In memory of my beloved daughter,
Margaret Lynn,
and for her sister,
Elizabeth Lee
As the first decade of the new millennium draws to a close, new developments in the perspectives on learning and thinking continue to refine our understanding of these complex processes. Among them are the discovery of mirror neurons in the brain, cognitive task analysis, cognitive load theory, and Baars’ theater metaphor of consciousness. Also new in this edition are the implications for assessment of each major theory, an expanded set of chapter questions for each major theory, Vygotsky’s view of imaginary play, and other revisions for clarity.

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Margaret E. Gredler
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PART I

Introduction

Why is the study of learning important and what are the available resources for understanding learning? Chapter 1 addresses the essential role of learning for both the individual and the human race, provides an overview of the trends that have influenced the study of learning, and discusses the philosophy known as constructivism.

Chapter 2 presents two early developments that initiated the role of theory in explaining learning: behaviorism and Gestalt psychology. Each addressed an important aspect of learning. The behaviorist perspectives, classical conditioning and Thorndike’s connectionism, each experimented with a different type of behavior. Classical conditioning explains the training of existing motor and emotional reactions to respond to different events. In contrast, Thorndike’s connectionism explains the linking of a self-selected response to a particular situation.

Gestalt psychology, in contrast, focused on the process of perception in the solution of problems. Initial research studies indicated that when chimpanzees perceived a stick as a tool, they were able to retrieve out-of-reach bananas. In human learning, Gestalt psychologists identified faulty problem perceptions referred to as functional fixedness and problem set.
CHAPTER 1
Overview

Man's power to change himself, that is, to learn, is perhaps the most impressive thing about him. (Thorndike, 1931, p. 3)

Learning is a multifaceted process that individuals typically take for granted until they experience difficulty with a complex task. However, the capacity for learning is the characteristic that sets humans apart from all other species. Only humans have highly developed frontal lobes in their brains, which are essential for all higher-order purposeful behavior (Goldberg, 2001). Included are identifying objectives, projecting goals, constructing plans, organizing resources, and monitoring the consequences (p. xi).

These cognitive activities are related to three unique aspects of human intelligence. First, humans are able to learn about the discoveries, inventions, and ideas of great thinkers and scientists of the past (referred to as inherited experience; Vygotsky, 1924/1979). Second, individuals can develop knowledge about places and events they have not experienced personally through the experiences of others (social experience, p. 13). Third, humans adapt the environment to themselves, rather than merely adapting to it. This effort is accomplished by first planning new strategies or products in their heads. Examples include a variety of pursuits from quilt making to architecture. Vygotsky named this cognitive activity repeated experience (p. 14).

Discussed in this chapter are various topics related to learning. They are the importance of learning, pretheoretical attempts to explain learning, the criteria for and functions of learning theory, influences on the development of learning theory, and the philosophy referred to as constructivism.

WHAT IS THE ROLE OF LEARNING IN EVERYDAY AFFAIRS?

The study of learning is not simply an academic exercise; it is of critical importance to both the individual and society. First, for the individual, learning accounts for the acquisition of a variety of capabilities and skills, strategies for functioning
in the world, and attitudes and values that guide one’s actions. From an economic perspective, data continue to indicate that the earnings of individuals with higher levels of education outpace those with only a high school diploma. In addition, the capacity for continued learning can contribute to a rich and diverse lifestyle. In our society, we are not surprised to find engineers who are gourmet cooks and professors who grow prize-winning roses.

Second is the importance of learning to society. One purpose, noted by Vygotsky (1924/1979), is learning about the values, language, and developments of one’s culture—inhherited experience. Suppose, however, that each new generation would only be able to learn those things that are half as difficult as the things currently learned (Thorndike, 1931). For example, instead of members of the present generation learning calculus, they would learn only algebra. Then the next generation would learn only arithmetic, and so on. The result is obvious. Most of human civilization’s accomplishments would be unusable in one generation, and civilization itself would soon disappear from the face of the earth (Thorndike, 1931).

Learning is also the basis for future progress in society. The developments produced by individuals that evolve from their learning and ingenuity contribute to new discoveries and inventions by subsequent generations. Computers and electronic guidance systems, for example, set the stage for unmanned space probes to the outer edges of our solar system, and cell analysis has led to explorations of gene replacement therapy to address debilitating diseases.

Given the critical importance of learning to both society and individuals, society cannot risk leaving the acquisition of learning to chance. Some system is needed to teach the cultural heritage to the young and to prepare them to take on productive adult roles. In early societies, the collective wisdom and folklore often were acquired by each member, usually by word of mouth. In technological societies, the available knowledge and information is so vast that no one can begin to learn all of it. Therefore, formal educational systems address both broad areas of knowledge and areas of particular expertise that individuals select for further study. This process requires several years and often includes the learning of particular prerequisite knowledge, such as chemistry for pharmacists and the musculoskeletal system for physical therapists.

However, changing situations in society pose new challenges for the successful planning and management of learning. For example, CDs, satellite-guided television, and the expansion of the Internet in the 21st century have made the knowledge of events, people, and places (the social knowledge noted by Vygotsky, 1924/1979) available in real time. Moreover, the Internet has increased the accessibility of other kinds of information. Challenges posed by these technologies include the need to address information authenticity, the potential for lack of meaningful interaction in online instruction, and the possibility of social isolation. Implications for the planning and management of learning, therefore, include “helping all students learn to use their minds well” (Jackson & Davis, 2000, p. 11). The challenge is to address both the skills of thinking (e.g., supporting reasons with evidence, evaluating resources, and examining and evaluating opposing reasons) and the value of engaging in such hard work (Kuhn & Udell, 2001).
Finally, learners construct their own meanings for themselves and from the contexts in which they live. That is, individuals select information from interpersonal and other interactive events occurring in the family, school, peer, community, and work environments. Individuals then relate the selected information to their prior knowledge, analyze it, and construct a representation in memory. In this view of learning, the knowledge in the mind is coextensive with the relationships that compose one’s interpersonal and societal environments. From this perspective, each new generation constructs a new society for itself (Meacham, 1993, p. 259). The key question then becomes, Can adults in democratic societies, for example, be confident that the next generation will construct society so as to reproduce the society’s traditions, values, commitments, and hopes? (p. 264). For example, how will farm children in the Midwest, growing up in an environment of worry, hopelessness, fear, and alienation as large numbers of independent family farms collapse, construct society? Or others of the one in four children under the age of 6 whose families are below the poverty line? According to Meacham (1993), these and similar questions have serious implications for any discussion of learning.

WHAT WERE THE PRETHEORETICAL ATTEMPTS TO EXPLAIN LEARNING?

Each generation seeks an explanation of the contemporary reality in which it lives. However, the search for understanding is restricted by the methods available at the time. The early Greeks, for example, lacking the tools to investigate the natural world and human affairs, created myths about powerful gods and goddesses who were responsible for otherwise unexplainable events. For example, the sea god Poseidon caused ocean storms, and lightning bolts were Zeus’s arrows unleashed in punishment. In human affairs, wisdom was the gift of the goddess Athena. However, these myths did not advance society’s knowledge about the actual workings of the physical and social environment.

Early myths gradually were replaced by traditional wisdom based on experience and structured belief systems referred to as philosophies. Then research and, finally, theory became methods for developing information about learning.

Traditional Wisdom

The sayings, proverbs, and maxims that often are derived from experience constitute traditional wisdom. An example is “Spare the rod and spoil the child.” However, a major problem with such sayings is that they may be interpreted in a variety of ways, and are inadequate as guidelines for educational practice. Some individuals, however, contend that good teaching practice constitutes a “traditional wisdom” that can inform others about learning and instruction. According to this view, more can be learned from good teachers than from either research or psychology. Of course, much can be learned from skilled teachers (Hilgard, 1964). However, ignoring the possibility of improving instruction through well-designed research is like “returning medical practice to the prescientific physician because we still value the bedside manner” (p. 404).
Philosophy

Unlike traditional wisdom, a philosophy is a structured belief system. Constructing a philosophy begins with the question, What is the nature of reality? Then, using logic and reasoning, the philosopher defines the terms truth, virtue, knowledge, learning, and others. The only requirement is that these definitions must reflect the philosopher's view of reality. For example, idealism, developed by the Greek philosopher Plato (417–327 B.C.), defined reality as the pure ideas of the mind. Consistent with this definition, he described the origin of knowledge as the ideas present in the mind at birth that are in the form of shadowy images. He also maintained that development of these inborn or innate ideas required studying the pure forms of mathematics (such as the circle and the square) and the classics. One school practice in the early 20th century based on Plato's philosophy was the use of intelligence tests (not achievement tests) to make major educational decisions about students. Until the late 1960s, the prevailing belief was that only the top 5% of the high school population should be admitted to higher education.

The other school practice in the late 19th and early 20th centuries based on Plato's philosophy was the mental discipline concept. Specifically, enrollment in courses such as trigonometry, physics, and Latin was believed to enable students to think clearly and deeply (Cox, 1997, p. 42), that is, "discipline" the mind. Edward Thorndike, referred to as the first educational scientist, conducted a study in the 1920s on the mental discipline concept. He compared the postcourse achievement of students in vocational courses and classical curricula and found no significant differences. He concluded that learning a particular subject, such as Greek, would not benefit intellectual performance in other areas. Thorndike (1924) also noted that the main reason certain school subjects superficially seemed to produce good thinking was that good thinkers tended to enroll in those courses. Furthermore, students became better thinkers because of the "inherent tendency of the good to gain more than the poor from any study" (p. 98). Researchers noted that, in succeeding years, Thorndike's research served as a major influence in turning curriculum designers away from the mental discipline concept and toward the practice of designing curriculum for more useful purposes (Cushman & Fox, 1938; Gates, 1938).

Plato had established the ideas of the mind as the basis of reality in his philosophy. Aristotle, Plato's pupil, developed a contrasting view known as realism. Aristotle's perspective defined reality as existing in the real world, not in the mind's ideas about it. Universal laws are not innate ideas; they are the relationships observed in nature. Learning occurs through contact with the environment, forming images of sensory experiences, and making associations among the images.

These contrasting descriptions of knowledge and learning illustrate the major requirement of a philosophy. Statements need only form a logical structure about broad abstract topics (e.g., virtue, the origin of knowledge), and need not agree with other philosophies or other ways of developing knowledge. The opposing beliefs of Plato and Aristotle fueled the nature/nurture controversy. The debate revolved around whether mental capabilities are inborn (Plato) or are developed through experience with the environment (Aristotle). John Dewey, a well-known American philosopher, psychologist, and educator, noted that this focus on the origin of knowledge had led to 30-year cycles of different emphases.
in educational practice. American education had swung in a wide arc from the view that education is development from within to education as formation from the outside (Dewey, 1929/1988, p. 5). One problem with a reliance on philosophical knowledge, Dewey noted, is that the focus is like looking in a rearview mirror. Instead, the factors that convey value on thoughts or ideas are not the origins of knowledge, but the outcomes produced by those ideas. Moreover, psychologists and educators now know that learning and cognitive development result from the interaction of an individual's inherited potential with his or her experiences.

Plato's idealism and Aristotle's realism eventually faded as influences on educational practice. However, in the late 20th century, a new philosophy, constructivism, emerged and is discussed later in this chapter.

The Emergence of Research

In the mid-16th century, Galileo introduced experimentation with objects as a method of developing knowledge about the physical world, and physical science was born. Reliable laws and principles gradually replaced mystical beliefs and untested maxims. The science of chemistry supplanted the practice of alchemy, and the methods of astrology were replaced by the science of astronomy.

Research on the mind, however, was not even considered. Society viewed the mind as the gift of God, and to conduct research on the mind would be calling that sacred gift into question. Also, the major role of the mind was to become attuned to an ultimate reality and philosophy was adequate for that task. However, some 300 years after the beginning of the physical sciences, two events set the stage for research on thinking and learning. One was Charles Darwin's *Origin of Species* in 1859, which described a reality based on change, not a static order. The other event was the introduction of the concept *scientific empiricism* by Hermann von Helmholtz, a medical doctor, scientist, and philosopher. It is based on the belief that ideas are the products of human experience; therefore, they are subject to human observation and analysis. Specifically, scientific empiricism is the accumulation of facts through carefully designed experiments. Von Helmholtz demonstrated the importance of this concept through his invention of the ophthalmoscope to observe the operations of the eye.

From research on the senses, which are living tissue, to research on the mind was only one short step. That step was taken by Wilhelm Wundt at the University of Leipzig. He established the first psychological research laboratory in 1879. Studies included research on reaction times, sensations, auditory perception, and attention. This work attracted graduate students and faculty from both Europe and the United States to study and conduct research in his laboratory.

Wundt had also advocated a "second psychology" that would rely on historical and anthropological methods to address language and reasoning. It was based on the concept proposed by two other German scholars that collective mentality exerts a powerful influence on individuals (see Jahoda, 1993, for a discussion). Wundt's writings on this topic, however, fell into oblivion. Nevertheless, the concept of the influence of the thinking of adults in a culture on the cognitive development of the next generation resurfaced in the work of Lev Vygotsky in the early 1930s.
The shift in ideas from the mind as the gift of a Creator to that of the brain as the key to mental activity was gradual rather than immediate. Books on psychology at the end of the 19th century continued to assert that psychology could not be an exact science because humans could never predict the interventions of the Creator to produce particular mental events in one's life. Nevertheless, Wundt's text on physiological psychology and the work in his laboratory dominated Western thought (Reed, 1997).

By the 1920s, empirical research had become a primary mechanism for generating information about psychological processes. However, the problem with a reliance on empirical research as the sole source of knowledge is that data collection does not necessarily clarify the nature of important events. The educational research of the 1920s, referred to as the scientific movement in education, collected data on such topics as the number of Latin verbs learned by students in 1 year and the amount of time required to learn the multiplication tables. Vygotsky (1993) decried the confusion that resulted from such uncoordinated collections of empirical data. And, as indicated by these examples, the extensive data collection did not contribute to an understanding of the basic processes of learning and instruction.

Some years later, research expanded to include qualitative methods such as narrative and field research (ethnography), interviews, and discourse analysis (Turner & Meyer, 2000, p. 75). For example, observations of classroom events have identified particular teacher actions and verbalizations that influence the development of students' self-regulation of their learning in the classroom (Meyer & Turner, 2002; Perry, VandeKamp, Mercer, & Nordby, 2002).

**Summary**

Early attempts to understand learning were traditional wisdom, which is usually based on experience, and philosophy. The problem with traditional wisdom is that the information can be interpreted in different ways. In contrast, although a philosophy is a structured belief system, different philosophies reflect opposing views. Although research on the physical world began in the 1500s, research on psychological processes lagged far behind. The events that set the stage for psychological research were the introduction of the concept of scientific empiricism and the concept of change in the emergence of animal species introduced by Darwin. Research on psychological processes began in Wundt's laboratory, followed several years later by data collection in the educational setting. Much of the data, however, did not inform educational practice. At about the same time, the 1920s, early theories of learning emerged to provide a framework for research.

**WHAT ARE THE CRITERIA FOR LEARNING THEORY?**

Early in the 20th century, classical conditioning, which describes the method for training reflexes to respond to new events, became the first theoretical approach to the study of learning. It was soon followed by two other perspectives: Edward Thorndike's connectionism, which addressed self-selected responses to situations,
and Gestalt psychology, which studied learner perceptions of visual problems. For the remainder of the 20th century, psychologists developed other theories of learning and also theories of cognitive development. Each theory addresses some aspects of these complex processes. In other words, no single theory can adequately account for all learning. Therefore, each theory describes particular features of learning or cognitive development and focuses on identifying the factors that will lead to identified outcomes.

An important aspect of evaluating a theory of learning is to determine the extent to which it meets four criteria, three of which describe essential components of a theory. A major purpose of applying the criteria is to avoid "theory"-labeled fashions that simply restate common-sense knowledge (van der Veer & Valsiner, 1991, p. 2).

**Criteria**

Clark Hull (1935), a behavioral theorist, identified three essential criteria for any theory. First is a set of explicit assumptions that are the theorist's basic beliefs about the phenomenon to be addressed. For example, three basic assumptions of Robert Gagné's (1972, 1977) conditions of learning are (a) learning is the acquisition of increasingly complex structures of learned capabilities that build on prior learning, (b) no one set of characteristics can be applied to all learning, and (c) an adequate conception of human learning should apply to all the various contexts in which learning occurs. Examples include home, school, business, trade occupations, military training, Internet situations, and others.

The second criterion is that a theory must include explicit definitions of key terms. For example, the term *capabilities* is the focus of Gagné's (1972, 1977) conditions of learning. He defined capabilities as the skills, knowledge, attitudes, and values that are acquired by human beings. These capabilities are the outcomes of learning.

The basic assumptions and definitions set the framework of a theory, according to Hull (1935). The next step for the theorist is to derive specific propositions (principles) from the assumptions that can be tested through research. These principles, the third criterion, form the body of the theory. For example, based on the assumption that no one set of characteristics can describe all human learning, Gagné (1972, 1985) identified five distinct varieties. Principles of the theory describe the particular type(s) of capabilities generated by each variety of learning as well as the teaching and testing requirements for each. Research indicates, for example, that the strategies for teaching verbal information are ineffective in producing attitudinal change (Gagné, 1984).

A fourth requirement, which applies only to learning theories, is that they should explain the underlying psychological dynamics of events that influence learning. For example, teachers are sometimes told that praising students is important. However, Brophy (1981) noted that teachers may use excessive public praise for right answers as well as global reactions, such as "What a good group you are." These reactions are at best ineffective and, at worst, counterproductive (Brophy, 1981). B. F. Skinner's (1968) principles of reinforcement address the factors that govern the effectiveness of consequences and the relationships of consequences
to other events. Familiarity with these principles can help teachers avoid misuses of praise and other behavioral consequences.

These criteria differentiate scientific theory from "naive theory." For example, a teacher may describe his or her "theory" about the activities and events that motivate students in a particular classroom. Such "theories" reflect the teacher's intuitive understanding of his or her students and may guide the teacher's actions in the classroom (Pintrich & Schunk, 2002, p. 7). In contrast, scientific theory is carefully derived from stated assumptions, defines key terms, and generates hypotheses that state relationships between the identified variables. The hypotheses are then tested empirically.

**Comparisons with Other Knowledge Sources**

The role of theories of learning differs from that of both philosophies and models of teaching. First, the purpose of a philosophy is to serve as a general value system (see Table 1.1). For example, Plato's idealism values the ideas of the mind and Aristotle's realism values direct sensory experience with the environment. In contrast, the purpose of theory is to identify real-world events required for learning. Second, statements generated by philosophy are limited by the definition of reality set by the philosophy, and these statements address only broad, abstract terms (e.g., the nature of truth, beauty, knowledge, and so on). Also, the suggestions for learning are broad statements that do not provide specific guidance for instruction. For example, Plato's idealism recommended the study of "pure" mathematical forms and the classics. The implication is that other subjects do not facilitate learning.

In contrast, each theory states basic assumptions about key aspects of the learning process (or cognitive development if a developmental theory such as that of Piaget) and defines key terms. This information generates specific principles that, in the form of hypotheses, are tested in the laboratory or real-world settings. Examples include (a) the ways that children of different ages approach problems that require logical inference (Piaget's cognitive-developmental theory), (b) the types of events responsible for increased responding in a learning situation (Skinner's operant conditioning), and (c) the developing capabilities of

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<td><strong>Theory</strong></td>
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<tr>
<td>1. Purpose</td>
<td>Serve as a broad value system</td>
</tr>
<tr>
<td>2. Criteria for propositions</td>
<td>Must be logically consistent with definitions of reality and nature and knowledge</td>
</tr>
<tr>
<td>3. Nature of statements about learning</td>
<td>General recommendations that are subject to a variety of interpretations</td>
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children and adolescents in using signs and symbols to guide and regulate their thinking (Vygotsky's cultural-historical theory).

Learning theories also differ from models of teaching that are descriptions of learning environments (Joyce & Weil, 1996, p. 11). Examples include cooperative learning (methods for organizing students to work together) and direct instruction (an approach with objectives, related activities, monitoring, and feedback). Some are specific, such as advance organizers, whereas others are more general (direct instruction). Furthermore, some are applicable only to certain subject areas and age levels. An example is the jurisprudential model that was created for secondary social studies. Students study cases involving social problems in areas that may benefit from public policy (p. 14). This model, however, is not appropriate for young children.

As indicated by these examples, teaching models are not derived from a comprehensive analysis of the learning process, and some are situation-specific. In contrast, instructional guidelines developed from theory reflect a coherent set of assumptions about aspects of the learning process. In other words, a focus on learning guides development of the framework for instructional guidelines instead of management, organization, or other events tangential to learning. Also, the instructional recommendations derived from theory are generalizable. That is, they are independent of subject area, grade level, age of the learner, and the setting for learning.

Summary

The three criteria essential for any theory are (a) a set of explicit assumptions about the aspects of learning addressed by the theory, (b) explicit definitions of key terms, and (c) specific principles derived from the assumptions that can be tested through research. A fourth requirement, which applies only to learning theories, is that the theory should explain the underlying psychological dynamics of events that influence learning.

The role of learning theory differs from both philosophy and models of teaching. A philosophy represents a general value system and addresses broad, abstract terms, such as the nature of truth and knowledge. Models of teaching describe particular learning environments, such as cooperative learning and direct instruction. In contrast, a focus on learning guides the development of learning theory.

WHAT ARE THE FUNCTIONS OF LEARNING THEORY?

A well-developed theory should fulfill both general and specific functions related to learning and instruction.

General Functions

Suppes (1974) identified four general functions of theories. First is to serve as a framework for conducting research (see Table 1.2). This function is related to the requirement that a theory include testable principles; a good theory should
translate into concrete research designs (Bronfenbrenner, 1993). Simply collecting data in the absence of an organizing framework, Suppes noted, is bare empiricism. It is a mental form of streaking, and nudity of body is much more appealing than nudity of thought (p. 6).

The second function is to provide an organizing framework for specific items of information, as illustrated in Table 1.2. Third is to reveal the complexity and subtlety of apparently simple events. The young children's illogical statements for their inability to topple a plastic dummy are not "errors," as adults might be inclined to conclude. Jean Piaget's (1963) analysis of cognitive development found that such statements are a natural and essential stage in the development of the child's logical thinking. Repeated interaction and experimentation with concrete objects by the child contributes to the subsequent development of more logical ways of thinking. Fourth, a theory may bring new insights to a situation such that existing principles or theories are reorganized, as indicated in Bandura's (1971) analysis of learning from models.

Fifth, a theory should serve as a working explanation of events. From the 1920s to the 1950s, psychologists had hoped to develop the one "grand theory" that would explain all learning. The prototype for this goal was classical physics (also known as Newtonian mechanics). Physicists and others viewed this theory as the explanation of the actions of physical forces throughout the universe.

However, psychologists were not successful in developing eternal principles of learning. In the 1940s, the early laboratory-based efforts were inadequate

<table>
<thead>
<tr>
<th>Functions</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serve as a framework for research</td>
<td>Thorndike's laws of learning identified the importance of the consequences of behavior in learning.</td>
</tr>
<tr>
<td>Provide an organizing framework for items of information</td>
<td>Gagné's conditions of learning developed categories for different learning processes; Weiner's attribution theory explains why a student might be dissatisfied with a grade of B and another is happy to earn a C.</td>
</tr>
<tr>
<td>Identify the nature of complex events</td>
<td>Piaget's theory of cognitive development explains the young child's contradictory explanations of events such as why some objects float in water.</td>
</tr>
<tr>
<td>Reorganize prior experience</td>
<td>Imitation initially referred to the immediate copying of an observed behavior. Bandura's social-cognitive theory explains the phenomenon of delayed matching.</td>
</tr>
<tr>
<td>Serve as a working explanation of events</td>
<td>Classical conditioning described the behavioral control of reflexes and simple emotional reactions until operant conditioning demonstrated the development of voluntary behaviors.</td>
</tr>
</tbody>
</table>

**TABLE 1.2**
General Functions of Learning Theory

<table>
<thead>
<tr>
<th>Functions</th>
<th>Examples</th>
</tr>
</thead>
</table>
for designing training for military personnel in World War II. Military training needs and the development of high-speed computers raised new questions about human learning and thinking and led to the development of theories that address the ways that learners process new information.

In other words, a theory does not stand for all time. As new information is discovered and new questions emerge from the changing social context, early theories give way to redefined relationships and new generalizations. Therefore, at one point in time, a generalization may adequately describe a particular system, but at a later point in time, it may be valid only as history (Cronbach, 1975).

The redirection or replacement of theories is not unique to psychology. For example, classical physics was insufficient to describe precisely the actions of physical forces in the entire universe. In classical physics, time is treated as a constant. With Einstein's discovery of the theory of relativity, in which time is a relative variable, classical physics became a special case of that theory. Classical physics is sufficiently accurate for activities on our planet, and it was sufficient for a civilization undertaking an industrial revolution. Interplanetary travel, however, requires a more precise theory of time and motion.

Similarly, in psychology, the experiments on reflexes conducted by Ivan Pavlov initially were believed to hold the key to the learning of complex behaviors. Today, his views, referred to as classical conditioning, are a special case in behaviorism. Classical conditioning explains the learning of many emotional responses, but it does not explain the acquisition of complex behaviors.

Theories also may coexist because they address different aspects of learning. For example, Skinner's operant conditioning addresses the role of consequences in bringing about behavioral change. In contrast, Gagné's conditions of learning describe the environmental and internal mental events necessary for the learning of different types of skills and attitudes. The coexistence of different theories is not unique to the field of learning. Sfard (1998) noted that several theoretical outlooks of an entity also occur in science. For example, chemistry and physics provide different, but not incompatible accounts of matter. Moreover, perspectives that may initially be viewed as incompatible may instead be considered as only incommeasurable. That is, no one set of vocabulary and no one set of rules explains them (p. 11). An example is Euclidean and non-Euclidean geometries.

Specific Functions

Regardless of orientation, learning theories may fulfill any of four specific functions (see Table 1.3). In addition to the two examples of serving as a guide for planning instruction in Table 1.3, other major theories also provide information on particular aspects of planning.

