What's It All About?

- What is development? How do we develop over time?
- What do we know about the brain and development?
- How do social interactions affect the development of our thinking and impact our teaching?
- When do we achieve specific developmental skills, and how does this relate to instruction?
- How do we acquire language? What exactly is acquired?

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Chapter 2

Developmental Foundations I: Thinking, Reasoning, and Language

Chapter Objectives

- Understand basic theories related to the developmental perspective.
- Appreciate the developmental path and its implications for understanding the whole person.
- Understand basic brain processes.
- Review the basics of the developmental neuroscience perspective.
- Learn different ways that an appreciation of developmental neuroscience can help promote effective education.
- Appreciate the difference between what cognitive skills develop over time versus how they develop.
- Understand the importance of Vygotsky's views on social interactions and language.
- Review the concepts of zone of proximal development and scaffolding.
- Learn the general principles guiding the work of Piaget.
- Understand the stages of Piaget's developmental theory.

- Evaluate Piaget's theory.
- Apply Piagetian theory to developmentally appropriate instruction.
- Compare Piaget's and Vygotsky's theories.
- Learn the different components of language.
- Understand different language acquisition theories.

Extended Outline

Developmental Foundations I: Thinking, Reasoning, and Language

From Today's Headlines

2.1 Typical Development and Developmental Differences
- 2.1a The Developmental Process
  - Defining Development
  - Principles of Development
- 2.1b Developmental Differences: Relative Perspective
  - Interindividual Comparisons
  - Intraindividual Comparisons

Summarize and Reflect

2.2 Cognition and Developmental Neuroscience
- 2.2a Neuronal Communication
- 2.2b Brain Development
- 2.2c Developmental Neuroscience
- 2.2d Implications for Teaching and Learning

Summarize and Reflect

2.3 Vygotsky and the Interactive Nature of Thinking
- 2.3a Perspectives on Development: Which Skills Develop versus How Skills Develop
- 2.3b The Importance of Social Interaction and Language
- 2.3c Instruction: The Zone of Proximal Development and Scaffolding

Summarize and Reflect

2.4 Piaget and the Inquisitive Child
- 2.4a Equilibration
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- 2.4c Organization
- 2.4d Stages of Development
  - Sensorimotor
  - Preoperational
  - Concrete Operations
  - Formal Operations
- 2.4e Evaluating Piaget's Theory
  - Underestimating the Abilities of Children
  - Overestimating the Abilities of Adolescents
  - Cognitive Development and Culture
  - Limited Explanations for Cognitive Changes

From Today's Headlines

Geoff Masters ◆ **(2021)** ◆ ***The Conversation***

Why the Curriculum Should Be Based on Students' Readiness, Not Their Age

This article by Geoff Masters calls for a change in how we progress students through grades.

Research on Australian schools indicates that instead of students starting each school year at approximately the same learning place, advanced students are about five to six years ahead of the least advanced students (Gonski, 2018). Despite this incredible discrepancy in skill level, students in the same grade are still compared against the same learning standard. This means many students are given work they are not ready to learn, and many others are given work that fails to challenge them. Although there is considerable appeal to giving all students an equal opportunity to successfully complete the same work, it is only producing marginal results. An equitable approach to learning where each student is given schoolwork they are ready to learn with assistance may produce the kind of learning excellence we strive for with student learning.

Not all students start the school year at the same place. According to the article, twenty-first century learning will not be driven by their age. What will drive learning will be teaching all students through a series of levels given what they are prepared to learn irrespective of age. Overall organization of the school would still be by grade levels, but the resulting grade-based classes would be mixed-ability classes with different students working on different material based on readiness. The author distinguishes this approach from "streaming," where students are permanently assigned to different instructional groups resulting in learning ceilings. Under this new approach all students are open to learning all curriculum levels but moving through the material at their own pace supporting mastery learning and academic success.

(Adobe Stock)

Not all students start the school year at the same place.

Make the Connection

This educational approach seems new, but has long-standing roots in educational research. In this chapter we will review some of the basic principles of development, including the idea that development proceeds at different rates. We will also cover the import work of Lev Vygotsky at the turn of the twentieth century, which specified that learning is most productive when instruction is geared toward information a student can learn with assistance. This will be followed by discussion of the work of Jean Piaget, who provided invaluable insights into the learning levels we progress through as we develop.

2.1 Typical Development and Developmental Differences

Next time you're in class, look around you. We are all unique, special, and different; yet, most of us took our first steps within six months of each other and said our first word when we were about a year old. We all learned to hold a pencil, went to our first day of school, dealt with fractions in third or fourth grade, and handled the social and academic complexities of high school. Within this similarity, however, is uniqueness. A few of us had trouble learning to hold a pencil, some of us loved fractions, and some of us excelled academically in high school. If you are one of the few students who did not struggle at all with fractions, you are not considered abnormal—yet you did develop differently. Your love of fractions may have developed for a variety of reasons, such as your analytical ability, brain organization, parental involvement, or motivating teacher. Likely, however, a combination of developmental, psychosocial, and educational factors interacted to influence your success with this form of math. Further, your success with fractions probably influenced your success in mastering more advanced math concepts. Thus, the interaction among many domains of development has important implications for teaching and learning.

(Adobe Stock)

We are all unique, special, and different; yet, we also have similarities, such as learning to hold a pencil.

This chapter addresses the similarities in our development, as well as the differences we demonstrate along the way. We will introduce you to the field of cognitive neuroscience and outline the ways in which research on brain development may update our understanding of developmental similarities and differences. We will also explore the ideas of the influential theorists Lev Vygotsky and Jean Piaget, applying their theories to children's thinking and learning development. Finally, we focus in on a very special developmental process—the development of language. We will explore theories of language development and outline the basic components of language. We will also outline how language differences affect teaching and learning.

2.1a The Developmental Process

People are constantly changing throughout their lifespans. Children's bodies undergo enormous changes as they progress from helpless newborn to coordinated toddler. Children also go through changes in their ability to think about their world. They learn to communicate using sophisticated language tools. They also learn to interact with others in socially complex ways. These changes represent our unique human experiences, and researchers have gathered an impressive body of knowledge regarding this process. Let's look at some of the concepts that lay the groundwork for a study of development.

Defining Development

Development refers to systematic continuities and changes in the individual over the course of life (Shaffer & Kipp, 2010). Developmental changes are not transitory, like changes in mood, but follow a specific order and are relatively permanent. Some developmental changes are the result of adaptation. **Adaptations** are environmentally dependent changes that allow us to better function in the world. For example, when a child who has had no experience in a structured pre-K program enters school, she may have difficulty sitting during circle time, being quiet while her teacher is talking, and raising her hand to speak during class time. As she gains experience in her new environment, however, she is likely to adapt, changing her behavior to better meet the demands of the classroom.

Development
Systematic continuities and changes in the individual over the course of life

Adaptations
Environmentally dependent changes that allow us to better function in the world

(Adobe Stock)

As students gain experience in a class environment, they will generally adapt to meet the demands of their classroom.

There are many ways that we might change to become better suited to our environment. We might change the way we think about ourselves (personal development), the way we interact with others (social development), or as the example above indicates, the way we regulate our own behavior (self-regulation development). We may also make adaptive changes in the way we think or remember (cognitive development), depending on our experiences. A third grader who has had great difficulty memorizing his multiplication tables might be taught to use physical movement and rhythm while rehearsing the multiplication facts—a memory strategy designed to engage both verbal and nonverbal areas of the brain. As he adapts or changes his memorization strategies, he greatly improves his recall of the multiplication facts, effectively meeting the environmental demands of third grade math. This type of developmental change is very different from maturation. **Maturation** refers to changes occurring naturally, irrespective of environmental demands. Maturational changes are largely genetically driven. For example, we are all genetically programmed to reach a certain height, and this is likely to be unaffected by the environment, unless we experience severe malnutrition or physical injury.

Maturation
Changes occurring naturally, irrespective of environmental demands

Often, we must reach a certain maturational level before we can acquire a particular skill. Take for example an eight-month-old infant who is just learning to crawl. Walking would clearly allow her to move about the world more easily; yet, until her musculature develops enough to support walking, this adaptive skill cannot be achieved. Clearly, maturation is important in the development of walking. It is, however, much more difficult to determine the role of maturation in more complex human behaviors such as cognition, language, and socialization. Maturation and adaptation interact in complex ways, making it difficult to tease apart the specific role of either process as development becomes more complex. This leads us to the first of three important developmental principles.

Principles of Development

Principle #1—Development Proceeds at Different Rates

Although there are similarities in our development, we each progress at a unique developmental pace. This individual pacing occurs for both maturation and adaptation-based development. Take puberty, for example. Some girls begin to show pubertal changes at ten or eleven years of age, while others showed no signs of puberty until the age of thirteen or fourteen. Ultimately, most of us went through similar physical changes, even though the process began at different times. It is also important to note that differences in timing of developmental

changes can impact other aspects of our functioning. When we reached puberty, we learned to adapt and incorporated these new feelings and physical characteristics into our lives. For some of us, adapting to change is easy; for others, the experience is more difficult. These differences interact with other aspects of our functioning in complex ways. For example, research shows that the way we adapt to the changes of puberty is related to maturational timing, or how early we enter puberty. In general, early pubertal development is associated with poorer outcomes, compared to typical or late development. Using an individual's subjective evaluation of their maturity, research shows early pubertal development in girls is associated with depression, antisocial behaviors, higher number of sex partners, drug use, fewer reports of good health, and higher body mass index (BMI). Results from boys are similar, with antisocial behaviors, higher number of sex partners, drug use, fewer sleep hours, and higher BMI (Hoyt et al., 2020). As you can see from these data, the concept of developmental variation is important, sometimes leading to very different outcomes.

Principle #2—Development Is an Orderly and Gradual Process

Most of us crawled before we walked and walked before we ran. This example of the progressive development of motor skills illustrates the orderly progression of skill acquisition that occurs in children. Further, we did not learn to walk in an hour or a day but learned gradually, over the course of many months. The developmental progression of motor skills is less complicated, and easier to quantify, than determining the sequence of cognitive development. However, most theorists agree that cognitive development also proceeds in a systematic, orderly, and gradual manner. Theorists, however, disagree about particular cognitive milestones and their sequence in cognitive development.

Principle #3—Development Occurs in a Sociocultural Context

Different cultures, subcultures, social classes, racial or ethnic groups, and disability groups have unique socialization experiences, which exert strong influences on the values, beliefs, and competencies of individuals who are members of the group (Bleidorn et al., 2016; Cole & Packer, 2011; Martin, 2007; Rogoff & Chavajay, 1995). By viewing development as occurring within social, cultural, and historical contexts, we lay the foundation for developing an understanding and appreciation of diversity and multiculturalism. This requires a more encompassing conceptualization of *difference*, which leads us to the next section on developmental differences.

2.1b Developmental Differences: Relative Perspective

In this section, we will explore the concept of developmental differences, an observable phenomenon in every classroom. Whenever we talk about difference, we are automatically making a comparison. Take Charlie, for example, who is able to read fluidly. Although we know something important about his academic level, we don't know if his skill in this area differs from those of other children. If we learn that Charlie is only four years old, however, we can compare him to other four-year-olds and see that his reading skills are clearly above average. This determination of difference was made based on an **interindividual comparison**, or a comparison between children. We may also be interested in making **intraindividual comparisons**, or comparisons within an individual. In Charlie's case, we might wish to know if he is advanced in other areas of development, as well as in reading, before we can determine an appropriate educational placement. We could compare his functioning in many different areas to determine areas of strength and weakness, outlining an academic plan to best suit his individual needs. Thus, the concept of difference is always relative, involving comparisons between or within individuals.

Interindividual comparison
A comparison between individuals

Intraindividual comparison
A comparison within an individual

Interindividual Comparisons

As our classrooms become increasingly diverse with regard to student culture, social class, race, ethnicity, and disability status, we are faced with the important task of providing educational experiences that support student differences. While the needs of students with significant developmental delays are usually addressed through Special Education, many students have developmental differences that do not meet criteria for inclusion in this program. This means today's regular education teachers are expected, more than ever, to work with students who have a variety of educational needs. This makes an understanding of developmental difference central to the field of education.

(Adobe Stock)

Today's regular education teachers are expected, more than ever, to work with students who have a variety of educational needs, such as autism.

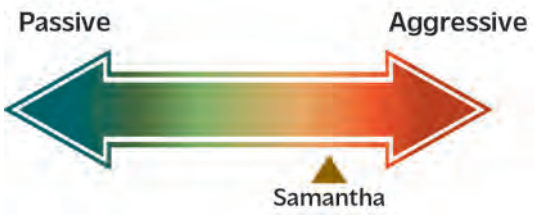
Developmental theorists have long debated the nature of developmental difference. Some argue that individuals with an atypical developmental progression are simply delayed in their development, acquiring the usual set of skills but at a slower rate. Others argue that individuals with atypical development are acquiring a different set of skills and are qualitatively different from those following a typical developmental path. Yet, how different does a child have to be from what is considered typical before that difference is seen as a problem rather than a manifestation of individual variation? We can answer this question by quantifying the difference, as we will discuss at length in Chapter 10; however, the answer almost always involves some measure of subjective judgment. Recall the important developmental principle discussed earlier in the chapter that development proceeds at different rates. This, in fact, dictates that we should *expect* variations in development between individuals, both within and between groups. A study of the behavior of children with autism illustrates this concept. The researchers explored whether the daily living skills of children with autism were qualitatively different (different in type) or simply delayed when compared to children with cognitive disabilities or a group of typically developing children (VanMeter et al., 1997). Results indicated that the pattern of daily living skills of children with autism *as a group* was indeed different, not just delayed, when compared to the other groups. They also noted, however, that the patterns of daily living skills were highly variable within the group of children with autism. This study illustrates the importance of considering individual differences, even among individuals who are grouped based on certain atypical traits. Thus, it is important to look closely at patterns of behavior *within* an individual, intraindividual, in addition to making comparisons *between* individuals, interindividual (Molenaar et al., 2003; Weinert & Helmke, 1998). This leads us to the next section, which emphasizes the importance of understanding intraindividual strengths and weaknesses.

Intraindividual Comparisons

In searching for an understanding of why discrepancies or differences in human development exist, it is easy to narrowly focus on differences between individuals (interindividual). By focusing on the way a child differs from others, we often lose sight of interacting strengths and weaknesses within the child. For example, if Samantha develops a problem with aggression, parents and teachers typically direct their attention to normalizing her behavior relative to other children. They want her to act more like other children. This approach may bring about change in Samantha's behavior, but Samantha does not experience her occasional acts of aggression as isolated events in an otherwise peaceful day. In fact, her aggressive actions are only one manifestation of her complex experience of the world. Attempts to understand the aggression by looking only at Samantha's overt (observable) actions is like trying

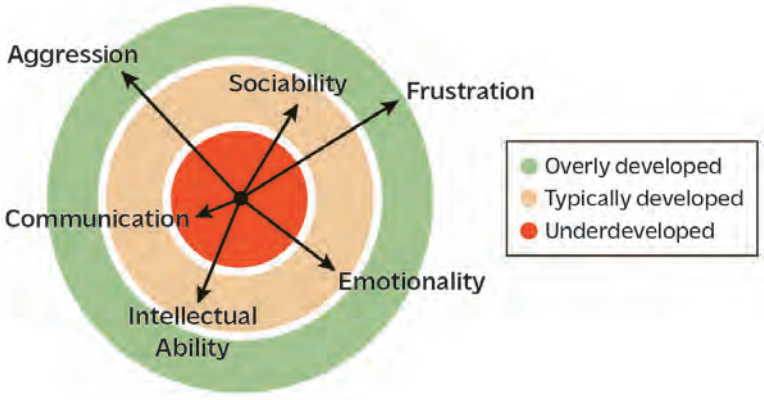
to understand how to drive a car by looking only at the steering wheel. Although focusing on specific issues may produce results, effective intervention is best achieved by understanding the complexities of the whole person.

One way to think about the whole person is to imagine an individual as a composite of many dimensions. For example, on the passivity-aggression dimension, Samantha might tend toward aggressive behaviors and prefer to be physically confrontational, as opposed to reserved and accepting of frustrating situations.



This is, however, only one of Samantha's many personal dimensions. We could also look at an infinite number of other dimensions, such as emotionality, communications skills, intellectual ability, or sociability. This dimensional approach helps us appreciate how an issue in a specific developmental dimension is best understood in the context of the whole person. For example, Figure 2–1 shows such a dimensional model for Samantha. The concentric circles represent the degree to which a given dimension is developed: overly developed, typically developed, or underdeveloped. Sample dimensions for Samantha's behaviors and skills are labeled as dark lines extending from the center of the circles. According to the figure, Samantha is typically developing in sociability, emotionality, and intellectual ability. Her aggression and frustration levels are overly developed. Further, and most importantly, she has a significant deficit in communication skills, a component that likely impacts her frustration level and aggression. Given this additional information regarding other dimensions of Samantha's functioning, it becomes clearer that her aggression problem would be addressed most effectively by helping her to improve her communication skills, thereby reducing frustration and subsequent aggression.

