shown that with effective instruction, children can learn to perform cognitive operations such as conservation. They do not have to naturally discover these ways of thinking on their own. Knowledge and experience in a situation affect the kind of thinking that students can do (Brainerd, 2003).

COGNITIVE DEVELOPMENT AND CULTURE. One final criticism of Piaget's theory is that it overlooks the important effects of the child's cultural and social group. Research across different cultures has generally confirmed that although Piaget was accurate about the sequence of the stages in children's thinking, the age ranges for the stages vary. Western children typically move to the next stage about 2 to 3 years earlier than children in non-Western societies. But careful research has shown that these differences across cultures depend on the subject or domain tested and whether the culture values and teaches knowledge in that domain. For example, children in Brazil who sell candy in the streets instead of attending school appear to fail a certain kind of Piagetian task—class inclusion (Are there more daisies, more tulips, or more flowers in the picture?). But when the tasks are phrased within concepts they understand—selling candy—then these children perform better than Brazilian children the same age who attend school (Saxe, 1999). When a culture or context emphasizes a cognitive ability, children growing up in that culture tend to acquire that ability sooner. In a study that compared Chinese first-, third-, and fifth-grade students to American students in the same grades, the Chinese students mastered a Piagetian task that involved distance, time, and speed relationships about 2 years ahead of American students, most likely because the Chinese education system puts more emphasis on math and science in the early grades (Zhou, Peverly, Beohm, & Chongde, 2001).

Even concrete operations such as classification may develop differently in different cultures. For example, when individuals from the Kpelle people of Africa 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 way of sorting is how a wise man would do it. Finally, the experimenter asked in desperation, "Well, how would a fool do it?" Then the subjects promptly created the four neat classification piles the experimenter had expected—food, tools, and so on (Rogoff & Morelli, 1989).

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

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VYGOTSKY'S SOCIOCULTURAL PERSPECTIVE

Psychologists today recognize that culture shapes cognitive development by determining what and how the child will learn about the world—the content and processes of thinking. For example, young Zinacanteco Indian girls of southern Mexico learn complicated ways of weaving cloth through informal instruction by adults in their communities. Cultures that prize cooperation and sharing teach these abilities early, whereas cultures that encourage competition nurture competitive skills in their children. The stages observed by Piaget are not necessarily "natural" for all children because to some extent they reflect the expectations and activities of Western cultures, as the Kpelle people just described have taught us (Kozulin, 2003; Kozulin et al., 2003; Rogoff, 2003).

A major spokesperson for this **sociocultural theory** (also called *sociohistoric*) was a Russian psychologist who died in 1934. Lev Semenovich Vygotsky was only 38 when he died of tuberculosis, but during his brief life he produced over 100 books and articles. Some of the translations are now available (e.g., Vygotsky, 1978, 1986, 1987a, 1987b, 1987c, 1993, 1997). Vygotsky began studying learning and development to improve his own teaching. He went on to write about language and thought, the psychology of art, learning and development, and educating students with special needs. His work was banned in Russia for many years because he referenced Western psychologists. But in the past 50 years, with the rediscovery of his writings, Vygotsky's ideas have become major influences in psychology and education and have provided alternatives to many of Piaget's theories (Gredler, 2009a, 2009b, 2012; Kozulin, 2003; Kozulin et al., 2003; Van Der Veer, 2007; Wink & Putney, 2002).

Vygotsky believed that human activities take place in cultural settings and that they cannot be understood apart from these settings. One of his key ideas was that our specific mental structures and processes can be traced to our interactions with others. These social interactions are more than simple influences on cognitive development—they actually create our cognitive structures and thinking processes (Palincsar, 1998). In fact, "Vygotsky conceptualized development as the transformation of socially shared activities into internalized processes" (John-Steiner & Mahn, 1996, p. 192). We will examine three themes in Vygotsky's writings that explain how social processes form learning and thinking: the social sources of individual thinking; the role of cultural tools in learning and development, especially the tool of language; and the zone of proximal development (Driscoll, 2005; Gredler, 2012; Wertsch & Tulviste, 1992).

The Social Sources of Individual Thinking

Vygotsky assumed that

> Every function in a child's cultural development appears twice: first, on the social level and later on the individual level; first between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relations between human individuals. (Vygotsky, 1978, p. 57)

In other words, higher mental processes, such as directing your own attention and thinking through problems, first are *co-constructed* during shared activities between the child and another person. Then these **co-constructed processes** are internalized by the child and become part of that child's cognitive development (Gredler, 2009a, 2009b; Mercer, 2013). For example, children first use language in activities with others, to regulate the behavior of the others ("No nap!" or "I wanna cookie."). Later, however, the child can regulate her own behavior using private speech ("careful—don't spill"), as you will see in a later section. So, for Vygotsky, social interaction was more than influence; it was the origin of higher mental processes such as problem solving. Consider this example:

> A six-year-old has lost a toy and asks her father for help. The father asks her where she last saw the toy; the child says "I can't remember." He asks a series of questions—did you have it in your room? Outside? Next door? To each question, the child answers, "no." When he says "in the car?" she says "I think so" and goes to retrieve the toy. (Tharp & Gallimore, 1988, p. 14)

Who remembered? The answer is really neither the father nor the daughter, but the two together. The remembering and problem solving were co-constructed—between people—in the interaction. But the child (and the father) may have internalized strategies to use next time something is lost. At some point, the child will be able to function independently to solve this kind of problem. So, like the strategy for finding the toy, higher functions appear first between a child and a "teacher" before they exist within the individual child (Kozulin, 1990, 2003; Kozulin et al., 2003).