In summary, a well-developed theory of learning fulfills several functions. In addition to serving as a framework for research, theory should bring new insights to situations, and serve as a working explanation of events. Specific
TABLE 1.3
Specific Functions of Learning Theory

<table>
<thead>
<tr>
<th>Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Serves as a guide for planning instruction</td>
<td>a. Robert Gagné’s conditions of learning provide a set of nine specific steps that parallels the sequence in which information is received from the environment, processed (encoded), and stored in long-term memory.</td>
</tr>
<tr>
<td></td>
<td>b. Jean Piaget’s cognitive-development theory provides insights into classroom practices that facilitate the development of logical thinking.</td>
</tr>
<tr>
<td>2. Evaluates current products for classroom use and current practice</td>
<td>Theories helpful in the evaluation of computer-based instruction include information-processing principles, Skinner’s operant conditioning, Gagné’s conditions of learning, and Bandura’s social-cognitive theory.</td>
</tr>
<tr>
<td>3. Diagnoses problems in classroom instruction</td>
<td>Difficulties experienced by low achievers often include low self-esteem and inadequate learning strategies. Weiner’s attribution theory, Bandura’s social-cognitive theory, perspectives on problem solving, and Vygotsky’s sociohistorical theory address various aspects of this problem.</td>
</tr>
<tr>
<td>4. Evaluates research conducted on theories</td>
<td>One study implemented models for prosocial behavior and post-tested the children at the end of the experimental session. The children’s lack of model imitation was taken as evidence that Bandura’s theory does not apply to certain social situations. However, according to the theory, children do not enact everything they learn.</td>
</tr>
</tbody>
</table>

functions primarily address instruction, including planning and evaluating instruction and providing information about classroom problems.

HOW HAVE EVENTS INFLUENCED THE DEVELOPMENT OF LEARNING THEORY?

The initial theoretical approaches to studying learning were classical conditioning, Edward Thorndike’s connectionism, and Gestalt psychology, described in Chapter 2. Classical conditioning and connectionism are behavioral theories because they focused on understanding behavioral change. Gestalt psychology, in contrast, focused on the perceptions of problem solvers in addressing visual problems. The goal of these perspectives was to determine the key components
of learning. The early theorists broke new ground because, unlike philosophy, they subjected their ideas to controlled experimentation.

However, the entry of the United States in World War II in December 1941 posed new questions for psychology. Among them was designing training for complex operations, such as those needed by aircraft gunners and equipment troubleshooters—operations for which insight (Gestalt psychology) and manipulating emotional reactions (classical conditioning) were inadequate. Also, although Thorndike’s law of effect, which stated that certain satisfying consequences strengthen behavior, is accurate (see Chapter 2), it was of no help in designing instruction for multistage tasks. Robert Gagné and others began to analyze the needs of instruction and brought new concepts to the development of learning theory (see Chapter 5).

The Shift from the Laboratory to the Classroom (1950–1975)

Despite the focus on designing effective instruction in the military, the idea of instructional theory did not impact public education until 15 years later. It was triggered by Russia’s successful launch of the space capsule Sputnik in 1957. Curiously, the American public viewed this technological feat by a Cold War adversary as a failure of the country’s educational system. The intensity of the international power struggle had magnified the role of education as the guardian of a free society’s scholarship and technological achievements.

The launch of Sputnik sparked a massively funded curriculum reform in the United States (see Table 1.4). A focus on developing thinking and discovery learning replaced the focus on learning isolated facts. Mathematics, science, and foreign language—subjects identified as essential to national security—were targeted first for development. Research on classroom learning, formerly regarded as less prestigious than “pure” laboratory research, became legitimate. Faced with the problem of curriculum redesign for thinking skills, and perhaps influenced by the precision of space technology, researchers expressed the need for an instructional technology. The goal was to translate learning theory into educational practice (see Bruner, 1964; Hilgard, 1980).

Although developing instructional theory did not remain a top priority, learning theorists began to address the needs of the classroom. Four theoretical perspectives applicable to the classroom gained prominence in this period. They are B. F. Skinner’s operant conditioning (see Chapter 4), Robert Gagné’s conditions of learning (Chapter 5), efforts to apply Jean Piaget’s cognitive-development theory (Chapter 8), and Jerome Bruner’s cognitive approach to curriculum development. Director of the Harvard Center for Cognitive Studies in the 1960s, Bruner (1961) maintained that the goal of education should be the student’s intellectual development. The curriculum, in his view, should foster problem solving through inquiry and discovery. This focus would develop students’ capabilities to ask strategic questions and use their memory efficiently.

Bruner (1966) also described three levels or stages of cognitive development. The first level is enactive. Knowledge is represented in actions, such as the
TABLE 1.4  
Some Major Events from 1950 to 2000

<table>
<thead>
<tr>
<th>Year(s)</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td></td>
</tr>
<tr>
<td>1956</td>
<td>Broadbent's model of human memory</td>
</tr>
<tr>
<td>1957</td>
<td>Soviet Union launches <em>Sputnik</em></td>
</tr>
<tr>
<td>1958</td>
<td>Newell and Simon's artificial intelligence</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td></td>
</tr>
<tr>
<td>1960-1969</td>
<td>Curriculum redesign</td>
</tr>
<tr>
<td>1960-1963</td>
<td>Piagetian concepts introduced to American education</td>
</tr>
<tr>
<td>1965</td>
<td>Gagné's conditions of learning</td>
</tr>
<tr>
<td>1967</td>
<td>Publication of Neisser's <em>Cognitive Psychology</em></td>
</tr>
<tr>
<td>1968</td>
<td>Publication of Skinner's <em>Technology of Teaching</em></td>
</tr>
<tr>
<td>1960</td>
<td>Bruner calls for a theory of instruction</td>
</tr>
<tr>
<td>1961</td>
<td>Skinner describes importance of teaching machines</td>
</tr>
<tr>
<td>1970</td>
<td></td>
</tr>
<tr>
<td>1970-1975</td>
<td>Various models of human memory proposed</td>
</tr>
<tr>
<td>1970</td>
<td>Piaget summarizes major concepts for psychologists</td>
</tr>
<tr>
<td>1971</td>
<td>Bandura's social learning theory introduced</td>
</tr>
<tr>
<td>1972</td>
<td>Weiner introduces attribution theory</td>
</tr>
<tr>
<td>1977</td>
<td>Gagné expands his theory to include information processing</td>
</tr>
<tr>
<td>1980</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>Dominance of research on cognitive processes</td>
</tr>
<tr>
<td>1984</td>
<td>Application of Vygotsky's concepts in reciprocal teaching</td>
</tr>
<tr>
<td>1985</td>
<td>Cognitive psychology emphasizes strategy instruction and metacognition</td>
</tr>
<tr>
<td>1985</td>
<td>Social, cultural, and personal factors in learning acquire prominence</td>
</tr>
<tr>
<td>1990</td>
<td></td>
</tr>
<tr>
<td>1990-1994</td>
<td>Various constructivist curricula are implemented</td>
</tr>
<tr>
<td>1995</td>
<td>Interest in neuroscience emerges</td>
</tr>
<tr>
<td>2000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motivational theories address classroom learning</td>
</tr>
</tbody>
</table>
child who operates a balance beam by adjusting his or her position. At the second level, iconic, the child visually summarizes images, as in drawing a picture of a balance beam. The use of words and other symbols to describe experience is the third stage, symbolic representation. The learner can explain the operation of the balance beam, using the concepts of the fulcrum, length of the beam, and weights to be balanced. The curriculum, in addition to addressing these developmental levels, should ensure that skill mastery leads to the mastery of still more powerful skills (p. 35). The basis for curriculum development should be organizing concepts (Bruner, 1964), which are introduced initially in a simple form. Gradually, the concepts become more complex as additional information is introduced—an organization referred to as a spiral curriculum.

Also, during the post-Sputnik curriculum reform, B. F. Skinner developed the teaching machine to make learning more successful (Rutherford, 2003, p. 7). The subject matter in the self-paced “stand-alone” instruction was sequenced from simple to complex, and students interacted with the content by responding to a series of incomplete statements. However, the teaching machine and the accompanying materials, programmed instruction, lasted less than 10 years (approximately 1957 to 1965). Concerns about technology contributing to the dehumanization of education (Rutherford, 2003, p. 9); dull, ineffective materials developed by individuals who did not understand the design principles; and the clumsiness of the teaching machine (which was eclipsed by high-speed computers) contributed to the decline of programmed instruction.


In addition to classical conditioning and Thorndike’s connectionism, Skinner’s operant conditioning also addressed behavior. His work describes the conditions necessary for acquiring complex behaviors, such as learning to read or to sing a song. Behaviorism, given a new lease on life with Skinner’s work, remained dominant through the 1960s. Interest in mental events had not disappeared, but they were not in the mainstream of psychology. Then three events outside of psychology reignited interest in cognition (Leahey, 1992, p. 314). One was the communications research initiated in World War II, which led to the conclusion that the learner is a complex information-processing system.

A second influence was the development of high-speed computers. These machines, which followed a set of instructions to operate on information, placed internal processes in the realm of tangible events. Newell and Simon (1961), for example, applied computer operations to the development of a model of human problem solving. In addition, computer capabilities in the manipulation, transformation, and storage of symbols served as the basis for the information-processing model of human memory. Proposed in 1958 by Donald Broadbent, this model includes (a) sensory registers, (b) short-term memory, and (c) long-term memory. A third influence was the work of Noam Chomsky (1957) who developed “rule-following” explanations of language processing (Greenwood, 1999). Ten years later, the study of cognitive processes acquired a formal identity with the publication of Ulric Neisser’s (1967) text *Cognitive Psychology*.
Although Jerome Bruner and others emphasized perception and cognition, information-processing theory, based on Broadbent's model, became the dominant view of mental processes. Bruner (1990) noted that the focus in cognitive psychology was not about learners constructing and making sense of their world and themselves. Instead, the focus became information instead of meaning and the processing of information instead of the construction of meaning.

Some discussions have described this period as that of the cognitive revolution. Leahey (1992), however, maintained that the advent of cognitive psychology did not meet the requirements for a revolution. Specifically, the requirements are (a) situations or problems that the dominant worldview cannot explain provoke a crisis, (b) an emerging worldview proposes new solutions to the problems, and (c) the emerging worldview passes critical review and converts others to its ideas. First, behaviorism was not a unified worldview. Some theorists maintained that only behavior should be studied (e.g., Skinner) and others proposed intervening variables that mediated the process between stimulus and response (e.g., Hull).

Second, problems faced by behaviorism, such as the discovery of biological limits on training reflex responses (classical conditioning), did not lead to the abandonment of the principles of behaviorism (Greenwood, 1999, p. 2). Third, this and other anomalies of behaviorism were not the primary stimulus for the emergence of cognitive theory. Instead, new developments in fields other than psychology introduced new possibilities and questions to be addressed. In other words, cognitive psychology bypassed behaviorism and focused on cognitive states and processes as legitimate objects of theoretical focus and explanation (p. 13). The point is that the story of psychology is a narrative of research traditions, not revolutions (Leahey, 1992, p. 316).

The Rise of Personal, Social, and Cultural Factors in Learning (1980–present)

Operant conditioning identifies the necessary events to bring about behavioral change, cognitive theories describe rational processes whereby learners acquire new information and problem-solving skills, and Piaget’s cognitive-development theory identifies the conditions required for individuals to reconstruct their thinking on more logical levels. These perspectives are universal theories because they describe the essential events that apply universally—wherever learning or cognitive development is addressed and with any type of student. Whether the setting is a third-grade classroom in the United States, for example, or community classes for adults in Sri Lanka, the specified events must take place.

In the latter part of the 20th century, some psychologists have suggested that the information provided by these theories is incomplete. That is, other factors also are important and should be considered. One group of such factors includes student goals, intentions, and expectations (Pintrich, Marx, & Boyle, 1992); they are components of learner motivation. One perspective that began to address this issue is Bernard Weiner’s (1979) attribution theory, which describes the influence of an individual’s perceived causes of success and failure (attributions) on subsequent achievement-related efforts.
Another perspective, Albert Bandura's (1986) social-cognitive theory, describes learning by observing behavioral models and learner self-efficacy, the individual's belief that he or she can be successful at difficult or ambiguous tasks (see Chapter 10). A third perspective examines the goal orientation of the classroom, mastery or performance goals, and the relationship to students' goal orientations (cf. Ames, 1992; Ames & Archer, 1988; Anderman & Midgley, 1997; Dweck, 1986). At present, these motivational characteristics are expressed in a particular theory (attribution theory) or in motivational models (e.g., goal orientation) (see Chapter 11) to be considered when addressing instruction.

In addition to aspects of learner motivation, the culture in which the individual lives also began to be considered an important factor in learning. This interest is based, in part, on the introduction of a few concepts from the cultural-historical theory of Lev Vygotsky, a Russian psychologist who developed his theory in the late 1920s and early 1930s. However, at the present time, misconceptions about his work abound. Vygotsky's theory does not address culture per se, but the signs and symbols a particular culture uses for thinking (e.g., speech, different forms of numeration and counting, algebraic symbols, blueprints, diagrams, and so on; Vygotsky, 1982–1984/1997a, 1960/1997b). They are the instruments or psychological tools that influence the level of thinking a member of the culture can attain (see Chapter 9).

Summary

The development of learning theory began in the early 20th century with three laboratory-based approaches. They broke new ground because the theorists tested the basic principles in experiments. Then the entry of the United States in World War II raised the issue of training for complex operations. This priority along with post-Sputnik curriculum needs legitimized classroom issues as a priority for learning theory.

Interest in mental events entered the mainstream primarily as a result of three events: the communications research initiated in World War II, the development of high-speed computers, and Chomsky's "rule-following" explanation of language processing. Computer capabilities in manipulating, transforming, and storing information became the basis for information-processing theory. Bruner and others pointed out that learner construction of meaning and making sense of one's world were forgotten in that emphasis.

As interest and research in cognition gained prominence, some described the period as the cognitive revolution. However, the cognitive focus did not propose new solutions to existing problems, the problems faced by behaviorism did not lead to the abandonment of its principles, and those problems were not the impetus for cognitive theory. In other words, psychology may be described as a series of different research traditions, not revolutions.

The theories of learning and Piaget's cognitive-development theory are universal theories. That is, they identify the essential events of learning or cognitive development that apply universally—in any learning setting and with any student. In the late 20th century, interest focused on personal and social factors that also should be considered. Among them are students’ attributions for success and failure, self-efficacy, and the goal orientations of classrooms and students.
WHAT IS THE PHILOSOPHY REFERRED TO AS CONSTRUCTIVISM?

The development of a philosophy typically begins with a definition of reality and proceeds to describe other entities in terms of that definition. In contrast, constructivism, in general, focuses on the nature of knowledge, setting aside or greatly reducing the role of an external reality in shaping beliefs (Phillips, 1997, p. 85). That is, constructivism assigns a major role to social processes which serve as the criteria to determine content knowledge.

Currently, constructivism may refer to either of two broad areas. One is the nature of the disciplines or bodies of human knowledge built up in human history (epistemology). That is, what is the nature of physics, calculus, or American history? The other area consists of beliefs about educational practices (educational constructivism) (Phillips, 2000b, p. 6). Furthermore, both moderate and extreme views are found in each of these areas and there may be no linkage between a particular philosophical orientation and beliefs about the nature of educational practices. For example, Thomas Kuhn held a constructivist view of science, but advocated an anticonstructivist pedagogy (Matthews, 2000, p. 163). In other words, one may accept a particular constructivist view of the nature of knowledge and favor any of several classroom practices. Similarly, advocates of constructivist classroom practices may justify them in a variety of ways and some may not be philosophically constructivist (Phillips, 2000a, p. 18).

In the late 20th century, the term constructivism became a part of philosophical, sociological, and educational discussions. However, these disciplines, and the various schools of thought within them, define the term in diverse ways (Bredo, 2000, p. 128). In addition, constructivism is used on many levels to address such issues as the formation of scientific knowledge, the development of children's knowledge, and the relationship between knowledge and reality (p. 128).

As stated, constructivist views of the nature of knowledge are social-constructivist perspectives, in that social processes play a major role in determining knowledge. Also, much of the discussion has focused on the disciplines of science and mathematics, particularly science (Phillips, 2000b, p. 30). Two variations of constructivism are (a) the view that science is independent of society, but social factors still "leak in" and influence its development, and (b) social relations "partially" construct knowledge, but nature "leaks in" at the end (Latour, 1992, p. 276, cited in Phillips, 2000b, p. 10). However, the subgroup that has generated the most controversy and that has major implications for both the nature of science and science education is radical social constructivism (Phillips, 1997, 2000b; Slezak, 2000).

Radical Social Constructivism

Unlike the other social-constructivist views, the radical perspective maintains that knowledge is entirely constructed out of social relations. As indicated in Table 1.5, objects in the natural world are not part of an external preexisting reality. Instead, humans construct objects in the course of their inquiries. Therefore, atoms, molecules, and quarks are entirely human constructions. They are social
TABLE 1.5
Premises of the Radical Social-Constructivist View of Science

1. Objects in the natural world are not real or objective, and do not have an independent preexistence. Instead, they are constituted by our inquiries (Woolgar, 1988, p. 94).

2. Therefore, the ideas of scientific theories do not explain or describe the real world. Instead, they are “rhetorical accomplishments” of a particular discourse community (Woolgar, 1988, p. 26). That is, “knowledge is a matter of conversation and social practice, rather than an attempt to mirror nature” (Rorty, 1979, p. 171; see also Gergen, 1994).

3. Scientific theories reflect the social milieu in which they emerge. They are the product of social forces, interests, and other historically contingent aspects of the local context (Woolgar, 1988, p. 95; see also Bloor, 1976).

artifacts that are products of social forces, interests, and historical characteristics of the local context (Bloor, 1976; Woolgar, 1988).

One version of this perspective maintains that entities such as molecules are constructed through words that “take on their meaning only within the context of ongoing relationships” (Gergen, 1995, p. 49). In other words, “scientific enclaves” form a “conversational world” by choosing “certain configurations to count as ‘objects,’ ‘processes,’ or ‘events,’ and by generating consensus about the occasions to which the descriptive language is to apply” (p. 50).

Criticisms

Scholars have identified some major problems with social constructivism. First, these views go beyond typical sociological studies that address the effects of peripheral social phenomena (such as institutional politics) that surround the production of science (Slezak, 2000, p. 96). Instead, social constructivist views attempt to explain the actual cognitive content in scientific theories (Phillips, 1997, p. 93; Slezak, 2000, p. 96). However, implying that a social milieu is a cause of the content in a particular theory leads to the illogical inference that Sir Isaac Newton may have articulated an inverse cube law of gravitation if society had been different (Slezak, 2000, p. 98).

Second, radical social constructivism does not rely on reasoning or scientific/physical evidence as criteria for the development and verification of theory (Matthews, 2000; Phillips, 1997, p. 93; Slezak, 2000). However, scientists would not have accepted Galileo’s discoveries related to gravity unless countless other physicists had verified the findings, regardless of the social context in which Galileo worked.

Four criticisms of radical social constructivism address implications for science education. First, if knowledge is a product of social conventions, then ideas reflect conformity to social consensus (see Table 1.6). Therefore, individual creativity or genius, such as Albert Einstein’s theory of the interrelationships among light, matter, energy, and time, cannot be explained in this framework.

Second, addressing independent critical thinking, viewed by many as important in the survival of society, would be no longer needed. Third, there would be
TABLE 1.6
Implications of Radical Social Constructivism for Science Education

1. If knowledge involves only consensus on arbitrary conventions, then education need only ensure that ideas conform to prevailing interests (Slezak, 2000, p. 91).

2. Because knowledge involves only consensus, efforts to develop students' capabilities for logical and critical thinking are not needed (Slezak, 2000, p. 93).

3. Because logic, evidence, and other accepted criteria for theories are not relevant to the status of a theory, some theories cannot be judged as false or implausible (Slezak, 2000, p. 93). Therefore, there are no grounds for teaching that Hitler's view of a superior race was a perversion of scientific truth (Slezak, 2000, p. 94).

4. The barrier between evidence and theory leaves space for ideology, group, self-interest, or simply "feel-goodness" to identify educational policy (Matthews, 2000, p. 169).

no basis for evaluating the falsity or implausibility of a theory or of discounting theories that subvert the scientific process. Finally, reliance on consensus as a criterion for the acceptance of ideas would allow ideology or group self-interest to identify educational policy.

WHAT IS EDUCATIONAL CONSTRUCTIVISM?

Factors that contributed to the emergence of constructivism in education were (a) the perceived "overselling" of the computer as a metaphor for learning (which excludes the everyday capabilities of individuals, everyday problems, and the role of context; Bredo, 1994); (b) the transmission model of learning (Marshall, 1996); (c) concerns that students were acquiring isolated, decontextualized skills and are unable to apply them in real-world situations; and (d) an interest in Vygotsky's cultural-historical theory. A basic premise of Vygotsky's theory is that the signs and symbols of a culture and the ways they are used by adults in their thinking influence the child's cognitive development. Currently, the four major varieties of educational construction are personal or individual, social (which includes emergent and apprenticeship), philosophical, and aphilosophical.

Personal or Individual Constructivism

Personal constructivism is also a radical view because of the basic belief that reality is not accessible to rational human knowledge (von Glaserfeld, 1995). That is, all knowledge is a human construction. However, unlike radical social constructivism, the individual, not the social group, creates knowledge and constructs concepts. Individual perspectives can be judged partly according to their correspondence to consensually accepted norms (e.g., the Earth revolves around the sun; the Earth is not flat). The focus is "the construction by the learner of schemes that are coherent and useful to them" (Driver, 1995, p. 387). The goal is to shift the focus from correctly replicating the teacher's words and actions to the student's successful organization of his or her own experiences (von Glaserfeld, 1987, 1995). However, teachers also must introduce the conventions of science
that students cannot discover from experience. This goal can be accomplished through carefully developed questions that “shape students’ reasoning toward the accepted science view” (p. 397).

Personal constructivism originated with Jean Piaget’s cognitive-develop-
ment theory. Three points of agreement between Piagetian theory and personal constructivism are as follows. First, learning is an internal process that occurs in the mind of the individual. Second, essential learning processes are the cognitive conflict and reflection that occur when one’s thinking is challenged (see Chapter 8 for details). Third, the teacher's role is to develop an adequate model of each student’s way of viewing an idea, devise situations that challenge the child’s way of thinking, and help students examine the coherence in their current mode of thinking (Confrey, 1985).

However, Piagetian theory differs from personal constructivism in two major ways. First, Piagetian theory maintains the existence of an external reality. Second, the focus of Piagetian theory is the various changes in thinking that develop from infancy through adolescence as the individual accommodates his or her strategies of understanding the world to that reality. In other words, Piaget focused on the development of reasoning and logical thinking whereas personal constructivism focuses on particular topics, such as photosynthesis.

### Social Constructivism

Social-constructivist beliefs differ from personal constructivism in three ways: (a) the definition of knowledge, (b) the definition of learning, and (c) the locus of learning (see Table 1.7). Social constructivists view the classroom as a community whose task is to develop knowledge. Because they also view knowledge as inseparable from the activities that produce it (Bredo, 1994; Dewey & Bentley, 1949), knowledge is transactional. It is socially constructed and is distributed among

<table>
<thead>
<tr>
<th>Definition of knowledge</th>
<th>A product of the particular classroom or participant setting to which the learner belongs; the endpoint or product of a particular line of inquiry that is inseparable from the occasions and activities that produced it (Bredo, 1994; Dewey &amp; Bentley, 1949).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of learning</td>
<td>Socially shared cognition that is a process of becoming a member of a sustained community of practice (Lave, 1991); social interaction that constructs and reconstructs contexts, knowledge, and meanings (Marshall, 1996).</td>
</tr>
<tr>
<td>Locus of learning</td>
<td>Not confined to the individual's mind (Marshall, 1996); occurs in a community of participants and is distributed among the co-participants (Bredo, 1994).</td>
</tr>
</tbody>
</table>
the co-participants. The role of the learner is to participate in a system of practices that are themselves evolving (Cobb & Bowers, 1999). Mathematics, for example, is an active construction by learners that is shared with others (Wood, Cobb, & Yackel, 1995, p. 405). Therefore, classroom learning can be analyzed in terms of evolving mathematical practices. For example, first-grade children early in the fall may use counters in various ways to determine the number of days remaining in the week. In the spring, they may be discussing different ways to address three-digit problems (Cobb & Bowers, 1999).

Social constructivists also consider their approach as an alternative to learning by discovery (Wood et al., 1995, p. 404). One difference is that the constructivist mathematics teacher creates situations that may be personally meaningful to students at different conceptual levels (p. 407). Children, in pairs or small groups, develop their own ways of solving the problems. Classroom requirements also include (a) children’s explanations and justifications of their problem approach, (b) active listening to and trying to make sense of other students’ explanations, and (c) verbalizing agreement, disagreement, or a failure to understand the explanations of others (p. 411). In this way, they participate in and contribute to a communal mathematical practice.

**Emergent Social Constructivism**

A subvariety of social constructivism, emergent constructivism, is a coordination of personal and social-constructivist positions (Cobb, 1994; Cobb & Yackel, 1996). It is based on the view that neither cognitive nor social processes should be considered secondary in efforts to understand mathematics learning and teaching in classrooms (Wood et al., 1995, p. 401). Accounts of cognitive activity cannot be derived from analyses of social processes and mathematics learning and teaching is more than a cognitive process that is influenced by social processes. For example, social processes include the rules of discourse jointly negotiated by a teacher and her second-grade pupils, and the individual perspective addresses the child’s mathematical beliefs and beliefs about his or her role in general mathematical activities (Cobb & Bowers, 1999, p. 177). Therefore, learning may be analyzed from both the social (group) and the individual perspective in situations in which neither is primary.

**Apprenticeship**

The apprenticeship perspective of Jean Lave (1991; Lave & Wenger, 1991), described by Bredo (1994) as neo-Marxist, derives from the perceived alienated condition in capitalism, which lacks opportunities for individuals to develop deep knowledgeable skill and identities of mastery. Lave called for research on situated social practice or situated learning such as Mayan midwives and West African tailors. Essential characteristics are the seamless immersion of the learner into a community of practice with gradual movement from peripheral tasks to full participation; didactic structuring is absent.