Figure 2–1 Dimensional Model for Samantha



This dimensional model of intraindividual difference is particularly important in educational settings since all students have a unique learning style made up of different strengths and weaknesses (Gardner, 1995; Kolb, 1984). Considerable research has been undertaken to better understand the impact of different learning styles in the classroom, and research

shows that effective learning is enhanced when teachers consider individual strengths and weaknesses when planning instruction (Dunn & Dunn, 1999; Mayer, 2011; Reif, 1993). Tailoring instruction to meet the needs of increasingly diverse learners is a central challenge for today's educators (NASBE, 2001; Shanley et al., 2020; Yamauchi et al., 2012), requiring knowledge of research and theory across many disciplines (Tate & Debroux, 2001).

Summarize and Reflect

1. Development refers to the ways we change over the course of a lifetime.
2. It is important to consider the interaction between adaptation and maturational types of development.
3. The following are the three major principles of development: a) Development proceeds at different rates; b) Development is an orderly and gradual process; c) Development occurs in a sociocultural context.
4. Discussion of interindividual differences underscores the importance of viewing typical and atypical development as existing on a continuum of functioning.
5. Intraindividual differences illustrate that a narrow focus on a specific problem area may result in a failure to appreciate more complex interactions among an individual's strengths and weaknesses.
6. Consideration of intraindividual differences is becoming more important as our classrooms become increasingly diverse with regard to student culture, social class, race, ethnicity, and disability status.
7. It is important to acquire interdisciplinary knowledge of research and theory in order to better meet the needs of all learners.

Informed Application

1. Ms. Klein is a fourth grade teacher. Given the first principle of development, what should Ms. Klein do at the beginning of the year to ensure lessons are appropriately tailored to each student?
2. How can a teacher use the concept of intraindividual differences to help students succeed?
3. You are a physical education teacher teaching a lesson on basketball and you find that a few students in particular have trouble with dribbling the ball. Explain why this would be better viewed as an instance of maturation rather than adaptation.

2.2 Cognition and Developmental Neuroscience

Cognitive neuroscience
The study of relations between the brain and thinking

Cognitive neuroscience is the study of relations between the brain and thinking. We are learning about the brain and cognition at an exponential rate, and this research has many implications for educational practice. Neuroscience research complements our understanding of individual and developmental differences in learning and has been used as support for a variety of instructional styles. Some researchers argue that the application of neuroscience research to the classroom is premature, asserting that the way in which findings in neuroscience map onto what we

know of development, cognition, and learning is unclear (Bruer, 1999; Dommett et al., 2011; Stanovich, 1998). In order to critically evaluate generalizations from neuroscience research to the classroom, we need a functional understanding of the brain and its processes. This section provides a broad overview of brain function, as well as an introduction to major research findings in developmental neuroscience, which have application to teaching and learning.

2.2a Neuronal Communication

The brain is an incredibly complex structure of the human body composed of hundreds of billions of **neurons**, specialized brain cells that send and receive information by conducting electrochemical impulses. A typical neuron is composed of three main parts: dendrites, cell body, and the axon (see Figure 2–2). The **dendrites** are responsible for receiving incoming signals from another neuron. This causes an electrical signal to travel down the dendrite and move across the **cell body**, which is responsible for carrying on basic life functions. When the sufficient signal comes to a specialized region of the cell called the axon hillock, it triggers an electrochemical signal to continue down the axon. The **axon** serves a transmission function, sending information to other neurons. Propagation down the axon is accelerated if the axon is myelinated. The signal continues down the axon until it reaches the terminal button. The signal causes the production of vesicles, which are filled with a neurotransmitter. Vesicles move the end of the terminal button where they fuse with the membrane, releasing the neurotransmitter into a space between neurons called a **synapse**. Moving across the synaptic cleft, they bind with receptors on the post-synaptic neuron creating a new signal in that cell, starting the cycle again. This process is **plastic**, meaning that the strength of the neuronal signal is modifiable by experience. This flexibility gives rise to the remarkable breadth we see in human learning. As more and more synapses form among neurons, they begin to develop into organized circuits, or networks, allowing distant neurons in the brain to communicate with one another. The nature of neuron communication is at least partially dependent on its physical location in the brain. Certain areas and structures in the brain are designed to carry out specialized functions.

Neurons
Specialized brain cells that send and receive information by conducting electrochemical impulses

Dendrite
Branch-like processes extending from the cell body of the neuron that receive chemical signals from other neurons

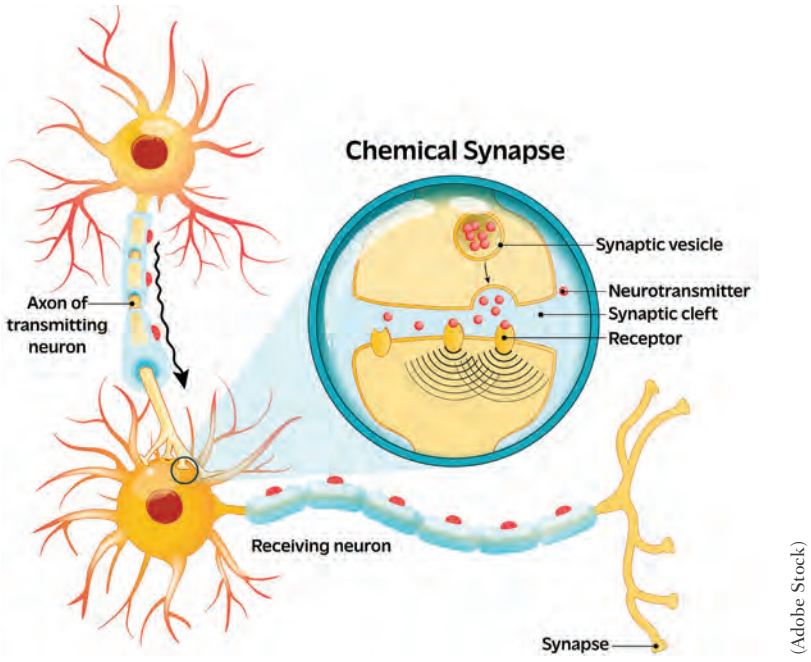
Cell body
The part of a neuron responsible for carrying on basic life functions

Axon
Extension of the neuron cell body that uses electrochemical signals to communicate with other neurons

Synapse
Space between neurons through which neurotransmitters pass from one neuron to the next

Synaptic plasticity
Modification of neuron signal strength by experience

Figure 2–2 Neuron Communication



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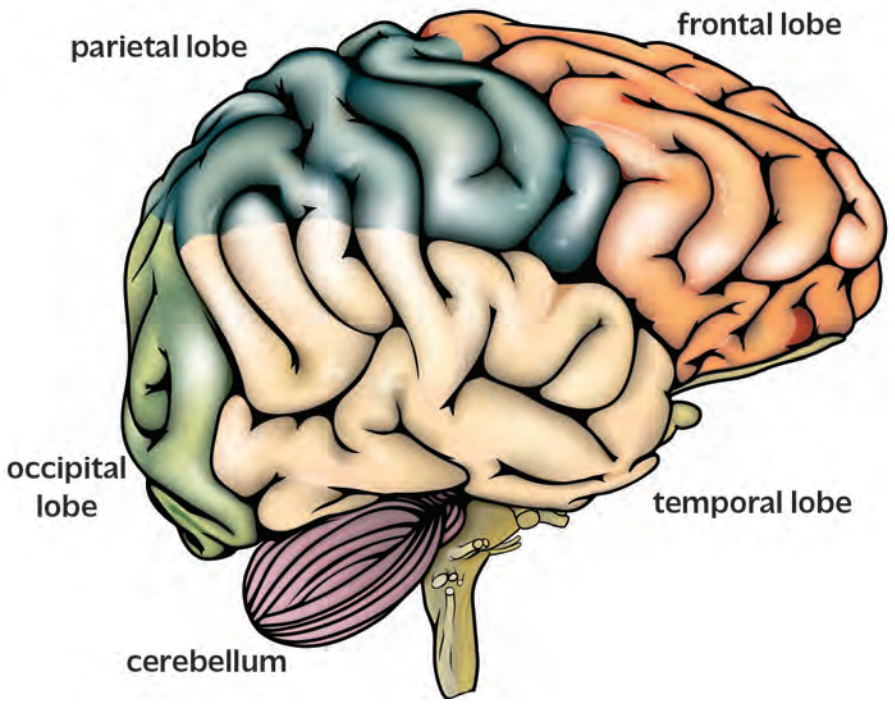
2.2b Brain Development

Cerebral cortex
The area of the brain most directly implicated in thinking and learning

Temporal lobe
The part of the brain primarily involved in processing auditory information

The **cerebral cortex**, which is the area of the brain most directly implicated in thinking and learning, is one of the most highly specialized brain areas. The cerebral cortex can be divided into four different lobes: *frontal, temporal, parietal,* and *occipital* (see Figure 2–3). Each of these brain areas is specialized for certain functions, although most human activities require many brain areas working together. For example, the **temporal lobe** is the part of the brain primarily involved in processing auditory information; yet in order to hear and interpret language, many different areas of the brain must work together. The temporal lobes are also important in memory and selective attention, with people who have temporal injuries exhibiting a wide range of problems related to auditory processing, verbal learning, and sensory integration (Flinker et al., 2011; Kolb & Wishaw, 1990).

Figure 2–3 The Four Lobes of the Cerebral Cortex



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Frontal lobes
Portion of the brain that plays a role in many human behaviors, including planning, anticipating consequences, and inhibiting behavior

Parietal lobes
Portion of the brain that is responsible for integrating somatosensory information, such as touch, temperature, and pain

The **frontal lobes** play a role in many human behaviors, including planning, anticipating consequences, and inhibiting behavior—behaviors, which are known collectively as *executive functions*. The frontal lobes also play a role in language, problem solving, and movement. People who have damage to this important brain area often have a wide variety of deficits (Kolb & Wishaw, 1990; Reilly et al., 2011), including impulsive behavior, poor judgment, and difficulty planning for the future. This cognitive and behavioral profile is similar to the problems seen in children with attention-deficit/hyperactivity disorder, or ADHD (see Chapter 11), leading many researchers to believe this disorder may have origins in frontal lobes deficits (Barkley, 1998; Gracia-Tabuenca et al., 2020).

The **parietal lobes** are responsible for integrating somatosensory information, such as touch, temperature, and pain. The parietal lobes are also involved in spatial activities such as being able to visualize the way an object will look from different angles and understanding the relationship among objects in space. Parietal lobe functions strongly correlate with

math performance (Desco et al., 2011; Price et al., 2018). Damage to the parietal lobes can result in problems with spatial relations, abnormalities in body image, and impaired body senses (Kandel et al., 1991).

The **occipital lobes** are primarily responsible for visual processing. Damage to this region can result in visual perceptual problems and if the damage is extensive enough, blindness. Near the area of the juncture between the occipital, temporal, and parietal lobes lies an area of the brain called the angular gyrus, which is important in reading and writing activities (Branzi et al., 2021; Shaywitz et al., 1998). People who have damage to the area of the angular gyrus lose the ability to read and write, while language function is maintained.

Interconnections

See Chapter 11 for a complete discussion of the identification and education of students with Attention-Deficit/Hyperactivity Disorder

Occipital lobes

Portion of the brain that is primarily responsible for visual processing

Another important aspect of the cerebral cortex is that it is divided down the midline into left and right hemispheres, each of which contains all four lobes discussed above. The two cerebral hemispheres are connected by a band of axons called the corpus callosum. The **corpus callosum** allows information to travel back and forth between the left and the right sides of the brain. Each side of the brain has specialized functions like the specialization seen in the four lobes of the brain. First, the right side of the brain controls the motor functions of the left side of the body, and the left side of the brain controls the motor functions of the right side of the body. For example, moving your right arm results from a brain signal originating in the left hemisphere. We consider specialized brain functions lateralized when they are primarily controlled by one hemisphere. Like motor function, language ability is another **lateralized brain function**. In most right- and left-handed people, language is lateralized to the left hemisphere. The right hemisphere is more dominant for non-verbal, visuospatial, creativity, and emotional processing (Mihov et al., 2010). A few left-handed people show the opposite pattern, and some individuals show a mixed laterality, or a lack of hemispheric dominance. This mixed laterality has been correlated with learning disabilities in reading; however, a causal relationship has not been established.

Corpus callosum

Section of the brain that allows information to travel back and forth between the left and the right sides of the brain

Lateralized brain function

A specialized brain function primarily controlled by one hemisphere

Left-brain/right-brain research is quite popular, and attempts have been made to develop teaching strategies designed to better engage one hemisphere or the other. The usefulness of left-brain/right-brain distinction in the classroom, however, is relatively limited. Although much of teaching and learning involves language, it is inaccurate to assume that the left hemisphere is in complete control in the classroom. While the left hemisphere may be more involved in the processing of verbal information, an intact corpus callosum constantly sends information back and forth between hemispheres, resulting in both sides of the brain operating in all learning activities. We do have evidence, however, that when teaching a primarily left-hemisphere language task, such as learning the initial sounds of the letters of the alphabet, addition of a multisensory component to instruction (a practice which activates all the brain's lobes in both hemispheres) can be highly effective (Wagmeister, 2000). While multisensory approaches to instruction have often been cited as effective in the scientific literature (Moustafa, 1999), the neuroscience perspective offers us the ability to better explain *why* it is effective.

(Adapted Adobe Stock)

Language ability is a lateralized brain function.

Interconnections

See Chapter 1 for a discussion of how to interpret a statistical correlation.

2.2c Developmental Neuroscience

Developmental neuroscience
The study of the orderly progression of changes in the brain that occur across the lifespan

Developmental neuroscience is the study of the orderly progression of changes in the brain that occur across the lifespan. Research from developmental neuroscience confirms much of what we already know and are already implementing in the classroom. What follows is a brief summary of some of the most exciting findings in this area and a discussion about generalizing findings to classroom practices.

First, research tells us that brain development is dependent on experience, or environmental input. Research has shown that animals deprived of experiences during development do not develop connecting circuits in the brain, which are as complex and organized as animals that receive stimulation (Rakic et al., 1994). Further, raising animals in enriched environments leads to an increase in the number of connections in the brain (Comery et al., 1996; Diamond, 1978). These findings indicate that brain development increases in complexity and organization as a function of experience. Research also shows that the brain is most receptive to environmental input in childhood (Fox et al., 2010). Synaptogenesis peaks in early childhood after which it declines until it stabilizes during mid- to late adolescence (Bruer, 1997). Although the brain continues to form new connections as a function of experience throughout life (Kelsch et al., 2010), it forms connections more intensely during childhood.

(Adobe Stock)

Developmental neuroscience is the study of the orderly progression of changes in the brain that occur across the lifespan.

2.2d Implications for Teaching and Learning

Since the brain develops as a function of experience, it follows that teachers, by providing learning experiences, are helping increase the complexity and organization of their students' brains (Benati et al., 2018; James, 2010; Rushton et al., 2010). While we know that effective teaching increases learning, neuroscience research gives us a physiological basis for this phenomenon. Research indicates that using meaningful contexts for teaching new information enhances learning (Billingsley, 1993). If we reflect on research findings from a variety of disciplines—including education, cognitive science, and developmental neuroscience—we may better understand why the use of meaningful context enhances learning. As discussed previously, neuroscience research tells us that when learning occurs, new connections are made between neurons; and these connections in the brain are organized into networks, or circuits. Examining learning at the level of the neuron is looking at the **microstructure**. This is important when documenting the foundation of learning, but it is difficult to translate this information into functionally relevant learning strategies. That is, knowing that specific neurons are communicating more does not usually lead to an instructional strategy that teachers can use in the classroom. More typically, brain-based educators are interested in the **macrostructure** of learning. This approach focuses on whole brain structures (rather than specific neurons) and how they operate during learning.

Microstructure
The level of learning involving the neuron

Macrostructure
The level of learning involving the operation of whole brain structures

When a student is attempting to learn something new, putting the new information in a meaningful context causes already existing circuits of neurons to activate, enabling the student to link the new information to existing knowledge. Cognitive psychologists call this linking of new information to information already known **elaboration**, and it has been shown to be a very powerful memory technique (Anderson, 1995; Bartsch et al., 2021; Holland et al., 2011) (see Chapter 6). Now, let's think about how these research findings might apply in a classroom example. Joy, who is trying to learn the addition fact 2 + 2 = 4, can already count and identify numbers and

Elaboration
The linking of new information to information already known

Interconnections

Elaboration is further defined and discussed in Chapter 6.

has one-to-one correspondence. This means she already has neural networks for numbers, and when she repeats the math fact, she activates these networks. If we give Joy a context for understanding the math fact, however, she will activate much larger areas of already existing neurons in her brain, making it easier for her to link the new information to the information she already knows. We might, for example, ask her how many apples she would have if she were already holding two and her friend gave her two more. This might result in her activating networks regarding numbers, quantity, apples, and friends, among others. If we actually give her apples to manipulate as we work on the math fact, she will activate already existing networks in her motor and somatosensory cortex. Thus, another effective teaching practice, multisensory instruction, can be understood more fully with the addition of a neuroscience perspective. While this research may only give us limited information with which we can develop curricula or programs, it does expand our understanding of how the brain is working during teaching and learning. Further, neuroscience is a rapidly developing field of study, and the future may yield more specific information that can be applied to educational practice and policy.