Here is another example of the social sources of individual thinking. Richard Anderson and his colleagues (2001) studied how fourth graders in small-group classroom discussions *appropriate* (take for themselves and use) argument stratagems that occur in the discussions. An *argument stratagem* is a particular form such as "I think [POSITION] because [REASON]," where the student fills in the position and the reason. For example, a student might say, "I think that the wolves should be left alone because they are not hurting anyone." Another strategy form is "If [ACTION], then [BAD CONSEQUENCE]," as in "If they don't trap the wolves, then the wolves will eat the cows." Other forms manage participation, for example, "What do you think [NAME]?" or "Let [NAME] talk."

Anderson's research identified 13 forms of talk and argument that helped to manage the discussion, get everyone to participate, present and defend positions, and handle confusion. The use of these different forms of talking and thinking *snowballed:* Once a useful argument was employed by one student, it spread to other students, and the argument stratagem form appeared more and more in the discussions. Open discussions—students asking and answering each other's questions—were better than teacher-dominated discussion for the development of these argument forms. Over time, these ways of presenting, attacking, and defending positions could be internalized as mental reasoning and decision making for the individual students.

Both Piaget and Vygotsky emphasized the importance of social interactions in cognitive development, but Piaget saw a different role for interaction. He believed that interaction encouraged development by creating disequilibrium—that is, cognitive conflict motivated change. Thus, Piaget believed that the most helpful interactions were those between peers, because peers are on an equal basis and can challenge each other's thinking. Vygotsky, on the other hand, suggested that children's cognitive development is fostered by interactions with people who are more capable or advanced in their thinking—people such as parents and teachers (Moshman, 1997; Palincsar, 1998). Of course, students can learn from both adults and peers, and today, computers can play a role in supporting communication across distances or in different languages.

Cultural Tools and Cognitive Development

Vygotsky believed that **cultural tools**, including technical tools (e.g., printing presses, plows, rulers, abacuses, graph paper—today, we would add mobile devices, computers, the Internet, real-time translators for mobile devices and chats, search engines, digital organizers and calendars, assistive technologies for students with learning challenges, etc.) and psychological tools (signs and symbol systems, e.g., numbers and mathematical systems, Braille and sign language, maps, works of art, codes, and language) play very important roles in cognitive development. For example, as long as the culture provides only Roman numerals for representing quantity, certain ways of thinking mathematically—from long division to calculus—are difficult or impossible. But if a number system has a zero, fractions, positive and negative values, and an infinite quantity of numbers, then much more is possible. The number system is a psychological tool that supports learning and cognitive development—it changes the thinking process. This symbol system is passed from adult to child and from child to child through formal and informal interactions and teachings.

TECHNICAL TOOLS IN A DIGITAL AGE. The use of technical tools such as calculators and spell checkers has been somewhat controversial in education. Technology is increasingly "checking up" on us. I rely on the spell checker in my word processing program to protect me from embarrassment. But I also read student papers with spelling replacements that must have come from decisions made by the word processing program—without a "sense check" by the writer. Is student learning harmed or helped by these technology supports? Just because students learned mathematics in the past with paper-and-pencil procedures and practice does not mean that this is the best way to learn. For example, in the Third International Mathematics and Science Study (Trends in International Mathematics and Science Study [TIMSS], 1998), on every test at the advanced level, students who said that they used calculators in their daily math course work performed much better than students who rarely or never used calculators. In fact, the research on calculators has found that rather than eroding basic skills, calculator use has positive effects on students' problem-solving skills and attitudes toward math (Ellington, 2003, 2013; Waits & Demana, 2000). There is a catch, however. On simple math problems it probably is better to attempt recalling or calculating the answer first before turning to a calculator. Self-generating answers before resorting to calculators supports math fact learning and fluency in arithmetic (Pyke & LeFevre, 2011).

PSYCHOLOGICAL TOOLS. Vygotsky believed that all higher-order mental processes such as reasoning and problem solving are *mediated* by (accomplished through and with the help of) psychological tools. These tools allow children to transform their thinking by enabling them to gain greater and greater mastery of their own cognitive processes; they advance their own development as they use the tools. Vygotsky believed the essence of cognitive development is mastering the use of psychological tools such as language to accomplish the kind of advanced thinking and problem solving that could not be accomplished without those tools (Gredler, 2012; Karpov & Haywood, 1998). The process is something like this: As children engage in activities with adults or more capable peers, they exchange ideas and ways of thinking about or representing concepts—drawing maps, for example, as a way to represent spaces and places. Children internalize these co-created ideas. Children's knowledge, ideas, attitudes, and values develop through *appropriating* or "taking for themselves" the ways of acting and thinking provided by both their culture and other members of their group (Wertsch, 2007).

In this exchange of signs and symbols and explanations, children begin to develop a "cultural tool kit" to make sense of and learn about their world (Wertsch, 1991). The kit is filled with technical tools such as graphing calculators or rulers directed toward the external world and psychological tools for acting mentally such as concepts, problem-solving strategies, and (as we saw earlier) argument strategems. Children do not just receive the tools, however. They transform the tools as they construct their own representations, symbols, patterns, and understandings. These understandings are gradually changed as the children continue to engage in social activities and try to make sense of their world (John-Steiner & Mahn, 1996; Wertsch, 1991). In Vygotsky's theory, language is the most important symbol system in the tool kit, and it is the one that helps to fill the kit with other tools.

The Role of Language and Private Speech

Language is critical for cognitive development because it provides a way to express ideas and ask questions, the categories and concepts for thinking, and the links between the past and the future. Language frees us from the immediate situation to think about what was and what might be (Driscoll, 2005; Mercer, 2013). Vygotsky thought that:

> the specifically human capacity for language enables children to provide for auxiliary tools in the solution of difficult tasks, to overcome impulsive action, to plan a solution to a problem prior to its execution, and to master their own behavior. (Vygotsky, 1978, p. 28)

Vygotsky placed more emphasis than Piaget on the role of learning and language in cognitive development. He believed that "thinking depends on speech, on the means of thinking, and on the child's socio-cultural experience" (Vygotsky, 1987a, p. 120). And Vygotsky believed that language in the form of private speech (talking to yourself) guides cognitive development.