Situated social practice also maintains that no strict knowledge boundary exists between the intra- and extracranial aspects of human cognition (Lave, 1991, p. 68). Instead, knowing is located in relations among practitioners, their practice,
and the social organization in a world in which social practices themselves may be changing (Lave & Wenger, 1991, p. 122). Although typical of informal and craft apprenticeships, the pedagogy for formal education can involve specially designed social activities that can permit novices to gain mastery of simplified domains of knowledge and activity (Ernst, 1995, p. 471).

A few educators (e.g., Packer & Goiochea, 2000) maintain that socially situated views of learning should not be labeled as constructivist. The reason is the focus on the characteristics of social participation, relationships, and the setting of the activity. More important, they do not emphasize the ways that knowledge is constructed on qualitatively different, and more progressively adequate, levels (p. 227). Therefore, according to this description, they should be viewed as socio-cultural instead of social constructivist approaches.

Aphilo sophical Constructivism

At least three subgroups of constructivists make no assumptions about the nature of knowledge. One group of educators “simply uses the label ‘constructivist’ to refer to anything which is pupil-centered, engaging, questioning, and progressive” (Matthews, 1997, p. 8). The other two subgroups interpret constructivism as representing the ways that students make meaning when reading and writing. Perhaps best known is the “holistic” approach to literacy known as whole language (Au, Mason, & Scheu, 1995; Poplin & Stone, 1992). The belief is that all forms of language, including written language, are most easily learned in the context of use. Therefore, literacy development requires immersion in authentic literacy events—activities that use language in functional ways and that have personal meaning for the student. Teachers should facilitate learning by creating authentic contexts that stimulate students to meet their own learning needs.

The third classroom-focused constructivist approach describes readers and writers as “building, shaping, and elaborating meanings when they understand or produce texts” (Spivey, 1995, p. 313). In reading, the constructivist process involves choosing relevant content suggested by the text, organizing it, and linking it to the reader’s prior knowledge (Spivey, 1987). Composing also is a constructivist process that focuses on the meanings to be generated from the final text. The writer’s anticipation of the reader’s knowledge and what the reader needs to know influences his or her writing.

Concerns

Educators have voiced four concerns about the social-constructivist classroom in which students construct knowledge through participation in a group. One is the exclusion of direct classroom instruction. Specifically, collaborative learning seems inappropriate for tasks such as learning the sounds of “a” (Howe & Berv, 2000) and developing knowledge of complex conceptual schemes built by human minds over hundreds of years (Matthews, 1997, p. 12). Included are such concepts as potential energy, mutation, linear inertia, and valence. A teacher is needed to illustrate and explain such concepts and show the relationships to other concepts (p. 13). Case studies of constructivist classroom activities conducted by Aulls (2002) indicated
that teachers whose students achieved the learning goals modeled procedures for self-checking important information, demonstrated ways to reduce information to paraphrases, taught content when needed, and scaffolded key procedures (p. 533).

Second is the difficulties faced by low-ability learners and those from other cultures. The participation structure can create barriers for them because they lack the knowledge and skills to participate (Cobb & Bowers, 1999; Delpit, 1988). Similarly, a reliance on authentic tasks that involve implicit rather than explicit instruction also can tax the cognitive skills of students at risk for learning difficulties (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998).

Third is the burden on the classroom teacher who faces challenges both within and outside the classroom. Windschitl (2002) identified four broad areas of dilemmas. They are (a) conceptual (grasping the underpinning of constructivism); (b) pedagogical (honoring students’ efforts to think for themselves while remaining true to accepted disciplinary ideas); (c) cultural (taking advantage of individual students’ knowledge and experiences while managing the transformation of beliefs and practices according to constructivist norms); and (d) political (facing issues of accountability and negotiating to teach for understanding) (p. 133).

Within the classroom, the teacher must (a) balance the competing demands of discovery and efficient understanding, and (b) exercise sensitive clinical judgments moment-by-moment to know when to intervene and when to allow interactions to continue (Palinscar, 1998; Perkins, 1999). In addition, observers have noted that some teachers do not ask challenging questions (Howe & Berv, 2000, p. 38), and do not challenge incoherence and inconsistencies (MacKinnon & Scarf-Seatter, 1997). In other words, the social-constructivist classroom requires teacher skills in establishing a discourse community with intellectual standards and a commitment to joint construction of meaning (Green & Gredler, 2002). Observations indicate that opportunities for learning and success differ as a function of teacher skills in establishing social norms and intellectual standards (Cobb & Bowers, 1999; Palinscar, 1998).

Finally, current research on working memory and long-term memory has implications for instruction. The function of working memory is the conscious processing of information (Kirschner, Sweller, & Clark, 2006). When dealing with new information, the capacity of working memory may be as low as four elements (Cowan, 2001). However, the limitations of short-term memory disappear when working memory is dealing with previously learned information that is stored in long-term memory (p. 77). The problem with minimal guidance methods of instruction (e.g., constructivist and inquiry-based instruction) is that they produce difficulties in processing and learning. Unlike guided instruction, these methods impose a heavy load on working memory. Also, while working memory is engaged in searching for problem-related information, it is unavailable for learning (p. 77). Moreover, research studies indicate that strongly guided learning produces deeper learning and fewer misconceptions (e.g., Moreno, 2004).

**Summary**

Constructivist views of the nature of knowledge either greatly reduce or set aside the role of external reality in the production of knowledge. The radical social-constructivist view maintains that knowledge is entirely the product of social
processes. Objects are social artifacts, and scientific theories simply reflect the social milieu in which they emerge. One radical social-constructivist perspective maintains that the task of describing the world is a linguistic rather than a cognitive process.

Major problems with radical social constructivism expressed by scholars include (a) the illogical conclusion that a scientist would have developed a different theory if he had lived in a different society, and (b) logical reasoning and scientific/physical evidence are not criteria for acceptance of a theory. Implications for science education are (a) if knowledge is a product of social conventions, then education need only ensure that ideas conform to prevailing interests, and (b) developing students’ critical thinking is not needed if there is no basis for judging theories as false or implausible. In other words, educational policy would be identified through group self-interest.

Currently, three types of educational constructivism may be identified. Personal or individual constructivism (a) considers all knowledge to be a human construction, (b) the individual creates knowledge and constructs concepts, and (c) viewpoints can only be partially judged according to their correspondence with consensually accepted norms. In the classroom, personal constructivism advocates two Piagetian principles: learning is an internal process, and cognitive conflict and reflection result from challenges to one’s thinking. Some educators who support personal constructivism also note that the student must also be granted access to the concepts of conventional science.

In contrast, social constructivists believe that knowledge is transactional, socially constructed, and distributed among co-participants. Classroom learning over several months can be described in terms of the evolving mathematical practices in a community of learners. One social-constructivist view, however, analyzes learning from both the social (negotiating rules of discourse) and the individual (child’s mathematical beliefs and view of one’s role in the classroom) perspectives. Another social-constructivist view is apprenticeship, in which knowing is located in relationships among practitioners. Proponents maintain that specially designed classroom activities can permit novices to develop mastery of simplified domains of knowledge. Some educators, however, maintain that socially situated views of learning should not be labeled as constructivist because they do not emphasize the ways that knowledge is constructed on qualitatively different and more adequate levels.

The third approach, aphilosophical, makes no assumptions about the nature of knowledge. Classrooms may be referred to as pupil-centered, implementing the holistic approach to literacy, or focusing on the ways that readers and writers develop meaning. Literacy development, therefore, requires immersion in activities that use language in functional ways and have personal meaning for students.

Concerns expressed about constructivism include (a) collaborative learning seems inappropriate for some learning, (b) low-ability learners and those from other cultures face particular difficulties, (c) the method places particular burdens on the teachers, and (d) some teachers do not ask challenging questions. In addition, current research indicates that minimally guided instruction places an excessive load on working memory, thereby inhibiting deep and accurate learning.
HOW DOES THIS TEXT PRESENT KNOWLEDGE ABOUT LEARNING?

A primary purpose of this text is to reflect the state of the art in theory development related to classroom learning against the backdrop of early theory development. A second purpose is to provide guidelines for instruction as the theorist identified them (e.g., Gagné, Skinner), or as extrapolated from the basic principles (e.g., information-processing theory). Third is to discuss other developments that are attracting the attention of educators, although they are not theories. The two examples in this text are constructivism, discussed in this chapter, and research on the brain, discussed in Chapter 3. Finally, to facilitate comparisons across theories, the text describes each of the seven contemporary perspectives in terms of the same template.

Organization of the Text

Developments are presented roughly in the chronological order in which they appeared. Chapter 2 discusses the first learning theories: classical conditioning, Thorndike's connectionism, and Gestalt psychology. As indicated in Figure 1.1, classical conditioning and connectionism are behavioral theories. Classical conditioning addresses reflexes and simple emotional reactions, and connectionism describes the learning of simple self-selected responses to situations. Gestalt psychologists, in contrast, focused on the role of perception in solving visual problems.

In the 1990s, improved brain imaging techniques led to an interest in the potential of cognitive neuroscience to inform theory. The research on brain functioning and mental activities is in its infancy, and there are no direct applications. One recent discovery, that of mirror neurons, seems promising in relation to imitation, and this development, along with other aspects and misinterpretations of brain research, is discussed in Chapter 3.

Chapters 4–11 present seven contemporary theoretical perspectives that address important events related to learning or cognitive development. B. F. Skinner's operant conditioning, which continued the behaviorist tradition, is discussed in Chapter 4. Robert Gagné's conditions of learning, Chapter 5, an interactionist perspective that integrates both behavioral learning outcomes and the processing of information by the learner, also serves as a bridge between operant conditioning and the cognitive theories that follow.

Chapter 6, "Cognitive Perspectives I," describes the ways that individuals take in information from the environment, and then process, store, and later retrieve the information when needed. Chapter 7, "Cognitive Perspectives II," discusses complex cognitive processes, referred to as metacognition and problem solving.

Chapters 8 and 9 present the two theories that address cognitive development rather than the specifics of learning. Chapter 8 discusses Jean Piaget's perspective, which describes the development of logical reasoning from early childhood to adulthood. Lev Vygotsky's cultural-historical theory is discussed in Chapter 9. Vygotsky described the role of cultural signs and symbols in developing the higher cognitive processes of self-organized attention, categorical perception, conceptual thinking, and logical memory.
FIGURE 1.1
Psychological perspectives of key factors in learning
Chapters 10 and 11 go beyond the cognitive processing perspectives to address aspects of motivation. Albert Bandura’s social-cognitive theory (Chapter 10) describes learning from observing the behaviors of others and the learner’s development of a self-regulatory system to manage one’s learning. Chapter 11 presents current models of motivation (expectancy-value and goal-orientation models) and attribution theory. The text concludes with the Epilogue, which first compares and contrasts the theories and then briefly discusses challenges for learning theory.

Table 1.8 classifies each theory in terms of major focus. Operant conditioning, Gagné’s conditions of learning, and cognitive theories directly address the learning process; Piaget and Vygotsky are cognitive-development theorists. Bandura’s social-cognitive theory and the motivational models and attribution theory are social-context theories. They address self-regulatory and motivational factors that include information from the social setting, which influences learner beliefs about their capabilities.

**Chapter Organization**

The discussion of each of the seven contemporary perspectives proceeds from the theoretical to the practical. The sections “Principles of Learning” and “Principles of Instruction” are parallel discussions (see Table 1.9). The fundamentals of each theory are explained in the former, and the ways in which these fundamentals are

<table>
<thead>
<tr>
<th>Theory</th>
<th>Type</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skinner’s operant conditioning</td>
<td>Learning process</td>
<td>The arrangement of consequences for learner behavior</td>
</tr>
<tr>
<td>Gagné’s conditions of learning</td>
<td>Learning process</td>
<td>The relationship of the phase of information processing to type of learning task and instruction</td>
</tr>
<tr>
<td>Cognitive theories</td>
<td>Learning process</td>
<td>The processes of acquiring information, remembering, managing one’s learning, and problem solving</td>
</tr>
<tr>
<td>Piaget’s developmental epistemology</td>
<td>Cognitive development</td>
<td>The growth of intelligence from infancy to adulthood</td>
</tr>
<tr>
<td>Vygotsky’s cultural-historical theory</td>
<td>Cognitive development</td>
<td>The role of cultural symbols in the development of higher mental functions</td>
</tr>
<tr>
<td>Bandura’s social-cognitive theory</td>
<td>Social context</td>
<td>The influence of models and other environmental and personal factors on behavior</td>
</tr>
<tr>
<td>Motivational models and theories</td>
<td>Social context</td>
<td>Influences on achievement-related behavior</td>
</tr>
</tbody>
</table>
TABLE 1.9
Topic Outline* for the Analysis of Each Contemporary Theory

<table>
<thead>
<tr>
<th>Topic</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principles of learning (or development)</strong></td>
<td></td>
</tr>
<tr>
<td>Basic assumptions</td>
<td>What assumptions about learning are made by the theorist? How is learning defined? Is learning viewed as behavioral change, a change in cognitive structure, or as some internal process?</td>
</tr>
<tr>
<td>The components of learning (or development)</td>
<td>What are the essential elements that must be present in each act of learning? What are the interrelationships?</td>
</tr>
<tr>
<td>The nature of complex learning</td>
<td>How are the components of learning (described in the preceding section) arranged to account for complex learning, such as how to solve problems?</td>
</tr>
<tr>
<td><strong>Principles of instruction</strong></td>
<td></td>
</tr>
<tr>
<td>Basic assumptions</td>
<td>What are the theorist’s assumptions about school learning?</td>
</tr>
<tr>
<td>The components of instruction</td>
<td>How do the components of learning relate to classroom instruction?</td>
</tr>
<tr>
<td>Designing instruction for complex skills</td>
<td>How is instruction to be developed for skills such as learning to play tennis and learning to solve problems?</td>
</tr>
<tr>
<td><strong>Educational applications</strong></td>
<td></td>
</tr>
<tr>
<td>Classroom issues</td>
<td>How does the theory explain individual differences, cognitive processes, and the social context for learning?</td>
</tr>
<tr>
<td>Developing a classroom strategy</td>
<td>What are the specific steps in the development of instruction?</td>
</tr>
<tr>
<td>Classroom example</td>
<td></td>
</tr>
</tbody>
</table>

*Minor wording changes have been made in Piaget’s cognitive-development theory, Vygotsky’s cultural-historical theory, and motivational perspectives.

The basic assumptions of each theory introduce the discussion of each perspective. No set of principles about learning is developed in a vacuum. Instead, each theory is derived from basic beliefs about the nature of learning. Such beliefs establish the emphasis and focus of the theory. For example, a theory that defines learning as behavioral change will focus on factors that influence behavior. Mental states or cognitive structures are the emphasis of other theories that define learning in terms of qualitative processes.
The purpose of the two sections “The Components of Learning” and “The Nature of Complex Learning” is twofold. One is to present and describe the fundamental elements that must be present in every learning episode apart from any other discussion. The components of learning are the core of each theory. In Skinner’s operant conditioning, for example, the components of each learning episode are (a) a discriminative stimulus, (b) a learner response, and (c) a consequence. In contrast, the essential components in Bandura’s social-cognitive theory are (a) the modeled behavior, (b) nature of the reinforcement for the model’s behavior, and (c) the learner’s cognitive processes. Understanding the components of learning and the relationships among them is essential to the analysis of instructional applications of the theory.

The ways in which the basic learning components are arranged for learning complex skills, such as learning to solve algebra problems, are often not intuitively obvious. Therefore, the section “The Nature of Complex Learning” (or development) is included to illustrate these situations. In operant conditioning, for instance, complex sequences of skills are acquired through the implementation of various patterns of subtle reinforcement contingencies.

The final section, “Educational Applications,” first relates the theory to classroom issues. Included are the theory’s position on individual differences, cognitive processes, and the social context for learning. Implications for assessment are also discussed. Then the specific steps required to develop an instructional strategy according to the theory are presented, followed by a classroom example. The exception to this format is information-processing theory, which is discussed in two chapters.

CHAPTER QUESTIONS

Understanding Concepts

1. Self-directed learning is important to the individual because it contributes to a varied and creative lifestyle. What are some reasons for the importance of self-directed learning to society?
2. One of the activities undertaken in the data collection efforts of the 1920s was determining the cost of teaching certain topics, such as Latin verbs. What is the problem with this particular piece of research, according to Suppes?
3. The view that one should study great books to improve one’s mind is consistent with which philosophy?
4. What is a major difference between the methods used by philosophy and theory?
5. What is Leahey’s argument that the so-called cognitive revolution was not a revolution?
6. According to the description of personal constructivism, in what ways does it agree with Piaget?

Applying Concepts to Instructional Settings

1a. A maxim sometimes provided to novice teachers is “Don’t smile until Christmas.” Why is such a directive of little help in the classroom?
1b. What do you think that maxim means and what should teachers be told instead?
2. A first-grade teacher sets up a mock grocery store with products to buy and a cash drawer to represent a cash register. She places signs on the products and gives the children fake money to use in their purchases. What form of constructivism does this scenario represent?
3. A first-grade teacher explains to the class that they will be working in pairs to determine how many different ways a set of numbers can sum to 10. She also asks each pair to be able to explain how they decided on each set (e.g., I know that 6 and 6 are 12, so I just subtracted 2). Also, the class understands that they are to listen carefully to the explanations of the other children and be able to say whether they agree, disagree, or don’t understand the strategy. Which type of constructivism is this and why?

4. Identify a curriculum area and a grade level. Describe the opportunities and challenges you would face in implementing emergent social constructivism.

REFERENCES


CHAPTER 2
Early Learning Theories

At any one time, a science is simply what its researches yield, and the researches are nothing more than those problems for which effective methods have been found and for which the times are ready. Each step in scientific progress depends on the previous one, and the process is not much hurried by wishing. (Boring, 1930)

Psychology, a young discipline at the beginning of the 20th century, faced two major questions: What should be the focus of study? and What should be the scope of the discipline? Psychologists also aspired to develop a precise science like physics and chemistry. However, suggestions lacked precise research methods. Into that breach came behaviorism, championed by its founder, John B. Watson. In his 1913 article, “Psychology as the Behaviorist Views It,” Watson noted that, in some 50-odd years, psychology had failed to become a natural science. The focus on consciousness and mental processes had led psychology into a dead end where the topics were “threadbare from much handling” (Watson, 1913, p. 174). He proposed a common subject of study—behavior—a topic that could unite all psychologists (Todd & Morris, 1992, p. 1447).

Behaviorism became the dominant movement from the 1920s to the 1950s, but its rise was not completely unchallenged. The opposing view, Gestalt psychology, emphasized the importance of the learner’s perceptions in problem-solving situations and kept alive the issue of cognition.

CLASSICAL CONDITIONING AND CONNECTIONISM

The two early approaches to the study of behavior were classical conditioning and connectionism. Both perspectives made learning a major priority and successfully manipulated different types of behavior in the laboratory.
A Rationale for Behaviorism

Changes in American society contributed to setting the stage for the study of behavior (Leahey, 1992). Industrializing cities were replacing rural communities and the urban migrants needed to learn new skills. In addition, an emerging American philosophy, pragmatism, identified concrete consequences (outcomes) as the test for validating ideas (p. 312). Truth, in other words, is "what works."

In this context, John Watson advocated the study of behavior. His rationale was that all organisms adjust to the environment through responses and certain responses typically follow certain events (stimuli). Through studying behavior, psychologists should be able to predict the response from the stimulus, and vice versa. When this goal is achieved, psychology will then become an objective, experimental science (Watson, 1913). In addition, the discipline would provide useful knowledge for the educator, physician, business leader, and others.

After the appeal to study behavior, Watson discovered the motor-reflex research of V. M. Bekheterev, a Russian physiologist (not the research of Ivan Pavlov, as is often believed [Boakes, 1934; Coleman, 1988]). Bekheterev's work was important because he had successfully manipulated simple behavioral reactions in the laboratory. On reading the research, Watson was convinced that behavioral control in the real world was within reach. His prediction was wrong, but his views were a major force in the use of precise methods of research and measurement by psychologists (Kratochwill & Bijou, 1987).

Basic Assumptions

The term behaviorism refers to several theories that share three basic assumptions about learning. They are as follows.

1. Observable behavior, rather than internal mental events or verbal reconstructions of events, should be the focus of study.
2. Behavior should be studied in terms of its simplest elements (specific stimuli and specific responses). Examples of behavioral reactions investigated by the early researchers include reflexes, observable emotional reactions, and motor and verbal responses.
3. The process of learning is behavioral change. A particular response becomes associated with the occurrence of a particular stimulus, and occurs in the presence of that stimulus.

Pavlov and Reflex or Classical Conditioning

The best-known experiments on reflexes were conducted in the research laboratories of Ivan Pavlov. The story handed down about Pavlov's research features the lonely scientist who accidentally discovered a way to control simple behaviors while researching the salivation reflex in dogs. He alone, according to the story, discovered that an involuntary reaction, salivation, could be trained to
respond to sounds unrelated to food. However, far from being a lonely scientist, Pavlov directed several physiological laboratories, which produced more than 530 research papers from 1897 to 1936. As director, Pavlov assigned research topics to coworkers and students and monitored their work, but he rarely experimented himself (Todes, 1997; Windholz, 1997).

Pavlov and the Bolsheviks
The years of the Bolshevik revolution (1917–1921) were particularly difficult for Pavlov, his family, and his laboratory. Pavlov's home was searched several times, he scavenged for firewood, and fed his family from a garden he tended at the Institute of Experimental Medicine. The Nobel Prize money he had received in 1904 for the work on digestive processes was confiscated and work in his laboratories almost ceased for lack of electricity, kerosene, and candles (Todes, 1995, p. 384).

In June 1920, at the age of 70, Pavlov wrote to the government for permission to emigrate. Considering the emigration of an internationally known scientist impermissible, the government accorded Pavlov special status. He received improved living quarters, liberal food rations for himself and his coworkers, and extensive laboratory support (Todes, 1995).

The Research in Pavlov's Laboratories
The focus of the research supervised by Pavlov was the salivation reflex in dogs. In the course of the research, a student researcher discovered that "teasing" dogs from a distance produced salivation. Also, dry and moist foods seen by the dog from a distance produced greater and lesser amounts of salivation (Windholz, 1997, p. 242). Pavlov initially named the salivation reaction to the sight of food as a conditional reflex.

Subsequent research by V.N. Boldyrev found that the salivary reflex may be trained to respond (conditioned) to objects or events from virtually any sensory modality—sight, sound, or touch (Windholz, 1997). For example, a tuning fork was sounded just moments before placing meat powder on the animal's tongue. After several such pairings, the tuning fork alone elicited the salivation reaction.

The research in Pavlov's laboratory was important for two reasons. First, it demonstrated that the salivation reaction is a reflex—a spontaneous reaction that occurs automatically to a particular stimulus. Second, to alter the natural relationship between a stimulus and a reaction was viewed as a major breakthrough in the study of behavior. To manipulate even a simple reaction held out the promise that the causes of complex behaviors also might be discovered. The research had demonstrated the potential of laboratory studies to discover new knowledge.

The Classical Conditioning Paradigm
The process by which new events or stimuli acquire the power to trigger responses became known as reflex or classical conditioning. An example of a reflex is the automatic reaction to a puff of air or foreign object in the eye; the stimulus is immediately followed by eye blinks. The process of classical conditioning consists of three stages (see Table 2.1). The first stage is the preexperimental or
natural relationship between a stimulus and a reaction (as in the above example). In the second stage, the researcher pairs the original stimulus with a new stimulus that has no relationship to the reaction. After several repetitions, referred to as “trials,” the new stimulus, on its own, elicits the reaction (stage three).

In the natural relationship, the stimulus and its automatic reaction are referred to as the unconditioned stimulus (UCS) and the unconditioned response (UCR). In the new relationship, formed as a result of the training, the new stimulus is referred to as the conditioned stimulus (CS). The reaction, which has been trained to respond to the new stimulus, is now a conditioned response (CR).

**Related Concepts.** The development of classical conditioning introduced a number of variables and new relationships that could be researched and precisely measured in the laboratory setting. Included are the amount or strength of the response (referred to as amplitude), the length of time between the stimulus and the response (latency), and the tendency of similar stimuli to elicit the reflex (stimulus generalization). For example, a reflex conditioned to a sound pitch of 256 also responds to sound pitches of 255 and 257 (Murphy, 1949). Others are resistance to extinction and inhibition. Resistance to extinction is the tendency of a response to persist for a time after the supporting conditions are withdrawn. Inhibition refers to the reduction in a response caused by the introduction of extraneous stimuli at the same time as the conditioned stimulus is applied. Examples include a sudden draft in the room or a change in the room’s illumination (Pavlov, 1927).

Pavlov (1927) also investigated the process of higher order conditioning. The researcher pairs a second stimulus to be conditioned (CS2) with the initial conditioned stimulus (CS1) instead of pairing it with the unconditioned stimulus (UCS). However, these relationships appear to be short-lived.
Two other enduring effects of Pavlovian conditioning are (a) research on animal survival cues in the natural environment, and (b) development of the process known as counterconditioning. Research on survival mechanisms indicated that an animal learns to respond to environmental cues that signal the likely presence of a predator (Hollis, 1997). Counterconditioning includes methods to address animal neuroses and became the foundation for clinical behavior therapy for human problems (Wolpe & Plaud, 1997). Animal neurosis develops when powerful conditioned environmental stimuli overwhelm an animal’s typical reactions and elicit anxiety or neurotic reactions. An example is repeated mild electric shock that elicits howling and rapid pacing back and forth. However, pairing the mild electric shock with the presentation of food triggered salivation instead of the animal’s defensive behaviors.