(Adobe Stock)

Elaboration is the linking of new information to information already known. The student already knows how to count, now she is learning to add.

While neuroscience research indicates that experiences are important for brain development and may help us better understand the learning process, the question of exactly which experiences are necessary for optimal human brain development is unanswered. Clearly, animals raised in enriched environments develop more synapses than those raised in impoverished environments, but how does this research relate to the development of human brains? We know that students from culturally impoverished backgrounds are more likely to have academic difficulty (Hirsch, 2001), and studies have shown that global, long-term neglect of human babies can severely stunt brain development (Perry, 2002). However, we do not yet have a good definition of the construct "enriched environment" in humans. In fact, it has been pointed out that the term "enriched environment," when applied to humans, has the potential to become value-laden and biased toward environments that are culturally preferred and middle-class (Bruer, 1998). This does not mean that we should not pursue the notion of enriched environments, but it is necessary to carefully approach the idea from a culture and class sensitive perspective.

Summarize and Reflect

1. Cognitive neuroscience is a field of study that focuses on the relationship between the brain and cognition.
2. Neural communication is important in development. Of particular importance is the role of experience in synaptogenesis, or the formation of new connections in the brain.
3. The brain develops areas specialized for carrying out certain functions, including the basic specializations of the four lobes of the cerebral cortex and the left and right hemispheres.
4. Brain areas may be specialized for specific functions, but most human activities require the use of many areas of the brain working together through circuits, or networks of neurons.
5. Neuroscience research demonstrates the dynamic interaction between the functioning of an individual's brain physiology, experiences, and development.
6. There are many educational implications of these findings for helping us better understand the complexities of both typical and atypical development.

7. Neuroscience research is growing at an exponential rate and may have implications for classroom practice, but we must be careful how we make connections between brain functioning and education.

Informed Application

1. As students begin to learn basic math facts, what parallel changes are likely to be taking place in the brain?
2. As a physical education teacher, you notice one student in particular has fine motor difficulty in her right hand. How does the concept of lateralization shape the way you view her brain development?
3. How does teaching elaboration affect the formation of neural networks?

2.3 Vygotsky and the Interactive Nature of Thinking

During the early part of the twentieth century, the Russian theorist Lev Semenovich Vygotsky (1896–1934) developed a theory of development that received relatively little attention in the United States until the 1970s and 1980s, when his ideas became widely circulated among educators. Vygotsky is considered a **sociocultural theorist** because of his interest in the nature of social interactions and the ways in which social processes shape an individual's thinking. Educators came to realize that Vygotsky's sociocultural theory had direct bearing on the process of formal schooling and the pivotal role of the teacher because formal education is inherently a dynamic social process. Vygotsky's basic theoretical premise is a departure from many developmental theorists, focusing on the *process* of development rather than the *product*.

Sociocultural theorist

A theorist interested in the nature of social interactions and the ways in which social processes shape an individual's thinking

2.3a Perspectives on Development: Which Skills Develop versus How Skills Develop

Education is a complex process ultimately resulting in a variety of learning products. Here the term *products* refers to any outcome resulting from a learning process, such as reading, understanding the function of cells, or riding a bicycle, etc. While both learning products and the process by which they are learned are important, theorists place varying levels of emphasis on each. In other words, some theorists emphasize what is learned or acquired during the developmental years (product), whereas others emphasize the nature of the path making these changes possible (process). Vygotsky chose to focus on the process behind development changes. This is a departure from popular stage theorists, who favor a theoretical approach that clearly outlines specific skills acquired during development. Stage theory takes a particular developmental continuum and divides it into unique stages. Characteristics or products acquired during each stage are then explicitly outlined. For example, a stage theorist might document that children typically begin to develop the ability to assign unique words to objects around twelve to fifteen months of age. Describing when a child starts to develop language is important in that it gives us a sense of *what* to expect from a child at a given age, yet it fails to give us a comprehensive account of *how* these skills develop. That is, how did the child begin to learn verbal labels? Vygotsky's theory adds to our understanding of cognitive development by providing a mechanism for understanding *how* an individual's thinking and reasoning changes over time. Given this focus, Vygotsky's theory can be viewed as a process theory. A **process theorist** deemphasizes the development of specific skills, like verbal

Process theorist

A theorist who deemphasizes the development of specific skills, such as verbal labeling, and focuses instead on what made the development of the skill possible

labeling, and instead focuses on what made the development of the skill possible. As you will see in the next section, Vygotsky considers the relationship between a student and a teacher or, more generally, between a learner and a knower, as the fundamental process for making possible the changes in cognitive development.

2.3b The Importance of Social Interaction and Language

As we grow and develop, it is clear that we undergo many striking changes in our ability to function in the world. We learn to talk and communicate our wants, our bodies become more coordinated and better able to operate within our environment, and our unique sense of ourselves begins to take shape. The fact that we all change over the course of our lives is quite clear, but equally clear is the fact that these changes are influenced by the environment in which we live. Children reared in different environments develop different ways to communicate, different physical capabilities, and different personalities. Most developmental theorists place such individual change at the center of their theory, trying to understand how individual changes lead to different ways of functioning in the world. For example, consider a young child who learns to read. How does the development of reading ability affect the child's functioning in the world? This is a very traditional question asked by developmental psychologists. Vygotsky's approach differed from traditional ways of looking at development in that his primary focus was on the effect of social interactions. He proposed that it is the interactions we have with others that are of primary importance in the process of development. First, we learn to more effectively interact with others by using tools such as speech, and then later use these social processes to understand and influence our own thinking and behavior (see Table 2–1).

Table 2–1 Traditional Developmental Theories vs. Vygotsky's Developmental Theory

Developmental Theory	Initial Process	Resulting Change
Traditional	Individuals change their thinking and subsequent behaviors.	This process results in changes in how the individual operates in the world.
Vygotsky's	Individual changes how they operate in their world (specifically how they internalize aspects of the world through social interaction).	This process results in the individual changing their thinking and behavior.

To get a better understanding of Vygotsky's unique perspective, consider a young child named Mora who is learning to talk. As she is busily playing one day, she becomes hungry and wants a cookie. She goes into the kitchen and ineffectively tries to reach the cookie jar. Her father notices her effort and asks if she wants a cookie. Since Mora has a very limited vocabulary, the father takes a cookie and holds it up in front of her and says clearly, "Cookie." Later in the week the child again wants a cookie, but this time approaches the father directly and says, "Coopie." Despite her articulation error, Mora is clearly using speech in a social context to get something she wants. This type of situation repeats itself across countless situations over several years until the child can interact with others in a very sophisticated manner.

Intermental changes
Modifications in thinking resulting from our social interactions

Vygotsky called this type of socially mediated change an intermental change, as illustrated in Figure 2–4 (Wertsch & Tulviste, 1992). **Intermental changes** are modifications in

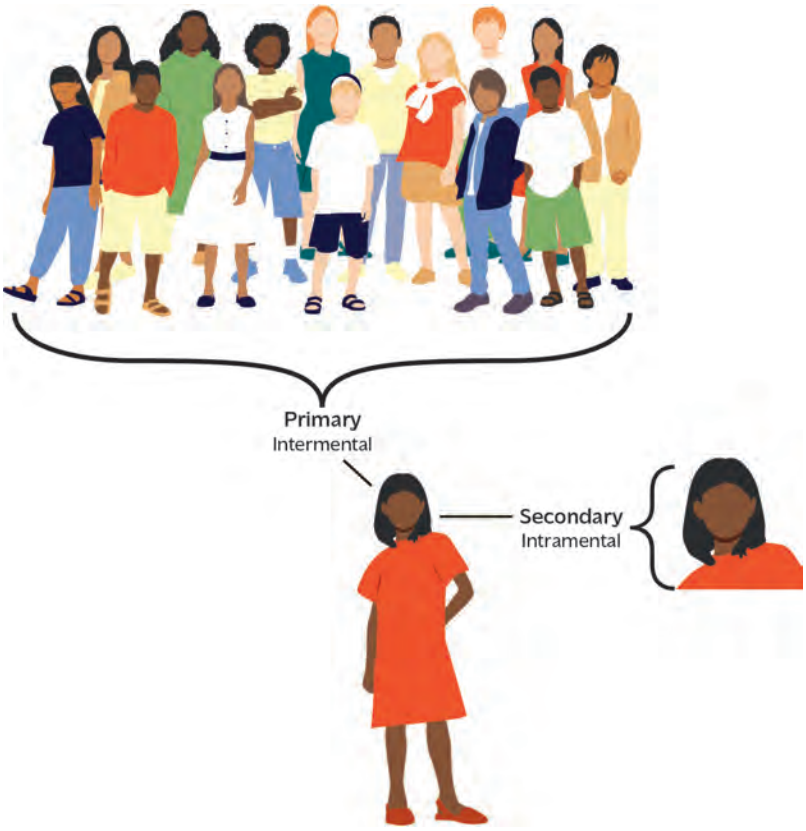
thinking resulting from our social interactions. "Mental" in this sense is not an activity exclusively within the mind of an individual. Vygotsky actually saw mental actions occurring in the socially mediated space between individuals. For him, this is the primary place for developmental changes in thinking. The difficulty you are probably experiencing right now in trying to understand a "social mental process" is a testament to how differently our society has thought of this activity. Simply put, Vygotsky believed that social processes are the fundamental basis for thinking. A secondary process called **intramental changes** refers to how individuals adapt socially derived mental processes to govern their own thinking and behavior.

Intramental changes

The process of adapting socially derived mental processes to govern our own thinking and behavior

Figure 2–4 Example of How Jan Experiences Both Intermental and Intramental Changes

The way that Jan reflects upon her own behavior is a product of the way she learned to think and reason from her social interactions with others. According to Vygotsky, it is this learning from others that is the primary or fundamental process in development, with individual thinking developing as a secondary process.



(Adapted Adobe Stock)

Egocentric speech

The use of overt speaking by an individual to modify his or her own actions

Private speech

The use of subvocal speaking addressed to oneself for the purpose of self-regulation

For example, as Mora increases her level of linguistic proficiency, she begins to use "speech" to modify her individual actions. This **egocentric speech** begins as overt talking while carrying out an activity (Gredler, 2009; Piaget, 1959; Vygotsky, 1986). As Mora becomes more adept at guiding her own performance through speech, she will begin to use **private speech**, which eliminates overt talking, but will continue to use subvocal speech to guide her actions. This type of speech is addressed to the self, as opposed to others, and is

used for the purpose of self-regulation and motivation (Fox & Riconscente, 2008; Sawyer et al., 2021), rather than communication (Bivens & Berk, 1990; Diaz & Berk, 1992). According to Vygotsky, this inner form of speech is thinking, which is developed via social mental processes. Thus, Vygotsky's theory focuses on the process by which our thinking develops, with language and sociocultural interactions as fundamentals of this process.

Vygotsky recognized the importance of his theory for formal education since many of society's fundamental mental tools are relayed to the individual during the formal educational process. Examples of these fundamental tools are not only verbal words and language but also written language, counting systems, works of art, maps, diagrams, etc. (Cole & Wertsch, 1996). It is in the school environment, through intermental processes or social interactions with others, that we learn to use these social and cultural tools in our thinking; that is, the processes become intramental. It is important at this point to emphasize that since our mental products are directly derived from our interactions at a social level, society and culture dictate how we perceive ourselves and the world around us. According to Vygotsky, we are able to direct our mental tools to whatever attracts our interest; however, the tools we have available for this work are simply those derived from the larger social context. This places educators in a very sensitive position because they significantly impact how students experience the social world and, therefore, how they come to think for themselves (Smagorinsky, 2007).

In the Classroom

Applying Theory

Vygotsky

Theory Basics

The idea that there is a form of thinking and reasoning present in our interactions with others, rather than in our own minds, is difficult for most individuals growing up in western societies. In our culture, we typically think of reasoning as a quality of the individual or a skill that an individual possesses. According to Vygotsky, however, these individual abilities are actually byproducts of a primary "mental" process present in the interactions *between* individuals. In general, societies communicate to the individual ways to think and reason instead of using skills inherent in the individual. Vygotsky suggested that the only mental abilities we have are taught to us through our interactions with others. Social interactions not only teach us fundamental communication tools like language but also other general approaches to mental processing like problem solving and perception. The reasoning skills present in the social world are called intermental processes, and the skills that are adopted and used by an individual are called intramental processes.

Classroom Application

Teachers often have difficulty figuring out how to take this theory and apply it to instruction. One approach to making this application successful is to remember that the key point—how we think as individuals—comes from our exposure to the "thinking" of people around us. Teachers should take this into consideration whenever they are teaching their students new material.

Teachers: Make a strong attempt to interact with each student and provide guiding information to aid the student in his/her understanding of the material.

Through social interactions with the teacher, students are able to clarify how the teacher is working through the problem, and they are then more competent in solving the problem on their own. This guiding approach is known as scaffolding. It is the way the teacher communicates the new mental skill. It is then the responsibility of the student to use that skill appropriately.

(continues)

(continued)

Teachers: Provide the general framework for understanding a new lesson in a way that is personal and meets the need of each student.

For example, if a math teacher shows her students how to reduce fractions, she would likely show the students several sample items. She might also provide examples for the student to solve with her guidance. Both of these methods help communicate how to think about the problem. Teachers who follow Vygotsky's work would likely extend these traditional approaches with other ways to think about the topic. The teacher could demonstrate the application of reducing fractions by baking a cake, modifying the distance run by the track team, or cutting wood to make a tree house. Have the students engage in these activities in a small group with an advanced student or a student from a higher grade. The social interaction will help to communicate the new skill more effectively.

Teachers: Consider that in our current information age, internet sources of information are readily available, which can greatly expand the student's world from which they learn.

Although we may have a typical approach to the instruction of fractions, the internet can be a gateway to other societies and their approach to education. This helps students benefit from the ever-growing world culture and the problem-solving tools present in other societies. Encourage students to conduct research on the internet while maintaining a critical perspective.

2.3c Instruction: The Zone of Proximal Development and Scaffolding

Vygotsky's ideas provide a theoretical foundation for teaching, whereby the social environment of the classroom is used to optimize cognitive development. The benefit of a Vygotskian approach to instruction is that much of the natural social interactions that occur between a teacher and student can be purposefully directed to enhance the educational process. For example, during the beginning of a new school year, teachers spend considerable time getting to know the students and helping them become familiar with the classroom. Although this is typically viewed as somewhat peripheral to actual instruction time, Vygotsky's theory holds that this social interaction has the potential for dramatic impact on education. If we apply Vygotsky's ideas to the classroom, the earliest part of the educational process consists of a preliminary dynamic between student and teacher. During this time, the teacher begins to learn three types of information. First, the teacher acquires an understanding of what skills a student has already acquired and can perform independently. These skills are likely to benefit from continued reinforcement, but are not as likely to need the active guidance of the instructor. The teacher must then develop a sense of what skills are realistically beyond the child's current ability, even if help is given. This leaves a third piece of information that the teacher needs to acquire; that is, discovering what the student has not already acquired but is capable of learning with assistance. Vygotsky referred to this area of potential development as the **zone of proximal development** (see Figure 2–5), or the distance between the skills the child has already internalized and the skills the child could learn with appropriate assistance (Tharp & Gallimore, 1988; Vygotsky, 1978; Wass et al., 2011).

Zone of proximal development

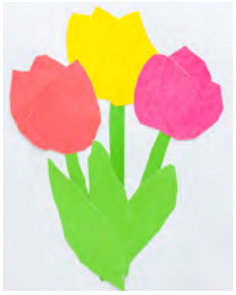
The distance between the skills a child has already internalized and the skills he or she could learn with appropriate assistance

If the teacher uses interactions with students as a tool to understand the child's particular zone of proximal development, then sensitive and effective instruction becomes a reality. It is important to remember that much of the teacher's assessment of a child's zone of proximal development can be imbedded in everyday interactions. It is also important to realize that each child's zone of proximal development is likely to vary, not only in terms of absolute level, but also in relative distance between known skills and skills the child could learn with assistance. That is, some students will only be able to learn a few skills beyond their current level of development, whereas other students will have a greater range of skills that they could potentially learn with appropriate assistance.

Figure 2–5 Zone of Proximal Development

(Adobe Stock)

Kara loves to paint and is ready to learn more. Her current skill level is fairly basic.



(Adobe Stock)

(Adobe Stock)

With instruction, Kara is able to extend her current skill level, with more complexity and detail.