PRIVATE SPEECH: VYGOTSKY'S AND PIAGET'S VIEWS COMPARED. If you have spent much time around young children, you know that they often talk to themselves as they play. 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**, and he labeled all of the children's self-directed talk "egocentric speech." He assumed that this egocentric speech is another indication that young children can't see the world through the eyes of others, so they chat away without taking into account the needs or interests of their listeners. As they mature, and especially as they have disagreements with peers, Piaget believed, children develop *socialized speech.* They learn to listen and exchange (or argue) ideas.

Vygotsky had very different ideas about young children's **private speech**. He suggested that, rather than being a sign of cognitive immaturity, these mutterings play an important role in cognitive development because they move children in stages toward *self-regulation:* the ability to plan, monitor, and guide your own thinking and problem solving. First the child's behavior is regulated by others using language and other signs such as gestures. For example, the parent says, "No!" when the child reaches toward a candle flame. Next, the child learns to regulate the behavior of others using the same language tools. The child says "No!" to another child who is trying to take away a toy, often even imitating the parent's voice tone. The child also begins to use private speech to regulate her own behavior, saying "no" quietly to herself as she is tempted to touch the flame. Finally, the child learns to regulate her own behavior by using silent inner speech (Karpov & Haywood, 1998).

For example, in any preschool room you might hear 4- or 5-year-olds saying, "No, it won't fit. Try it here. Turn. Turn. Maybe this one!" while they do puzzles. Around the age of 7, children's self-directed speech goes underground, changing from spoken to whispered speech and then to silent lip movements. Finally, the children just "think" the guiding words. The use of private speech peaks at around age 9 and then decreases, although one study found that some students from ages 11 to 17 still spontaneously muttered to themselves during problem solving (McCafferty, 2004; Winsler, Carlton, & Barry, 2000; Winsler & Naglieri, 2003). Vygotsky called this inner speech "an internal plane of verbal thinking" (Vygotsky, 1934/1987c, p. 279)—a critical accomplishment on the road to higher-order thinking.

This series of steps from spoken words to silent inner speech is another example of how higher mental functions first appear between people as they communicate and regulate each other's behavior, and then emerge again within the individual as cognitive processes. Through this fundamental process, the child is using language to accomplish important cognitive activities such as directing attention, solving problems, planning, forming concepts, and gaining self-control. Research supports Vygotsky's ideas (Berk & Spuhl, 1995; Emerson & Miyake, 2003). Children and adults tend to use more private speech when they are confused, having difficulties, or making mistakes (R. M. Duncan & Cheyne, 1999). Have you ever thought to yourself something like, "Let's see, the first step is" or "Where did I use my glasses last?" or "If I read to the end of this page, then I can . . ."? You were using inner speech to remind, cue, encourage, or guide yourself.

This internal verbal thinking is not stable until about age 12, so children in elementary school may need to continue talking through problems and explaining their reasoning in order to develop their abilities to control their thinking (Gredler, 2012). Because private speech helps students regulate their thinking, it makes sense to allow, and even encourage, students to use private speech in school. Teachers' insisting on total silence when young students are working on difficult problems may make the work even harder for them. Take note when muttering increases in your class—this could be a sign that students need help.

Table 2.4 contrasts Piaget's and Vygotsky's theories of private speech. We should note that Piaget accepted many of Vygotsky's arguments and came to agree that language could be used in both egocentric and problem-solving ways (Piaget, 1962).

TABLE 2.4 • **Differences Between Piaget's and Vygotsky's Theories of Egocentric, or Private, Speech**

	PIAGET	VYGOTSKY
	Represents an inability to take the perspective of another and engage in reciprocal communication.	Represents externalized thought; its function is to communicate with the self for the purpose of self-guidance and self-direction.
Course of Development	Declines with age.	Increases at younger ages and then gradually loses its audible quality to become internal verbal thought.
Relationship to Social Speech	Negative; least socially and cognitively mature children use more egocentric speech.	Positive; private speech develops out of social interaction with others.
Relationship to Environmental Contexts		Increases with task difficulty. Private speech serves a helpful self-guiding function in situations where more cognitive effort is needed to reach a solution.

Source: From "Development of Private Speech among Low-Income Appalachian Children," by L. E. Berk and R. A. Garvin, 1984, Developmental Psychology, *20, p. 272. Copyright © 1984 by the American Psychological Association. Adapted with permission.*

The Zone of Proximal Development

According to Vygotsky, at any given point in development, a child is on the verge of solving certain problems—"processes that have not matured at the time but are in a period of maturation" (Vygotsky, 1930–1931/1998, p. 201). The child just needs some structure, demonstrations, clues, reminders, help with remembering details or steps, encouragement to keep trying, and so on. Some problems, of course, are beyond the child's capabilities, even if every step is explained clearly. The **zone of proximal development (ZPD)** is the area between the child's current performance (the problems the child can solve independently without any support) and the level of performance that the child could achieve with adult guidance or by working with "a more fully developed child" (p. 202). It is a dynamic and changing space as student and teacher interact and understandings are exchanged. This is the area where instruction can succeed. Kathleen Berger (2012) called this area the "magic middle"—somewhere between what the student already knows and what the student isn't ready to learn.

Video 2.3
In this video, one teacher guides young children in putting together puzzles and another guides a boy to create a pattern by organizing toy trucks based on color. Is the process of organizing toys in a pattern based on color a skill that is in the boy's zone of proximal development, or is it still too advanced for a child at his developmental level?