**Classical Conditioning and Drug Reactions.** A third outcome of Pavlovian research is the identification of cues that influence reactions in habitual substance abuse. Pavlov had observed that, after a time, the salivation reaction occurred in response to the arrival of the person who fed the dog. Seeing the person served as a cue that food was forthcoming and it elicited the salivation reaction. This example, a reaction to a pre-food cue, also explains relationships that occur in both laboratory and clinical studies of drug addiction. After a few administrations of a drug, cues associated with the administration elicit drug-compensatory responses referred to as conditional-compensatory responses (CCRs) (Siegel, 2002; Siegel, Baptista, Kim, McDonald, & Weise-Kelly, 2000; Siegel & Ramos, 2002). CCRs are important because they weaken the effects of the particular drug that is being administered. For example, in the laboratory, Subkov and Zilov (1937) injected dogs with adrenaline—a drug that stimulates the heart and increases blood pressure and heart rate. However, after a few administrations of the drug, the dog’s heart rate decreased somewhat as it was about to be injected (see Figure 2.1). The reflex reaction of the decreased heart rate is a CCR elicited by the drug administration cues, and is a compensation for the high heart rate produced by the drug. In addition, placing the dog in the injection stand and administering an inert substance instead of the adrenaline also set in motion the CCR, the decreased heart rate.

In clinical studies, the decrease in the effect of a particular drug after repeated administrations is referred to as drug tolerance. It is the result of CCRs, elicited by drug administration cues, which weaken the effect of the drug. Researchers have documented CCRs to several drugs, including commonly abused substances such as opiates, ethanol, and caffeine (see Siegel & Ramos, 2002, p. 165).

The most important pre-drug cue that can elicit CCRs is the context in which the drug is administered. The pre-drug cue of the same setting for administration gradually strengthens the associated CCRs; in other words, drug tolerance is situation-specific (Siegel & Ramos, 2002, p. 165). An example is an addict who goes into the bathroom each morning, turns on the shower, and then self-administers his or her heroin dose. The setting, the bathroom, and the running shower are CCRs that mitigate the effects of the drug.
The situation-specific nature of CCRs provides an explanation for so-called “drug overdose” situations. In the above example, if circumstances require administering the heroin in another room in the house, the addict risks suffering the symptoms of a drug overdose. Interviews of heroin overdose survivors indicated that they had self-administered the drug in a setting different from the usual setting. The new, unfamiliar circumstance did not trigger the context-related CCRs that would weaken the drug’s effects (Gutiérrez-Cebollada, de la Tore, Ortuño, Garcés, & Cami, 1994). In addition, autopsies of heroin addicts labeled as overdose victims indicated that most of them did not have high levels of the drug in their system. Research indicates that the level of tolerance (context-related CCRs that counter the respiratory depressive effects of heroin) was missing. In other words, in Pavlov’s research the salivation reaction to the person who always fed the dog (a reaction to a pre-food cue) is the model for the development of tolerance to addictive drugs (CCRs that respond to the usual drug-administration context).

**Summary**

At the beginning of the 20th century, the newly formed discipline of psychology was searching for a direction and major focus. Watson’s directive to study behavior with the goal of explaining the relationships between stimuli and responses became the dominant perspective. The major assumptions of behaviorism are that observable behavior is the focus of study, the simplest elements of behavior should be studied, and the process of learning is behavioral change.

Reflex conditioning in the experiments of Bekhterev and Pavlov reflected these assumptions and demonstrated that the natural relationship between a stimulus and the associated reflex could be altered. This research held out the promise that the causes of complex behaviors might be discovered.

Training a reflex to respond to a new stimulus requires the repeated pairings of the new stimulus with the stimulus that naturally elicits the reflex. As a result, the new conditioned stimulus (CS) elicits the now-conditioned response (CR) on its own. Known as classical conditioning, this model accounts for animal responses to cues associated with danger and the identification of methods to counter maladaptive reactions in animals and humans. In addition, the model
accounts for the development of conditional-compensatory responses (CCRs) to pre-drug cues in the usual setting for drug administration. This phenomenon accounts for both drug tolerance and so-called drug overdoses.

**John Watson’s Behaviorism**

Watson contributed to the development of psychology in three ways. First, he organized the findings of the research on conditioning into a new perspective, behaviorism, and persuaded other psychologists of the importance of his views. Behaviorism, as Watson (1916b) viewed it, should apply the techniques used in conditioning animal behavior to humans. (He redefined mental concepts as behavioral responses, and described thinking as subvocal speech; Watson, 1924.)

Second, an original contribution of his work was his extension of the methods of classical conditioning to emotional responses in humans. Third, his work increased the status of learning as a topic in psychology (Rilling, 2000a, p. 277).

**Theory of Emotion**

Watson identified three emotional reactions of infants that are instinctive. That is, they occur naturally. These reactions are love, rage, and fear (Watson, 1928; Watson & Morgan, 1917). For example, the fear response occurs in the natural environment following a loud noise or loss of support for the infant. It begins with body jerks and an interruption in breathing.

Watson agreed with Sigmund Freud that the adult’s emotional life begins in infancy and that emotions may be transferred from one object or event to another (Watson & Morgan, 1917). However, he did not approve of Freud’s psychoanalytic methods for discovering the roots of the individual’s emotional life (probing childhood memories and other emotion-producing events). Instead, Watson maintained that the process involved conditioning the three basic reactions (love, fear, rage) to a variety of situations. Also, information about emotional conditioning should be based on direct behavioral observations conducted in the laboratory (Rilling, 2000b, p. 308).

**The Conditioning Experiment with Albert.** The purpose of Watson’s well-known experiment with an 11-month-old child named Albert was to test his theory of emotion (Rilling, 2000b, p. 309). In the experiment, unethical by today’s standards, Watson and his graduate assistant Rosalie Rayner, conditioned Albert’s fear reaction to several soft furry objects (Watson & Rayner, 1920).

Albert was tested first to confirm that live animals and objects (such as a mask and cotton) did not elicit his fear response. Then, for several trials, a white rat was presented to Albert and a laboratory assistant behind Albert struck a steel bar with a hammer. On the first pairing of the white rat and the loud noise, the infant jumped violently; on the second trial (pairing), he began to cry. On the eighth trial, the white rat alone elicited crying and crawling away (Watson & Rayner, 1920).

Five days later, the fear reaction also appeared in response to a white rabbit. Non-furry objects, such as the child’s blocks, did not elicit the fear response,
but mild fear reactions occurred in response to a dog and a sealskin fur coat. The stimulus pairings had transferred the child's emotional response to furry animals and objects, and it persisted for longer than a month.

Albert's conditioned emotional response of crying on the presentation of a rabbit, which had not been paired with the loud sound, demonstrated Freud's concept of transference (Rilling, 2000b). The fear reaction to the white rat had been transferred to the rabbit.

In recent years, researchers have questioned the experiment because the requirements for classical conditioning were not strictly followed. The loud noise was not paired with the presentation of the rat. Instead, the noise occurred as Albert reached out his hand to touch the animal. However, the experiment demonstrated that emotions could be studied by controlled research methods, and it promoted research on conditioning (Kratochwill & Bijou, 1987).

A related topic, the elimination or "unconditioning" of children's fear reactions, was pioneered by Mary Cover Jones. She found that efforts to talk the child out of the fear or relying on extinction to eliminate the fear were ineffective (Jones, 1924). Instead, a planned program was required. The two successful strategies were (a) the child's observation of other children's acceptance of the feared object, and (b) the gradual presentation of the feared object during a favorite activity, such as eating.

**Predictions.** In the "behaviorist manifesto," Watson (1913) foresaw practical goals for behaviorism (Logue, 1994, p. 112). He predicted that educators, physicians, jurists, and business executives could utilize behavioral data as soon as it was experimentally available (Watson, 1913, p. 168).

Some years later, Watson (1924) made the following claims for conditioning, although he stated he was going beyond his facts:

> Give me a dozen healthy infants, well formed, and my own specified world to bring them up in, and I'll guarantee to take any one at random and train him to become any type of specialist I might select—doctor, lawyer, artist, merchant-chief—regardless of his talents, penchant, tendencies, abilities, vocations, and race of his ancestors. (p. 82)

One result of Watson's work was that the simplicity of the method for conditioning responses and the novelty of the procedure led to a multitude of applications and experiments. In the 1920s almost every psychologist seemed to be a behaviorist, and none appeared to agree with any other (Boring, 1950). The term *behaviorism* became attached to several developments, including a particular research method, objective data in general, and a materialistic view of psychology.

Watson also believed that behaviorism would place psychology in the ranks of the "true" sciences, along with zoology, physiology, physical chemistry, and others. These same views on the potential of behaviorism also were raised in the 1950s by B. F. Skinner.

Contrary to Watson's predictions, conditioned reactions did not add up to complex self-initiated behavior. However, psychologists believed that they would,
very likely because they had accepted the general belief of the importance of scientific methods in all fields (Baars, 1986, p. 53).

**Conditioned Emotional Reactions**

Through paired association, positive and negative reactions may be conditioned to a variety of objects and events. For example, a whiff of the paste used to fasten labels to bottles brought back painful memories of a miserable childhood for the well-known author Charles Dickens (Ackerman, 1990). The bankruptcy of Dickens's father had driven him to abandon young Charles to a workhouse where such bottles were made.

In addition, current research indicates that parental reactions paired with a novel stimulus facilitate the conditioning of the child's approach or avoidance reaction to the stimulus. For example, parental disgust reactions when confronted with spiders facilitated the children's acquisition of spider fear (de Jong, Andrea, & Muris, 1997). In another study, Gerull and Rapee (2002) found that mothers' positive (happy/encouraging) or negative (fearful/disgusted) reactions to novel stimuli (rubber snake or rubber spider) significantly influenced the approach and avoidance reactions of their toddlers.

Emotional reactions may, in certain situations, be conditioned in a single pairing of stimuli. An example is an automobile driver who narrowly misses a fatal accident with a large truck on a particular S-shaped curve. He or she experiences a rapid pulse, sweating palms, and increased blood pressure. A few days later, on approaching the same S-shaped curve, he or she experiences the same physiological reaction.

However, “pure” examples of classical conditioning to aversive stimuli are difficult to find in the natural setting. Typically, individuals are not “trapped” by emotion-producing stimuli. They may engage instead in escape behaviors that, in some situations, produce satisfying outcomes. For example, Albert's fear responses of crying and whining (conditioned response) to the furry object (conditioned stimulus) were followed by crawling away (escape behavior). In the natural setting, the baby's mother would likely pick him up and comfort him, perhaps even rock him for a few minutes. Thus, a selected response, the escape behavior of crawling away, is followed by receiving the mother's attention and comfort.

A positive example of classical conditioning is the nostalgic reaction (response) to a song (conditioned stimulus) that was a hit during a former love affair. The song has acquired the power to elicit some of the same feelings originally associated with the person in the former relationship. Such emotional reactions often occur without the awareness of the individual; thus, their origin may be difficult to identify.

**Classical Conditioning in the Classroom**

An essential step in developing the appreciation of literature, art, science, and other subjects is that of associating students' early experiences with positive reactions (Estes, 1989). However, the problem is that negative emotional reactions may become attached to the same situations and lead to the passive escape behaviors of apathy and “tuning out.”
One strategy is to make use of already-established relationships that elicit positive reactions. For example, sustained reading is an important activity in learning to appreciate literature. Carpeting one corner of the room and furnishing it with large sofa cushions to create an area for sustained reading may, over time, elicit positive reactions to the free-time reading included in the daily schedule.

Such strategies are particularly important in situations in which a particular setting or activity is expected to elicit a negative reaction. For example, for some children, unfamiliar situations generate anxiety reactions. Introducing a difficult activity, such as a mathematics activity, on the first day of school may lead to the association of an anxiety reaction to mathematics (see Figure 2.2a). Positive strategies observed in some elementary school classes included greeting the children warmly as they arrived and starting the day with drawing or coloring activities (Emmer, Evertson, & Anderson, 1980) (see Figure 2.2b). In addition, no difficult activities were introduced the first week while the children were becoming accustomed to classroom routines. Instead, the teachers reduced the potential for anxiety by repeatedly pairing the unfamiliar setting with relaxing activities.

![Diagram of classical conditioning in the classroom]

**FIGURE 2.2**
Applying classical conditioning in the classroom
Summary
In addition to persuading others of a view of behaviorism to be built on classical conditioning, John Watson developed a behavioral theory of emotion. He maintained that the adult's emotional life resulted from the conditioning of the instinctive emotional reactions (love, rage, fear) to a variety of objects and events. Watson demonstrated his theory in his experiment with Albert, an 11-month-old infant. Albert's fear reaction was conditioned to a white rat and the reaction transferred to a white rabbit. Another researcher, Mary Cover Jones, demonstrated the unconditioning of children's fear reactions by gradually introducing the feared object during a favorite activity.

Current research indicates that parental reactions paired with a novel stimulus, such as a rubber spider, influence the approach or avoidance reactions of their toddlers. In the classroom, teachers should select activities for the opening days of school that tend to elicit approach rather than avoidance or anxiety reactions.

Edward Thorndike's Connectionism
Although Edward Thorndike's connectionism is typically referred to as a behaviorist theory, it differs from classical conditioning in two major ways. First, Thorndike was interested in mental processes, and he designed his first experiments to address the thought processes of animals. Second, instead of reflex or involuntary reactions, Thorndike researched voluntary or self-directed behaviors.

Prior to Thorndike's doctoral thesis, the information on animal behavior was a morass of questionable anecdotes and engaging tales (Galef, 1998, p. 1128). Thorndike (1911) noted that "dogs get lost hundreds of times and no one ever notices it or sends an account of it to a scientific magazine. But let one find his way from Brooklyn to Yonkers and the fact immediately becomes a circulating anecdote" (p. 24).

Instead of depending on chance observations of intriguing bits of behavior, Thorndike insisted on experimentation under controlled conditions. In the experiments, animals were confined in cages with food outside or food was placed in a latched box. The task for the hungry animal was to open the box or cage and get to the food. Thorndike referred to his experiments as instrumental conditioning to reflect the differences with classical conditioning. The theory is known as connectionism because the animal establishes connections between particular stimuli and self-initiated behaviors.

Thorndike's views were not immediately accepted. One early review of his research maintained that Thorndike studied "starved, panic-stricken cats and dogs that had temporarily lost their normal wits, so that their intelligence was grossly under-estimated" (Mills, 1899, in Galef, 1998, p. 1130). However, as Thorndike's research became better known, it led to the establishment of laboratories to study animal behavior.

Experimental Procedure
Thorndike experimented with baby chicks, dogs, fish, cats, and monkeys. (While he was a student at Harvard, his landlady forbade him to continue hatching chicks in his room. William James offered the basement of his home for Thorndike's...
research, to the dismay of Mrs. James and the excitement of the children.) The typical experimental procedure required each animal to escape from a confined space (or to open a closed space) to reach food. Thorndike used a puzzle box that required the tripping of a latch or other mechanism in order to escape (Figure 2.3).

When confined, the animal often engaged in a variety of behaviors, including scratching, biting, clawing, and rubbing against the sides of the cage. Sooner or later the animal tripped the latch and escaped to the food. The behaviors unrelated to escape decreased during subsequent confinements, and the escape time was shorter. The most dramatic change was observed with monkeys. In one experiment, a box containing a banana was placed inside the monkey's cage. On the first trial the animal pulled out the nail that held the wire fastener in 36 minutes and completed the second trial in only 2 minutes 20 seconds (Thorndike, 1911).

Thorndike recorded the experimental data from each series of trials in the form of a learning curve of the faster escape times. He concluded from this data that the escape response gradually became associated with the stimulus situation in trial-and-error learning. For this reason, Thorndike's theory is described as an association theory.

The Laws of Learning
During the series of trials in the experiment, the correct response was gradually "stamped in" or strengthened. Incorrect responses were weakened or "stamped out." In other words, problem solving involves establishing associations or connections between the stimulus (the problem) and appropriate responses.

Thorndike originally identified three major laws of learning to explain this process. First, the law of effect states that a satisfying state of affairs following the...
response strengthens the connection between the stimulus and the appropriate behavior, and an annoying state weakens the connection. However, punishment is not equal to reward in its influence on learning. The law of effect is particularly important because it identified a new mechanism as responsible for learning. Instead of stimulus pairing to alter the relationship of a response to stimuli, Thorndike induced new behaviors through particular consequences for the novel responses.

Second, the law of exercise states that repetition of the experience increases the chances of a correct response. However, repetition does not enhance learning unless a satisfying state of affairs follows the response (Thorndike, 1913b, p. 20). Third, the law of readiness describes the conditions that govern the states referred to as “satisfying” or “annoying.” The execution of an action in response to a strong impulse is satisfying, whereas the blocking of that action or forcing it under other conditions is annoying.

Applications to School Learning
Thorndike based his interpretations of the learning process on his behavioral studies. However, because his theory also includes references to mental events, it occupied a middle ground between a cognitive perspective and the “pure” behaviorism of other researchers. In his view, connections between ideas accounted for most knowledge in its popular sense (Thorndike, 1913b, p. 19). This connection system includes both specific examples, such as $9 \times 5 = 45$, and connections to multiple configurations. An example is the concept that $1 \times 1 = 1/2 \times 2 = 1/3 \times 3$ (Cox, 1997). Other examples include events and dates, such as Columbus and 1492, and persons and characteristics, such as John has blue eyes.

Thorndike’s rules for teaching identify the requirements for establishing connections between stimuli and responses. Specifically, (a) do not form a bond that will have to be broken, and (b) form bonds in the way they are later required to act (Thorndike, 1922, p. 101). He also described five minor laws that are the first effort to account for the complexity of human learning. For example, the law of multiple response states that a variety of responses often occurs initially to a stimulus. Examples include developing a strong forehand in tennis and learning to pronounce words in a foreign language.

Connectionism, with its emphasis on establishing bonds between stimuli and responses, was particularly relevant for school learning in the early 20th century. At that time, the emphasis was on the learning of specific information and procedures.

The application of connectionism to school subjects is an example of Thorndike’s focus throughout his career—that of developing an educational psychology based on empirical data (Beatty, 1993). In addition to the research on the mental discipline concept described in Chapter 1, Thorndike also investigated transfer of learning. A series of studies conducted by Thorndike and Woodworth (1901) found that training in particular tasks facilitated the later learning only of similar tasks but not dissimilar ones.
Referred to as the father of educational psychology, Thorndike founded the *Journal of Educational Psychology*, developed tests of mathematics and handwriting, and produced more than 500 publications in his career, including 50 books (Dewsbury, 1998). His son later noted that his father was a workaholic primarily because he enjoyed analyzing data more than anything else (R. L. Thorndike, 1991).

**The Retreat to the Laboratory**

Thorndike cautioned his fellow psychologists that the proper laboratory for research was the classroom and the appropriate research subject was the student (Shulman, 1970). However, most of the theorists from 1930 to 1950 ignored Thorndike’s advice. They conducted research instead on animals and humans in artificially contrived situations. Rats ran mazes and escaped from boxes, and humans solved puzzles.

The goal during the 1920s and 1930s was to develop the one comprehensive theory that would explain all learning. However, behaviorism, the dominant movement during this period, was by no means a unitary approach to learning. Two theories, referred to as S-R theories, are the views of Clark Hull and Edwin Guthrie. Hull (1943), influenced by the concept of evolution, maintained that behavior functions to ensure the organism’s survival. Reinforcement in his theory referred to a biological condition, in the form of satisfaction of a biological need.

In contrast, Guthrie’s contiguity theory stated one learning principle, the law of contiguity. Specifically, a combination of stimuli accompanied by a movement will tend to be followed by the same movement on its recurrence (Guthrie, 1942, 1952, p. 23). Learning occurs because the last movement that is made changes the stimulus situation and no other response can occur. An example is answering a ringing telephone. Guthrie also advised teachers to associate stimuli and responses in appropriate ways by ensuring that their directives, such as please pass your homework papers forward, are followed by appropriate student responses.

**Summary**

Thorndike’s research with animals investigated self-initiated behaviors, not reflex reactions. Observing faster times in acquiring food, he concluded that correct responses were “stamped in” through association with access to the food, a satisfying state (the law of effect). His research on transfer of learning indicated that training on certain tasks only facilitated the learning of similar tasks and that difficult school subjects do not function as mental exercise to enhance thinking skills.

Two other approaches to learning, referred to as S-R theories, were developed by Clark Hull and Edwin Guthrie. Hull described reinforcement as fulfilling a biological need and Guthrie identified a single principle of learning, the association or contiguity of stimulus and response.
the chemical organization of the product. The effect on the silver cannot be understood either as a reaction to the particular elements or to their sum.

The second and third assumptions state that individuals perceive aspects of the environment as organizations of stimuli and respond on the basis of their perceptions. In addition, the Gestalt theorists maintained that the organization of stimuli in the environment is itself a process and this process influences an individual's perception (assumption four). For example, Koffka (1935, p. 159) noted that when pattern 4a in Table 2.2 is presented without the others, it is seen as a plane figure, either as a hexagon with diagonals or as a type of cross or starlike pattern. In this pattern, the plane figure is both symmetrical and simple; therefore, it is dominant.

In contrast, pattern 4c appears as a three-dimensional cube. Here, the plane figure is very irregular and difficult to see. Pattern 4b, on the other hand, is seen as either two-dimensional (a plane figure in which the pattern is lying on top of a hexagon) or three-dimensional (a cube). The reason is that the two- and three-dimensional forces are more balanced in pattern 4b than in the others. Figure 2.4 illustrates another example of balanced forces within the perceptual field. In this figure, the viewer typically sees either a black Maltese (German iron) cross or white propeller (Hartmann, 1942, p. 176).

The description of the behavioral environment and the dynamic organization of the sensory environment illustrate Gestalt efforts to apply the concept of field theory in physics to psychology. A field is a dynamic interrelated system in which every component influences all the other components. In Gestalt theory, the behavioral environment is a field and small groups of stimuli, such as the examples in Table 2.2, are each a small field.

**Laws of Perceptual Organization**
The Gestalt theorists maintained that the primary task for psychology was to determine how the individual psychologically perceives the geographic environment. They first defined perception as a process of organizing observed stimuli in which the observer conveys meaning on the stimulus array. The next step was to determine the characteristics of a stimulus display that influence perception. The basic Gestalt law, the law of Prägnanz, and related primary laws describe these influences.

**The Law of Prägnanz.** The term Prägnanz refers to essence, and the law refers to the psychological organization of a group of stimuli. In any stimulus array, the organization perceived by the individual is the one that is (a) most comprehensive, (b) most stable, and also (c) free of the casual and arbitrary (Murphy, 1949). An example is a particular type of puzzle picture popular several years ago. The picture, a line drawing, typically portrayed a landscape, and faces and objects were hidden in various parts of the drawing. The structure that prevailed was the overall scene, and often finding the "hidden" objects required much searching. In contrast, the forces in example 4b, Table 2.2, and Figure 2.4 are evenly balanced, and are, therefore, unstable. Perception of the figures alternates between the two possibilities.

**Related Laws.** The laws of perceptual organization describe four primary characteristics of the visual field that influence perception. They are the nearness of
elements to each other (proximity), shared features, such as color (similarity), the
tendency of elements to complete a pattern (open direction), and the contributions
of stimulus elements to a total simple structure (simplicity) (Wertheimer, 1938).
Perceptions tend to be meaningful and complete (the law of Prägnanz) and these
characteristics influence the completeness. For example, a series of dashes that
form a round pattern will be perceived as a circle (the open direction principle).

Since Wertheimer's (1938) work, researchers have continued to explore fea-
tures of the visual field that influence perception. For example, Tse (1998, 1999)
identified the contour of penetration (COP). It is a smooth curve that leads to the
perception of a complete figure for less-than-complete visual input, and the illu-
sion that the image is three-dimensional (see Figure 2.5).

he was boarding a bus. Another is Alexander Fleming's discovery of penicillin following his accidental notice that bacteria flourishing in the laboratory dish did not grow near mold (Seifert, Meyer, Davidson, Patalano, & Yariv, 1995, p. 93).

Some creative insights in various disciplines may indeed occur in this manner. However, research on introspective reports and interviews of creative individuals indicates that four phases often are involved. They are (a) hard work and research (mental preparation), (b) a period of idle time (incubation), (c) the moment of insight (illumination), and (d) work, including elaboration, to develop the idea (verification) (Csikszentmihalyi & Sawyer, 1995; Hadamard, 1949; Wallas, 1926). For example, by Poincare's own account, his mathematical discovery involved several weeks of work with seemingly no progress, a brief seaside vacation in which an idea came to him, further work followed by an impasse, a second insight, and work to develop a finished product (Gruber, 1981, 1995).

Although insight is unpredictable, the long-term and short-term conditions most likely to lead to insight are known (Simonton, 1995). Long-term preparation includes (a) an early home environment that provides extensive cultural and
intellectual stimulation, including an appetite for reading; (b) development by
the individual of a huge reservoir of discipline-relevant information intercon­
nected into a complex network of meanings and unusual associations; (c) study
with more than one mentor; and (d) keeping up to date on developments beyond
the boundaries of a particular specialty area. These factors make possible the
linkage of disparate ideas that become breakthroughs in a discipline.

In everyday life, preparation involves phases a and b of the above process.
That is, a favorable climate for insight involves preliminary work, including explori­
ng possibilities and recognizing dead ends, followed by a period of incubation in
which the individual focuses on other activities (Simonton, 1995).

Arbitrary and Meaningful Learning

Applying the concepts of structure and wholeness to the analysis of learning,
Wertheimer differentiated between “senseless” and meaningful learning methods
in the classroom (Katona, 1967). Meaningful structures should not be learned in
a senseless or rote manner. An example of a meaningful structure is \((a + b)^2\),
which means \(a^2 + 2ab + b^2\). Wertheimer (1945/1959) observed that once children
had learned a particular problem-solving approach, such as determining the area
of a parallelogram, they often were unable to see other approaches to similar
tasks. They were likely to say “We haven’t had that yet.”

In working with one group of children, Wertheimer first showed them how to
calculate the areas of rectangles. He then presented a parallelogram, suggesting
that they could make use of their knowledge of rectangles to determine the area.
After some false starts, some children cut off the “triangle” at one end of the par­
allelogram and placed it on the other end, forming a rectangle (see solution a,
Figure 2.7). They then calculated the area of this rectangle. Others, in contrast, cut
the parallelogram in half, inverted one of the halves, and placed the diagonal ends
together to form a rectangle (see solution b, Figure 2.7). Solving the problem
depended on the children’s reorganization of the field and their reaction to the
reorganization.