(Adobe Stock)

After a teacher has successfully determined the zone of proximal development for each child, instruction can be tailored to the student, or to groups of students who have similar zones of proximal development for a given skill. Jerome Bruner first used the term *scaffolding* in the 1970s to refer to instruction that is based on Vygotsky's notion of supporting the development of new skills within a student's zone of proximal development (Bruner, 1978; Wood et al., 1976). **Scaffolding** does not use explicit step-by-step instructions—it supports learning by helping the student engage in purposeful and meaningful usage of psychological tools (Doolittle, 1997). The scaffolding process consists of three main characteristics (see Figure 2–6) (van de Pol et al., 2010). This first is **contingency** and refers to the teacher adapting instruction to the specific learning needs exhibited by the student. For example, a teacher may model a particular learning product, but also provide critical foundations just beyond the student's skill level that are necessary to reach the desired outcome. The student then attempts the skill on her own, with the teacher monitoring student performance and providing sensitive feedback. Over time, the teacher minimizes assistance through the process of **fading**, and the intermental dynamic becomes intramental, with the student moving toward independent practice (Jonassen, 1997; Rosenshine & Meister, 1992). This process provides a gradual **transfer of responsibility** for learning from the teacher to the student.

Vygotsky's theories provide us with valuable insights into the process of effective education. Yet, if a teacher must begin each new school year with a systematic assessment of each child's individual developmental level, followed by individualized instruction for each child based on that assessment, then a classroom of twenty-five children becomes difficult, if not impossible, to teach. While every teacher is indeed confronted with as many unique zones of proximal development as they have children in class, development is an orderly and gradual process, one that proceeds similarly for most children. Teachers should, and are expected to, factor this into their educational programming. This helps teachers educate a group of students, while still providing the support each student needs. We are now going to turn our

Scaffolding
A method of instruction that supports learning by helping the student engage in purposeful and meaningful use of psychological tools

Contingency
Adapting instructional support to the individual learning needs exhibited by the student

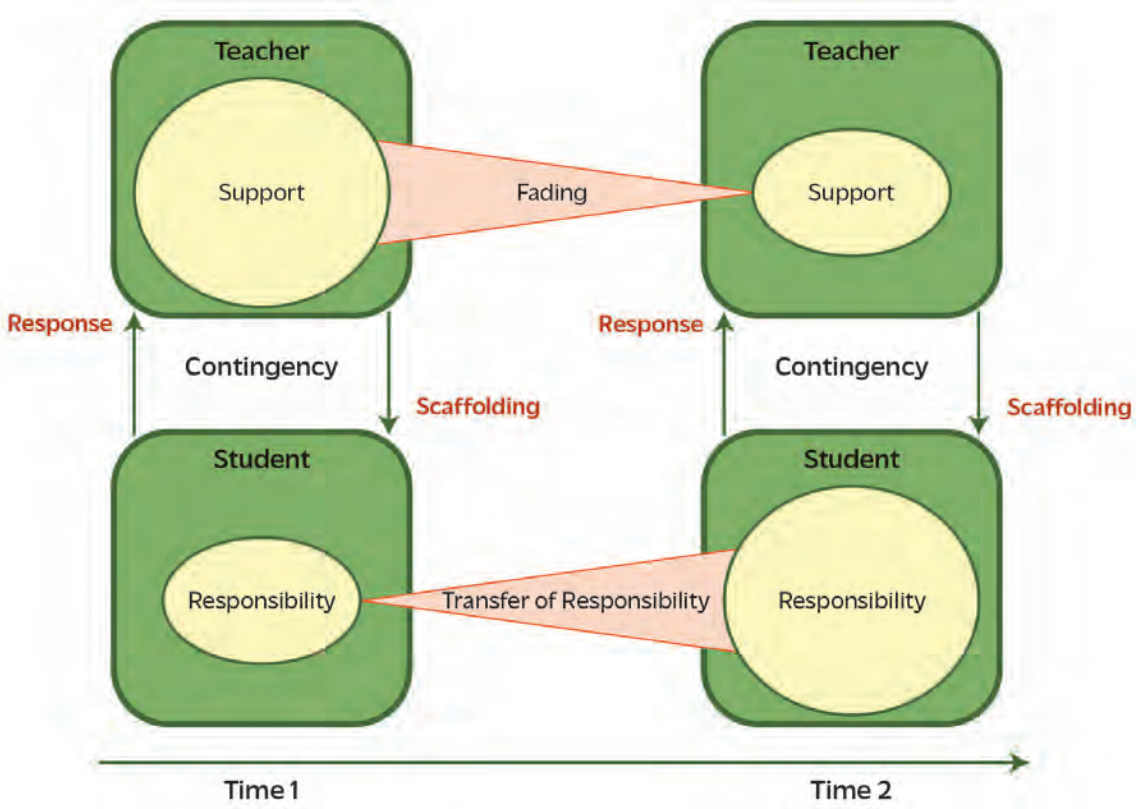
Fading
The process of gradually withdrawing teacher support as student learning progresses

Transfer of Responsibility
Shifting performance responsibility from the teacher to the student

attention to another developmental theorist, whose theory of cognitive development was fundamental in shaping our expectations regarding what children learn or are capable of learning at particular ages. As you will see, his theory is quite different from the work of Vygotsky, but still pivotal in shaping education.

Figure 2–6 Scaffolding

Scaffolding supports student learning by engaging in purposeful and meaningful usage of psychological tools. Through contingency, the teacher adapts instruction to the student's exhibited learning needs while providing a foundation just beyond the student's skill level for her to reach the desired outcome. As the student attempts the skill on her own, the teacher monitors her performance and provides sensitive feedback. Over time, the teacher minimizes assistance through fading, the dynamic moves from intermental to intramental, and the student moves toward independent practice, resulting in a gradual transfer of responsibility for learning from the teacher to the student.



Source: Adapted from Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher–student interaction: A decade of research. *Educational Psychology Review,* 22(3), 271–296. https://doi.org/10.1007/s10648-010-9127-6

Summarize and Reflect

1. Lev Vygotsky's sociocultural theory of development provides an emphasis on process, focusing on social interactions and language as mediators of cognitive change.
2. Cognitive development is driven by the primary process of *inter*mental change and then adapted as an *intra*mental process.
3. Vygotskian theory includes the concept of the zone of proximal development and its role in the educational process.
4. Scaffolding, instructions which supports the development of new skills within a student's zone of proximal development, allows students to accomplish what they are not sufficiently expert to do independently.

Informed Application

1. How can you use the concepts of intermental and intramental changes to best prepare a group of students to study abroad?
2. Explain what a teacher could do to provide instructional scaffolding specific to a given student.

2.4 Piaget and the Inquisitive Child

Jean Piaget was born the same year as Lev Vygotsky; however, unlike Vygotsky, he lived a long life (1896–1980). During his extraordinary career, he became one of the most prolific and influential scientists of the twentieth century, contributing much to our understanding of the developing child and greatly influencing education practice. Like Vygotsky, Piaget was interested in understanding the development of mental abilities (Piaget, 1952, 1954, 1959, 1963, 1970). Piaget's focus was children's active, inquisitive exploration of the world, and he used a descriptive observational method. His observations resulted in a detailed theory regarding *what* children and adolescents are able to accomplish cognitively at different ages, viewing cognitive development as an orderly sequence of stages. As mentioned previously, theorists using a stage approach divide the developmental process into discrete sections to help categorize and understand changes. Piaget divided the development of cognitive processes into four stages, each identified by qualitative changes in a child's thinking. Piaget believed that these qualitative changes in thinking were facilitated by the child's active exploration and attempts to understand the world.

(Adobe Stock)

Piaget's focus of study was children's active, inquisitive exploration of the world.

2.4a Equilibration

Piaget's quest to understand the developing mind resulted in a vast amount of research and observation. From this work, it became clear to Piaget that a child's cognitive development was far from haphazard; rather, key developmental processes systematically drove it. He believed cognitive changes result from three basic processes: *equilibration, assimilation,* and *accommodation* (Piaget, 1952). When our understanding of the world is adequate for making sense of the situations we encounter, Piaget theorized a state of **cognitive equilibrium** existed.

Cognitive equilibrium

The state in which our understanding of the world is adequate for making sense of the situations we encounter

Throughout our lifetimes, however, we are faced with the difficult task of changing our views in order to understand a new situation. For example, we may feel we are quite capable of explaining basic addition to a five-year-old child until we meet a child with significant learning problems. The child's inability to benefit from our explanation or demonstration may necessitate the development of new ways to view additive concepts. **Disequilibrium** is the state where our current understanding is insufficient to make sense of a new experience. In other words, no longer does our understanding of addition meet the demands of this new situation. In order to restore equilibrium, we must adapt to this new situation—a process that Piaget called **equilibration**. Piaget argued that individuals are inherently driven to correct a state of disequilibrium in order to adapt to new situations (Wadsworth, 1996).

Disequilibrium
The state in which our current understanding of the world is insufficient to make sense of a new situation

Equilibration
The restoration of equilibrium by adapting to the situation that had caused disequilibrium

Schema
Organized ways of understanding related elements

Assimilation
A process in which an existing schema is satisfactorily used to explain a new experience

Accommodation
A process in which an existing schema is altered to better account for a new experience

2.4b Assimilation and Accommodation

How does this adaptation take place? Consider a young boy who is studying magnets in his science class. During the course of the lesson, he plays with the magnet and the accompanying metal shapes. By the end of the lesson, he tells his teacher, "Magnets stick to metal." At this point, we would say the boy has organized certain experiences into an understanding of magnetism. This is what Piaget called a **schema,** or an organized understanding of related elements. The next day the young boy finds his magnet and proceeds to "stick" the magnet to other types of metal around the classroom. He sees that the magnet is attracted to the teacher's filing cabinet and the metal door in much the same way it was to the items in the magnet kit. This illustrates the process of **assimilation**, or when an existing schema is satisfactorily used to explain a new experience. Here, the boy's observation that the magnet sticks to different metal items around the class affirms his understanding of magnetism developed the previous day. His understanding of the world and his experiences are in equilibrium. When he tries to put the magnet on the chrome chair, however, his schema regarding magnetism no longer works. This time the magnet falls to the floor. He tries to place the magnet on the chair a second time with the same result. He runs to his teacher and tells her, "Magnets don't stick to chair metal." This experience exemplifies the process of **accommodation**, whereby an existing schema is altered to better account for a new experience.

In the Classroom

Applying Theory

Piaget

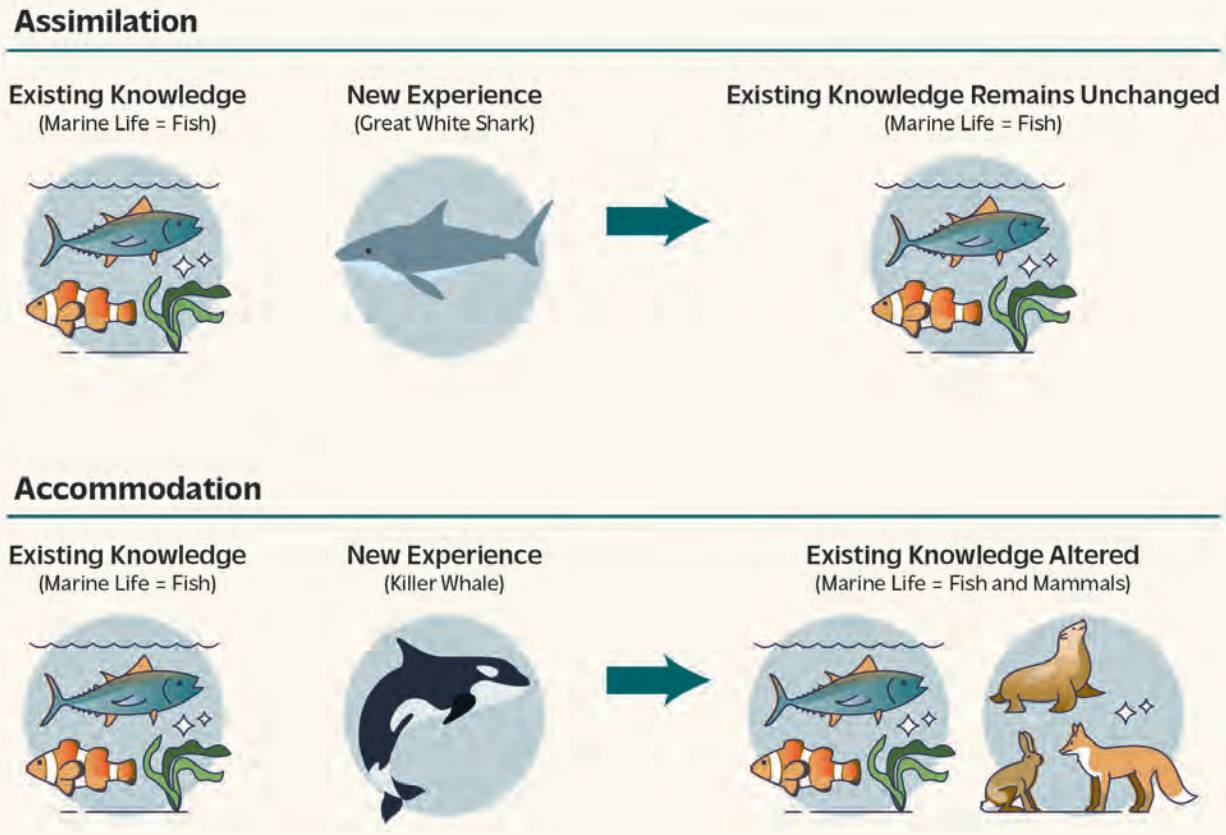
Theory Basics

Piaget's theory provides a mechanism for how students come to an understanding of new information. As new information is encountered, the student actively tries to make sense of the information. They compare the new information with information already known. Essentially, they ask themselves, "Can I understand this new information with the knowledge I currently have?" If their existing knowledge were sufficient to understand the new information, Piaget would say the student *assimilated* the information. If the student needed to make modifications to what they already knew, then Piaget would say that the student *accommodated* the information.

Classroom Application

Jennifer, a third grader who is learning about predators in the marine life section of her science book, has started reading about the great white shark. Her teacher explains that sharks are really just another type of fish, having gills and laying eggs like other fish. The next day, Jennifer learns about another type of marine predator, the killer whale. Her teacher explains that although killer whales live in the ocean, they are not actually fish but mammals. Like other mammals, they have lungs and breathe air and also give birth to live young.

In this example, Jennifer is able to assimilate the information about great white sharks because the information is similar to her existing knowledge about marine life. The information about killer whales, however, must be accommodated because Jennifer's current understanding of marine life does not allow for the presence of aquatic mammals.



(Adapted Adobe Stock)

Teachers: Consider the existing knowledge base of a student when teaching new information.

The nature of a student's knowledge has a direct impact on what they do when new information is presented. By thinking ahead, teachers can watch for those times when new information is qualitatively different from what the students already know. This can help the teacher present the information in a way that helps the students make the necessary adjustments (accommodations) to their thinking. Similarly, if new information is just an extension of existing knowledge, teachers can help students recognize the utility of using what they already know to understand the new information.

2.4c Organization

Using the processes of assimilation and accommodation, the developing child learns to adapt their thinking to their experiences. This allows enormous flexibility in how children establish their unique way of being in the world and also creates a constantly changing understanding of the world. According to Piaget, these cognitive changes are not stored randomly; rather, he saw humans as incredible organizers, who inherit a basic tendency to organize experiences and knowledge into meaningful associations.

Each new experience a child encounters results in new information. Sometimes experiences merely underscore the child's current understanding of the world (assimilation). Other experiences require the child to modify his current understanding in order to make sense of the new experience (accommodation). Either way, the child becomes more knowledgeable. Piaget believed that as we acquire new information and knowledge, we naturally look for connections to existing information. We look for similarities and differences between the old and new information, and consequently we move toward an understanding of the world that is a closer approximation of the complex world in which we live. For example, a preschool teacher might begin a lesson on shapes by identifying a yellow triangular-shaped block. The teacher points to the block and says, "Triangle." After a brief period of time the child can readily pick out the yellow triangle from a basket of other blocks. Several weeks later the teacher presents the basket of blocks to the child. The teacher has removed all the yellow blocks, but has included several green and blue triangles. The teacher asks the child to pick out the triangle. The child indicates that there are no "triangles" in the basket. Having carefully planned this instructional moment, the teacher readily explains that it is the shape of the block that makes it a triangle, not the color. The teacher continues the lesson, providing multiple opportunities for the student to practice the concept. The second part of this lesson presents the student with additional information about how to understand a certain aspect of his world. This new information is not retained by the child as a completely new and unrelated fact but as a piece of information related to other information already learned. As children acquire new knowledge, their relatively simple view of the world is gradually replaced with an organizational structure more closely corresponding to the richness and complexity present in the world around them.

In sum, using the fundamental processes of equilibration, assimilation, and accommodation, children build an organized understanding of the world. According to Piaget's research, children develop this organized understanding of the world, similarly, in a defined pattern of cognitive development. Piaget's account of this pattern, or his Stage Theory of Development, is discussed in the next section.