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PRIVATE SPEECH AND THE ZONE. We can see how Vygotsky's beliefs about the role of private speech in cognitive development fit with the notion of the ZPD. Often, an adult uses verbal prompts and structuring to help a child solve a problem or accomplish a task. We will see later that this type of support has been called *scaffolding.* This support can be gradually reduced as the child takes over the guidance, perhaps first by giving the prompts as private speech and finally as inner speech. As an example, think of the young girl described earlier who had lost her toy. Let's move forward several years in her life and listen to her *thoughts* as an older student when she realizes that a schoolbook is missing. They might sound something like this:

"Where's my math book? Used it in class. Thought I put it in my book bag after class. Dropped my bag on the bus. That dope Larry kicked my stuff, so maybe. . . ."

The girl can now systematically search for ideas about the lost book without help from anyone.

THE ROLE OF LEARNING AND DEVELOPMENT. Piaget defined *development* as the active construction of knowledge and *learning* as the passive formation of associations (Siegler, 2000). He was interested in knowledge construction and believed that cognitive development has to come before learning—the child had to be cognitively "ready" to learn. He said that "learning is subordinated to development and not vice-versa" (Piaget, 1964, p. 17). Students can memorize, for example, that Geneva is in Switzerland, but still insist that they cannot be Genevan and Swiss at the same time. True understanding will take place only when the child has developed the operation of *class inclusion*—that one category can be included within another. But as we saw earlier, research has not supported Piaget's position on the need for cognitive development to precede learning (Brainerd, 2003).

In contrast, Vygotsky believed that learning is an active process that does not have to wait for readiness. In fact, "properly organized learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning" (Vygotsky, 1978, p. 90). He saw learning as a tool in development; learning pulls development up to higher levels, and social interaction is a key in learning. In other words, what develops next is what is affected by learning (Bodrova & Leong, 2012; Gredler, 2012; Wink & Putney, 2002). Vygotsky's belief that learning pulls development to higher levels and more advanced thinking means that other people, including teachers, play a significant role in cognitive development. This does not mean that Vygotsky believed memorization is learning. When teachers try to directly communicate their understanding, the result can be a "meaningless acquisition of words" and "mere verbalization" (Vygotsky 1934/1987b, p. 356) that actually hides an understanding vacuum (Gredler, 2012). In Vygotsky's words, the teacher "explains, informs, inquires, corrects, and forces the child to explain" (p. 216).

Limitations of Vygotsky's Theory

Vygotsky's theory added important considerations by highlighting the role of culture and social processes in cognitive development, but he may have gone too far. As you have seen in this chapter, we may be born with a greater store of cognitive tools than either Piaget or Vygotsky suggested.

Some basic understandings, such as the idea that adding increases quantity, may be part of our biological predispositions, ready for use to guide our cognitive development. Young children appear to figure out much about the world before they have the chance to learn from either their culture or teachers (Schunk, 2012; Woodward & Needham, 2009). The major limitation of Vygotsky's theory, however, is that it consists mostly of general ideas; Vygotsky died before he could expand and elaborate on his ideas and pursue his research. His students continued to investigate his ideas, but much of that work was suppressed by Stalin's regime until the 1950s and 1960s (Gredler, 2005, 2009b; Kozulin, 1990, 2003; Kozulin et al., 2003). A final limitation might be that Vygotsky did not have time to detail the applications of his theories for teaching, even though he was very interested in instruction. So, most of the applications described today have been created by others—and we don't even know if Vygotsky would agree with them. It is clear that some of his concepts, like ZPD, have been misrepresented at times (Gredler, 2012).

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IMPLICATIONS OF PIAGET'S AND VYGOTSKY'S THEORIES FOR TEACHERS

Piaget did not make specific educational recommendations, and Vygotsky did not have enough time to develop a complete set of applications. But we can glean some guidance from both men.

Piaget: What Can We Learn?

Piaget was more interested in understanding children's thinking than in guiding teachers. He did express some general ideas about educational philosophy, however. He believed that the main goal of education should be to help children learn how to learn, and that education should "form not furnish" the minds of students (Piaget, 1969, p. 70). Piaget has taught us that we can learn a great deal about how children think by listening carefully and 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 current knowledge and abilities; in other words, we will be better able to differentiate instruction.

Even though Piaget did not design programs of education based on his ideas, his influence on current educational practice is huge (Hindi & Perry, 2007). For example, the National Association for the Education of Young Children has guidelines for developmentally appropriate practice (DAP) that incorporate Piaget's findings (Bredekamp, 2011; Bredekamp & Copple, 1997).

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Implications of Piaget's Theory (I, A2)
The music, physical education, and art teachers in a rural, pre-K-to-8 school district work with students who characterize several of Piaget's stages. How should these three teachers adjust their teaching from level to level over the course of a week?

UNDERSTANDING AND BUILDING ON STUDENTS' THINKING. The students in any class will vary greatly in both their level of cognitive development and 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, Case (1985) 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? Students are the best sources of information about their own thinking (Confrey, 1990).

An important implication of Piaget's theory for teaching is what J. 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 unexpected results 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 the situation, and new knowledge may develop.

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 a group of students to be introduced to a topic together, and then work individually on follow-up activities matched to their learning needs. Using multilevel lessons is called *differentiated instruction* (Hipsky, 2011; Tomlinson, 2005b). We will look at this approach more closely in Chapter 14.

ACTIVITY AND 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. In Piaget's words:

> Knowledge is not a copy of reality. To know an object, to know an event, is not simply to look at it and make a mental copy or image of it. To know an object is to act on it. To know is to modify, to transform the object, and to understand the process of this transformation, and as a consequence to understand the way the object is constructed. (Piaget, 1964, p. 8)

For example, research in teaching mathematics indicates that students from kindergarten to college remember basic facts better when they have learned using manipulatives versus using abstract symbols only (Carbonneau, Marley, & Selig, 2012). But 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 (Gredler, 2005, 2012). For example, after a social studies lesson on different jobs, a primary-grade teacher might show 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 center 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 on, manipulate, observe, and then talk and/or write about (to the teacher and each other) what they have experienced. Concrete experiences provide the raw materials for thinking. Communicating with others makes students use, test, and sometimes change their thinking strategies.