Wertheimer did not recommend specific teaching methods based on Gestalt
theory. However, the implication from this example is that providing informa­
tion that assists students to reorganize their view of the problem should be an
integral component in teaching problem solving.

Specific Factors in Problem Solving

Other Gestalt theorists identified other factors that influence perception in prob­
lem solving. Concepts relevant to today’s classrooms are transfer of training,
problem approach and functional fixedness, and problem set.

Transfer of Training. The effects of different ways of demonstrating problem
solutions on problem-solving skills were investigated by George Katona. He con­
ducted a series of experiments on matchstick problems. In these puzzles, the task
was to change the number of squares formed by the matchsticks by moving a
minimal number of matches. A typical example is to move three matchsticks to
make five squares, illustrated in Figure 2.8.
Katona’s (1940) research indicated that the method he referred to as “guided discovery” was the most effective. He illustrated six transitions in the matchstick configuration by moving only a few matches. For example, removing only three matchsticks created a “hole” in the center of the configuration. This method provided hints to solving other problems by illustrating the structural principles that one matchstick may serve as a side in two squares simultaneously.

**Problem Approach and Functional Fixedness.** Karl Duncker (1926) noted that most theories seek to explain problem solving in terms of a “third factor,”
such as past experience or imitation. However, Duncker’s analysis of successful problem solvers indicated three general steps. They are (a) comprehending a conflict or problem, (b) developing a clear identification of the basic difficulty, and (c) developing a problem solution that addresses the basic difficulty. Such solutions, in his view, are examples of productive thinking and are referred to as solutions with functional value.

In the X-ray problem, illustrated in Table 2.3, the key to solving the problem is to note that the rays are too “thick”; they are too concentrated (basic difficulty). The solution is to provide “thin” rays from various angles that converge on the tumor. Productive thinking, in other words, is distinguished by an inventory of the problem situation, and the recognition of a definite lack (Aufgabe) that is supplied by the thinking process (Duncker, 1926, p. 707).

Students who are unable to perceive the elements of the situation in a new way are said to suffer from functional fixedness (Duncker, 1945). An example is the subjects in Maier’s pendulum experiment who failed to “see” a new use for the pliers.

**Problem Set.** Functional fixedness is one perceptual difficulty in problem solving. A related concept is problem set or Einstellung. Identified by Abraham Luchins (1942), problem set refers to rigidity in problem solving because the individual perceives that a series of problems must be solved in the same way. In the water jar problems, subjects receive three jars of different capacities. They are asked to measure a particular amount of water; however, the solution to each problem requires pouring certain amounts of water from one jar to another. For example, the task may be to measure 5 units of water when jar A holds 18 units, jar B holds 43 units, and jar C holds 10 units. The solution (B – A – 2C) requires (a) filling jar B, then (b) filling jar A from B, and (c) filling jar C twice from jar B (43 – 18 = 25 – 20 = 5).

In the experiments, an initial set of six problems were solved by B – A – 2C (see Table 2.4). They were designated as the set-inducing problems. The next two

<table>
<thead>
<tr>
<th>Problem</th>
<th>Comprehended Conflict</th>
<th>Difficulty</th>
<th>Solution with Functional Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ape wants the food outside the cage.</td>
<td>Ape cannot reach the food.</td>
<td>Ape's arm is too short.</td>
<td>Make use of something that extends the animal's reach.</td>
</tr>
<tr>
<td>Man needs X-ray treatment for tumor inside his body.</td>
<td>X-ray cannot cure man because surrounding tissue would be damaged.</td>
<td>Bundle of X-rays is too concentrated, too united (or too “thick”).</td>
<td>Scatter out X-rays, send weak (thin, momentary) rays from various angles.</td>
</tr>
</tbody>
</table>

*Note: Summarized from “A Qualitative (Experimental and Theoretical) Study of Productive Thinking (Solving of Comprehensible Problems)” by K. Duncker, 1926, Pedagogical Seminary, 33, 642–708.*
TABLE 2.4
Series of Water Jar Problems on Problem Set

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems 1–6 (set inducing problems)</td>
<td>( B - A - 2C )</td>
</tr>
<tr>
<td>Ex: Measure 5 units of water</td>
<td>( B - A - 2C )</td>
</tr>
<tr>
<td>Given: Jug A = 18 units, B = 43 units, C = 10 units</td>
<td>( B - A - 2C )</td>
</tr>
<tr>
<td>Problem 7: Measure 20 units</td>
<td>( A - C^* )</td>
</tr>
<tr>
<td>A = 23, B = 49, C = 3</td>
<td>( A - C^* )</td>
</tr>
<tr>
<td>Problem 8: Measure 18 units</td>
<td>( A + C^* )</td>
</tr>
<tr>
<td>A = 15, B = 39, C = 3</td>
<td>( A + C^* )</td>
</tr>
<tr>
<td>Problem 9: Measure 25 units</td>
<td>( A - C ) only</td>
</tr>
<tr>
<td>A = 28, B = 76, C = 3</td>
<td>( A - C ) only</td>
</tr>
<tr>
<td>Problem 10: Measure 22 units</td>
<td>( A + C^* )</td>
</tr>
<tr>
<td>A = 18, B = 48, C = 4</td>
<td>( A + C^* )</td>
</tr>
<tr>
<td>Problem 11: Measure 6 units</td>
<td>( A - C^* )</td>
</tr>
<tr>
<td>A = 14, B = 36, C = 8</td>
<td>( A - C^* )</td>
</tr>
</tbody>
</table>

*Solvable also by \( B - A - 2C \)


problems, 7 and 8, could be solved by a simpler method, either \( A - C \) or \( A + C \). Then problem 9 could only be solved by \( A - C \). Of the more than 1,000 subjects in the research, 83% used the more cumbersome method (\( B - A - 2C \)) in problems 7 and 8, and 64% failed problem 9 (Luchins & Luchins, 1959, p. 110). Those who failed problem 9 demonstrated rigid behavior because they continued to use a prior strategy that was completely inadequate.

In one variation of the basic experiment, the solutions of elementary school children to the first set of problems were collected prior to the distribution of problems 7-9. The children were told not to use the same method on those problems. Although the children heeded the warning, most of them failed problems 7 and 8. Some of the children explained that the old method “kept ‘popping up’ in their minds and they could not help using it” (Luchins & Luchins, 1959, p. 134).

Efforts to answer the question of what is learned during the problem-solving activity revealed a variety of answers. Some subjects learned to generalize a rule, others learned to begin with the middle jar, and others learned to begin with the largest jar. Thus, problem rigidity appears to be not one factor, but many.

Other Developments
In the early 1930s, Koffka (1935) maintained that the principles of field organization in perception also apply to the formation of groups. Maier (1970) investigated
the dynamics of problem solving in the work setting, including supervisors and employees. Kurt Lewin, who was associated with the Gestaltists, addressed motivation, and his work led to the focus now referred to as group dynamics. The basic concept in Lewin's (1933) theory is that to understand or predict psychological behavior (B), one has to determine the momentary structure and state of the person (P), as well as the state of the psychological environment (E). In other words, 
\[ B = f(P,E) \] (p. 598). Albert Bandura later used this formula in his analysis of learning in the social setting. Lewin (1942) also pointed out that tasks such as learning French vocabulary and learning to like broccoli are very different processes with different laws of learning (Lewin, 1936, p. 220).

Another psychologist, E. Tolman (1932), referred to his work as a “subvariety of Gestalt psychology” (p. 230). He defined goal-directed behavior as behavior that is maintained by the environment, such as a rat that moves through a maze that ends when the rat reaches the food. The subject learns the critical events that lead to some goal, referred to as a “sign-Gestalt-expectation.” For example, in Tolman’s view, Pavlov’s dogs learning that “waiting-in-the-presence-of-sound” led to food. Two terms introduced by Tolman are latent learning and cognitive maps, the learning acquired by the rats in going through the maze. Latent learning refers to knowledge that is acquired, but is not necessarily enacted. Albert Bandura later incorporated this distinction into his theory of learning.

Tolman also defended the use of rats to demonstrate cognitive learning. Rats “do not go on binges the night before one has planned an experiment; they do not kill each other off in wars; . . . they avoid politics, economics, and papers on psychology. They are marvelous, pure, and delightful” (Tolman, 1949, p. 166). Currently, the International Society for Gestalt Theory and Application (GTA), founded in 1978, focuses on the development of Gestalt theory in both basic research and practice. The Society holds an annual conference and publishes the quarterly journal entitled *Gestalt Theory* (see http://gestalttheory.net). Current applications include pedagogy, art and design, economics, linguistics, musicology, and psychotherapy.

**Summary**

Gestalt psychology contributed several concepts to the understanding of problem solving. Perhaps the best known is insight, which involves reorganizing one’s perceptions in order to “see” the solution. Contemporary analyses indicate that creative insight into novel problems requires hard work and research, a period of incubation, the moment of insight, and further work on the problem. In everyday life, insight into a problem may be achieved through reencoding some aspects of the problem, elaboration, and constraint relaxation.

Other contributions of Gestalt psychology areWertheimer’s distinction between arbitrary (senseless) learning and meaningful learning, and other factors that impact problem solving. Included are clearly identifying the problem goal to develop a solution with functional value, the role of guided discovery in meaningful problem solving, and avoiding particular impasses in problem solving. They are functional fixedness, the inability to see elements of the problem in a new way,
and problem set, which refers to rigidity in problem solving. Other developments included the application of Gestalt concepts to the formation of social groups and motivation and the concept of latent learning.

**A COMPARISON OF BEHAVIORISM AND GESTALT THEORY**

Early behaviorism and Gestalt theory differed from philosophical views of learning in the identification of testable principles, reliance on observations for verification, and application of the principles to real-world situations. Both theories illustrate the development of new knowledge through precise measurement and research under controlled conditions.

**Applications to Education**

Behaviorism and Gestalt psychology based their research on different assumptions about the nature of learning and the focus of study. Behaviorism defined learning as behavioral change and identified specific stimuli and responses as the focus of research. In contrast, Gestalt psychology maintained that individuals respond to organizations of stimuli and the individual's perceptions are an important factor in problem solving. These different orientations to learning led to different contributions to education.

**Behaviorism**

Classical conditioning demonstrated that pairing stimuli can link reactions to new stimuli. In addition to the contributions to psychology (descriptions of neuroses and factors in drug addiction), classical conditioning also addresses aspects of everyday situations. For example, for the young child, parental facial reactions paired with new unfamiliar stimuli often cue the child's avoidance or approach reactions. In the classroom, activities should be selected in kindergarten and elementary school in the first days of school to avoid the association of anxiety and other negative feelings to the school setting.

In contrast to classical conditioning, Thorndike researched voluntary or self-initiated behavior. Applying the principle of association observed in his research, Thorndike cautioned teachers not to form connections that will have to be broken and to form connections in the way they are to be enacted. Although often applied to such information as number facts and dates, names, places, and historical events, connectionism also accounts for the contemporary use of mnemonics. An example is the sentence "Every good boy does fine" to remember the musical notes on the lines of the treble clef (e, g, b, d, f).

Guthrie also advised teachers to associate stimuli and responses in appropriate ways. For example, the teacher should ensure that directives such as to line up for lunch are not followed by disruptive behavior. The problem is that a directive can become the cue for disruptions in the future. If punishment is to be used
for inappropriate responses, then it must "undo" the association between a stimulus and the inappropriate behavior. If students are disruptive following the directive to line up by rows, they should be sent back to their seats so that they can respond appropriately.

**Gestalt Psychology**

Issues raised for education by the Gestalt perspective were meaning, understanding, and insight, which are distinctly human characteristics (Wertheimer, 1991). Computer programs, in contrast, can model human problem solving only after the relevant information about the problem has been extracted and fed into the program. In other words, the computer can address a problem once it has been understood (Wertheimer, 1991). The organizing, the thinking, and the understanding are, instead, in the mind of the programmer (p. 203). Therefore, education should address these issues, rather than the steps undertaken after understanding and reorganization have occurred. The reason is that situations or problems include some elements that are structurally central and others that are peripheral. Essential in learning to solve problems is to grasp the structurally central elements and differentiate them from the peripheral or unimportant features (Wertheimer, 1945/1959).

The difficulty in applying the Gestalt perspective in the classroom is the lack of a set of clearly defined principles of learning. Instead, Gestalt researchers developed general suggestions for problem-solving instruction. First, embed the problem or learning task in concrete, actual situations (Wertheimer, 1945). Finding the area of a rectangle, for example, may be embedded in the situation in which two farmers wish to exchange two plots of land (p. 272). In other words, the teacher should provide reasonable problem situations that the student attempts to address. Then cooperative help should be provided as needed.

Second, the assistance provided during problem solving should not be that of copying or repeating procedures. Instead, the teacher should provide guided discovery in the form of cues or hints to help learners reorganize their view of the problem and overcome inadequate or inaccurate views of the problem (referred to as functional fixedness). The goal is for students to discover a solution with functional value; that is, a solution that addresses the basic difficulty posed by the problem. The test of the occurrence of real learning is to determine if the individual can solve a related problem or task (the principle referred to as transfer) (Cox, 1997; Wertheimer, 1945/1959). If the student has only memorized some steps, he or she will not be able to recognize the similarities of the two situations and will be unable to solve the situation. Third, instruction should not present students with sets of trite problems that can be solved by learning a series of rote steps. This approach leads to the difficulty known as problem set.

Two Gestalt concepts, problem set and insight, continue to be discussed by contemporary cognitive psychologists. Problem set (referred to as stereotypy) occurs with poor students who may have appropriate skills but who stick to one strategy even when it is not successful (Kaplan & Davidson, 1988). However, an
incubation period sometimes permits the unproductive associations to weaken. Furthermore, when students reach an impasse on problems that require creative solutions, researchers suggest that taking a break accompanied by hints and self-reflection can lead to insight (Seifert et al., 1995).

Discussion

In the mid-1930s, both behaviorism and Gestalt psychology became overextended. Each perspective attempted to develop the one comprehensive theory that would explain all learning. Less than a decade later, the conflict between the two theories was criticized for nonproductivity. Two practices contributed to this problem (McConnell, 1942). First, the terms used by each perspective magnified the differences between them. For example, the terms “insight” and “connection” represent extreme descriptions of the learning process. Also, task difficulty may be a factor in the learning process that is described by the theorist. If the task is so difficult that the learner cannot establish relationships with the situation, he or she must resort to trial and error. In contrast, less difficult tasks, in which past experience may play a role, may be reacted to quickly and accurately. Therefore, the flashes of insight described by the Gestalt psychologists may, in some cases, be included under transfer through identical elements (McConnell, 1942, p. 26).

Second, different descriptions of learning arose, in part, from differences in the experimental context (see Table 2.5). Tasks can be classified according to the amount of discovery required to make a correct response. Rote learning, for example, is reflected in simple connectionist situations. However, complicated, unstructured situations require the learner's reorganization of past experience and discovery of the appropriate behavior pattern (McConnell, 1942).

As the decade of the 1950s approached, interest in the development of all-encompassing theory declined. Hilgard (1964), in his review of the end of this period of theory development, noted that the “great debate” among comprehensive theories was now over. Vygotsky (1982–1984/1997b), some 30 years earlier, had predicted this outcome in his discussion of the life cycle of an idea. In the first stage of the cycle, a discovery tends to become an explanatory principle for some psychological event (e.g., conditioning reactions to new stimuli; reorganizing one's perceptions of a situation). In the second stage, the idea becomes a general theoretical concept. The idea spreads to other areas in the third stage, and then becomes “more or less an abstractly formed principle” (p. 242). It is altered by new material and it also alters the discipline in which it began.

In the fourth stage, forces push the idea to continue developing, where it separates from the basic concept and becomes a worldview. In this stage, Watson had forecast that he could train any healthy infant into any vocation he chose, and the Gestalt psychologists applied the concepts of form and structure to such situations as group dynamics. The problem with this stage, Vygotsky
TABLE 2.5
A Comparison of Behaviorism and Gestalt Theory

<table>
<thead>
<tr>
<th>Major Characteristics</th>
<th>Behaviorism</th>
<th>Gestalt Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic assumption(s)</td>
<td>(a) Observable behavior, not consciousness or mental events, should be studied. (b) Learning is behavioral change. (c) The relationships between stimuli and responses should be studied.</td>
<td>Individuals react to unitary, meaningful wholes; therefore, learning is the organization and reorganization of a sensory field. The whole possesses emergent properties that differ from that of the elements.</td>
</tr>
<tr>
<td>Typical experiment(s)</td>
<td>(a) Trial and error: Rats run mazes; animals escape from cages. (b) Emotional or reflex responses: Stimulus pairing.</td>
<td>Reorganization: Subjects are placed in situations that require restructuring for solution.</td>
</tr>
<tr>
<td></td>
<td>(b) Emotional responses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stimulus 1 → Response</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stimulus 2</td>
<td></td>
</tr>
</tbody>
</table>

(1925/1997a) noted, is that efforts to make a principle broader also make it easier to stretch it to cover almost any fact (p. 64). Vygotsky (1982–1984/1997b) chided the behaviorists that, from their view, “everything in the world is a reflex. Anna Karenina [a tragic Russian heroine], kleptomania, the class struggle” (p. 245). Similarly, the Gestalt concept “appeared to be the basis of the world. When God created the world he said: let there be Gestalt—and there was Gestalt everywhere” (p. 245).

Then, in the fifth stage, the idea, which was taken too far, can easily “burst like a soap bubble” (Vygotsky, 1982–1984/1997b, p. 242). It “is forced to go through its development backward” (p. 243). In this stage, the idea is accepted as a new discovery, but is no longer treated as a worldview. It may continue to function in the realm of ideas, but is no longer viewed as all-encompassing. In the case of classical conditioning, for example, it occupies a place in behavioral change along with Skinner’s development of operant conditioning. Thorndike’s connectionism, which emphasized the consequences of behavior as the key to learning, became the model for Skinner’s operant conditioning. Also, the concepts of the perceptions of stimuli, insight, problem set, and functional fixedness are part of current discussions of problem solving.
CHAPTER QUESTIONS

Understanding Concepts

1. At summer camp, a spider is thrust in a child’s face at the same time that some girls scream and shout “Boo!” The next night, the girls scare her just as she turns down the sheet and finds a spider. Diagram these events and predict the outcome of these experiences.

2. A student who relies on coffee to wake up in the morning finds, over time, that he requires a stronger brew to be alert. How does classical conditioning explain the problem?

3. In the 1980s, some advocates of teaching computer programming skills maintained that such learning would promote the broad skills of rigorous thinking (Cox, 1997). These beliefs reflect what concept that was refuted in the early 20th century?

4. Students in mathematics sometimes complain that they cannot solve word problems that have been rearranged or restated in some way. According to Wertheimer, what is the source of the students’ difficulty?

5. Katona (1940) found that illustrating different ways that matches may be arranged (“guided discovery”) was successful in assisting students in solving certain matchstick problems. According to Gestalt theory, why should this type of assistance be helpful?

6. How do the insight problems used by the Gestalt psychologists differ from insight in a subject domain?

7. The following problem on the National Assessment of Educational Progress (NAEP) is mishandled frequently. One hundred thirty children are waiting to go on a field trip. How many buses are needed if each bus holds 50 students? Students often produce a fractional answer, not recognizing the absurdity. Silver (1986) maintained this error results in part from the division word problems in the curriculum that require partitioning a number into groups of a particular size. What is the Gestalt explanation for this situation?

Applying Concepts to Instructional Settings

1. What are the implications for the classroom inherent in the major differences between Thorndike’s connectionism and classical conditioning?

2. Thorndike’s connectionism accounts for such verbal mnemonics as using the sentence “Every good boy does fine” to remember the notes on the lines of the treble clef. What are some other examples?

3. Teachers in the early grades are advised to introduce activities in the first days of the school year that are associated with positive feelings. How might middle and high school teachers implement this advice?

4. Thorndike and Katona conceptualized transfer of learning in different ways. Describe an example of each in different subject areas.

5. Wertheimer differentiated between arbitrary or “senseless” and meaningful learning connections. Describe examples in particular curriculum areas.

REFERENCES


Cox, B. D. (1997). The rediscovery of the active learner in adaptive context: A development­

tary moment. In R. J. Sternberg & J. E. Davidson (Eds.), The nature of insight (pp.

Cushman, C. L., & Fox, G. (1938). Research and the public school curriculum. In G. Whipple
(Ed.), The scientific movement in education. The thirty-seventh yearbook of the National


Duncker, K. (1926). A qualitative (experimental and theoretical) study of productive thinking


teaching (pp. 1–49). Hillsdale, NJ: Erlbaum.


(Ed.), The scientific movement in education. The thirty-seventh yearbook of the National

the acquisition of fear and avoidance behaviour in toddlers. Behaviour Research and
Therapy, 40, 279–287.

Sternberg & J. E. Davidson (Eds.), The nature of insight (pp. 197–228). Cambridge, MA: MIT Press.

of ideas. History of Science, 19, 41–59.

Davidson (Eds.), The nature of insight (pp. 397–432). Cambridge, MA: MIT Press.

association. In N. B. Henry (Ed.), The psychology of learning: The forty-first yearbook
of the National Society for the Study of Education, part II (pp. 17–60). Chicago: University
of Chicago Press.


pic drug consumption and other factors associated with drug overdose. Drug and Alcohol

Hadamard, J. (1949). The psychology of invention in the mathematical field. Princeton, NJ:
Princeton University Press.

Hartmann, G. W. (1942). The field theory of learning and its consequences. In N. B. Henry
(Ed.), The psychology of learning: The 41st yearbook of the National Society for Study of

In E. R. Hilgard (Ed.), Theories of learning and instruction. The sixty-third yearbook of
the National Society for the Study of Education (pp. 416–481). Chicago: University of
Chicago Press.

gist, 52(9), 956–965.


Tolman, E. C. (1949). There is more than one kind of learning. Psychological Review, 56, 144–155.


Chapter 3

The Human Brain

The human brain is the most complex natural system in the known universe; its complexity rivals and probably exceeds the complexity of the most intricate social and economic structures. It is science's new frontier. (Goldberg, 2001, p. 23)

The designation of the 1990s as the decade of the brain by the U.S. Congress and the increasing use of neuroimaging methods have contributed to an unprecedented interest in the human brain. A question generated by this interest is whether answers about the brain can be obtained in the same way that breakthroughs in genetics resulted from the discovery of the structure of DNA (Damasio, 1994, p. 260). The problem is that the equivalent for the mind-producing brain involves detailing the activities of several billion neurons in their micro- and macro-levels of organization, as well as the host of local and global influences on their performance. Also, the performance of each neuron occurs in tens of milliseconds. In other words, the mind/brain puzzle (the construction of a mind from the activity of the brain) does not have a single answer, but many answers (Damasio, 1994). Required then are various techniques that address the many levels of structure and function in the human brain. Through the use of neuroimaging techniques, new findings are accumulating rapidly. However, the potential problem is that the flood of new facts may overwhelm the ability to think clearly (p. 258).

A further complication is that media reports and commentaries as well as discussions among scientists and others have led to speculations about the ways that research findings can improve or enrich educational practice (Organisation for Economic Co-operation and Development, 2002, p. 69; Thompson & Nelson, 2001). One result is that some who promote brain-based research to teachers fail to communicate the relative paucity of the studies from which they draw their claims. Others advocate brain-based teaching strategies that are not based on research (p. 69). In addition, expectations of the utility of brain research have contributed to the rapid growth of myths.
One purpose of this chapter is to provide an overview of the organization and development of the human brain. A second purpose is to discuss the cognitive and educational issues related to brain research.

**ORGANIZATION AND DEVELOPMENT**

The human brain is a complex system that is organized on several levels. They consist of basic neurons and networks of neurons (the microscopic structure) and larger organizations, subcortical and cortical structures.

**Overview of the Microscopic Structure**

Discussed in this section are the events that result in the emergence of neurons and neuronal networks prior to birth and their subsequent postnatal development.

**Building a Brain**

The basic building blocks of the brain are the neurons, which are the unit of communication, and glial cells, which provide structural support for the neurons. Each neuron consists of a cell and the communication “wires” between neurons—an axon (the long “tail”) and a set of dendrites or branches.

During prenatal development, the emergence of neurons and their fascinating journey to the appropriate brain location consists of events and processes that must occur at certain times and in a particular sequence (Nowakowski & Hayes, 2002). This development begins at the end of the third week of conception when the outer surface of the embryo folds in on itself to form a trough and then fuses over to form a tube. Eventually, approximately 50 percent of the tail of the tube develops into the spinal cord and the head becomes the brain (p. 62). When formed, this neural tube sinks below the surface of the embryo and is imbedded deep inside (Rose, 2005).

**The Birth and Migration of Neurons.** Following the formation of the neural tube, most of the neurons are born in the first hundred days in one location of the tube (a kind of “neuronal maternity ward,” p. 65). The neurons then “leave home in search of destiny, migrating accurately over huge distances” (p. 65). Some neurons only move a short distance and then are pushed out farther by the neurons behind them. Others, in contrast, move directly to the farthest locations and the distances that many of these young neurons are required to travel may be tens of thousands of times their own length. These distances are equivalent to a distance of 25 kilometers for a human (p. 71).

Major questions about this migration are, How does the neuron know where it is going? How does it find its way? and How does it know when it reaches its final destination (where it puts out axons and dendrites and makes synaptic connections)? For the journey, specialized glial cells (radial glia) make up an advance party for the neurons; they spin out long tails that form the
scaffolding along which the neurons move. The membranes of the glial cells also
contain cell adhesion molecules (CAMs) that protrude outward. The neurons
can clutch the CAMs on the glia and “ratchet themselves along” (p. 72). The
migrating neurons also produce a slime trail (much like a snail) as they ooze
along—a trail that other neurons can follow.

Information about the destination of the neuron comes from at least three
sources. They are a signaling molecule sent out by the target location, a glial-
derived signaling factor, and a protein secreted by the early-born neurons. The
protein, reelin, acts as a stop signal for waves of neurons arriving in the cortex,
telling them to leave the glial fiber and begin to develop as mature neurons
(Rose, 2005, p. 74).