2.4d Stages of Development

Piaget based his theory of cognitive development on observations of children. The basis for his theory is simply that children change noticeably in the way they see the world as they get older. Piaget observed that younger children think, not just fewer thoughts, but also think *differently* than older children. Thus, a seven-year-old can solve problems that a four-year-old cannot, and a four-year-old makes errors in reasoning that a seven-year-old will not. Piaget theorized that these changes are based both in maturation and adaptation, with children becoming able to adapt in new ways as they mature. Piaget believed that all humans develop cognitively in the same sequence of qualitatively different stages—an idea termed **invariant sequencing**. While Piaget outlined typical ages at which children reach each of these stages, he also noted that individual children develop at different rates; and it is possible that some individuals may not move into the highest stages of cognitive development. We now turn to Piaget's four stages of cognitive development: sensorimotor, preoperational, concrete operational, and formal operations. Table 2–2 provides an overview of the stages followed by an in-depth look at each stage.

Invariant sequencing

The idea that all humans develop cognitively in the same sequence of qualitatively different stages

Table 2–2 Piaget's Four Stages of Cognitive Development

Piagetian Stage	Approximate Age Range	General Characteristics
Sensorimotor	0–2 years	▸ Object Permanence ▸ Intentional Behavior
Preoperational	2–7 years	▸ Symbolic Representation (Semiotic Function) ▸ Egocentrism ▸ Centration
Concrete Operations	7–11 years	▸ Conservation (Decentration/Transformation) ▸ Reversibility ▸ Classification ▸ Seriation
Formal Operations	11 years–adult	▸ Hypothetico-Deductive Reasoning ▸ Adolescent Egocentrism

Sensorimotor

The sensorimotor stage is so named because in this stage, the child's primary mechanisms for exploring the world are sensory and motor. Infants and toddlers think about their world through their ability to see and touch; therefore, much of early learning is directly dependent on a child's ability to actively interact with people and objects. During this early period of cognitive development, children achieve one of the first of Piaget's cognitive milestones, object permanence. **Object permanence** is the child's ability to mentally represent, or think about, an object after it has been removed from her field of vision or other senses. As an adult, it may be difficult to imagine a time when you did not appreciate that an object's permanence is independent of sight or touch, but this is a unique mental ability you acquired early in life. For most children, the beginning of an understanding of object permanence occurs during the first year (Bremner et al., 2015; Marcovitch & Zelazo, 1999). The presence or lack of object permanence can be observed by watching a child's behavior after an object has been removed from her field of vision. Children who have not yet acquired object permanence will typically treat the removal of an interesting object with indifference, not even looking for the object when it is gone. Quite simply, if it is out of sight, it no longer exists. Once a child has begun to achieve object permanence, she will look for the object, moving in a deliberate manner to reacquire it.

Object permanence
A child's ability to mentally represent or think about an object after it has been removed from his or her field of vision or other senses

Intentional behavior
Refers to the purposeful manipulation of the environment to achieve an outcome

The development of object permanence is directly related to a more general tendency toward intentional behavior. **Intentional behavior** refers to the purposeful manipulation of the environment to achieve an outcome. Early in the sensorimotor period, children fail to differentiate between the outside world and their own bodies, with self and the environment seen as roughly equivalent. As children develop, they become aware that they are able to control some aspects of the world and that there is a difference between self-control and manipulation of the environment. Through trial and error, children begin to develop better control over their bodies in the process of

(Adobe Stock)

Once a child has begun to achieve object permanence, most often during the first year, he will look for an object, moving in a deliberate manner to reacquire it.

manipulating the environment, consequentially becoming better able to interact with the world and meet their needs. Their behavior has moved from being almost random to being purposeful and goal-directed. These new mental abilities lay the foundation for the more sophisticated cognitive challenges acquired in the next stage of cognitive development, the preoperational period.

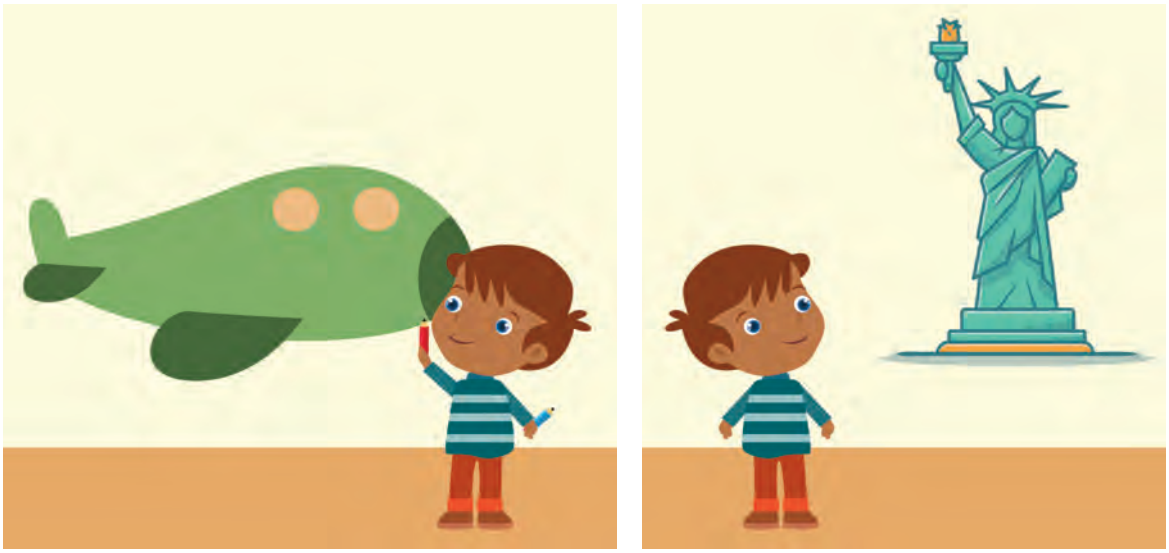
Preoperational

Operations
Our application of mental resources

When children enter the preoperational stage, they are not so dependent on actual experiences; instead, they develop better ways of representing things mentally (see Figure 2–7). Piaget referred to our application of mental resources as **operations**; thus children in the preoperational period are laying the groundwork necessary for the concrete operations developed in the next stage.

Figure 2–7 Preoperational Stage of Reasoning

Jimmy, a seven-year-old child, is in Piaget's preoperational stage of reasoning. He can easily use a concrete object like a pencil to play an imaginary game of "airplanes." Both the pencil and the airplane are within his direct experiences. He is not yet ready, however, to think about abstract concepts like "freedom." When presented with the word freedom, he thinks about its meaning in terms of concrete objects like the Statue of Liberty. He is not able to think about its relation to the general state of being free. This is because children in the preoperational stage still need to think about these concepts in terms of something they can see and touch.



(Adapted Adobe Stock)

Symbolic representation
The ability to represent an object or experience with a symbol

Semiotic function
The use of symbolic representation

One of the necessary steps toward the development of operations is **symbolic representation**, or the ability to represent an object or experience with a symbol. For example, when a boy uses his pencil to play "airplanes" with a classmate, he is using symbolic representation. Piaget referred to this use of symbolic representation as a **semiotic function**. A child's ability to use symbolic representation develops rapidly during the preoperational period (Gleason et al., 2000). This is especially true for language development, which is perhaps the most sophisticated use of symbolic representation.

Despite the dramatic development of symbolic thinking in the preoperational period, mental activity of children in this stage is still far from abstract. The thinking of the child in the preoperational period is still tied to symbols of actual objects (rather than abstract concepts) or immediate experiences, and problems are solved based only on what is actually perceived.

Piaget referred to children's thinking in this stage as **egocentric**, or the inability to view the world from someone else's perspective (Frick et al., 2014). This is commonly seen in children's play behavior (Ruffman & Olson, 1989). Imagine a young boy playing hide-and-seek with his father. The child diligently tries to find the ideal hiding place and exclaims loudly, "This table is a great hiding place." He then places himself behind the table, taking care to move his head so that he cannot see his father. What the boy fails to appreciate is that from his father's perspective, the father not only heard the child's comment regarding the hiding place, he could also see the child's legs under the table. This reliance on actual perception also leads to other errors in reasoning such as **centration**, or the inability to think of more than one aspect of a problem at a time. Like egocentric thinking, centration is a problem with being bound by one's perceptions. For adults and children alike, every situation has certain elements that capture our attention more so than others. When several adolescents enter the school cafeteria, for example, one person may immediately notice how many boys are in the room. Another member of the group may exclaim that it is pizza day, and yet another's attention may be drawn to the presence of the principal in the corner of the room. Each person in this example can be said to have found different prominent factors (or salient factors) in the cafeteria environment. As individuals grow, they develop greater facility in directing their attention and thoughts to factors other than those that may be more salient for the individual. The child in the preoperational period, however, is quite limited in this ability. Typically, they are drawn to the most salient aspect of a situation and have difficulty attending to other aspects of their environment (Flavell et al., 1989). This causes children in the preoperational period to center their thoughts and general mental ability on a single aspect of a situation, which is problematic if the situation requires a flexible perspective. Consider one of Piaget's classic problems used in his study of children's thinking, the conservation task (Flavell, 1963). The **conservation task** requires the child to consider two environmental factors at the same time to generate a correct answer.

Egocentric
The inability to view the world from someone else's perspective

Centration
The inability to think of more than one aspect of a problem at a time

Conservation task
A problem that requires a child to consider two environmental factors at the same time to generate a correct answer

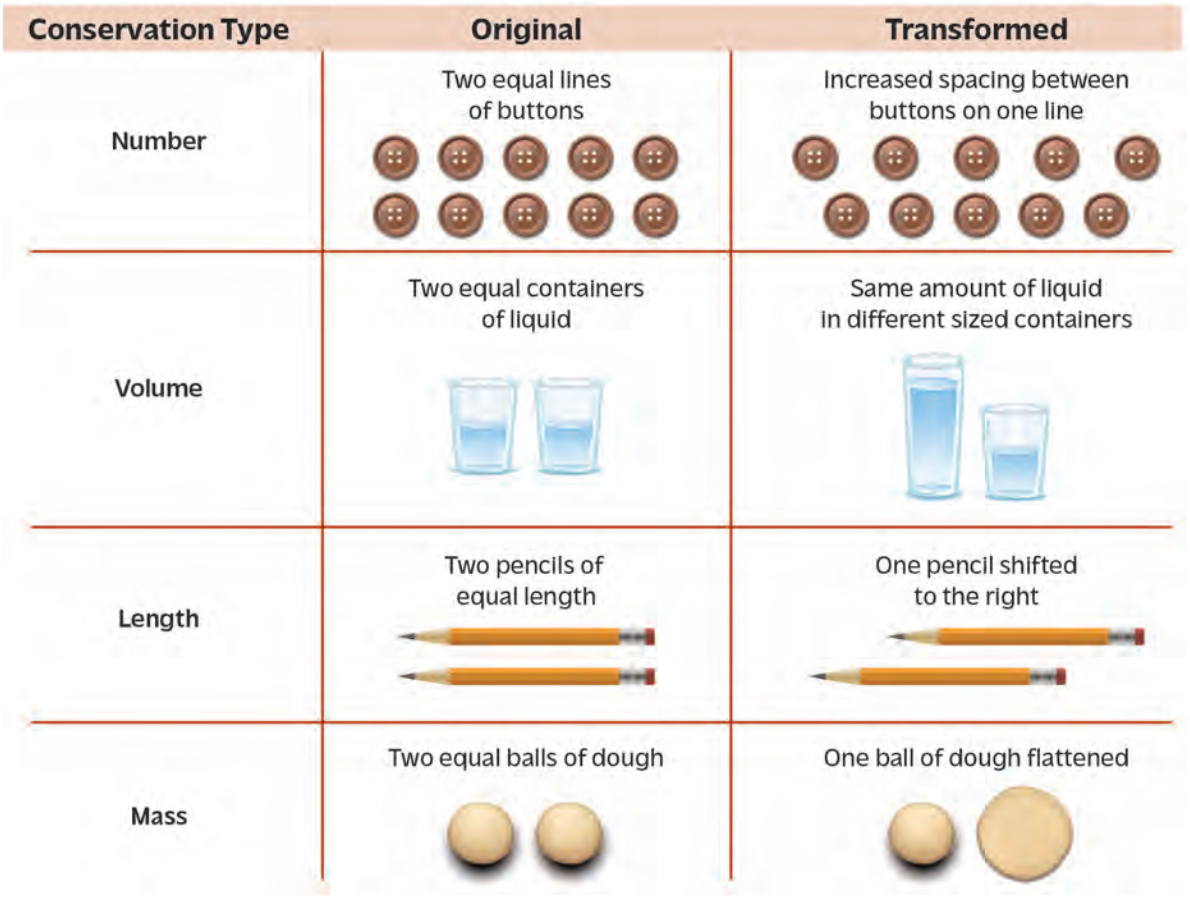
One version of the conservation task presents the child with two rows of five buttons (see Figure 2–8). Initially, the buttons are laid out evenly with the buttons in one row directly above the buttons in the other row. The experimenter then asks the child which row has the most buttons. Children typically respond with the obvious fact, that the rows have the same number of buttons. The experimenter then moves one of the rows of buttons, spacing them further apart and again asking the child to identify which row has more buttons. Children in the preoperational period are likely to respond that the row with the buttons spread out has *more* buttons. What is immediately salient for the child is the length of the row; and the child is bound by this perception, showing little facility to adjust his perceptions to account for both the number of buttons and the length of the row. To successfully reason through a conservation task, the child must *decenter,* or focus on more than one aspect of the problem at the same time. To answer the problem correctly, the child must attend to the fact that one row of buttons is longer *and* attend to the fact that there are still five buttons in the row. Without attending to both features, the child is unable to answer the question correctly.

In Figure 2–8, the child attended to the beginning and end states of the problem, deemphasizing the intermediate steps. In other words, the child attended to the row of buttons before and after they were moved, but failed to fully appreciate that these two states were achieved by moving the buttons, not adding any buttons. Piaget called this a problem with **transformation**, or having knowledge of the sequence of changes when a situation is transformed. For example, if a preoperational child watches a teacher using play dough, first forming a ball of dough and then rolling it out on the desk, the child is likely to tell her, "Wow, we have a lot more dough now!" The child attends to the initial ball of dough and the perceptually larger rolled out dough, but has difficulty appreciating the intermediate steps that would help her realize it is still the same amount of dough. Nothing was added or removed. In fact, if the child's teacher tells her to mentally reverse the sequence of events involved in the dough rolling, she is unlikely to be able to do so. That is, she has not yet achieved **reversibility**, or the ability to mentally represent and "undo" events in a logical sequence. These errors in reasoning experienced by children in the preoperational period are, however, temporary. Over time, children adapt their thinking to enable them to better operate within their world, and many reasoning errors characteristic of the preoperational period are resolved as the child moves into the concrete operational stage.

Transformation
The sequence of changes when a situation is transformed

Reversibility
The ability to mentally represent and "undo" events in a logical sequence

Figure 2–8 Conservation Task



(Adapted Adobe Stock)

Concrete Operations

Decenter

Change in thinking from focusing on the most salient features of the problem to a consideration of other relevant factors

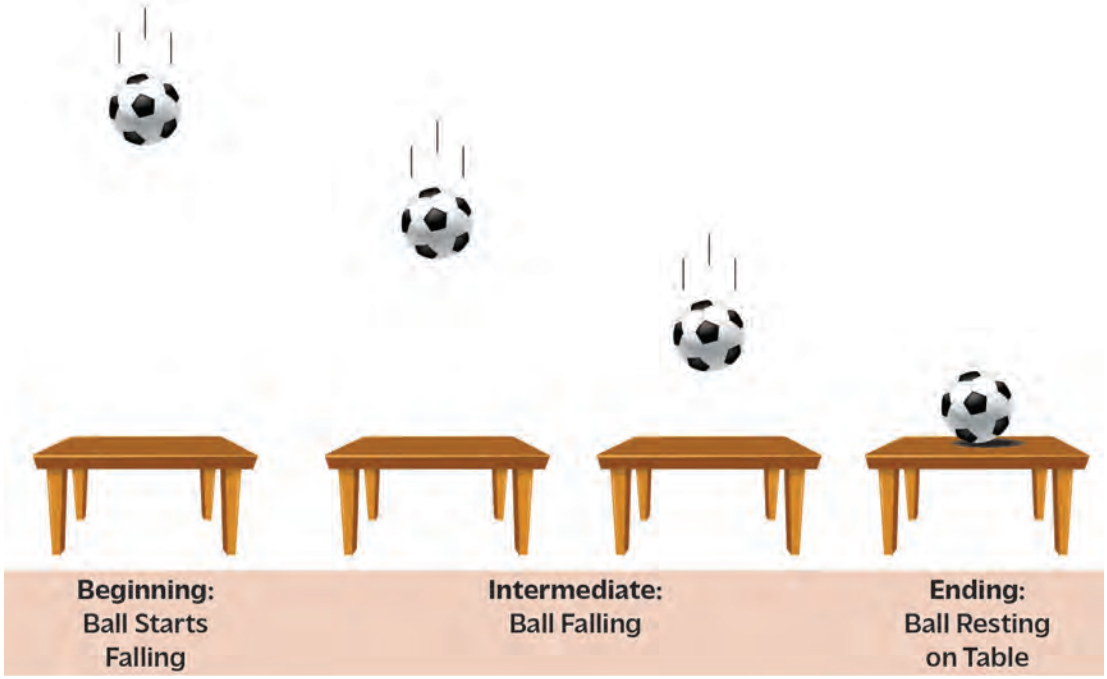
During the concrete operational stage, children move beyond strict ties to perception in favor of logical reasoning. As children gain a greater appreciation of the workings of the world, they are able to recognize perceptual irregularities and reason through situations where things are not as they appear to be by using logic. This is a significant step forward in mental ability and is made possible by the resolution of several issues prominent during the preoperational period. The child in the concrete operational period is now able to accurately solve problems of conservation. They are able to **decenter** their thinking from the most salient features of the problem to a consideration of other relevant factors. For example, when a child in the concrete operational stage is asked how many buttons are in the row with the buttons spread out, she recognizes that spreading out the buttons does not change the quantity and answers, "The number of buttons is the same, so both rows are equal."