Vygotsky: What Can We Learn?

Like Piaget, Vygotsky believed that the main goal of education was the development of higher mental functions, not simply filling students' memories with facts. So Vygotsky probably would oppose educational curricula that are an inch deep and a mile wide or seem like "trivial pursuit." As an example of this trivial pursuit curriculum, Margaret Gredler (2009a) described a set of materials for a 9-week science unit that had 61 glossary terms such as *aqueous solution, hydrogen bonding,* and *fractional crystallization*—many terms described with only one or two sentences.

There are at least three ways that higher mental functions can be developed through cultural tools and passed from one individual to another: *imitative* learning (one person tries to imitate the other), *instructed* learning (learners internalize the instructions of the teacher and use these

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Implications of Vygotsky's Theory (I, A2)
Make a list of scaffolding techniques that would be appropriate with different instructional levels and content areas. Think of scaffolding techniques that others have used when you learned things outside of school (e.g., sports, hobbies).

instructions to self-regulate), and *collaborative* learning (a group of peers strives to understand each other and learning occurs in the process) (Tomasello, Kruger, & Ratner, 1993). Vygotsky was most concerned with the second type, *instructed* learning through direct teaching or by structuring experiences that encourage another's learning, but his theory supports learning through *imitation* or *collaboration* as well. Thus, Vygotsky's ideas are relevant for educators who teach directly, intentionally use modeling to teach, or create collaborative learning environments (Das, 1995; Wink & Putney, 2002). That pretty much includes all of us.

THE ROLE OF ADULTS AND PEERS. Vygotsky believed the child is not alone in the world "discovering" the cognitive operations of conservation or classification. This discovery is assisted or mediated by family members, teachers, peers, and even software tools (Puntambekar & Hubscher, 2005). Most of this guidance is communicated through language, at least in Western cultures. In some cultures, observing a skilled performance, not talking about it, guides the child's learning (Rogoff, 1990). Some people have called this adult assistance **scaffolding**, taken from Wood, Bruner, and Ross (1976). The idea is that children use the help for support while they build a firm understanding that will eventually allow them to solve the problems on their own. Actually, when Wood and his colleagues introduced the term *scaffolding,* they were talking about how teachers set up or structure learning environments, but Vygotsky's theory implies more dynamic exchanges between student and teacher that allow the teacher to support students in the parts of the task they cannot do alone—the interactions of assisted learning, as you will see next (Schunk, 2012).

Video 2.4
The children in this class are learning about earthworms. How does the teacher guide the students to encourage them to make their own discoveries?

ENHANCEDetext *video example*

ASSISTED LEARNING. Vygotsky's theory suggests that teachers need to do more than just arrange the environment so that students can discover on their own. Children cannot and should not be expected to reinvent or rediscover knowledge already available in their cultures. Rather, they should be guided and assisted in their learning (Karpov & Haywood, 1998).

Assisted learning, or guided participation, requires first learning from the student what is needed; then giving information, prompts, reminders, and encouragement at the right time and in the right amounts; and gradually allowing the students to do more and more on their own. Teachers can assist learning by adapting materials or problems to students' current levels; demonstrating skills or thought processes; walking students through the steps of a complicated problem; doing part of the problem (e.g., in algebra, the students set up the equation and the teacher does the calculations or vice versa); giving detailed feedback and allowing revisions; or asking questions that refocus students' attention (Rosenshine & Meister, 1992). Cognitive apprenticeships (Chapter 10) are examples. Look at Table 2.5 for examples of strategies that can be used in any lesson.

An Example Curriculum: Tools of the Mind

Deborah Leong and Elena Bodrova (2012) worked for years to develop a curriculum for preschool through second-grade children based on Vygotsky's theory. In Russia, Dr. Bodrova had studied with students and colleagues of Vygotsky and wanted to bring his ideas to teachers. The result is the *Tools*

TABLE 2.5 • **Strategies to Provide Scaffolding**

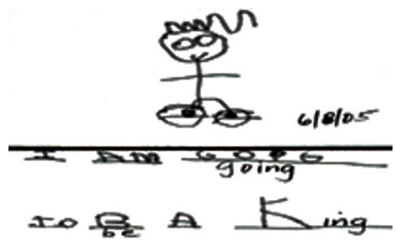
- Model the thought process for the students: Think out loud as you solve the problem or outline an essay, for example.
- Provide organizers or starters such as *who, what, why, how, what next?*
- Do part of the problem.
- Give hints and cues.
- Encourage students to set short-term goals and take small steps.
- Connect new learning to students' interests or prior learning.
- Use graphic organizers: timelines, charts, tables, categories, checklists, and graphs.
- Simplify the task, clarify the purpose, and give clear directions.
- Teach key vocabulary and provide examples.

FIGURE 2.5

BRANDON'S PLAY PLANS

At the beginning of age three, Brandon's play plans show that he wants to go to the art center. By the end of age four, Brandon plans to pretend to be a king. He is beginning to use sounds in writing.

Beginning of age three



End of age four

Source: "Brandon's Plan, Beginning Age 3 Preschool". Tools of the Mind. http://www.toolsofthemind .org/curriculum/preschool. Used by permission.

of the Mind project that includes curriculum ideas for preschool, kindergarten, and special needs (see toolsofthemind.org). One key idea taken from Vygotsky is that as children develop mental tools such as strategies for focusing attention, they cease being prisoners of their environment—having their attention "grabbed away" by any new sight or sound. They learn to control their attention. A second key idea is that play, particularly dramatic pretend play, is the most important activity supporting the development of young children. Through dramatic play children learn to focus attention, control impulses, follow rules, use symbols, regulate their own behaviors, and cooperate with others. So a key element of the *Tools of the Mind* curriculum for young children is play plans, created by the students themselves. Children draw a picture of how they plan to play that day, and then describe it to the teacher, who may make notes on the page and thus model literacy activities. Plans become more complex and detailed as children become better planners. Figure 2.5 shows Brandon's simple play plan at the beginning of age three and then another plan at the end of age four. His later plan shows better fine motor control, more mature drawing, increased imagination, and greater use of language.