Another aspect of development is the huge overproduction of neurons. The
axons of many of them do not find target cells; they are unable to build synapses
(the junctions for communication among neurons), and they die. Although this
process may seem to be merely competition and selection, it is also a form of
cooperation (Rose, 2005). Overproduction may be essential to ensure that a suffi-
cient number of neurons reach their destinations and make connections (p. 76).
(This process is apoptosis, or programmed cell death.)

The emergence, migration, partial elimination, and development of neurons
does not result in a static structure. Instead, the brain’s architecture is dynamic.
The shapes of mature neurons are “in constant flux” (Rose, 2005, p. 146). The
dendrites grow and retract, develop protruding spines and then withdraw them,
and form and break synaptic connections.

About the third prenatal month, “very slow waves of electrical activity can
be detected at the surface of the brain” (Rose, 2005, p. 80) and continuous elec-
trical activity seems to occur in the brain stem about the fourth month. This activ-
ity indicates that the neurons are signaling to each other at an early stage in the
development of the fetus (p. 80).

The glial cells, in addition to providing scaffolding for migrating neurons, also
fulfill other roles. Some produce the fluid that cushions the brain and spinal cord
against the bumps and jarrings of everyday life. Also, soon after the infant’s birth
the glial cells increase rapidly and one type (oligodendroglia) forms the myelin
sheaths that insulate the axons and form the white matter of the brain.

The Neural Net. Neurons are connected in circuits and each functions as a
receiver and transmitter of electrical or chemical signals. Within this network,
the individual builds up internal models of the real world and also coordinates
plans of action on that world (Rose, 2005, p. 30).

The tree-like structures that branch out from the cell body, the dendrites,
collect signals from other neurons. Then the integrated signal is sent down the
long tail, the axon, to another neuron or several neurons. The junction where
the signal passes to a dendrite of another neuron is the synapse. There are some
100 trillion synapses in the human brain and “up to several tens of thousands per
cell” (p. 34). In other words, each neuron can receive signals from many thou-
sands of synapses, and the communication may be one-to-one, one-to-many, or
many-to-one (p. 143).
The architecture formed by the axons, synapses, and dendrites is not a set of neatly constructed circuits. Instead, they resemble a "jungle" where the various extensions of thousands of different neurons are entangled (Changeux, 1985, p. 54). Many neurons communicate within relatively local circuits in particular brain areas. However, others project across regions of the brain. The length of the axon cables that form neuron circuits in the brain is approximately several hundred thousand miles (Damasio, 1994, p. 259).

**The Role of Neurotransmitters.** When a neuron becomes active, it transmits an electric current down the axon to the synapse. This action is referred to as "firing" (Damasio, 1994, p. 29). The time frame for firing is minute, approximately tens of milliseconds, and the brain produces millions of firing patterns over a large variety of circuits.

Typically, when the electrical current arrives at the synapse, it is then transported across the synapse by a chemical messenger known as a neurotransmitter. This process requires less than 10 millionths of a second. The effect of the neurotransmitter on the receiving neuron may be to increase the likelihood that the receiving neuron will be activated (excitatory) or decrease the likelihood of activation (inhibitory). The functioning of neurons suggests the image of a "gigantic assembly of billions of interlacing neuronal spiders' webs, in which billions of electrical impulses flash by, relayed from time to time by a rich array of chemical signals" (Changeux, 1985, p. 126).

Scientists have identified more than 50 neurotransmitters (Fischbach, 1992), although information about their effects is incomplete. One of the main neurotransmitters found in the brain is serotonin, which includes approximately 14 types and contributes to almost all aspects of cognition and behavior (Damasio, 1994, p. 76).

One difficulty in understanding the complex role of neurotransmitters on perception, cognition, memory, and emotion is that the same neurotransmitter can have different effects. Differences depend, in part, on the area or region of the brain in which the chemical is acting and the nature of the receptors of the receiving neurons. For example, the degeneration of neurons that produce dopamine leads to Parkinson's disease. However, an excess of dopamine in another part of the brain contributes to the hallucinations that occur with schizophrenia (Hockenbury & Hockenbury, 1997).

Interventions into brain function developed by pharmaceutical companies target the synapse and the neurotransmitters. Treatments for both neurological disorders (e.g., Alzheimer's and Parkinson's disease) and psychiatric problems (e.g., depression and anxiety) interact with the functions of neurotransmitters (Rose, 2005, p. 148). For example, L-dopa for Parkinson's disease compensates for the loss of the neurotransmitter dopamine.

**Potential Damaging Factors.** Normal development can be disrupted by any of several factors. For example, the failure of the neural tube to close at the lower end leads to the condition known as spina bifida. Deficiency of the vitamin folic acid in the mother's diet can lead to neural-tube defects, including spina bifida.
In addition, factors such as physical injury, malnutrition, and harmful substances ingested by the mother contribute to cognitive impairment in the infant. An example is heavy consumption of alcohol. Another is Accutane, the medication for severe acne. Researchers have documented severe mental, physical, and behavioral disorders in children whose mothers accidentally conceived while taking the medication (Rafshoon, 2003).

**Summary.** Development of the brain begins at the end of the third week of conception. Neurons are born at one location in the neural tube and migrate to other locations that develop into parts of the brain. Neurons are assisted in their migration by glial cells that function as scaffolding. Signals from the neuron’s target location, the glial cells, and early-born neurons provide information about the neuron’s destination. Overproduction of neurons ensures that a sufficient number reach the target destinations, but those that do not find target cells die. The resulting architecture, however, is not static. Branches of the neuron (dendrites) grow and retract, and form and break connections with other neurons.

Neurons are connected in circuits in which their dendrites collect signals from other neurons. They then transmit these signals down their axons across junctions referred to as synapses. The electrical signal is transported across the synapse by a chemical messenger, a neurotransmitter. In this process, each neuron may communicate with one or many other neurons. Research indicates that neurons are signaling to each other in this way as early as the third prenatal month. Although scientists have identified more than 50 neurotransmitters, information about them is incomplete. One difficulty is that a particular neurotransmitter can have different effects in different regions of the brain.

Normal brain development can be hindered by any of several factors. Among them are malnutrition, physical injury, and harmful substances ingested by the mother, such as alcohol.

**The Postnatal Brain**

Following birth, unlike other species, the human brain undergoes a lengthy period of development (Changeux, 1985, p. 242). For example, development of the cortical area (the site of executive functions such as goal setting and evaluation) extends approximately four times longer in humans than in other primates (Johnson, 1997, p. 59). Also, by age 20, the average weight of the human brain has increased to approximately 1,350 grams from the birth weight of 350 grams (Blinkov & Gieser, 1968).

**The Concept of Growth.** The term *growth*, when used in reference to the brain, refers to the lengthening and branching of nerve fibers that connect the cell bodies to their targets (Changeux, 1985, p. 212). In many parts of the brain, in the early months and years of life, neurons exhibit “exuberant” growth. They extend axons to other neurons in addition to the target neuron (Nowakowski & Hayes, 2002, p. 74). This growth is accompanied by a dramatic increase in the number of dendrites and synapses. For example, synapses in the visual and auditory cortices attain a maximum density that is 150% of adult levels between the ages of 4 and 12 months (Huttenlocher, 1990, 1994a, 1994b; Huttenlocher, de Courten, Garey, & Van der Loos, 1982; Johnson, 1977).
The bursts in synaptic development are followed by a period of loss and reduction in the number of synapses to adult levels (Changeux, 1985, pp. 216–219, 227–229). The timing of this loss, however, varies across cortical regions of the brain. Synapse elimination in the visual cortex begins at about 1 year and is completed by approximately age 10 (Huttenlocher, 1994a, p. 143). Synapse elimination is somewhat slower in the frontal cortex (the area of the brain that integrates and interprets information), occurring between age 7 and adolescence (p. 143). Data from other species that also indicate bursts in synaptic development followed by elimination of synapses suggests that this is a universal phenomenon.

In addition to these structural developments, some chemical neurotransmitters that assist neurons in communicating with each other also undergo a developmental rise and fall (Johnson, 1997, p. 37). Among them are glutamate and serotonin (Benes, 1994).

The Rationale for Structural Plasticity. Researchers suggest that the overproduction of synapses fulfills an important function. First, it reduces the genetic load that would be required to reprogram the huge number of synapses required to deal with the complexities of life (Chugani, Phelps, & Mazziotta, 2002, p. 112). Also, the number of genes is insufficient to determine the precise structure and location of the billions of neurons and their synapses (Damasio, 1994, p. 108). Second, a brain determined entirely by genes would be "rigid." The number of possible operations would be limited, and the organization of the brain would not be open to the social and cultural environment (Changeux, 1985, p. 278).

Furthermore, early theories that maintained the brain is "hard wired" at birth are not supported by research. Many studies on rats through the years have indicated that training and experience led to changes in the brain (e.g., Greenough & Volkmar, 1973; Holloway, 1966; Krech, Rosenzweig, & Bennett, 1960; Turner & Greenough, 1985). More recently, neuroimaging studies of identical twins, who have the same genes, indicated striking differences in cortical areas (Johnson, 1997, p. 38).

The current view is that of structural plasticity, in which development of the brain emerges from the complex and variable interactions between genes and the environment (Johnson, 1997; Oyama, 1985). Also, structural plasticity is not restricted to the early years of life. Studies with both rats and humans indicate that stimulating environments can lead to cerebral changes throughout the lifespan (e.g., Bennett, Diamond, Krech, & Rosenzweig, 1964; Black, Isaacs, Anderson, Alcantara, & Greenough, 1990; Greenough, 2002; Riego, 1971). For example, autopsy studies of university graduates and high school dropouts indicated 40% more synaptic connections in the university graduates (Jacobs, Schall, & Scheibel, 1993). However, university graduates who had not led mentally stimulating lives had fewer dendritic connections.

Research also suggests that cognitive challenges throughout life may provide some protection against the debilitating effects of Alzheimer's disease. Autopsies indicated that more educated individuals, although their brain cells were damaged, did not experience the devastating symptoms of Alzheimer's disease (Albert et al., 1995; Katzman, 1993; Snowdon et al., 1996; Stern, Gurland, & Tatemichi, 1994).
Summary. The human brain undergoes a lengthy period of development that continues into the early 20s. Growth in the brain refers to the lengthening and branching of neuronal axons (which increases dendrites and synapses). In each cortical region, a period of exuberant growth is followed by a reduction to adult levels. This process occurs at different times in different regions. Researchers suggest that the overproduction is important because it allows the individual’s environmental experiences to influence brain development.

The term “structural plasticity” refers to the growth patterns of axons and synapses in different brain regions and also to other changes throughout the lifespan. Research suggests that cognitive challenges throughout life help to preserve mental functioning.

The Macroscopic Organization

At the macroscopic level of brain organization, neurons are grouped into cohesive structures, either nuclei or cortical regions, and each consists of millions of neurons. They often are categorized as subcortical and cortical.

The Subcortical Structures

The category subcortical reflects the location of particular structures in the brain, which is below the cortex. Some researchers, who describe the development of the brain in terms of evolution, state that the subcortical structures developed millions of years before the cortex and managed the complex behaviors of several organisms (e.g., Changeux, 1985; Goldberg, 2001; Johnson, 1997). Included in the subcortical structures are the thalamus, hypothalamus, amygdala, and cerebellum. Each is divided into twin halves, left and right—they are part of the left and right hemispheres of the brain. With the exception of the cerebellum, which is attached to the back of the brain stem, the subcortical structures are buried deep in the brain. As indicated in Table 3.1, these structures are responsible for rather low-level tasks, relatively speaking. Included are preliminary processing of sensory information, monitoring internal states, maintaining muscle coordination and equilibrium, routing information to other parts of the brain, and rapid precognitive assessment of a potentially dangerous situation (the amygdala). Some research in the 1950s indicated a reduction in aggressiveness in rats following surgical removal of the amygdala. This led to a brief consideration of using the same “psychosurgery” on prison inmates who exhibited violent behavior (Rose, 2005, p. 228). However, the plan was not put into practice.

The Cortex

Like the subcortical structures, the areas in the cortex also have two halves, referred to as the right and left hemispheres. From an evolutionary perspective, the cortex emerged late in the development of species (Changeux, 1985; Goldberg, 2001; Johnson, 1997). Initially, this development included the cingulate cortex (roughly the shape of a capital C), which is implicated in emotions, and the hippocampus (the seahorse-shaped structure).
TABLE 3.1
Functions of Subcortical Structures

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thalamus</td>
<td>Collections of nuclei that each process a particular type of sensory information (e.g., visual, auditory, tactile). One set of nuclei integrates this information and communicates with the prefrontal cortex.</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>Collections of nuclei that each monitor an internal state (e.g., food intake, liquid intake, body temperature). One set of nuclei regulates hormone release from the pituitary gland.</td>
</tr>
<tr>
<td>Amygdala</td>
<td>The key entry point for emotional learning; provides rapid, precognitive, affective assessment of a situation in the context of survival value (Goldberg, 2001, p. 13).</td>
</tr>
<tr>
<td>Cerebellum</td>
<td>Responsible for muscle coordination, fine motor movements, and equilibrium. Research also indicates that it contributes to complex planning (e.g., Grafman et al., 1992).</td>
</tr>
</tbody>
</table>

The Hippocampus. The learning of new information begins in the hippocampus. Also, neuroimaging studies of the brain while subjects recalled episodes from their near and distant past activated the hippocampus. The hippocampus also is involved in spatial learning. A comparison of the brain scans of 16 London taxi drivers with those of 50 controls indicated larger posterior hippocampi in the cab drivers (Maguire et al., 2000). A job requirement for London taxi drivers is learning the complex street patterns of that large city.

As people grow older, hormonal processes influence the death of neurons in the brain. For example, chronic stress increases the production of cortisol and a chronic increase accelerates cell death in the hippocampus (Rose, 2005, p. 176). In addition, the memory loss that occurs in Alzheimer’s disease begins with neuron loss in the hippocampus (p. 182).

The Neocortex. The neocortex resembles a blanket with many folds and creases. In mammals, it is a thin sheet, approximately 3–4 millimeters, and it covers the subcortical structures in the brain. Between the subcortical structures and the neocortex and just above the cingulate cortex is the corpus callosum. It is a large “C”-shaped bundle of fibers that links the left and right hemispheres of the brain.

The neocortex is more highly developed in primates, particularly humans. For example, the cortex of a cat is approximately 100 square centimeters, whereas the human neocortex is approximately 2,400 square centimeters (Johnson, 1997, p.28). This large area accounts for its creased appearance, because it is too large to fit within the available space in the skull and two-thirds of the neocortex is hidden deep in the fissures.
**The Major Neocortical Lobes.** The neocortex consists of four major lobes; each is involved in processing a different type of information received from other parts of the brain. Visual information from the thalamus is processed further in the occipital lobes (which are at the back of the head). Auditory information from the thalamus is processed in the auditory cortex area of the temporal lobes (which are just above the ears), and the parietal lobes process information about tactile sensations. In addition to processing information from other areas, a portion of each lobe serves as a communication link between the prefrontal cortex and the other brain areas.

The frontal lobes consist of the primary motor cortex, which controls voluntary movements, and the prefrontal lobes. They carry out goal setting, planning, and evaluating alternatives, as well as emotional expression and control. Research on the growth indices of neurons indicates that the prefrontal lobes are the last brain areas to mature. This development typically is completed in the 20s.

Figure 3.1 illustrates the arrangement of the cortical lobes in the neocortex. As illustrated, the primary motor cortex is a band at the rear of the frontal lobes. Also, the subcortical areas are hidden deep inside the brain.

In summary, four of the subcortical structures of the brain are the thalamus, hypothalamus, amygdala, and the cerebellum. They are involved in monitoring and maintaining important functions of the organism essential to survival. The hippocampus, a cortical structure, fulfills a critical role in learning and memory, and the cingulate cortex is involved in emotions. In contrast, the neocortical lobes primarily are engaged in processing and integrating different types of information. The exception is the prefrontal cortex, which is involved in goal setting and planning and in controlling emotions.

**COGNITIVE AND EDUCATIONAL ISSUES**

Discussed in this section are the approaches to linking brain structures and functions and the issues involved in cognitive neuroscience and learning.

**Linking Brain Structures and Functions**

The three organizations of the brain that researchers have linked to functions are brain centers, areas of specialization, and brain systems.

**Brain Centers and Areas of Specialization**

The idea that the brain consisted of many organs was first raised by Franz Joseph Gall in the 1700s. Two subsequent discoveries contributed to the belief in brain centers that were responsible for separate functions. First, Pierre Paul Broca, a French neuroanatomist, studied autopsies of his patients who had difficulty speaking, but who understood written and spoken language. The information indicated brain damage in the lower left frontal lobe associated with serious speech problems. The patients' speech had ranged from only being able to produce a single syllable to a total reliance on nouns and verb infinitives (Changeux, 1985, p. 120).
A few years later, Karl Wernicke, a German neurologist, found that damage to a particular area of the left temporal lobe resulted in the inability to understand spoken or written communication. Also, patients spoke in nonsense syllables and were unable to construct meaningful sentences (Changeux, 1985, p. 121). The two
Subsequent research seemed to indicate that language is more intimately concerned with the left hemisphere than the right. Initially, the right hemisphere often was referred to as "the silent hemisphere" or "the minor hemisphere" (Goldberg, 2001, p. 43). Research then began to pursue the role of each of the hemispheres. However, media reports of some isolated studies oversimplified and overgeneralized the results (Coren, 1993). For example, a psychologist reported in a talk that university students recognized melodies heard only through the left ear, not those heard only through the right ear. Inaccurate media interpretations said that the right side of the brain controls musical ability, musicians are right-brained, and the study explained the large number of left-handed musicians.

Other inferences about differences in hemispheric activity also are unsupported by research. Included are that individuals who are analytic are left-brained and creativity is linked to the right brain. These beliefs about hemispheric dominance were identified as "neuromythologies" in the forums on cognitive neuroscience sponsored by the Organisation for Economic Co-operation and Development (2002, pp. 69–77).

Moreover, the close relationship between language and the left hemisphere requires further exploration (Goldberg, 2001, p. 41). First, describing the functioning of one hemisphere as executed through language and the other as related to spatial processing is counterintuitive. Other body organs with two halves, such as the kidneys and the lungs, do not divide the organ's functions. Second, biochemical and structural differences between the two hemispheres is insufficient for assigning different functions to them. These same differences also occur in orangutans, gorillas, and chimpanzees, although they do not possess language (p. 42).

One potential explanation of the stronger association between the left hemisphere and language is that (a) the relationship between the hemispheres is dynamic, (b) novel tasks are addressed in the right hemisphere, and (c) control shifts to the left hemisphere as tasks become routine (Goldberg, 2001, p. 46). For example, musically naive individuals process music primarily in the right hemisphere and trained musicians primarily process music in the left hemisphere (Berer & Chiarello, 1974). Also, positron emission tomography imaging indicated that, for a variety of tasks, changes in blood flow in the brain indicated right-hemisphere activation for novel tasks, with decreased activation on the second presentation (Martin, Wiggs, & Weisberg, 1997). In addition, obscure faces are processed primarily in the right hemisphere, and familiar faces in the left (Marzi & Berlucci, 1977).

The Concept of Brain Systems
The current view is that interconnected units of the brain each contribute to systems that are themselves responsible for relatively separable functions (Damasio, 1994, p. 15). In other words, no single locales in the brain are responsible for vision, language, social behavior, or other complex capabilities.

The interconnectedness is indicated by the six layers of neurons in the neocortex. As indicated in Figure 3.2, layers one through three form horizontal
connections that link different cortical areas. The axons of neurons from the subcortical areas terminate in layer four in the neocortex, and cortical neurons in layers five and six send their axons to subcortical areas.

An example of the systems functioning of the brain is the processing of sensory data. Studies of brain tissue using electron microscopes indicate that the axons of the sense organs (eyes, ears, etc.) terminate in subcortical areas of the brain, primarily the nuclei of the thalamus. Then neurons in the thalamus relay the data to layer four of the appropriate cortical structure (e.g., occipital, parietal, temporal) for further interpretation. Neurons in layers five and six of the particular cortical structure send information back to the appropriate subcortical structure. In addition to sensory information, information on motor activity also is received in the cortex from a particular nucleus in the thalamus, and the cortex sends information back to the thalamus (Changeux, 1985, p. 54).

The neuroscience analysis of Pavlovian fear conditioning also indicates different pathways for different types of stimuli. When the conditioned stimulus is auditory, the pathways of the input come from both the auditory thalamus and the auditory cortex to an area in the lateral amygdala (LA) and then to the central amygdala, which controls the expression of fear responses (LeDoux, 2000, p. 163). However, contextual fear conditioning in which fear responses are executed in the chamber in which the tone and shock were paired, follows a different pathway. The hippocampus and the amygdala are involved in that experience. In other words, an integrated cerebral function cannot be assigned to a single center or a single neurotransmitter. Instead, it “belongs to a system of ‘transit stations,’ where different states of electrical and chemical activity are integrated” (Changeux, 1985, p. 204).

**Summary.** Gall first introduced the concept that the brain consists of many organs, each of which is responsible for a particular reaction. Two subsequent discoveries contributed to this belief. One was Broca’s area, which plays a critical role in speech production. The other is Wernicke’s area, which is essential in understanding spoken and written symbols and in speech. However, other brain areas also are involved in these tasks.
Subsequently, interest turned to possible differences between the left and right hemispheres as explanations for certain cognitive tasks. However, statements that the right hemisphere controls music ability, analytic individuals are left-brained, and creativity is linked to the right brain are "neuromythologies." The current view of cognitive functioning is that of brain systems in which cortical and subcortical areas participate in the execution of integrated brain functions.

**Cognitive Neuroscience and Learning**

The aim of cognitive neuroscience, a relatively new discipline, is to determine the links between neural activity in the brain and cognitive behaviors (Kosslyn & Shin, 1992). However, this task is complicated by the fact that the brain is a paradox. It is simultaneously a fixed structure and a set of dynamic processes, and properties or "functions" of the brain are "simultaneously localized and delocalized, embedded in small cell clusters or aspects of the working of the system as a whole" (Rose, 2005, p. 3).

Discussed in this section are the misapplications of some of the brain research of the 1970s and 1980s, current research methods, and the discovery of mirror neurons.

**Misapplications of Some Brain Research**

Calls for linking educational policy to brain research in the 1990s primarily referred to some animal studies conducted in the 1970s and 1980s (Bruer, 1998a, 1988b, 1999). Referring to this research, the rationale of policymakers for providing enriched environments for children prior to the age of 3 was (a) this age is the critical period in brain development, (b) the crucial learning opportunities occur before the age of 5, and (c) enriched environments can influence brain development in uniquely beneficial ways (see Begley, 1996; Newman, 1997; Shore, 1997). Some recommendations for enriched environments for infants and young children included listening to Mozart and looking at colored mobiles.

Providing such experiences to infants and toddlers may be important for a variety of reasons, such as socialization. However, the impetus to focus educational efforts on the toddler and preschool years is not supported by the neurobiological data (Bruer, 1997, 1998a, 1998b, 1999; Schoenfeld, 1999).

Three types of animal studies, although unrelated, were erroneously applied to early childhood development. One type reflects the so-called "sensitive period" or "critical period" concept (Bateson, 1979), which is the brief opening of a window in which experience can influence development in major ways. Most of the research data, however, is from studies in which kittens were reared in darkened environments devoid of visual movement (Cynader & Chernenko, 1976), or one eye was sutured shut for the first 3 months of life (see Bruer, 1997, for a discussion). Visually deprived cats had fewer synapses per visual cortex than non-deprived cats (Cragg, 1975). Subsequent research, however, has indicated a period following sensory deprivation in which training and therapy led to near-normal functioning (Daw, 1995).

Second is the research that documents the postnatal burst of synaptic growth followed by a period of synaptic loss and pruning. The popular belief (referred to
as a “neuromyth”; Organisation for Economic Co-operation and Development, 2002) is that “enriched” learning experiences at an appropriate time can prevent synaptic loss, thereby promoting greater intelligence or greater learning potential (p. 73). However, as stated earlier, the rapid growth of synapses followed by loss seems to be a universal and natural development.

A related perspective is that of “phrenoblysis” or growth spurts of the entire brain during particular developmental periods (see Greenough, Black, & Wallace, 1987, for a discussion of this view). Although a proponent of this perspective recommended educational changes to correspond to “whole brain spurts,” research has discredited the analysis (Marsh, 1985).

The third line of research compared rats raised either (a) in environmentally complex situations, (b) in pairs with food and water, or (c) in isolation with food and water (Greenough, Hwang, & Gorman, 1985; Greenough & Volkmar, 1973; Turner & Greenough, 1985). The complex environments were large cages with various objects for exploration and play, and housed about a dozen animals. Findings indicated a greater number of visual synaptic connections in the rats raised in the complex environment (Greenough et al., 1987, p. 197). However, the research does not support the introduction of early educational interventions for children. Instead, it concurs with the studies of Romanian orphans that indicated the ill effects of severely limited environments (see O'Connor, Bredencamp, & Rutter, 1999).

Furthermore, the term complex does not translate into enriched, which typically refers to activities selected according to one's value system (Bruer, 1997). Examples include Sesame Street but not other programs, and Mozart rather than Sting. Neuroscience, in other words, does not provide support for such choices (Bruer, 1997, 1998b).

In summary, some policymakers maintain that birth to ages 3 or 5 is the critical period in brain development, and particular experiences must occur during that period or learning opportunities will be lost. However, the studies on visual deprivation of kittens, the documentation of early synaptic growth followed by loss, and the comparison of rats raised in complex and other environments do not support this belief.

Current Research Methods
The aim of cognitive neuroscience, a relatively new discipline, is to determine the links between neural activity in the brain and cognitive behaviors (Kosslyn & Shin, 1992). Early methods of researching the brain consisted of (a) case studies of individuals with brain damage from illness or injury, and (b) the practice of surgically altering animals' brains to observe the effects on behavior. However, damage in one area of the brain also may disturb functioning in another area. Also, the findings from animal studies may not apply to the human brain.