This stage is also characterized by an ability to follow transformations from beginning to end. When a ball is dropped onto a table, for example, the concrete operational child is not only able to draw a picture of the ball at the starting and ending positions but at intermediate positions as well (see Figure 2–9).

Concrete operational children are also able to mentally reverse a transformation. Recall that a child in the preoperational period has difficulty holding a sequence of events in memory and logically reversing the sequence from end to beginning. Children in the concrete operational stage are able to make such two-way logical deductions. If given index cards with

pictures of the beginning, ending, and intermediate stages of the ball illustration above, a concrete operational child can place them in order from the end state, through the intermediate steps, to the beginning state.

Figure 2–9 Concrete Operational Stage Illustration



(Adapted Adobe Stock)

Children in the concrete operational stage also develop a far more elaborate structure for the classification of objects (Gelman et al., 2011; Kyhl, 1995). **Classification** is the ability to mentally organize observed similarities and differences in the environment. Instead of only having knowledge of simple categories, children are able to understand the complex relations between memberships in multiple categories. For example, a concrete operational child who is presented with a container full of buttons of different shapes, sizes, and colors can easily sort them by category. Additionally, they also understand that one category may include another; that is, some blue buttons may also fit within the large button category. This type of complex classification requires decentered thinking, as children must think about more than one aspect of the problem at a time. As children move through the concrete operational stage, they begin to develop more intricate category relations, allowing them to think about the world in new ways.

Classification
The ability to mentally organize observed similarities and differences in the environment

Another concept mastered during the concrete operational period is **seriation**, or the ability to arrange objects into an orderly sequence. Seriation applies to a variety of object dimensions, including length, mass, and volume. One of Piaget's classic seriation tasks involves presenting a child with a set of sticks of varying lengths (see Figure 2–10). The child is then asked to put the sticks in order from smallest to largest. Preoperational children have difficulty with this task, even when the solution is demonstrated for them. They either place the sticks randomly or are only able to order a pair of sticks at a time, creating pairs of small and large sticks. Children moving into the concrete operational stage begin to recognize that there should be an orderly progression in the heights of the sticks, ordering the tops of the sticks to create a continuous upward slope; however, they frequently ignore the bottoms of the sticks, which are not lined up on a straight horizontal. Finally, the child who has fully mastered

Seriation
The ability to arrange objects into an orderly sequence

concrete operations is able to complete the task accurately, recognizing that any one stick in the sequence has two important relations; that is, it is larger than the sticks before it in the sequence and yet, at the same time, smaller than the sticks coming after it in the sequence. This realization allows them to appropriately place the sticks in order.

Figure 2–10 One of Piaget's Classic Seriation Tasks

(Adapted Adobe Stock)

The new collection of mental abilities achieved in the concrete operational stage gives children the ability to more effectively operate in their world; however, the concrete operational period is so named because children can conduct operations only with things with which they have had concrete, or actual, experience. For example, a student may be able to understand the dynamic and complex interactions between fish and plants in their classroom fish tank. They have learned which fish can live well together, which plants play specific roles in maintaining a healthy aquatic environment, and which fish and plants will survive in this habitat. When asked questions regarding general principles of ecology and aquatic animal behavior, however, they are unable to extrapolate from their experiences, having knowledge only of their classroom fish tank. In order to be able to speculate about what might be true for as yet unexplored areas, they will need to master formal operations, which occur in Piaget's final stage of cognitive development.

Formal Operations

The formal operational stage is in many ways similar to the concrete operational stage. Individuals at this stage develop sophisticated classifications systems. They are also able to logically reason in forward and reversed directions. The fundamental difference in reasoning at the formal operational stage is that individuals are now able to use their reasoning abilities for situations with which they have had no direct experience. For this reason, formal operational reasoning is frequently referred to as "might be" reasoning, whereby individuals are able to apply their reasoning and problem solving to completely abstract issues. To help make the distinction between concrete operations and formal operations, consider the following example of a social studies teacher trying to explain the economic principles of import and export to a child in the concrete operational stage. The teacher explains that the history of the child's home state indicated economic prosperity depended on the state's development of trade agreements with neighboring states. States that failed to successfully develop import and export routes were economically unstable, given the limited resources available locally. When the child clearly understands the example, the teacher asks the child to explain how this situation might apply to the countries of Europe. European countries were studied the

previous term. The child attempts a solution but is unable to generalize his learning to the European context because his understanding of the process of importing/exporting is dependent on the example related to his home state. Now let's consider the same situation, but this time the student is an older adolescent in the formal operations stage. This student is likely to successfully generalize to the concept of importing and exporting to the European countries, not only because they understood the specific example, but also because they understood the essential *form* of this basic economic principle; hence, the name *formal operations*. In other words, the student's formal operational understanding of the economic impact of trade is independent of any specific example, which makes it possible to apply the general principle of importing and exporting in variety of situations. This type of flexibility in thinking is the hallmark of formal operational thought.

The ability to think independently of specific examples or context is important because it allows for general principles and methods of thinking. Individuals capable of formal operational reasoning are able to explore ideas that are completely hypothetical. For example, **hypothetico-deductive reasoning** is the ability to speculate about how a particular situation functions and then test the prediction or guess (Inhelder & Piaget, 1958; Kuhn et al., 1988). Let's say that a student is assigned a project involving discovering the necessary environmental factors for plant life. The student is not allowed to use outside references but is required to solve the problem through observation. If the student is capable of formal thought, then they are likely to begin the project by first developing a series of **hypotheses**, or educated guesses, as to what constitutes a necessary factor to sustain plant life. Perhaps one hypothesis might be that light is necessary for plants to live. Following this prediction, the student devises a systematic approach to investigating the hypothesis. The student decides to put one plant outdoors in direct sunlight, an identical plant in partial shade, and a third plant under a cardboard box in complete darkness. Based on the results of this investigation, the student *deduces* whether light is necessary for plant growth. She then turns her attention to her next hypothesis regarding plant life. Her systematic approach to the problem indicates she has internalized the basic hypothetico-deductive process, enabling her to speculate about possible outcomes and test ideas accordingly.

Hypothetico-deductive reasoning

The ability to speculate about how a particular situation functions and then testing the prediction or guess

Hypothesis

An educated guess as to the outcome

(Adobe Stock)

Individuals capable of formal operational reasoning are able to explore ideas that are completely hypothetical so they can speculate about how a particular situation functions and then test the prediction or guess.

While it is beneficial to be able to reason about the possible outcomes of a particular situation without having to wait for the situation to actually resolve, individuals in the early stages of formal operations often use this newfound ability in a more universal way than is actually productive. Adolescents moving into the formal operations stage are likely to vigorously argue points of politics, religion, or morality based on ideas they have been able to deduce through logic. These logical deductions appear to them to be flawless and as immutable as actual reality; however, they often fail to recognize potential validity of other perspectives. Piaget referred to an adolescent's focus on their own thoughts and the inability to see the perspective of others as **adolescent egocentrism**. It is important to recognize that this is not the egocentrism observed in preoperational children. In the preoperational period, children simply fail to understand that there is any difference between another's perspective and their own. Adolescents recognize that others have a different perspective. The difference in the two types of egocentrism is that adolescents are often so convinced by their own logic that they assume anyone who challenges their reasoning is demonstrating flawed judgment. They fail to recognize that there may be factors of which others are aware that they (the adolescents) have not considered or assumptions, which they have made, that are not valid. If an adolescent recognizes that others have a different perspective, but they invalidate that perspective, it makes it difficult to benefit from that perspective. In a functional sense, they are also being egocentric since they are not benefiting from the perspective of others. Research indicates that this type of reasoning may extend into early adulthood (Frankenberger, 2000).

Adolescent egocentrism

An adolescent's focus on his or her own thoughts and the inability to see the perspective of others

However, as individuals progress in their mastery of formal operations, they become better able to understand that multiple perspectives exist with regard to abstract problems, and their thinking becomes less egocentric. Piaget's notion of adolescent egocentrism helps explain the idealism and questioning of authority that may occur during adolescence; and while this may not make it easier to relate to adolescents, it does help to inform our understanding of adolescent behavior and its relation to cognitive development.

2.4e Evaluating Piaget's Theory

Piaget's theory is unquestionably one of the most influential developmental theories, and his ideas have strongly impacted our educational methods (Beilin, 1992; Voyat, 1998); however, this does not mean that Piaget's ideas and research go unchallenged. There is a growing body of research that qualifies, and at times contradicts, some of Piaget's tenets. The most commonly cited of these criticisms is that Piaget's theory underestimates the competence of children (Baillargeon, 1987; Gelman & Baillargeon, 1983; Gelman & Ebeling, 1989; Siegal, 1991).

Underestimating the Abilities of Children

Recall that Piaget based his theory on observations of children as they engaged in a variety of cognitive tasks, which he believed tested certain cognitive abilities. Newer studies—which have modified Piaget's instructions, simplified questions, or otherwise made tests more available to children—suggest that younger children are more capable than Piaget thought. For example, Baillargeon (1987) developed a different object permanence task that used the child's indication of surprise, rather than an active search for an object, as the indicator of the child's understanding of object permanence. This approach produced evidence that children as young as three to four months of age have an appreciation of the permanence of objects. Other studies have found similar findings of children meeting milestones at ages earlier than Piaget predicted. For example, Moll and Meltzoff (2011) found that three-year-old children were capable of taking the viewpoint of someone else, decentering from their own. It is important to note, however, that newer studies that alter Piaget's tasks may not necessarily be measuring the same things Piaget was assessing; and the information obtained, therefore, might not contradict, as much as expand or refine, Piaget's ideas (Lourenco & Machado, 1996).

Overestimating the Abilities of Adolescents

Piaget's theory has also been criticized for failing to capture the distribution of skills present in adolescents and young adults. Based on Piaget's theory, individuals begin moving into the formal operations stage around the age of eleven. His theory, however, is somewhat misleading because additional studies indicate that few individuals may ever actually show formal operational thinking (Babakr et al., 2019). Studies have shown that only 50–60 percent of eighteen- to twenty-year-olds were adept formal reasoners (Commons et al., 1982). Thus, Piaget's ideas regarding the typical age at which formal operational thinking is reached may have overestimated the abilities of adolescents and adults. Research also provides evidence for an upward trend in the percentage of thirteen- to fifteen-year-olds proficient with formal reasoning, with a 1967 study finding that 5 percent were mature formal operators and a 1996 study finding that 15 percent were consistently able to reason at a formal level (Flieller, 1999). This increase in the percentage of formal thinkers was attributed to a greater tendency for teachers to instruct with tables and structural diagrams that require more formal types of thinking, suggesting that formal operational thinking may be influenced by education more than initially proposed by Piaget.

Cognitive Development and Culture

Another often cited criticism of Piaget's work is his tendency to ignore the impact of social interactions and culture (Broughton, 1981; Buck-Morss, 1982; Winegar & Valsiner, 1992). Although a careful review of Piaget's work indicates an ongoing concern with the impact of social interactions (DeVries, 1997), he did not articulate a clear mechanism for how social interactions and culture affect cognitive development. Studies specifically examining Piaget's theory across cultures have generally supported the order of Piaget's stages, but have found cultural differences in the rate of progression through the stages (Hughes & Noppe, 1991; Leadbeater, 1991; Rogoff & Chavajay, 1995). Studies also indicate that there may be differences in rate of progression through stages between socioeconomic groups within a particular culture (Case, 1975). These findings suggest that culture may play a more central role in development than Piaget's theory assumes.

(Adobe Stock)

Early social interactions and culture affect cognitive development.

Limited Explanations for Cognitive Changes

Piaget has also been criticized for developing a theory that is predominantly descriptive and providing little explanation for how changes in cognitive development occur (Boden, 1979; Campbell & Bickard, 1986; Flanagan, 1992). He argued, however, that before we can engage in a productive search for an *explanation* for cognitive development, we first need an account of *what* those changes are (Piaget, 1974). Piaget did, however, attempt to develop a complete theory of cognitive development, including how the process occurs. Recall his thoughts on mechanisms of change (equilibration, assimilation, and accommodation) outlined earlier in this section.

Extending Piaget's Theory: Neo-Piagetian Theory and Brain Research

Many of today's theorists continue to find Piaget's basic tenets a useful framework for understanding development. A growing group of researchers, generally referred to as **neo-Piagetian theorists**, attempt to retain much of Piaget's original insights and to extend those insights to better account for the latest research findings. Most neo-Piagetian theorists maintain the stage-like approach proposed by Piaget, but they have refined what defines a stage. Rather than viewing development as a stage, which generally corresponds to years of age, newer research (Case, 1998, 1992; Chuechote et al., 2020) has supported the idea that stages exist within a specific domain, such as motor development, math ability, or social ability. Development within one domain does not necessarily indicate development in other domains, and there is much variability in individual strengths and weaknesses. Using chronological age as a benchmark for development is therefore problematic because it may or may not apply to all domain areas.

Neo-Piagetian theorists

A group of researchers attempting to retain much of Piaget's original insights and to extend those insights to better account for the latest research findings

Current theorists also add to Piaget's conceptualization of maturation, equilibration, and assimilation/accommodation as driving forces behind developmental changes. One information-processing theorist, for example, proposes that as children learn from their interactions with the world, they develop rules for understanding. These rules are later challenged by new experiences that do not completely conform to the rule. This requires the individual to engage in rule assessment to develop rules more consistent with current experiences (Siegler, 1998). Not unlike assimilation and accommodation, this approach encourages teachers to

provide educational experiences that challenge children and provide them with a vehicle for change. Other researchers in the area of cognitive psychology are also beginning to provide a more specific account of how cognitive development progresses in such areas as memory, problem solving, and attention, allowing us to expand on Piaget's seminal ideas and better understand the way cognitive development influences teaching and learning.

Recall from the developmental neuroscience section (see earlier section of this chapter) that brains change as a function of experience, a finding that is consistent with Piaget's idea: Children develop cognitively as a function of experiences, which challenge their cognitive equilibrium. Also consistent with Piaget's theory is the research indicating that brain development is most prolific during childhood. In fact, some neuroscience studies have shown correspondence between periods of brain growth and changes in cognitive development, providing support for Piaget's stage theory of cognitive development. For example, research indicates that brain growth peaks can be seen between the ages of two to four, six to eight, ten to twelve, and fourteen to seventeen (Epstein, 1974, 1977); these ranges are quite similar to those proposed by Piaget. Developmental changes in the electrical activity of the brain (Hudspeth & Pribram, 1990), as well as changes in cortical organization (Thatcher et al., 1987), have also been shown to correspond with Piaget's stages of cognitive development. Some researchers have measured brain functioning during children's completion of conservation and categorization tasks, which indicate developmental changes in brain activity between conservers and nonconservers (Houdé et al., 2011), and concrete and formal operational thinkers (Van der Molen & Ridderinkhof, 1998). While this research does not prove that Piaget's theory is without flaws, it does provide a physiological basis for understanding the cognitive changes that occur during development. Additionally, some research has helped to clarify aspects of Piaget's theory, such as one study which demonstrated that adult brains still show certain activity patterns indicating they have not fully overcome earlier cognitive limitations (Leroux et al., 2009).

Piaget's theory, while not without problems, is eminent, and his ideas continue to exert influence in both psychology and education. Now that we have explored Piaget's theory at length, let's consider the application of his theory to educational practice.

2.4f Piaget and Developmentally Appropriate Instruction

Piaget's theory has greatly influenced education over the last fifty years, inspiring curriculum reform and greatly changing education practice (Case, 1985). His descriptions of cognitive skills attained at different ages are often used as a foundation for deciding developmentally appropriate methods and curricula (Hanfstingl et al., 2019; Hinde & Perry, 2007; Ojose, B., 2008; Wavering, 2011). His theory also provides instructors with a general approach to motivating students to learn.