Reaching Every Student: Teaching in the "Magic Middle"

Both Piaget and Vygotsky probably would agree that students need to be taught in the magic middle (Berger, 2012), or the place of the "match" (J. Hunt, 1961)—where they are neither bored nor frustrated. Students should be put in situations where they have to reach to understand but where support from other students, learning materials, or the teacher is also available. Sometimes the best teacher is another student who has just figured out how to solve the problem, because this student is probably operating in the learner's ZPD. Having a student work with someone who is just a bit better at the activity would be a good idea because both students benefit in the exchange of explanations, elaborations, and questions. In addition, students should be encouraged to use language to organize their thinking and to talk about what they are trying to accomplish. Dialogue and discussion are important avenues to learning (Karpov & Bransford, 1995; Kozulin & Presseisen, 1995; Wink & Putney, 2002). The *Guidelines: Applying Vygotsky's Ideas in Teaching* on the next page gives more ideas for applying Vygotsky's insights.

Connect and Extend to PRAXIS II®

Distinctions Between Piaget's and Vygotsky's Theories (I, A2)
Consider how two teachers—one based in Vygotskian theory and one based in Piagetian theory—might differ in their concepts of learning and teaching and the instructional techniques that they might prefer.

GUIDELINES
Applying Vygotsky's Ideas in Teaching

Tailor scaffolding to the needs of students.

Examples

1. When students are beginning new tasks or topics, provide models, prompts, sentence starters, coaching, and feedback. As the students grow in competence, give less support and more opportunities for independent work.
2. Give students choices about the level of difficulty or degree of independence in projects; encourage them to challenge themselves but to seek help when they are really stuck.

Make sure students have access to powerful tools that support thinking.

Examples

1. Teach students to use learning and organizational strategies, research tools, language tools (wikis, dictionaries, or computer searches), spreadsheets, and word-processing programs.
2. Model the use of tools; show students how you use an appointment book or electronic notebook to make plans and manage time, for example.

Build on the students' cultural funds of knowledge (N. Gonzalez, Moll, & Amanti, 2005; Moll et al., 1992).

Examples

1. Identify family knowledge by having students interview each other's families about their work and home knowledge (agriculture, economics, manufacturing, household management, medicine and illness, religion, child care, cooking, etc.).
2. Tie assignments to these funds of knowledge, and use community experts to evaluate assignments.

Capitalize on dialogue and group learning.

Examples

1. Experiment with peer tutoring; teach students how to ask good questions and give helpful explanations.
2. Experiment with cooperative learning strategies described in Chapter 10.

Source: For more information about Vygotsky and his theories, see tip.psychology.org/vygotsky.html

Cognitive Development: Lessons for Teachers

In spite of cross-cultural differences in cognitive development and the different theories of development, there are some convergences. Piaget, Vygotsky, and more recent researchers studying cognitive development and the brain probably would agree with the following big ideas:

1. Cognitive development requires both physical and social stimulation.
2. To develop thinking, children have to be mentally, physically, and linguistically active. They need to experiment, talk, describe, reflect, write, and solve problems. But they also benefit from teaching, guidance, questions, explanations, demonstrations, and challenges to their thinking.
3. Teaching students what they already know is boring. Trying to teach what the student isn't ready to learn is frustrating and ineffective.
4. Challenge with support will keep students engaged but not fearful.

ENHANCEDetext *self-check*

SUMMARY

- **A Definition of Development (pp. 32–34)**

  What are the different kinds of development? Human development can be divided into physical development (changes in the body), personal development (changes in an individual's personality), social development (changes in the way an individual relates to others), and cognitive development (changes in thinking).

  What are three questions about development and three general principles? For decades, psychologists and the public have debated whether development is shaped more by nature or nurture, whether change is a continuous process or involves qualitative differences or stages, and whether there are critical times for the development of certain abilities. We know today that these simple either/or distinctions cannot capture the complexities of human development where coactions and interactions are the rule. Theorists generally agree that people develop at different rates, that development is an orderly process, and that development takes place gradually.

- **The Brain and Cognitive Development (pp. 34–44)**

  What part of the brain is associated with higher mental functions? The cortex is a crumpled sheet of neurons that serves three major functions: receiving signals from sense organs (such as visual or auditory signals), controlling voluntary movement, and forming connections. The part of the cortex that controls physical motor movement develops or matures first, then the areas that control complex senses such as vision and hearing, and last, the frontal lobe, which controls higher-order thinking processes.

  What is lateralization, and why is it important? Lateralization is the specialization of the two sides, or hemispheres, of the brain. For most people, the left hemisphere is the major factor in language, and the right hemisphere is prominent in spatial and visual processing. Even though certain functions are associated with particular parts of the brain, the various parts and systems of the brain work together to learn and perform complex activities such as reading and constructing understanding.

  What are some implications for teachers? Recent advances in both methods and findings in the neurosciences provide exciting information about brain activity during learning and brain activity differences among people with varying abilities and challenges and from different cultures. These findings have some basic implications for teaching, but many of the strategies offered by "brain-based" advocates are simply good teaching. Perhaps we now know more about why these strategies work.