Prior to neuroimaging methods, electroencephalography (EEG) was the method applied to actual brain activity. An EEG can measure electrical activity associated with a stimulus presentation or action (Johnson, 1997, p. 13). However, the electrical signal recorded at any particular electrode may not accurately reflect the area of the brain that produced it. Instead, it reflects both local and distant brain activity that may have proceeded through neural networks to that electrode.
A major contribution to the emergence of cognitive neuroscience was the development of neuroimaging methods (Gur & Gur, 1991; Sarter, Berntson, & Cacioppo, 1996). These methods are analogous to the importance of the invention of the telescope which made possible detailed investigations of the heavens (Goldberg, 2001). For example, portions of the cerebellum may be important in problem solving (Kim, Ugurbik, & Strick, 1994), and areas of the prefrontal cortex are activated in the 8- to 10-year-olds during spatial memory tasks (Truwit et al., 1996).

Two current neuroimaging methods are positron emission tomography (PET) scans and functional magnetic resonance imaging (fMRI). Although referred to as neuroimaging, they do not measure neural activity directly (Gabrieli, 1998). Instead, they are based on the assumption that incremental changes in regional cerebral metabolism or blood oxygenation are related to brain activity. However, yet to be defined is the nature of the link between changes in the blood and neural activity (Fitzpatrick & Rothman, 2002, p. 807).

**Functional Magnetic Resonance Imaging.** Currently, PET scans are used less than fMRIs, in part because fMRIs are noninvasive. A PET scan requires injection of a radioactive isotope (such as glucose or oxygen) into the bloodstream. In an fMRI, the subject is placed in a magnetic tube and a magnetic field is passed over the brain. The most popular brain signal used in the research is blood oxygen level dependent (BOLD) imaging; the intensity of this signal is related to changes in metabolism in the brain. The data from these studies typically is derived from comparing the differences in signal intensity between a task state and a reference or control state (the paired image subtraction method) (Raichle, 1994). The difference image presumably represents the brain areas involved in the mental activity uniquely associated with the task (Sarter et al., 1996, p. 16).

The availability of MR scanners has led to an exponential increase in the number of articles that have implemented brain imaging; they typically “present data as visually appealing multicolored ‘brain images’” (Fitzpatrick & Rothman, 2002, p. 806). The color-coded areas are those areas in which statistically significant differences in signal intensity between a task state and a reference or control state were found.

**Limitations of Neuroimaging Methods.** Although neuroimaging methods are a landmark development, there is some controversy about their efficacy. For example, some studies use cognitive tasks that are fairly simple. Examples include reading words or sentences, naming objects, identifying words as concrete or abstract, and simple addition. Others use such broad labels that generalizations to other studies cannot be made. An example is “semantic decisionmaking” (Gernsbacher & Kashak, 2003, p. 108).

Two other limitations are a result of the data analysis methods (see Table 3.2). The “standard” brain to which coordinates of brain activity are converted is a stereotaxic brain atlas developed by French neuroradiologist Talairach and his colleagues (Raichle, 1997, p. 20; Talairach & Tournoux, 1988). The practice of data conversion, along with averaging data across subjects, contributes to the impression
TABLE 3.2  
Limitations of Current Neuroimaging Methods

1. Task labels typically indicate either very simple tasks or broad areas that are difficult to interpret.
2. a) Conversion of the coordinates that indicate brain activation in the different images to the coordinates of a standard brain space.
   b) Averaging the data across subjects.
3. Characteristics of the statistical software packages used to analyze the data can influence the information that is reported.
4. Diffuse organization of some of the neural circuits produces only a weak signal when they are activated that is not detected (Sarter et al., 1996, p. 16).

that performance is more localized than indicated by brain lesion studies (Byrnes, 2001, p. 21). Marcus Raichle’s (1997) response to these concerns is that general organizing principles emerge that transcend individual differences (p. 24). Research that indicates that the metabolic activity in the frontal cortex lags behind all the other areas in the cortex is an example (Nelson, 2002, p. 163).

The software used to analyze the data identifies statistically significant differences between brain activity in a control condition and activity during completion of a task. Depending on the design of the study, for example, the same signal obtained in the research may be statistically significant in one person but not another (Fitzpatrick & Rothman, 2002, p. 807). In addition, some statistical packages are biased to support localization of brain functions, because the software deletes the areas common to both tasks (p. 812). One study of a bilingual subject, for example, indicated that different areas of the brain were involved in the speaking of the two languages. However, careful review of the data indicated that the differences reflected only a small shift in the same mental processes involved in producing one language, rather than a separate area for the second language. Finally, some brain activity may be missed because some neural circuits produce only a weak signal that may go undetected (Sarter et al., 1996, p. 16).

The excitement generated by fMRI methods also has contributed to many researchers overlooking what can and cannot be said in response to the question, What can the fMRI signal tell us about neural and mental processes? (Fitzpatrick & Rothman, 2002). In other words, in the efforts to localize brain activity, what exactly is localized? (Sarter et al., 1996, p. 15). A related general question is, How does the processing identified in different areas of the brain occur and what does it mean?

The Potential of Brain Research. Despite the current limitations of neuroimaging methods, some well-designed research has contributed to an understanding of cognition and learning. Research on the brain has contributed information in the area of lifelong learning. Studies have identified the importance of cognitive challenges throughout life in providing some protection against the effects of Alzheimer’s disease.

Some neuroimaging studies do provide a glimpse into the potential of brain research for three areas of cognitive development and learning. Two areas are
the principles of cognitive development and learning disabilities. An example is research that seems to shed further light on Jean Piaget's description of preoperational thinking. In problems requiring logic, the preoperational child is unable to hold two different perceptions in the mind at the same time, relate them to each other, and inhibit a response based on initial perception. Research on patients with damage in the dorsolateral prefrontal cortex (DL-PFC) indicated (a) they made the same kinds of errors on problems similar to the Piagetian tasks (cf. Price, Daffner, Stowe, & Mesulam, 1990) and (b) increasing levels of the transmitter dopamine in DL-PFC that occurs with maturation makes possible cognitive improvement in such problems (cf. Luciana, Depue, Arbisi, & Leon, 1992; Simon, Scatton, & LeMoal, 1980).

An extended research program on children treated for phenylketonuria (PKU) found that they had the same difficulties with Piagetian-type tasks (Diamond, 2002). Although treatment for PKU (a genetic disorder that otherwise produces extensive brain damage and mental retardation) leads to IQ scores in the normal range, the children have (a) the specific cognitive deficit associated with preoperational thinking, and (b) reduced levels of dopamine in the DL-PFC (p. 478). In other words, the studies indicate the role of the DL-PFC in Piagetian-type tasks, the importance of dopamine, and the particular cognitive deficit in PKU-treated children.

Third, cognitive neuroscience may contribute to the principles of information processing. Two levels of processing identified in cognitive models are (a) automatic, in which extensive practice has produced actions that require no conscious control, and (b) controlled, which requires deliberate processing. Raichle (1994), using neuroimaging, assessed the neural differences in automatic and deliberate processing. The tasks required that subjects generate verbs for nouns presented one at a time and practice learning the pairs (deliberate processing). The two images (free choice and last practice session) indicated that the production of verbal responses represents two different distributed neural processes with several widely separated areas of brain activity (p. 342). Furthermore, the prefrontal cortex is a major participant in the subjects' initial selection of a verb for each noun. However, it is not involved in the practiced execution of the task. This finding is congruent with other research that indicates patients with frontal lobe damage cannot complete tasks involving some free choice by the subject. In other words, the frontal lobes are critical in tasks in which the subject must decide on the interpretation of the situation (Goldberg, 2001, p. 80).

Another concept informed by research is episodic memory, which involves the recall of past events in one's life. These tasks require (a) going back in time, (b) an awareness of subjective time in which events occurred (autonoetic awareness), and (c) a sense of self (Tulving, 2002, p. 2). Studies that support the view that episodic memory differs from semantic (declarative) memory include clinical studies of brain-damaged patients with intact semantic memory and impaired episodic memory (summarized in Kapus, 1999, and Wheeler & McMillan, 2001), and an analysis of PET data pooled from several studies. That data suggested different retrieval sites for semantic and episodic memory (Lepage, Ghaffar, Nyberg, & Tulving, 2000).
Another line of research in information processing is the association of John Anderson's ACT-R model of cognition with particular regions of the brain. For example, in solving simple linear equations in algebra and other transformations, the left posterior parietal region is activated when information for solving the task is retrieved (cf. Anderson, Qin, Stenger & Carter, 2004; Sohn, Goode, Stenger, Carter, & Anderson, 2003).

Finally, cognitive neuroscience may identify elements and processes in the human brain that are not yet known, but may contribute to our understanding of cognition and learning. An example is the discovery of mirror neurons, discussed in the following section.

### The Discovery of Mirror Neurons

In the late 1980s, Giacomo Rizzolatti and his colleagues at the University of Parma, in Italy, discovered that certain neurons in the premotor cortex of the macaque monkey fired when the animal executed particular actions, such as reaching for or biting a peanut. Further study of this area yielded a surprising finding. As the experimenter picked up an object to hand it to the monkey, some of the same neurons fired at that time (diPellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992). The observed hand actions that activated the neurons in the monkey's brain were grasping, placing, and manipulating. Most of the neurons responded to the observation of only one action, such as the experimenter grasping or biting a peanut. Also, the neurons did not fire when the experimenter simply made a miming movement in the absence of the object. The researchers named these neurons "mirror neurons" because they "mirror" the behavior of others (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996, p. 995). In addition to firing on the observation of specific hand actions, mirror neurons also were activated when the experimenter broke a peanut or ripped a sheet of paper and when the monkey heard the breaking and ripping sounds (Köhler et al., 2002).

Research on humans indicates that the human brain has more than one neuron system that specializes in understanding both the actions of others and their intentions and their emotions. This understanding is not achieved through conceptual thinking, but by feeling instead. First, mirror neurons are activated by both the observation and execution of grasping actions, but not by the observation of only objects or the dimming of a light (e.g., Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995). The inclusion of these two situations ruled out the possibility that attention could account for the individuals' reactions.

Second, studies indicated that mirror neurons fire in response to both the execution of ripping or breaking actions and to the sounds of those actions (e.g., Gazzalo, Aziz-Zadeh, & Keysers, 2006). Also, neuron reactions were stronger in individuals who scored higher on a self-report empathy scale, suggesting a link between the motor neuron system and empathy.

Third, mirror neurons are activated by both action videos of grasping (picking up a teacup by the handle or the cup itself) and intention videos (context only): (a) table is set for having tea, and (b) table indicates cleaning up after tea is the next step (Iacoboni et al., 2005).
Fourth, studies indicated the activation of mirror neurons both when the subjects viewed video clips of individuals expressing disgust or pleasure at smelling contents of glasses and when they experience disgust or pleasure when smelling odorants themselves (e.g., Jabbi, Swart, & Keysers, 2007; Wicker et al., 2003). This research also confirmed earlier studies that indicate patients with particular brain injuries are unable to recognize disgust in others and report reduced disgust sensations themselves (e.g., Calder, Keane, Manes, Antoun, & Young, 2000).

The implications of mirror-neuron research are twofold. First, the research indicates a temporoparietofrontal neuron circuit and the location of this circuit and its properties indicate a key role of imitation in learning and communication. Although this is not news to researchers and educators who are studying imitation in various settings, this research illustrates the functional neuronal characteristics of a behavior domain (i.e., empathy) (Iacoboni, in press). In other words, it explains the events that make possible one’s tearing up at a sad movie and the experience of excitement upon observing an athlete succeed at a difficult task.

Second, comparisons with nonautistic and autistic individuals indicates a deficiency in the mirror neurons of autistic individuals. For example, when watching the finger motions of others, their mirror neurons are less active (Théoret et al., 2005). Other research, in which autistic children watched different faces displaying anger, fear, happiness, sadness, or no emotion, indicated virtually no activity in the part of the neuron system that recognizes intentions (e.g., Dapretto et al., 2006). This research helps to explain the difficulties of autistic children in social interactions— their brains do not “read” the expressions of others.

**Summary.** The development of neuroimaging methods that can monitor brain activity during cognitive or behavioral tasks is a major factor in the emergence of cognitive neuroscience. Early methods included case studies of patients with brain damage and surgical alterations of the brains of animals.

New methods can produce maps of brain activity based on changes in electrical activity (EEG), brain metabolism (PET scans), or blood oxygenation (fMRI). Disadvantages include the accuracy of the recorded electrical activity (EEG), the hypothesized links between changes in blood or oxygenation levels and actual neural activity, the image subtraction method, the practice of converting the data to a standard brain image, possible shortcomings of data analysis software, and the inability to detect a weak signal.

Some well-designed studies provide a glimpse into the potential of brain research for cognitive development and learning. Included are brain correlates of preoperational thinking, the relationship between PKU and preoperational thinking, and research on information processing and episodic and semantic memory. Also, the discovery of mirror neurons indicates neural systems that react to (a) certain tasks performed by others and their intentions, and (b) observation of and execution of behaviors that indicate pleasure or disgust. The latter is an indication of the empathy that individuals feel with others. Research also indicates that the mirror neurons of autistic individuals have little or no reaction to the movements of others and different facial expressions.
CHAPTER QUESTIONS

Understanding Concepts

1. What does the term growth mean in relation to the brain?
2. What information supports the structural plasticity view of the brain as opposed to a genetic hard-wired view?

3. What is the major difference between the subcortical and neocortical structures of the brain?

REFERENCES


From cognitive neuroscience to social science. Cambridge, MA: MIT Press.


PART II

Learning-Process Theories

Three theories continue and expand on the directions initiated by behaviorism and Gestalt psychology. B. F. Skinner’s operant conditioning describes the events and conditions responsible for complex patterns of executed behaviors. Examples are pigeons learning to bowl and children learning to read. Skinner’s analyses include the various types of consequences that influence behavioral change, the emotional by-products of aversive consequences, and a mechanism for individualizing instruction.

Robert Gagné addressed both behavioral and cognitive aspects of learning in his analysis of the various tasks that comprise human learning. His conditions of learning describe five major types of capabilities, each reflected in a particular performance. His theory details the cognitive processes and learner states required for each type of capability, as well as the essential steps for instruction.

The cognitive perspective, influenced by the development of high-speed computers, introduced an information-processing model to portray the ways that the learner receives, processes, and later recalls information. Cognitive theory and research also address problem-solving and learner strategies for the management of information and learning.
CHAPTER 4

B. F. Skinner's Operant Conditioning

A baby shakes a rattle, a child runs with a pinwheel, a scientist operates a cyclotron—and all are reinforced by the results. (Skinner, 1968b, p. 153)

The psychologists who adopted Pavlov's model tried unsuccessfully for more than a decade to apply it to the learning of complex, voluntary behaviors. Then, in the 1930s, Skinner (1935) pointed out that they were looking in the wrong place. His research indicated that the outcome produced by a response was the important event in changing behavior (Skinner, 1953). The baby's accidental movement of a rattle produces a new sound, and soon the baby is shaking the toy for several minutes at a time. Similarly, a scientist discovers an efficient way to stain slides for cell analysis. He then begins to spend evenings and weekends in the laboratory perfecting the technique. The outcome initially produced by each behavior leads to repetition of the action.

Skinner's analysis led to more than 50 years of research on what seems, at first glance, a very simple principle. However, in situations involving two or more persons, actions can sometimes inadvertently strengthen undesirable behavior. For example, consider the situation in which a well-meaning teacher delays helping a student so that he can show what he can do (Skinner, 1968b). However, when the student shows discouragement, the teacher quickly comes to his aid. For the anxious or insecure student, giving up on a difficult problem has "produced" adult attention and assistance. The teacher's reaction has strengthened an undesirable behavior (giving up), which, as a result, is likely to be repeated.

Skinner's work began with an analysis of the differences between reflexes and other behaviors (Skinner, 1935), and his principles of operant conditioning soon followed (Skinner, 1938, 1953). He later turned his attention to the school setting with the development of the teaching machine (Skinner, 1961) and a technology of classroom teaching (Skinner, 1968a, 1968b, 1973). His later comments on education include recommendations for microcomputer instruction (Skinner, in Green, 1984, Skinner 1989b).

In the 1980s, Skinner continued to apply his concepts to various issues. Included were an analysis of the similarities and differences in natural selection and operant
conditioning (Skinner, 1981, 1987), an analysis of aging (Skinner & Vaughn, 1983), a description of cultures and their development (Skinner, 1981, 1987, 1989b), and a further analysis of rule-governed behavior (Skinner, 1987). The scope of his work includes (a) a philosophy of science, (b) a theory of behavior, and (c) a system for applying his principles in the natural setting (Kratochwill & Bijou, 1987, p. 138).

PRINCIPLES OF LEARNING

Like John Watson (1913), Skinner believed that psychology could become a science only through the study of behavior. Unlike Watson, he pursued the study of a different class of behaviors—those that are not automatically triggered by a particular stimulus.

Basic Assumptions

The foundation for Skinner’s work consists of his description of the nature of a behavioral science and the nature of learning.

The Nature of a Behavioral Science

The goal of any science, such as biology, chemistry, or physics, is to discover the lawful relationships among natural events in the environment. Similarly, the task for a science of behavior is to discover the lawful or “functional” relationships among physical conditions or environmental events and behavior. The task is to determine which changes in independent variables (conditions or events) lead to changes in the dependent variable, behavior. For example, What are the conditions or events responsible for one student attending to academic tasks and another’s avoidance of homework? To refer to one student as “motivated” and the other as “unmotivated” does not, in Skinner’s view, answer the question.

However, developing a science of behavior is difficult because behavior is both complex and varied; it is a temporal, fluid, and changing process (Skinner, 1953). The challenge is to discover the order and uniformity in ongoing streams of behavior in different situations (Skinner, 1953). The foundation for Skinner’s approach to this challenge includes (a) his discussion of the problems with theories and internal states as a basis for behavioral research, and (b) his approach to research, the experimental analysis of behavior.

Problems With Theories and Internal States as a Basis for Behavioral Research. Skinner believed that theories should not be used as frameworks for research. In his view, theories merely create an artificial world of order and lawfulness by explaining one statement in terms of another. The problems are that undiscovered lawful relationships are obscured and the scientist’s sense of curiosity may be stifled, thereby thwarting future research (Skinner, 1950).

A second source of problems in developing a science of behavior is the practice of describing behavior as “caused” by some mental state or set of feelings. First, such explanations simply raise another issue—that of explaining the states
themselves (Skinner, 1963a). For example, if anxiety is proposed as an explanation for poor test-taking skills, then what causes the anxiety?

Second, an emphasis on states treats behavior as simply an indicator or “symptom” of some inner activity (Skinner, 1966b, p. 213). Behavior becomes a “second-class variable” when it is treated as merely an indicator of a process (e.g., learning or maturation), a state (e.g., alertness), or a drive or emotion.

Third, a focus on inner states diverts attention from research that may identify both the sources of problems and the solutions. For example, the state referred to as “consumer lack of confidence” in the economy is described as a “problem” in overcoming an economic recession. However, people plan to buy less when their money does not go very far, and the decreased buying is described as lack of confidence. Thus, governmental actions to “restore confidence” are, in reality, actions taken to restore consumer buying—that is, to change behavior.

A personal situation is the mild depression that an individual experiences when moving to a new city. The problem is that the old set of behaviors is now useless (Skinner, 1987, p. 155). The old stores, restaurants, theaters, and friends are no longer present, and a new set of behaviors must be acquired. When this is done, the “depression” is relieved.

In the classroom, a student who demonstrates poor reading skills also will perform poorly in his or her academic subjects. The student may be labeled as lacking in self-esteem or as having a poor self-concept, which refers to his lack of initiative in school. However, the problem is not that of the student’s internal state, but instead, a lack of reading skills (Belfiore & Hornyak, 1998, p. 186).

**Experimental Analysis of Behavior.** Skinner began his work with an analysis of Pavlov’s empirical model of behavioral change. First, it addressed only a narrow form of behavior—reflexes. (An example is the knee jerk triggered by a hammer tap to the knee.) Skinner (1938) referred to reflexes as elicited responses because they are automatically triggered or elicited by a particular stimulus. Second, although Pavlov successfully conditioned elicited responses to respond to new stimuli, his model could not account for the learning of new behaviors.

In contrast to reflexes, which are a small fraction of behavior, most behaviors are not tied to a particular event or condition. They range from simple actions such as opening a door or reciting a poem to complex behaviors, such as writing an essay or singing a song. Someone may break into song, for example, while in the shower, driving a car, or as part of a music recital. Skinner (1935) named these behaviors emitted responses.

To study emitted responses, the researcher must manipulate observable events in a controlled setting, a procedure referred to as the experimental analysis of behavior. This requirement meant studying behavior in the laboratory where conditions can be carefully controlled and systematically manipulated. Skinner also studied animals because basic processes can be more easily revealed, and their behavior can be recorded for longer periods of time (Skinner, 1953, p. 38). The first subjects in his experiments were rats; later he used pigeons.

One criticism of Skinner’s laboratory research was that he applied the findings on animals to humans. First, however, other sciences, such as human
embryology, have made use of research on animals. Second, science begins with the simple, and then advances to the more complex (p. 38).

Third, the data collected on animal subjects revealed information about the interactions between all organisms and the environment. “The schedule of reinforcement which makes the pigeon a pathological gambler is to be found at the racetrack and the roulette table, where it has a comparable effect” (Skinner, 1969, p. 84).

To control environmental conditions, Skinner designed an experimental space that was free of distractions. It was a soundproof darkened box that included (a) one or more response devices such as levers, keys, or discs, and (b) mechanisms to provide reinforcers (e.g., food and water). Sometimes other stimuli were used, such as lights, loudspeakers, or mechanisms for the delivery of mild shock. The chamber was automated so that food pellets or some other consequence was delivered immediately after an appropriate response, and automated devices recorded the frequency of responses. Closed-circuit television was added when it became available and the behavior videotaped for later review.

Skinner (1953, 1968b) also studied the responses of individual subjects rather than group behavior because a group average does not provide a clear picture. For example, the average 68.33 provides little information about the three scores on which it is based: 55, 60, and 90.

Some have criticized the experimental analysis of behavior for neglecting cognitive skills. However, any science “begins with facts that can be predicted and controlled with some precision and then moves on to more complex facts only when the increasing power of the analysis permits” (Skinner, 1987, p. 9).

**Definition of Learning**

The assumptions that support Skinner’s study of behavior are summarized in Table 4.1. The importance of these assumptions is that they reflect the requirements for psychology to become a science and they make possible the application of laboratory findings to human behavior in the everyday world. First, Skinner (1950) specifically defined learning as behavioral change. “Learning is not doing—it is changing what we do” (Skinner, 1989a, p. 15). The young child, for example, may look at a group of three apples and a group of 10 apples and be able to say that the group of 10 apples is larger. Subsequently, when the child learns to count, he or she can identify the specific number in each group and the quantitative difference between them.

Also, applications of the experimental study of learning to the classroom did not focus on “developing the mind” or, for example, developing some vague “understanding” of mathematical relations (Skinner, 1968b, p. 26). Instead, the goal was to develop techniques designed to establish the behaviors that define thinking. In arithmetic, in addition to basic operations (addition, subtraction, etc.), these behaviors include, for example, calculating percentages, various operations with fractions, and many others.

In his research, Skinner defined the dependent variable as a change in the likelihood or probability of an emitted response. Because the likelihood of a behavior is difficult to measure, the rate or frequency of responding is measured instead. Although not precisely the same as the probability of future performance,
### TABLE 4.1
Summary of the Basic Assumptions in Operant Conditioning

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Learning is behavioral change.</td>
<td>1.–4. To qualify as a science, psychology must (a) study observable, measurable events, (b) under carefully controlled conditions, and (c) determine the environmental events that are the causes.</td>
</tr>
<tr>
<td>2. Behavioral change is functionally related to changes in environmental events or conditions.</td>
<td></td>
</tr>
<tr>
<td>3. The lawful relationships between behavior and the environment can be determined only if behavioral properties and experimental conditions are defined in physical terms and observed under carefully controlled conditions.</td>
<td></td>
</tr>
<tr>
<td>4. Data from the experimental study of behavior are the only acceptable source of information about the causes of behavior.</td>
<td>5. Precise relationships can only be determined through research on individual subjects.</td>
</tr>
<tr>
<td>5. The behavior of the individual subject is the appropriate data source.</td>
<td>6. Because the goal is to identify observable events that strengthen or weaken the frequency of responses (behavioral change), the particular organism (animal or human) is not a major factor.</td>
</tr>
<tr>
<td>6. The dynamics of an organism's interactions with the environment are the same for all species.</td>
<td></td>
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</tbody>
</table>

it is an initial step in the analysis of behavioral change (Skinner, 1963b). In addition, response rate applies to a variety of behaviors, from the movements of pigeons in the laboratory to student responses in the classroom.

**Summary**
The goal of any science is to discover the lawful relationships among natural events in the environment. Therefore, a science of behavior must discover the lawful relationships among environmental events and behavior. To develop psychology as a science, Skinner established several requirements for behavioral research. First, theories and discussions of internal states should not be the basis for planning research. Second, the researcher should conduct experiments with individual subjects and manipulate observable events in a controlled setting. Third, the researcher must define the properties of behavior and experimental conditions in physical terms. In his research, Skinner identified frequency of responding as an adequate measure of the likelihood of future responding. In other words, when learning occurs, responses increase.

**The Components of Learning**
Skinner (1953, 1963b) identified Thorndike's research as the basis for understanding behavioral change. Described as the law of effect, the research had identified the basic rule for behavioral change. In Thorndike's research, an animal's
escape led to food. When confined again, the animal repeated the new behavior. This research demonstrated that concepts such as purpose, intention, and expectancy were not needed to explain future behavior (Skinner, 1963b, p. 503). Discussed in this section are Skinner’s adjustments to this rule: the discriminative stimulus, the essential principles of reinforcement, and categories of reinforcement. Also discussed are punishment and the relationships between cultural practices and operant conditioning.

The Basic Rule of Behavioral Change
Thorndike had identified the three essential components of behavioral change (Skinner, 1953). They are (a) the occasion on which the behavior occurs, (b) the behavior itself, and (c) the consequence of the behavior (Skinner, 1953; 1968b, p. 4). That is, emitted responses often act on the environment to produce different kinds of consequences, and certain consequences lead to repetition of the response. Singing a song, for example, may “operate” on the environment to produce consequences such as praise, applause, or money—consequences that lead to an increased frequency of the behavior. Skinner (1935) named these emitted responses operants.