Use Disequilibrium to Motivate

Recall that according to Piaget's theory, a child becomes motivated to learn when his representations of the world are challenged by new, conflicting information. Piaget referred to this as a state of disequilibrium and argued that children have a natural tendency to find ways to alter their existing schemas so they can incorporate the new information. This returns them to a state of equilibrium. This is an important point to consider when providing "developmentally appropriate" instruction; that is, instruction should be tailored to challenge a child's existing schema by producing disequilibrium (Walsh, 1991). In order to optimize the construction of

knowledge, teachers must challenge children to go beyond existing mental structures, so that the equilibration process begins. The following example illustrates instruction that challenges a student's existing classification schemes. The teacher gives May, a five-year-old child in the preoperational stage, a yellow car and asks her to choose another similar toy from the toy box. May is able to do so with ease, choosing a yellow yo-yo. When asked to pick another similar toy, she chooses a round wooden block because it is similar in shape to the yo-yo. The particular feature May pays attention to changes based on whatever feature is most salient for her at the moment. She pays little attention to maintaining a grouping based on a common feature (e.g., picking only cars). In order to challenge her toward disequilibrium, the teacher might plan a lesson whereby the goal is to group several objects into a set based on function. This requires May to focus on a particular similarity across a group of objects, rather than whatever happens to be most salient for her at the time. This challenges her existing cognitive structures regarding classification of objects and motivates her to learn.

Appreciate the Construction of Knowledge

Piaget's theory is also notable for his view that children actively construct knowledge of the world through active exploration (see Chapter 12). Since the publication of his theory, this idea of knowledge construction has developed steadily and is becoming a primary area of focus in education. While all teachers should strive to develop appropriate instructional methods, Piaget has taught us that it is equally important to pay attention to the learning process from the perspective of the student. Learners are not merely passive recipients of the knowledge taught by the instructor but are actively constructing their understanding. For example, in his high school health class, Michael completed a lesson designed to help him understand the importance of fats in his diet. Michael reflected upon this information and decided that he did not consume enough fat. Over the course of the next few weeks, Michael began to shift a greater portion of his total calories to fats. In fact, he reasoned that if he really ate a significant amount of fats, his health would improve proportionately. About a month later, Michael began to notice that his weight had increased substantially, and he had less energy. This example demonstrates that what is taught and what is learned are not necessarily the same thing. Although the health teacher provided accurate information on nutrition and dietary fat, instruction is only part of the learning equation. Michael's knowledge construction is another important factor. Rather than passively learning the facts being taught, he attempted to integrate the information into his own life, applying the information in a way that seemed appropriate. Besides providing facts and information, developing meaningful contexts, which are learner focused, better allows students to construct their own knowledge.

Interconnections

The instructional implications of knowledge construction are discussed in Chapter 12

Build Understanding

In addition to providing us with a student-centered perspective on learning, Piaget also stressed the importance of understanding learning as a building process. An art teacher may want her students to paint their interpretation of Van Gogh's *Sunflowers*, but she will have to start by teaching some basic painting principles. The novice begins the learning process by developing an appreciation of the basic learning elements in that domain. In the art class, the teacher will likely need to begin with basics such as lighting, perspective, and brush techniques. Each one of these will require a complex dynamic between teaching and learning. They will also require the student to build meaningful relationships between each element to become an effective painter. Teachers must facilitate learning by providing a solid foundation

of information, as well as providing support for more advanced content integration. Piaget's theory clearly indicates that it is impractical for the teacher to begin at the highest level of skill; rather, building and integrating skills is the key to effective learning.

(Adobe Stock)

An art teacher must teach basic painting principles before having her students paint something more complex.

2.4g Piaget and Vygotsky: Important Comparisons

Despite considerable attention in the scientific literature on the differences between Piaget and Vygotsky, there are actually many similarities between their theories (Shayer, 2003). Fundamentally, both theorists are constructivists (Fowler, 1994; Siegler & Ellis, 1996; Walsh, 1991). Both theories have, as central tenets, the idea that knowledge and learning are active processes and that each child constructs his own understanding of the world. Further, they both discuss the role of social interaction in development, including interpersonal interactions, cultural interactions, and historical influences (DeVries, 1997; Piaget, 1965; Piaget & Inhelder, 1966; Vygotsky, 1981). They differed, however, in how central the social processes were in cognitive development. While Vygotsky placed social interactions at the center of his theory, Piaget was less specific about how social interactions influence development. Winegar and Valsiner (1992) suggest that Piaget and Vygotsky differ in *contextualizing* development in a social world versus developing a *contextual* approach. Piaget's theory follows a contextualizing approach, which means that development is influenced by social interactions but is, nevertheless, a distinct process that is driven by the child's exploration of the world. Piaget saw the importance of considering the context in which a child develops, but he emphasized that development is still primarily occurring within, and because of, the child. Vygotsky's contextual approach, on the other hand, places no such boundary between the social world and an individual's development within that context. He saw individuals as deriving their thinking from larger societal patterns of thinking, and, therefore, saw distinguishing between the two as unnecessary and inappropriate.

Piaget and Vygotsky also emphasized different types of social interactions. Piaget believed that interactions between peers produced the strongest influence on development. He theorized that conceptual differences between peers are likely to lead to disequilibrium and subsequently to adaptations in thinking. He believed interactions with adults were problematic because children would be less likely to engage in adaptive behaviors, preferring to simply accept the adult's point of view, given their superior status in the social dynamic. Vygotsky had a very different perspective on interpersonal interactions. He believed that an individual's

way of thinking is derived from social interactions with someone who is more knowledgeable. Adults, by virtue of their greater experience, are likely to have mental skills the child has yet to internalize; therefore, the adult is in a unique position to facilitate the child's cognitive development. Another child, according to Vygotsky, is likely to have similar cognitive structures and can therefore offer little in terms of furthering development (Tudge & Winterhoff, 1993).

While the theories of Vygotsky and Piaget have fundamental differences, they can be used in a complementary manner (Fuson, 2009), as can be seen in the constructivist approach to teaching and learning. In contrast to the behaviorist view that was pervasive in education in the early and middle 1900s, the constructivist perspective views the role of the learner as dynamic and active in cognitive development. The theories of both Piaget and Vygotsky embody this perspective, without minimizing the importance of a learner's interactions in the environment. For Piaget, these interactions involve active exploration of the environment and symbolic representations of the world. For Vygotsky, the interactions with the environment that shape thinking are social and language based. In the next section we will further explore language, arguably the most complex symbolic representation system we use, and the foundation it plays in complex social interactions.

Summarize and Reflect

1. Jean Piaget developed one of the most influential theories of cognitive development.
2. According to Piaget, children seek to maintain equilibrium between their schema and their experiences through the processes of assimilation, accommodation, and equilibration.
3. Piaget's theory has four cognitive stages of development: sensorimotor, preoperational, concrete operational, and formal operational. These stages highlight characteristic patterns of thinking exhibited within each stage.
4. Piaget's theory has implications for developmentally appropriate instruction.
5. Comparison of the theories of Piaget and Vygotsky emphasizes the importance of both theorists in the development of the constructivist teaching approach.

Informed Application

1. Describe how a teacher can use disequilibrium to motivate a student to advance their understanding of gases, liquids, and solids.
2. First, define hypothetico-deductive reasoning, then provide an example of this important type of reasoning.

2.5 Language Development

Language, as our instructional vehicle, is unavoidably linked to the process of education. Symbols, such as the alphabet or the number system, are a written form of language; and much of our educational system is based on teaching children to use these symbols effectively. Further, language may play a primary role in cognitive development, as Vygotsky theorized. This underscores the importance of teachers having a solid background in the development of language. The next section presents language fundamentals and connects language development to the instructional process.

2.5a Components of Language

Semantics
The meaning of words

Language is communication of ideas using symbols. These symbols may be spoken, written, or expressed in a manual form of communication such as sign language. For example, the word *cat* symbolizes a specific small, furry animal. Understanding the meaning of words is referred to as **semantics**—the first of the five components of language we will cover (see Table 2–3). When we speak the word *cat*, we are semantically representing the idea of this animal through *expressive* language, or language production. To understand or comprehend the word *cat* when it is spoken, one uses *receptive* language.

Table 2–3 The Five Components of Language

Language Production	Phonology	Morphology	Syntax	Semantics	Pragmatics (including discourse)
Listening (spoken language) When listening, able to ...	Identify and distinguish phenomes	Understand morphemes	Understand elements of sentence structure	Use listening vocabulary	Understand the social aspects of spoken words and conversation
Speaking (spoken language) When speaking, able to use ...	Appropriate phonological patterns	Correct morphemes	Correct elements of sentence structure	Speaking vocabulary	Cohesive and relevant language in conversation and social situations
Reading (written language) When reading, able to understand ...	Associations of letters and sounds	Grammar	Sentence structure	Reading vocabulary	Point of view and audience needs
Writing (written language) When writing, able to ...	Accurately spell words	Use appropriate grammar	Use correct sentence structure	Use writing vocabulary	Convey intended message and point of view

Source: Adapted from American Speech-Language-Hearing Association. (2022, September). *Language in brief*. ASHA. https://www.asha.org/practice-portal/clinical-topics/spoken-language-disorders/language-in-brief/. Copyrighted by the American Speech-Language-Hearing Association (ASHA).

Syntax
The order of words to create meaning

Phonology
The sounds in speech

Morpheme
The smallest unit of meaning in a language

Words are not the only way we can represent ideas. **Syntax**, our second component of language, is our ability to put words together in a certain order to represent more complicated ideas. For example, "The cat ran from the dog" has a very different meaning from "The dog ran from the cat." Changing single words in minor ways can dramatically affect meaning. In spoken languages, letters represent certain sounds, or phonemes. **Phonology** is our third component of language and refers to speech sounds. Phonemes have no meaning when standing alone; for example, the letter *c* in the word *cat* is meaningless by itself. Change the *c* to an *r*, however, and the meaning of the word, and the sentence, changes. The fourth component of language is **morphemes,** or the smallest unit of meaning in a language, such as the affixes placed at the beginning or ending of word stems (e.g., *ed, ing,* and *un*). Morphemes can be single letters or combinations of letters. Adding the letter s to the word dog, for example, changes the number of animals represented because in English, adding s to the end of a noun

usually makes the noun plural. The fifth component of language involves the social aspects of communication, or pragmatics. **Pragmatic language** allows us to communicate appropriately within a given context, such as taking turns in a conversation, standing an appropriate distance away from the person to whom we are speaking, and providing feedback to indicate that we are listening. Before we review these components in more detail, let's first look at two general theories about the acquisition of language.

Pragmatic language
Using verbal and nonverbal cues appropriate to a given context

2.5b Language Acquisition Theories

The question of how we acquire our incredibly complex language ability is frequently debated. We know learning plays a role in the development of language, because we are not born with the ability to produce or understand it. Yet, while learning clearly plays a role, maturation also appears to be important. Children worldwide acquire language in the much the same way and at about the same time, regardless of culture or language structure, suggesting a biological influence.

Reinforcement versus Maturation

The idea that we learn language exclusively via the behavioral learning principles of imitation and reinforcement, as proposed by B. F. Skinner in the 1950s, is difficult to support (Skinner, 1957). Skinner's idea was that language or verbal behavior was no different than any other aspect of our behavior. It is controlled by the same reinforcement and punishment principles (see Chapter 4). This view, however, has been challenged as providing an incomplete view of language learning (Chomsky, 1967). While the average two-year-old has about two hundred words in her expressive vocabulary (words that she has clearly been exposed to), there are an infinite number of ways in which these words can be put together. Even very young children produce original sentences—saying things that they have never heard before or been rewarded for, such as "Truck fast" or "Here, Mommy, cake." This indicates that more than imitation and reinforcement are operating in the development of this generative aspect of human language (Chomsky, 1965). The linguist Noam Chomsky became world famous in the 1960s by proposing that humans come into the world prewired to acquire language, possessing what he called a language-acquisition device (LAD). His theory that humans are born preprogrammed to acquire language, or the Nativists' perspective, emphasizes the role of biology and maturation—the nature side of the nature-nurture debate.

According to his original ideas, humans are born with an innate understanding of the basic functions of language. He referred to this as the deep structure of language. Deep language structure was then translated into our overt language (the surface structure) based on the language used in our particular cultural environment. This process was called transformational grammar (Chomsky, 1957). This theory directly contrasts the behaviorist notion that the environment, or nurture, is responsible for the acquisition of language.

Another developmental phenomenon, which points to maturation as an important process in language acquisition, is the fact that children develop language at a phenomenal rate. At around eighteen to twenty-four months, children experience a tremendous increase in vocabulary, learning up to twenty new words per week (Reznick & Goldfield, 1992). The average two-year-old, with her two-hundred-word vocabulary, will have learned to recognize around ten thousand new words by the time she enters first grade, and thirty thousand more by the time she reaches fifth grade (Anglin, 1993). This rapid and exponential growth in language in the first few years of life differs from second language learning later in life, a point to which anyone taking a foreign language in college can attest. Eric Lenneberg, in the 1960s, tried to explain this later difficulty with learning language, proposing that we

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Children develop language at a phenomenal rate.

have a window of opportunity for acquiring language easily. He proposed a critical period in language development, a window of opportunity that is strongest initially early in early childhood and ends around adolescence. Lenneberg based his ideas on research findings with individuals who had brain injuries in the language areas of the brain, causing loss of language skills, a clinical condition known as **aphasia**. Adults with aphasia, Lenneberg noted, require intensive therapy to reestablish even rudimentary language skills, while children with aphasia often recover in a manner that appears effortless. Since the development of the critical-period hypothesis, many studies have been completed that support the idea of a window of opportunity in language development, at least for acquiring syntax (Hoff, 2001; Patkowski, 1980). Many contemporary theorists, however, prefer to refer to this window as a sensitive, rather than critical, period in development. The fact that we can learn second languages in adulthood, for example, even if it is effortful, indicates the window of opportunity never really closes.

Aphasia

A clinical condition in which language skills are lost due to injury in the language areas of the brain

Interactionist Perspective

Many contemporary theorists believe that maturation and learning interact significantly in language development (Bohannon & Bonvillian, 1997; Rice, 1989; Tomasello, 1995). They argue that humans, as a species, are indeed biologically predisposed to learn language easily early in life and in relatively the same way. We learn language easily, not because of a language acquisition device, but rather for the same reason that we all develop cognitively in much the same way, because we all have brains that develop, or mature, in a similar manner. What we learned of brain development in the developmental neuroscience section of this chapter supports this interactionist view of language development. Recall that research indicates infants come into the world biologically primed to make synaptic connections in their brains as a function of experience, in this case exposure to language. Also supporting this biological predisposition is the finding that most people use the left hemisphere for processing language (Pujol et al., 1999). Thus, most people have highly organized areas of neuronal connection existing in the same location in the brain, suggesting that, as a species, we may have specific neurons that are genetically preprogrammed to make connections when exposed to language.

Finally, several other processes also interact with maturation and learning in the development of language, including cognitive, motivational, and social factors. For example, research shows that language development and cognitive development are strongly linked with children's use of language, adapting along with their changing understanding of the world (Engel de Abreu et al., 2011). Language also serves a social, communicative function. We are motivated to use language not only because we want to express our ideas and understanding of the world but also so that others can understand our ideas. We may learn to use grammatically correct sentences, for example, because it is necessary for us to interact with others socially (Bates, 1999). In line with Vygotsky's ideas regarding cognitive development, many integrationists believe that the process of a child's interacting with others who are linguistically more sophisticated initiates the development of the brain's language centers, which in turn allows the child to interact in new ways (Bloom et al., 1996). In the next section, we will explore language in the classroom, where the complex interaction of biological, environmental, cognitive, and social factors in the development of language is easily seen.

Max Palen

"The reinforcement theory seems reasonable, but I don't understand the maturation view. According to this view, is reinforcement meaningless?"

Professor Campbell

"Many contemporary linguists recognize the importance of both processes. Imagine putting your clothes away in a closet without any shelves. This would be a fairly disorganized process. Now imagine putting clothes in a closet with built-in shelves. The process would be much more organized and efficient. Maturationists simply proposed we have built-in shelves for language. We can still be reinforced for what goes onto the shelves."

2.5c Language and Linguistic Diversity in the Classroom

Language develops in much the same way and at about the same time for most people. Like Piaget's cognitive stages, language learning proceeds through a series of developmental milestones (e.g., first words, joining words, etc.) (Table 2–4). Language milestones are based on normative data, however, and should be used cautiously when charting an individual child's progress regarding language development. Teachers should, however, have a basic understanding of linguistic trends. Moats and Lyon (1996) assert that "a new approach to teacher education is needed that emphasizes the importance of language knowledge for literacy instruction, as well as its skilled application to instructional planning" (p. 73). In this section, we will focus on language development in the preschool and school-age period, exploring the classroom significance of each of the five components of language outlined earlier.

Anne Rome

"That makes sense, but explain how this perspective is supported by neuroscience research?"