- **Piaget's Theory of Cognitive Development (pp. 44–56)**

  What are the main influences on cognitive development? Piaget's theory of cognitive development is based on the assumption that people try to make sense of the world and actively create knowledge through direct experiences with objects, people, and ideas. Maturation, activity, social transmission, and the need for equilibrium all influence the way thinking processes and knowledge develop. In response to these influences, thinking processes and knowledge develop through changes in the organization of thought (the development of schemes) and through adaptation—including the complementary processes of assimilation (incorporating into existing schemes) and accommodation (changing existing schemes).

  What is a scheme? 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 (grasping, recognizing a square), or they may be larger and more general (using a map in a new city). People adapt to their environment as they increase and organize their schemes.

  As children move from sensorimotor to formal-operational thinking, what are the major changes? Piaget believed that young people pass through four stages as they develop: sensorimotor, preoperational, concrete-operational, and formal-operational. In the sensorimotor stage, infants explore the world through their senses and motor activity, and they work toward mastering object permanence and performing goal-directed activities. In the preoperational stage, symbolic thinking and logical operations begin. Children in the stage of concrete operations can think logically about tangible situations and can demonstrate conservation, reversibility, classification, and seriation. The ability to perform hypothetico-deductive reasoning, coordinate a set of variables, and imagine other worlds marks the stage of formal operations.

  How do neo-Piagetian and information processing views explain changes in children's thinking over time? Information processing theories focus on attention, memory capacity, learning strategies, and other processing skills to explain how children develop rules and strategies for making sense of the world and solving problems. Neo-Piagetian approaches also look at attention, memory, and strategies and at how thinking develops in different domains such as numbers or spatial relations. Research in neuroscience suggests that when learning a new skill, children move through three tiers—from *actions* to *representations* to *abstractions.* Within each tier, the pattern is moving from accomplishing a single action to mapping or coordinating two actions together such as coordinating addition and multiplication in math, to creating whole systems of understanding.

  What are some limitations of Piaget's theory? Piaget's theory has been criticized because children and adults often think in ways that are inconsistent with the notion of invariant stages. It also appears that Piaget underestimated children's cognitive abilities; he insisted that children could not be taught the operations of the next stage but had to develop them on their own. Alternative explanations place greater emphasis on students' developing information processing skills and ways teachers can enhance their development. Piaget's work is also criticized for overlooking cultural factors in child development.

- **Vygotsky's Sociocultural Perspective (pp. 56–62)**

  According to Vygotsky, what are three main influences on cognitive development? Vygotsky believed that human activities must be understood in their cultural settings. He believed that our specific mental structures and processes can be traced to our interactions with others; that the tools of the culture, especially the tool of language, are key factors in development; and that the ZPD is where learning and development are possible.

  What are psychological tools and why are they important? Psychological tools are signs and symbol systems such as numbers and mathematical systems, codes, and language that support learning and cognitive development. They change the thinking process by enabling and shaping thinking. Many of these tools are passed from adult to child through formal and informal interactions and teachings.

  Explain how interpsychological development becomes intrapsychological development. Higher mental processes appear first between people as they are co-constructed during shared activities. As children engage in activities with adults or more capable peers, they exchange ideas and ways of thinking about or representing concepts. Children internalize these co-created ideas. Children's knowledge, ideas, attitudes, and values develop through appropriating, or "taking for themselves," the ways of acting and thinking provided by their culture and by the more capable members of their group.

  What are the differences between Piaget's and Vygotsky's perspectives on private speech and its role in development? Vygotsky's sociocultural view asserts that cognitive development hinges on social interaction and the development of language. As an example, Vygotsky describes the role of children's self-directed talk in guiding and monitoring thinking and problem solving, whereas Piaget suggests that private speech is an indication of the child's egocentrism. Vygotsky, more than Piaget, emphasized the significant role played by adults and more-able peers in children's learning. This adult assistance provides early support while students build the understanding necessary to solve problems on their own later.

  What is a student's ZPD? At any given point in development, there are certain problems that a child is on the verge of being able to solve and others that are beyond the child's capabilities. The ZPD is where the child cannot solve a problem alone but can succeed under adult guidance or in collaboration with a more advanced peer.

  What are two criticisms or limitations of Vygotsky's theory? Vygotsky may have overemphasized the role of social interaction in cognitive development; children figure out quite a bit on their own. Also, because he died so young, Vygotsky was not able to develop and elaborate on his theories. His students and others since have taken up that work.

- **Implications of Piaget's and Vygotsky's Theories for Teachers (pp. 62–66)**

  What is the "problem of the match" described by Hunt? The "problem of the match" is that 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 carefully balanced to encourage growth. Situations that lead to errors can help create an appropriate level of disequilibrium.

  What is active learning? Why is Piaget's theory of cognitive development consistent with active learning? Piaget's fundamental insight was that individuals construct their own understanding; learning is a constructive process. At every level of cognitive development, students must be able to incorporate information into their own schemes. To do this, they must act on the information in some way. This active experience, even at the earliest school levels, should include both physical manipulation of objects and mental manipulation of ideas. As a general rule, students should act, manipulate, observe, and then talk and/or write 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.

  What is assisted learning, and what role does scaffolding play? Assisted learning, or guided participation in the classroom, requires scaffolding—understanding the students' needs; giving information, prompts, reminders, and encouragement at the right time and in the right amounts; and then gradually allowing the students to do more and more on their own. Teachers can assist learning by adapting materials or problems to students' current levels, demonstrating skills or thought processes, walking students through the steps of a complicated problem, doing part of the problem, giving detailed feedback and allowing revisions, or asking questions that refocus students' attention.

PRACTICE USING WHAT YOU HAVE LEARNED

To access and complete the exercises, click the link under the images below.

Zone of Proximal Development

ENHANCEDetext *application exercise*

Developmental Differences

ENHANCEDetext *application exercise*

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CONNECT AND EXTEND TO LICENSURE

MULTIPLE-CHOICE QUESTIONS

1. Mr. Winstel was worried about his former star student, Ramon. As the seventh-grade year progressed, Ramon was frequently being called into the principal's office for skateboard stunts that broke school rules and bordered on dangerous. Recently, Ramon's parents contacted Mr. Winstel to alert him to the fact that Ramon had been skipping school to hang out with some older boys in the neighborhood. Which of the following answers would typically best describe what is happening with Ramon?
   A. Ramon's culture demands that boys of his age begin to engage in behaviors that reflect fearlessness.
   B. Ramon's limbic system is maturing, but his prefrontal lobe has not yet caught up.
   C. Ramon is engaging in deviant behaviors as a cry for attention from his parents.
   D. Ramon is undergoing a period of synaptic pruning, which causes adolescents to engage in risk-taking behavior.
2. Miss McClintock discovered that five of the children in her class were developmentally advanced. All of the students' language skills were exploding! Although many of the students still had trouble sharing, a few appeared to understand that by sharing, everyone could be happy. Finally, there was even one child who could solve conservation problems. According to Piagetian theory, in what stage are the students in Miss McClintock's class?
   A. Formal Operations
   B. Concrete Operations
   C. Preoperational
   D. Sensorimotor
3. In introducing students to persuasive advertising methods, which of the following approaches would be most apt to lead to student retention?
   A. Determine what students already know about the topic, and connect new information to their prior knowledge.
   B. Have students initially watch several commercials and take notes.
   C. Lecture students on the major persuasive techniques, and have a quiz to assess learning.
   D. Have students form groups to research persuasive techniques.
4. Research studies involving the brain and learning indicate all but which one of the following statements is true?
   A. There is no such thing as "left-brain" and "right-brain" thinking.
   B. The production of new neurons continues into adulthood.
   C. Using different modalities for instruction and activities that draw on different senses may support learning.
   D. Pruning can damage heavily used cognitive pathways.

CONSTRUCTED-RESPONSE QUESTIONS

Case

When planning for instruction, Mr. Gething remembered that students should be neither bored nor frustrated. Although this made sense to him, he was unsure how he would compensate for the diverse group of students he had in his second-period language arts class. Some students had difficulty with the English language, and other students planned to participate in the school's annual Shakespearean play. He knew that by grouping students of mixed ability, he could occasionally draw on the talents of his knowledgeable students to assist the less-advanced students. He also understood that without guidelines, students might not accomplish anything.

5. Explain the theory of learning Mr. Gething is initially drawing on, and identify the individual credited with it.
6. What is the term for the assistance that the more knowledgeable class members may provide to the less-advanced students in order for them to succeed? List some strategies these students might use to assist their peers.

ENHANCEDetext *licensure exam*

TEACHERS' CASEBOOK

WHAT WOULD THEY DO? SYMBOLS AND CYMBALS

Here is how several expert teachers said they would help their students understand abstract concepts.

LINDA GLISSON AND SUE MIDDLETON—Fifth-Grade Team Teachers
St. James Episcopal Day School, Baton Rouge, LA

To begin the lesson, I would have the students use a dictionary to define the word *symbolism* (root word—*symbol*) to discover that it means "something that stands for or represents something else." I would then give them a brief "across the curriculum" exercise in ways they incorporate symbols and symbolism into their thinking every day. Examples follow. *Social studies, American history:* The American flag is just a piece of cloth. Why then do we recite a pledge to it? Stand at attention when it passes in a parade? What does it stand for? *English, literature—fables and fairy tales:* What does the wolf usually represent (stand for)? The lion? The lamb? *Art:* What color stands for a glorious summer day? Evil? Goodness and purity? I would continue with math symbols, scientific symbols, and music symbols and lead the students toward contributing other examples such as symbols representing holidays. I would then tell them about their own examples of symbolism that I had recorded. The students' participation in and enthusiasm for the exercises would serve to determine whether they were ready for the material.

DR. NANCY SHEEHAN-MELZACK—Art and Music Teacher
Snug Harbor Community School, Quincy, MA

Even very young children can recognize symbols if the symbol is presented first and the explanation required second. A drawing of an octagon on a pole has always elicited the answer, "A stop sign," whenever I have shown it. Children recognize symbols, but the teacher needs to work from their concrete knowledge to the more abstract concept, and there are a great many symbols in their daily life on which one can draw. Children as young as first-graders can recognize traffic sign shapes, letters of the alphabet, and numbers, and further can recognize that they stand for directions, sounds, and how many. When they talk about these very common symbols, they can also realize they all use them for the same meaning.

VALERIE A. CHILCOAT—Fifth/Sixth-Grade Advanced Academics
Glenmount School, Baltimore, MD

Concrete examples of symbolism must come from the students' own world. Street signs, especially those with pictures and not words, are a great example. These concrete symbols, however, are not exactly the same as symbolism used in poetry. The link has to be made from the concrete to the abstract. Silly poetry is one way to do this. It is motivating to the students to read or listen to, and it can provide many examples of one thing acting as another. This strategy can also be used in lower grades to simply expose children to poetry containing symbolism.

KAREN BOYARSKY—Fifth-Grade Teacher
Walter C. Black Elementary School, Hightstown, NJ

You can tell a lot about students' thinking simply by interpreting their reactions. Knowing how to interpret students' reactions is just as important as any other assessment tool you might use. In this case, it is clear that the students are confused about the concept of symbolism. This is a difficult concept even for many fifth-graders to understand and should be approached slowly. One approach to this topic would be to present students with pictures of familiar symbols, such as McDonald's Golden Arches, the Nike Swoosh, or the Target logo. Students could attempt to explain what each of these symbols mean. A discussion about why manufacturers choose to use symbols instead of words would follow. Another approach would be to have the students interpret comparisons that use *like* or *as*. For example, "Sue is as pretty as a flower." The teacher would guide the student to see that the author is using a flower to symbolize Sue's looks.