Professor Campbell

"One of the best sources of research evidence supporting that we are at least somewhat pre-wired for language comes from the simple fact that the vast majority of people have language functioning specialized on the left side of the brain. This is well over what would be expected by chance. It seems the brain is designed to place control of language on this side of the brain."

Table 2–4 Speech and Language Milestones: Birth–Three Years of Age

Age	Hearing/Understanding	Speech/Language/Communication
Birth–3 months	Reacts to loud sounds Calms or smiles when spoken to Recognizes and, if crying, calms at the sound of your voice	Makes cooing and pleasure sounds Has different cries for different needs Smiles at people
4–6 months	Moves his or her eyes to follow sounds Responds to changes in the tone of a person's voice Notices toys that make sounds Pays attention to music being played	Coos and babbles in speech-like ways Makes gurgling sounds when alone or when playing with someone Uses different sounds, especially those that begin with consonants p, b, and m Laughs and giggles Babbles when excited or unhappy
7 months–1 year	Happily plays peek-a-boo and pat-a-cake Turns and looks in the direction of sounds Listens when spoken to Responds to simple requests or phrases such as "Come here" or "Want more?" Understands words for common items such as "cup" or "juice"	Uses gestures such as waving bye-bye or holding up arms Babbles to get and keep attention Imitates different speech sounds Babbles using different groups of sounds ("tata, upup, bibibi") By first birthday, says one or two words such as "hi," "dog," "mama," or "dada"

(continues)

Age	Hearing/Understanding	Speech/Language/Communication
1–2 years	Knows and can point to some parts of the body when asked Follows simple directions, such as "Roll the ball" Understands simple questions, such as "Where's your shoe?" Enjoys listening to simple stories, songs, and rhymes Points to pictures, when named, in books	Regularly acquires new words Asks one- or two-word questions, such as "Where kitty?" or "Go bye?" Puts together two words, such as "More cookie" Uses more consonant sounds at the beginning of words, such as b, p, m, h, and w
2–3 years	Understands two-part instructions, such as "Put the spoon in the bowl." Answers questions like "Which one do you want?"	Has a word for nearly everything Uses the sounds k, g, f, t, d, and n Speaks in ways that are understood by familiar family members and friends Asks for objects by name or to direct attention to them Uses two- or three-word phrases when talking about or asking for things

Sources: National Institute on Deafness and Other Communication Disorders. (n.d.). Speech and language developmental milestones, https://www.nidcd.nih.gov/health/speech-and-language; American Speech-Language-Hearing Association. (1997–2023). Communication milestones: Age ranges. https://www.nidcd.nih.gov/health/speech-and-language

Phonology

Phonological awareness
The ability to recognize different units of sound within words

The songs and rhymes preschool children love serve an important purpose; that is, they are exercises in receptive phonology. When we try to think of a word that rhymes with *cat*, we might exchange the *c* for an *r*, manipulating the speech sounds so that the word we choose, in this case *rat*, "sounds" the same except for the beginning. In kindergarten, much of the curriculum centers on the development of sound-symbol correspondence or learning that each letter has a particular sound. In first grade, most children begin to understand that words are made up of these speech sounds blended in left to right order, whether this is taught implicitly or explicitly. Some children, however, do not have good phonological awareness skills, and research shows that these children may have difficulty learning to read (Boets et al., 2007; Law et al., 2017; Lyon & Chhabra, 1996). **Phonological awareness** refers to the ability to recognize different units of sound within words. Research also suggests that children who show problems with phonological awareness may require instruction that is tailored to their individual learning needs to avoid reading failure and later diagnosis of learning disability (Ehri et al., 2001).

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The songs and rhymes preschool children love serve an important purpose; that is, they are exercises in receptive phonology.

Expressive phonology involves the production of speech sounds. During the preschool years, it is not atypical for children to have difficulty producing some of the sounds in their native language, especially the following letters: *s, th, z,* and *v* (Bowen, 1998). These problems may persist in early elementary school, resolving without intervention; however, pronunciation problems that are very severe or that hinder communication may require speech/language articulation interventions. Children with expressive phonology problems respond well to this

treatment. Many collaborative techniques have also been developed as alternatives to the traditional articulation interventions.

Morphology

A morpheme is the smallest unit of meaning in a language. Morphemes may be single words, grammatical modifiers such as prefixes and suffixes, or the inflection used to convey a specific meaning in a sentence. Children begin to understand the rules for using grammatical morphemes, such as the plural and possessive forms of nouns, the complicated conjugation of the verb *to be*, and the appropriate use of prepositions, in the preschool years. Many preschoolers, in fact, *overextend* these rules, making errors in their use of grammatical morphemes. A three-year-old who says, "I goed to the store" or "I brush my tooths" is actually showing a beginning understanding of the morphological rules of English; he is simply applying the rules in cases which are exceptions to the rule. Most children start school with sophisticated implicit knowledge of morphology rules, and this knowledge is further developed by explicit teaching. When we teach the formation of plurals, possessives, or verb tenses, for example, we are actually teaching the morphological rules of Standard English. Many students find verb tenses and plural forms easy to learn since they naturally use these when speaking. Not all children, however, have equal degrees of experience with the Standard English morphology. Children who have limited English proficiency may be accustomed to using a language that has different morphology rules. Cultural differences in English language use may also influence knowledge of Standard English morphology. Ebonics, or the speech form used in some communities of African Americans, has morphological rules that differ from those of Standard English, particularly with regard to verb tenses and pluralization (Rickford, 1997). Since a child's sophistication with morphology rules can influence reading and spelling skills, this places many students at a distinct disadvantage when learning to read, spell, and express their thoughts in written form. Furthermore, moving to a second language can have disruptive effects on morphological structure that persist into adulthood (Clahsen et al., 2010). This issue lies at the heart of the controversy regarding whether teaching should be accomplished using Standard English or a student's primary language or dialect, a debate that we will explore from both sides in Chapter 8.

Semantics

Recall that semantics refers to the meaningful basis of language, both of individual words and combinations of words. Children understand far more than they can produce, or their receptive language is more advanced than their expressive language, at all ages (Oviatt, 1980). Preschoolers show not only exponential growth in their vocabularies, they also begin to understand and use relational words, such as high/low, in/on, and here/there. According to research, vocabulary knowledge increases from around ten thousand words in first grade to around forty thousand words in fifth grade (Anglin, 1993). There is much individual variability, however, in vocabulary knowledge. Some research indicates that children from low-income backgrounds may have heard only 50 percent of the words and can understand only 50 percent of the meanings of words understood by children from high-income backgrounds, putting them at a distinct disadvantage in the classroom (Hirsch, 2001; Walker et al., 1994). In addition, there are increasing numbers of students in the US with limited English proficiency (LEP). These students may have typical, or even advanced, vocabularies in their native languages, but they are at a significant disadvantage at an English-only school (Abramson et al., 1993). We will discuss these and other issues related to linguistic diversity in more detail in Chapter 8.

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Children understand far more words than they can produce.

Syntax

All languages have syntax or rules for word order. Most of us speak in syntactically correct sentences; that is, the order in which we place our words follows the rules of English. Even preschool children follow these rules although they have never been explicitly taught to do so. In fact, trying to learn the syntactical rules of English explicitly is often quite difficult, even for a native English speaker. For example, many of us remember the difficulty we had in high school identifying the *direct object* or *past participle* in a sentence. When we are able to think about language and language rules by reflecting on language itself, instead of using it to communicate, we are showing **metalinguistic awareness**. Metalinguistic awareness increases significantly with age, allowing us to understand and use sentences that are increasingly complex (Whitehurst & Lonigan, 1998). Additionally, research shows that students benefit from instructional approaches that support metalinguistic awareness (Gonzalves, 2021; Zipke, 2008). Interestingly, when learning a second language in adulthood, we generally start from a metalinguistic perspective, developing an awareness of the rules first and then constructing our sentences accordingly. Speaking or writing can be a tedious process when having to think about syntactical rules, as many of us well know from taking foreign language classes in high school and college. Students who have native languages other than English may experience problems in the classroom related to the unfamiliar syntax. Other students that have English as their native language may have less experience with complicated syntax because of language impoverishment or limitations in their exposure to rich language usage. In fact, some researchers believe that the reading achievement gap that exists between low-income and middle-class students may in actuality be a language gap, with low-income students showing a lack of familiarity with complex syntactical structures, as well as the decreased vocabulary knowledge discussed earlier (Hirsch, 2001). Thus, instruction that is language sensitive may help us to build not only functional reading skills but also literacy for challenging and diverse texts.

Metalinguistic awareness

The ability to think about language and language rules by reflecting on language itself

Pragmatics

Pragmatic language, or communicating appropriately in a given context, has a significant impact on a student's social functioning (Coplan & Weeks, 2009; Schumaker & Deshler, 1984). Students with pragmatic language problems may have difficulty using language in a socially acceptable manner; they may speak too loudly, stand too closely, enter conversations inappropriately, or interrupt because they have trouble taking turns in a conversation. They may also have trouble understanding the verbal and nonverbal communication cues of others, including understanding facial expressions, body language, or other nonverbal "hints." One area of difficulty for children with pragmatic language problems involves understanding the true meaning of an indirect request. For example, your roommate asks you, "Could you turn the music down?" You know she really is not asking but rather telling you to turn it down. A child with pragmatic language problems may not understand a request that is phrased as a question and answer "Yes" to the question, "Must you tap your pencil?" Frequently, this type of response causes others to think the child is being oppositional, when in fact the child simply missed the point of the indirect request. This is an important aspect of language functioning to consider in the classroom. Research shows that teachers "ask politely" quite frequently, with some studies showing rates as high as 2 percent of the utterances of K–8 teachers consisting of indirect requests (Lazar et al., 1989). Most pragmatic rules are implicit; that is, no one ever really teaches us out loud that we should stand a distance of around two feet away from a stranger with whom we are conversing (Yuxiang, 2020). Yet, we feel very uncomfortable when someone violates this rule. We learn pragmatic language skills through our interactions with others over time; therefore, many pragmatic rules are culturally mediated, including loudness of voice, amount of eye contact, and use of gestures (Hurley, 1992). Additionally, non-native

English speakers have been shown to have difficulty understanding appropriate responses for initiating and maintaining conversations, as well as for adjusting request strategies to meet classroom norms (Ellis, 1992; Wolfson, 1989). It is frequently very difficult to identify exactly where a student is having difficulty in a conversation or interaction, much less to explicitly teach the subtle language skills that will help him better navigate socially in the classroom.

Summarize and Reflect

1. Language has the following components: semantics, syntax, morphology, phonology, and pragmatics.
2. Maturation and learning play a role in the acquisition of language. Research evidence indicates that not only are both processes important but also the complexity of language development is best explained by an interaction between the two.
3. Language and linguistic diversity are important aspects of the classroom environment. The impact of language and linguistic diversity on academic and social functioning is affected by the developmental progression of the five components of language.

Informed Application

1. During the first years of life, children experience an exponential growth in known words. What explains this tremendous development? Compare this phenomenon to the experience of learning a second language.
2. In addition to the information presented in the book, identify and provide a novel example for a student's failure to use language appropriate to a given context.

The Chapter in Review

In this chapter, we explored the developmental foundations of thinking, reasoning, and language from a variety of perspectives. Since human development is one of the most complex phenomena we study, there are an infinite number of places on which to focus our quest to understand the development of cognition and language. We started our exploration by viewing development from a broad perspective, with a focus on the basic developmental processes of maturation and adaptation and an emphasis on the inextricable interaction between the two in human development. We discussed similarities and differences in development between individuals, and we highlighted the importance of being aware of the interaction between intraindividual strengths and weaknesses, as well as interindividual differences. We then explored the ways in which our understanding of development may be both validated and furthered by research in cognitive neuroscience, highlighting basic brain processes and function and major research findings that may have implications for teaching and learning. We reviewed in detail the influential theories of Lev Vygotsky and Jean Piaget, outlining each of their perspectives on developmental change and discussing implications of their theories for the classroom. We compared their theories, emphasizing that while they essentially viewed development through different lenses, both of their theories have strongly influenced the field of education and the constructivist view of teaching and learning. Finally, we focused our attention on the uniquely human phenomenon of language, exploring theories of language acquisition from both maturational and learning perspectives, again providing evidence that the interaction of the two is paramount in development. We outlined the five components of language and explored language and linguistic diversity in the classroom, illustrating the complex interaction among biological, environmental, cognitive, and social factors in the development of each component of language and the impact of language and linguistic diversity in the classroom.

Interdisciplinary Case Focus

Student/Teacher Case Focus

Drew, Student

Interdisciplinary Team

- Regular Educator
- Psychologist
- Parents
- Social Worker

Referral Question

Concern about the possibility of Attention-Deficit/Hyperactivity Disorder

Meet Drew

Drew, a six-year-old boy, is having great difficulty adjusting to the increased structure of Ms. Craig's first grade classroom. Drew has trouble staying in his seat, keeping his hands to himself, and being quiet when Ms. Craig is talking. He also has difficulty with task persistence, seldom completing assignments. If he does finish, he often forgets to turn in his work. He has lost his home/school folder three times since school began, and twice he accidentally threw his lunch box away. He has yet to learn to raise his hand, interrupting other children or blurting out answers impulsively when his teacher has called on another child. So far, Ms. Craig has been able to accommodate many of Drew's behaviors by allowing him to sit outside the circle during circle time so that he can move around, by moving the desks of the other children so that they are outside his reach, and by providing multiple verbal prompts to help him stay on task and turn in his work. While these efforts have been somewhat effective, Ms. Craig is aware of the possibility that Drew may have attention-deficit/hyperactivity disorder (ADHD); and with his parents' consent she refers him for testing.

Assessment

✦ Educator

Ms. Craig shared information with the school psychologist regarding Drew's behavior in class, as well as her attempts at intervention. She indicated that she was unsure if Drew's behavior is significantly different from average for his age since he is the youngest child in her class, and she expressed the hope that he would improve as the year progressed.

✦ Psychologist

Jackie Robes, PhD, the school psychologist, first conferred with Drew's teacher since Ms. Craig was most familiar with his behavioral issues in the classroom. She then conducted a detailed interview with Drew's parents, asking questions regarding his early development and his behavior in other situations—as well as questions related to his inattention, impulsivity, and hyperactivity. She had Drew's parents complete standardized behavior rating scales, so that she could compare Drew's behavior to the behavior of other children his age across a variety of settings. Results indicated that while Drew may be more active and inattentive than other children his age, he is not significantly so. Dr. Robes also had Drew's teacher complete a standardized rating scale, with similar results. Consulting with Drew's family physician, Drew was not diagnosed with ADHD.

✦ Parents

Drew's parents reported concern regarding his problems in class, and they expressed interest in doing whatever they could to help. They said that Drew has always been an active child who is somewhat easily distracted; however, he did not seem to have significant problems in his preschool or kindergarten classes. They also indicated that they have recently divorced and are sharing custody of Drew. Drew's father reported that he had just moved into a new house and was still unpacking boxes, and he wondered if the divorce and moving between houses could be affecting Drew in school.

✦ Social Worker

Michael Young, LCSW, met with Drew's parents to discuss their concerns regarding Drew's adjustment to their divorce, as well as to discuss various aspects of their shared custody arrangement.

Collaborative Intervention Plan

While Drew's behaviors did not meet the criteria necessary for a diagnosis of ADHD, they will likely continue to interfere with his functioning in the classroom; and each member of the interdisciplinary assessment team had something to offer regarding intervention.

✦ Educator

Ms. Craig, after consulting with the school psychologist, developed some simple strategies that helped Drew dramatically. One of the most successful strategies involved a brief home/school collaborative reward program that she and Drew's parents implemented together. Initially, Drew received three extra minutes of playtime whenever he raised his hand before speaking. He was easily able to succeed with this plan, and Ms. Craig added new criteria each week. She used this home/school reward system and other ideas that the psychologist offered not only with Drew but also with several other students. She found that her classroom quickly became more manageable.

✦ Psychologist

Dr. Robes provided Drew's teacher with several possible ideas for helping to decrease his problem behavior. She explained that while Drew did not have ADHD, many of his problems were on the same spectrum. Clearly Drew's problem behaviors resulted from a complicated set of factors, including changes in his family and home situation, as well as possible mild attention and activity problems. She made several suggestions, including giving Drew formalized time to move around, a structured verbal prompt schedule, a "buddy" to sit next to who would be a good role model, and a positive, home/school collaborative behavior program to be implemented with both parents.

✦ Parents

Drew's parents agreed to implement a consistent home/school collaborative program to reward improvements in Drew's classroom behavior. They discussed and implemented some of the scheduling and organization techniques for minimizing the disruption involved in Drew's movement between two houses. They also helped Drew become involved in a local support group for children of families in transition.

✦ Social Worker

Michael provided Drew's parents with strategies for maximizing the logistics of shared custody, including organization and scheduling ideas. He told them about a local, community family services support program called "Children with Two Houses" and gave them the director's contact information. He also offered his support in the future and expressed that he was impressed with their willingness to work with the team to help Drew.

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