One flaw in Thorndike’s analysis is that he identified the consequence that leads to an increase in the behavior as a reward. The problem is that reward implies payment for services performed (Skinner, 1989b, p. 92) or compensation that offsets a loss or sacrifice of some kind (Skinner, 1963b, p. 505).

Skinner substituted the terms reinforcing consequence and reinforcement for reward, and defined them in terms of the relationship to behavior. Specifically, reinforcement is any behavioral consequence that strengthens behavior; that is, a reinforcer increases the frequency of a response. A reinforcing event is any outcome produced by an operant that changes the organism in such a way that the behavior is repeated. Skinner identified the three components of learning as the discriminative stimulus ($S^D$), the response ($R$), and the reinforcing stimulus ($S^{\text{reinf}}$) and the sequence of learning events is ($S^D$)–($R$)–($S^{\text{reinf}}$).

The Discriminative Stimulus
Any stimulus that is consistently present when a response produces reinforcement is a discriminative stimulus. For example, in Thorndike’s research, tripping the latch of the cage repeatedly produced the outcome of access to food. The confined animal soon responded only to the fastener and ignored other parts of the cage. The latch is referred to as the discriminative stimulus. It does not trigger or elicit a response (Skinner, 1953, p. 110). Instead, through repeated association with the reinforced response, the discriminative stimulus serves as a cue for behavior.

Skinner (1953) demonstrated the process whereby the discriminative stimulus becomes a behavioral cue. In the experiment, a pigeon’s behavior of pecking a red key produced food pellets. When the color of the key was changed to green in mid-stroke, the pigeon’s head stopped and its beak did not strike the key. This process is typically referred to as discrimination; however, the organism is simply responding more often to settings with certain properties (Skinner, 1989a, p. 128).

Behavioral change can, of course, be explained without reference to the preceding stimulus (Skinner, 1953). An example is neck stretching in the pigeon,
which typically occurs without an $S^D$. Like other behaviors, neck stretching will increase in rate as a result of the behavior producing continued food pellets, for example. However, if neck stretching produces a food pellet only when a signal light is on, then eventually, the behavior will occur only in the presence of the light (Skinner, 1953, p. 107).

The Role of Discriminative Stimuli. The likelihood that a response will be repeated is maximized by the presence of a discriminative stimulus. Examples that acquire control over behavior in everyday life include red and green traffic lights, stop signs, and other signals (Skinner, 1953). Also included are numerous verbal commands, such as “Take out your pencils” and “Please pass the salt.” Signals, verbal commands, and other discriminative stimuli acquire behavioral control because operants emitted in their presence produce reinforcing consequences. For example, requests such as “Please pass the salt” and “Please pass the bread” acquire a measure of behavioral control because, when growing up, the child’s response (passing the requested item) produced adult approval. This consequence, for a child, typically increases the chances of the behavior occurring again.

Discriminative stimuli also may be constructed by individuals for themselves. Examples are making resolutions, announcing expectations or intentions, and developing plans (Skinner, 1963b, p. 513). However, these stimuli must be followed by the particular behavior and an outcome that leads to repetitions of the behavior. In addition, to be most effective in controlling behavior, these self-generated stimuli must be visible in some durable form, such as drafting a written plan or posting the resolution on a bulletin board (Skinner, 1963b).

Two or more different stimuli that share a common feature may also acquire control over a particular response. A pigeon's pecking response to both a lighted bar and a lighted disc and a child’s verbal identification of $p$, $P$, and $p$ are examples. Skinner referred to this process as induction (commonly known as stimulus generalization).

Summary
The key to understanding complex behaviors is to understand the events and processes responsible for emitted responses. These responses, unlike Pavlov’s elicited responses, are not automatically associated with a particular stimulus. Instead, they can occur in many different situations. The key to understanding these responses, in Skinner’s view, was Thorndike’s law of effect. Emitted responses act on the environment to produce different kinds of consequences that affect the animal or the human in such a way as to alter future behavior. The three essential components of learning that Skinner derived from Thorndike’s paradigm are the discriminative stimulus ($S^D$), the response ($R$), and the reinforcing stimulus ($S^{reinf}$).

The discriminative stimulus is any stimulus that is consistently present when a response produces a reinforcing consequence. Through repeated association with the reinforced response, the discriminative stimulus becomes a behavioral cue for the response. Discriminative stimuli often are environmental events and the verbal statements of others. However, individuals also construct discriminative stimuli for themselves, such as lists and written plans.
Essential Principles of Reinforcement

Two key topics in reinforcement are the dynamics of the process and factors that influence reinforcement.

The Dynamics of Reinforcement. To be effective in altering behavior, reinforcement must occur immediately “on the heels of” the operant, and be directly linked to that behavior. “A reinforcer is most powerful when it follows very quickly—optimally within a fraction of a second” (Skinner, 1989b, p. 97). The reinforcement, in other words, is contingent on the execution of a particular behavior. For example, when the baby moves her arm shaking the rattle, that behavior is immediately reinforced by the sound, and the behavior of shaking the rattle occurs again.

The two key processes in operant conditioning are variation (of behavior) and selection by consequence. Different behaviors are executed, but only some are strengthened by the outcomes. For example, the rat’s behaviors of sniffing the corners of the cage and looking at the ceiling do not produce a food pellet. Because these behaviors do not generate reinforcement, they decrease in frequency.

Two practices should be avoided in describing reinforcement. First, to say that operant reinforcement “strengthens the response which precedes it” is not accurate (Skinner, 1953, p. 87). The change that has occurred is the future likelihood of responding. The particular behavior that occurs immediately prior to the reinforcement has passed into history. However, the animal or the human is changed by the particular consequence and later responds as a changed organism (Skinner, 1989b, p. 64).

Second, reinforcers should not be described as pleasant or satisfying. This description assumes that (a) individuals can describe their feelings objectively, (b) reinforcement both strengthens behavior and generates certain feelings, and (c) one does not occur without the other (Skinner, 1953, p. 82). However, feelings are subjective, and the presence of particular feelings is not a requirement for a stimulus to strengthen behavior.

Not every behavioral consequence functions as a reinforcer. A direct test is needed to determine whether a particular event strengthens a response; that is, acts as a reinforcing consequence (Skinner, 1953, p. 73). The proposed event is made contingent on the particular response that is to be strengthened, and the rate of responding with the added consequence is observed. If the frequency of the behavior increases, the event is reinforcing in the particular situation. For example, the attention of an adult in the form of praise for appropriate behavior is typically reinforcing in the case of young children. In contrast, praise for appropriate behavior in the case of teenage males, particularly in front of the class, is likely to produce embarrassment and possibly anger.

Sometimes behaviors are reinforced accidentally. This process leads to the development of superstitious behavior (Skinner, 1953, p. 85). Random behavior that is reinforced accidentally increases in frequency, and very likely receives accidental reinforcement again. Skinner (1948) demonstrated superstitious behavior in the laboratory by providing a food pellet to a pigeon every 15 seconds. Behaviors that were strengthened were those actions that were occurring when the food was delivered. Examples include strutting, wing flapping, bowing, and scraping.

Random behaviors also are reinforced in the natural setting. For example, a man waiting for a bus may look in the direction that the bus is to appear, then
pace up and down and look at his watch several times. None of these actions makes the bus arrive, yet all are reinforced by the appearance of the vehicle. When the man waits for a bus again (or a train), he is likely to pace up and down and check his watch repeatedly.

Reinforcement increases the rate of responding, and elimination of the reinforcing consequence decreases the rate. The decreased rate is known as extinction (Skinner, 1938, 1963b). If reinforcement is withdrawn completely, behavior will gradually cease. An important function of reinforcement in everyday life is to prevent the extinction of behavior.

Factors That Influence Reinforcement Contingencies. Three factors associated with the individual influence the extent to which particular events may function as reinforcers. They are the individual’s skills, past reinforcement history, and inherited characteristics. For example, the acquisition of new skills, such as playing a musical instrument or using a personal computer, opens up new possibilities for reinforcement (see Table 4.2). Another example is fluent reading, which

<p>| TABLE 4.2  |
| Factors that Influence Contingencies of Reinforcement |</p>
<table>
<thead>
<tr>
<th>Factor</th>
<th>Effects</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Skill level</td>
<td>1. The acquisition of new skills opens up new opportunities for reinforcement.</td>
<td>1. Learning to operate a personal computer makes possible the potential reinforcers of success in learning the new skills, access to the Internet, editing text quickly, and others.</td>
</tr>
<tr>
<td>2. Past reinforcement history</td>
<td>2. Individuals are “enthusiastic,” “uninterested,” “ignorant,” or “learned,” primarily as a result of different histories of reinforcement (Skinner, 1953, p. 196).</td>
<td>2. A child has received a small gift or toy from his or her parents simply by asking. Subsequent efforts to foster polite behavior through verbal consequences is ineffective.</td>
</tr>
<tr>
<td>3. Genetic endowment</td>
<td>3. Different IQ levels and artistic and other abilities are influenced by different types of reinforcers.</td>
<td>3. Concrete reinforcers are effective in teaching simple discriminations to a mentally retarded adult (Skinner, 1968b). Verbal reinforcers are effective with others.</td>
</tr>
<tr>
<td><strong>Species</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Survival mechanisms successful for early humans</td>
<td>4. Survival mechanisms are transmitted to current generations as susceptibilities to particular kinds of reinforcement.</td>
<td>4. Overeating, the tastes of sugar and salt, sexual contact, the outcomes of aggressive behavior.</td>
</tr>
</tbody>
</table>
is reinforced by the sense of story or the new information conveyed by the sentences and paragraphs. The individual’s eye movements across the page produce new meanings for him or her.

The second factor is past reinforcement history. The effects of prior reinforcers lead to individuals who are, for example, either enthusiastic or uninterested students. Similarly, a particular history of punishments leads to individuals who are described as “cowed” or “timid” (Skinner, 1953, p. 196). The third factor is the individual’s genetic endowment. Included are level of mental ability and other inherited characteristics, such as artistic ability.

Current generations also have inherited susceptibilities to particular kinds of reinforcement from early humans. They lived in a difficult and dangerous environment, and certain behaviors were powerfully reinforced by survival. Included were eating as much as possible at one time whenever food was found and eating the few foods that were sweet, which often were especially nutritious (Skinner, 1987, p. 174). Western civilization, however, has an abundant food supply, and many people today often face health problems from overeating as well as from consuming excessive amounts of salt and sugar.

In addition, sexual contact that led to procreation and aggressive behavior against predators led to the survival of the strong breeders and fighters. Problems currently faced by their descendants include overpopulation and a susceptibility to reinforcement by the outcomes of aggression.

**Summary.** A reinforcing event is any behavioral consequence that increases the frequency of the response. To be effective, the consequence must be immediately contingent on the execution of the particular behavior. Reinforcement should not be described as strengthening the preceding response; the change is the likelihood of the response in the future. In addition, reinforcers should not be described as pleasant or satisfying. Feelings are subjective and they are not a requirement in reinforcement.

Three characteristics of individuals influence the extent to which events or stimuli may function as reinforcers. They are the person’s past reinforcement history, the skills repertoire of the individual, and the particular characteristics inherited by the individual. In addition, current generations have inherited susceptibilities to particular reinforcements from early humans. Although reinforced by survival in earlier times, these susceptibilities are now problems.

**Categories of Reinforcers**

Three broad classifications of reinforcers are (a) primary or secondary, (b) generalized, and (c) positive or negative.

**Primary, Secondary (Conditioned), and Generalized Reinforcers.** As societies grow more complex, a greater variety of events can function as reinforcers (Skinner, 1989a). Included are getting a key to the executive washroom, winning an Olympic medal, and finding information on the Internet.

How do such events become reinforcers? The process begins with a small group of stimuli that are primary reinforcers (Skinner, 1953, 1963b). Under
appropriate conditions, primary reinforcers are the stimuli that can increase the frequency of behavior without training. They also are essential to the survival of the species (see Table 4.3). For example, food pellets function in the laboratory as reinforcers for the behavior of food-deprived rats and pigeons.

Other events that strengthen behavior are conditioned or secondary reinforcers. They acquire reinforcing power through association with (a) a primary reinforcer or (b) an already-established conditioned reinforcer. For example, in the laboratory, the click of the food-delivery mechanism acquires reinforcing power by occurring a fraction of a second before the food pellet appears. Then, for a time, the click alone can strengthen behavior. In the everyday world, smiles and being rocked or cuddled often accompany the feeding of the young infant. In this way, receiving affection and the approval of others become secondary reinforcers.

Conditioned reinforcers play an important role in the development of complex human behaviors. First, if primary reinforcers alone strengthened behavior, then human behaviors would be limited to those actions that produce food, drink, sleep, shelter, and sexual contact.

Second, conditioned reinforcers bridge the gap between the early stages of complex behavior and some future consequence. For example, “people are said to write articles or books for money or acclaim. Those may be rewards, but they

<table>
<thead>
<tr>
<th>Type of Reinforcer</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Strengthen behavior without training (conditioning) and are essential to the survival of the species</td>
<td>In appropriate conditions, food, drink, shelter, sexual contact</td>
</tr>
<tr>
<td>Conditioned (secondary)</td>
<td>Strengthen behavior through association with (a) a primary reinforcer or (b) an already-established secondary reinforcer</td>
<td>(a) In the laboratory, the sound of the food-delivery mechanism; in the everyday world, smiles affection, and approval (possibly linked initially with food) (b) medals, certificates, and other awards associated with attention and approval</td>
</tr>
<tr>
<td>Generalized</td>
<td>Effective in a variety of situations; includes (a) social reinforcers provided by others, and (b) successful manipulations of the physical environment</td>
<td>(a) attention, affection, various forms of approval (smiles, nods of agreement, verbal commendations) (b) engagement in crafts, artistic endeavors, and solving puzzles (Skinner, 1953, p. 77)</td>
</tr>
</tbody>
</table>
do not occur soon enough to be reinforcers. At one’s desk the reinforcers are the appearances of sentences that make sense, clear up puzzles, answer questions, make points” (Skinner, 1986, p. 109). These conditioned reinforcers, rather than ultimate publication or acclaim, maintain the day-by-day behavior of writing.

**Generalized reinforcers.** Some secondary reinforcers are restricted to a particular setting because they are linked to only one primary reinforcer. The click of the food delivery mechanism, for example, functions only in the laboratory. Others, however, are generalized reinforcers; they function in a variety of situations. Generalized reinforcers include (a) social reinforcers and (b) successful manipulation of the physical environment. One social reinforcer, the attention of others, is important because it is a necessary condition for other social reinforcers, such as approval (Skinner, 1953, p. 78).

However, the attention of others can, on occasion, inadvertently strengthen inappropriate behavior. An example is the teacher described at the beginning of this chapter who moves to help a student when he or she shows discouragement. Another can occur when an individual is being stalked by another person. The worst action a victim of stalking could enact is to initiate direct contact with the stalker. Regardless of the message the victim conveys, the contact, for the stalker, is a reinforcer. The result is a significant increase in pursuit behavior.

Money also has been referred to as a generalized reinforcer. Skinner (1987) noted that money strengthens behavior when it is paid on commission or on a piece-rate basis (amount of payment is linked to number of garments sewn together, for example). However, “wages paid for the amount of time worked do not, strictly speaking, reinforce behavior at all” (p. 19). Wages received at the end of the week, for example, do not affect behavior during the week (p. 19).

One powerful generalized reinforcer that often is overlooked is the reinforcement provided by successful manipulation of the physical environment. For young children, successful manipulation includes cutting with scissors and other activities, such as constructing objects and buildings from blocks and Lego pieces. Our tendency to participate in activities that depend on skill, such as crafts, artistic creations, and skill sports such as bowling and tennis, may be a function of this generalized reinforcer (Skinner, 1953, p. 77). Similarly, in an early video game, “No one really cares whether PacMan gobbles up all those little spots on the screen. Indeed, as soon as the screen is cleared, the player covers it again with more little spots to be gobbled up. What is reinforcing is successful play” (Skinner, 1984, p. 24).

**Positive and Negative Reinforcers.** Another categorization of reinforcers is based on the ways that stimuli strengthen behavior. Some reinforcements are additions to a situation; they are positive reinforcers (Skinner, 1953, p. 73). For example, the rat’s lever pressing and the pigeon’s key pecking each produce a new stimulus—a food pellet. Similarly, the child’s accurate identification of one or more primary colors produces adult approval. In each of these examples, a new stimulus appears in the situation (food pellet, adult approval).

In contrast, some reinforcers function in a different way. They strengthen behavior through their termination or removal from a situation. For example, a
rat experiences mild electric shock through an electrified floor grid. Backing into or otherwise touching the wall removes (terminates) the electric shock. The response, touching the wall, increases in frequency (is strengthened) because it successfully removes the mild shock. In that situation, the mild electric shock is the discriminative stimulus, the response is touching the wall, and the reinforcer is the termination of the electric shock. Specifically, “a negative reinforcer is properly defined as ‘a stimulus the reduction or removal of which strengthens behavior’” (Skinner, 1989b, p. 127).

In negative reinforcement, the discriminative stimulus is an object or event that is aversive, and it is aversive “only if its removal is reinforcing” (Skinner, 1953, p. 171). An aversive stimulus is not referred to as unpleasant or annoying (p. 173). Like the term “pleasant” in relation to positive reinforcers, unpleasant or annoying are subjective terms, and they do not provide information about the effects of an aversive stimulus in relation to behavior.

The response that brings about the termination or removal of the discriminative stimulus is referred to as escape behavior (Skinner, 1953, p. 171). For example, an individual may respond to a loud piercing noise by putting her fingers in her ears, closing intervening doors or windows, or shutting off the noise at its source (pp. 171–172). Each of these actions is a form of escape behavior.

Negative reinforcement is also known as escape conditioning because it strengthens escape behaviors. An example is a boy who has not made friends and is not doing well in school. One day he says that his stomach hurts, and he is allowed to leave class. A few days later he avoids school by saying he has a stomachache. The next Monday morning, he insists he does not feel well enough to attend classes. This set of events, which has strengthened an escape behavior, is one of negative reinforcement. The learning sequence is (a) the school (discriminative stimulus), (b) feigning illness to avoid school (escape behavior), and (c) avoiding school (reinforcement). On subsequent days, the boy engaged in behavior through which he avoided school.

The similarities and differences between positive and negative reinforcement are illustrated in Table 4.4. The similarity is that both consequences strengthen behavior (increase response frequency). They differ in the ways that they strengthen behavior. The consequence in positive reinforcement is the addition of a new stimulus (e.g., a cup of coffee). In contrast, the consequence in negative reinforcement is the removal of or escape from the discriminative stimulus (the bright light).

**Emotional By-Products.** The use of negative reinforcement to regulate behavior introduces undesirable emotional by-products that accompany the subject’s escape or avoidance behavior (Skinner, 1953, 1989b). Included are the emotions referred to as “anxiety” and “fear.” The set of reactions called anxiety, for example, includes conditioned reflexes of the intestinal muscles, such as gastric changes, a sudden loss of blood from the face, and possibly, increased blood pressure.

These emotional reactions, through Pavlovian conditioning, become attached to the situational characteristics of the aversive stimulus. For example, a horse runs faster to escape from being whipped. In the future, the sight of the riding crop
TABLE 4.4
Examples of Positive and Negative Reinforcement

<table>
<thead>
<tr>
<th>Discriminative Stimulus</th>
<th>Response</th>
<th>Consequence</th>
<th>Type of Consequence</th>
<th>Type of Reinforcement*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee machine</td>
<td>Subject puts change in machine and pushes</td>
<td>Subject receives a cup of coffee</td>
<td>Subject's behavior &quot;produces&quot; a new stimulus</td>
<td>Positive</td>
</tr>
<tr>
<td>Parent nags teenager to clean up room</td>
<td>Subject straightens up his room every day for 2 weeks</td>
<td>Nagging stops</td>
<td>Subject's behavior has been followed by the withdrawal of the discriminative stimulus</td>
<td>Negative</td>
</tr>
</tbody>
</table>

*The assumption here is that the response increases in frequency; therefore, the described consequence is functioning as reinforcement.

elicits reactions referred to as anxiety (the horse rolls its eyes, becomes restive, and possibly rears up). Similarly, the child who has completed his chores to avoid a scolding from the parent may become agitated when the parent arrives home.

**Interactive Examples.** In many situations, both positive reinforcement and mild negative reinforcers function to strengthen the same behaviors. For example, the scientist’s long hours of work in the laboratory may be reinforced positively by the conditioned reinforcers of manipulating the experimental situation and, intermittently, by identifying new facts. In addition, perhaps social “small talk” with other people is mildly aversive. When the scientist leaves a party to go to work in the laboratory, escaping from the party is functioning as a negative reinforcer.

In interactions between two or more people, a careful analysis is required to determine discriminative stimuli, responses, and reinforcers. For example, a child may begin to whine whenever the parents entertain guests. The parents may turn their attention momentarily to the disruptive child. In that situation, the child’s interruption is an **aversive stimulus** and is the discriminative stimulus for the parent’s attention (Figure 4.1). Their attention terminates the interruption (withdrawal of the aversive stimulus), which serves as a negative reinforcer for the parents. For the child, the parents’ absorption in conversation with their guests is the discriminative stimulus for the child’s whining and crying. The attention of the adults, particularly if prolonged, functions as a positive reinforcer for the child’s disruptive behavior.

**Summary.** Three broad classifications of reinforcement may be identified. One is that of primary and secondary (conditioned) reinforcers. Primary reinforcers are those that, under appropriate conditions, can increase the frequency of behavior without training (food, shelter, drink, and sexual contact). Secondary or
conditioned reinforcers acquire reinforcing power through association with events that already function as reinforcers. The second category, generalized reinforcers, refers to reinforcers that function in a variety of situations. Generalized reinforcers typically are one of two types: social reinforcers and successful manipulation of the physical environment.

The third category, positive or negative reinforcement, refers to the way that the reinforcing consequence functions. In positive reinforcement, the response produces a new stimulus; for example, a lever press produces a food pellet. In contrast, negative reinforcement refers to the withdrawal or termination of the discriminative stimulus. Another term for negative reinforcement is escape conditioning because behaviors that affect escape from aversive stimuli are strengthened. One problem associated with negative reinforcement is that undesirable emotional responses, such as anxiety and fear, accompany the subject’s escape or avoidance behavior. However, in many situations, both positive and mild negative reinforcement function to strengthen behavior.

**Punishment**

The most common control technique in modern life is punishment (Skinner, 1953). Governments rely on punishments such as fines and imprisonments, religions implement penances and the possibility of excommunication, and individuals exert control through censure, disapproval, or banishment (p. 182). The intention of these actions is to reduce the frequency of particular behaviors. In addition, punishment is not restricted to the actions of others. For example, a child who puts his hand into a flame is punished by being burned (p. 185).

**Types of Punishment.** From the perspective of operant conditioning, behaviors may be punished in either of two ways. One form is the removal of a positive reinforcer (Skinner, 1953, 1968b). For example, when a child misbehaves, the parent withdraws his or her approval. The other form of punishment is the addition
of a negative reinforcer to a situation. Examples include being sent to one’s room and writing 50 times “I will not talk in class.”

Because both punishment and negative reinforcement involve aversive stimuli, they often are confused. However, they differ in two major ways. One is the relationship of the individual to the aversive stimulus. In negative reinforcement, the individual successfully escapes from or avoids the aversive situation. In contrast, in punishment, the individual is placed in an aversive situation. Second, the effects on behavior differ. Negative reinforcement (successful escape or avoidance of an aversive situation) strengthens a particular behavior. In contrast, although punishment immediately reduces the target behavior, this outcome is only temporary (Skinner, 1953, p. 190). For example, a child punished for scribbling on the furniture may decorate a bedroom wall a few days later.

Effects of Punishment. In terms of effect, punishment is not the opposite of reinforcement (Skinner, 1953). At least four undesirable effects of punishment may occur. First, as already mentioned, punishment only temporarily suppresses behavior; it is not a permanent solution. Second, it also produces undesirable emotional reactions, such as frustration, anger, and guilt. Third, actions other than the unwanted behavior also may be punished. Red marks on a term paper and a low grade for misspelled words punish the errors. Also punished, however, are the student’s time and effort in writing the paper.

However, the major shortcoming associated with punishment is that it does not generate positive behaviors (Skinner, 1953, 1968b). Interest in schoolwork does not result from the punishment of indifference (Skinner, 1968b, p. 149). Similarly, students do not learn correct speech by being punished for bad grammar.

Alternatives. If punishment should not be used, then what are some alternatives? First, avoid the conditions that make punishment necessary. For example, punishing students for shouting out in class can be avoided by eliminating events that ask for call-out behavior, such as “Who has their homework done?” Also, lessons with purpose that move briskly with clear signals to students leave few opportunities for misbehavior. Interruptions and confusion resulting from missing props, unclear directions, false starts, and backtracking do not occur.

Second, reinforce a behavior that is incompatible with the undesirable behavior. For example, we suppress competitive behavior when we reinforce cooperation (Skinner, 1968b). In other words, punishing a student for being out of his or her seat may be unnecessary if the student has tasks to complete that earn reinforcement (in-seat behavior).

In summary, both negative reinforcement and punishment involve aversive stimuli. However, negative reinforcement strengthens an escape behavior, whereas punishment temporarily suppresses behavior. The shortcomings of punishment are the negative emotional reactions, the punishment of behaviors associated with the punished behavior, the inability to generate positive behaviors, and the fact that the punished behavior is only temporarily suppressed.
**Cultural Practices and Operant Conditioning**

Skinner (1981) maintained that the essential processes in conditioning individual behavior also operate at two other levels. One, already discussed, is the biological evolution of the species. The other is the development of cultures. Skinner (1989b, p. 52) defined a culture or a set of social practices as the contingencies that are maintained by a group. An example is the American practice of joining family members or friends on Thanksgiving. Celebrating this holiday is positively reinforced by good food and social reinforcers such as affection, companionship, and the approval of others. It is also mildly negatively reinforced through escape from work.

The reinforcement contingencies in cultural practices shape the behavior of each member of the group. Also, social practices are transmitted when members shape the behavior of new or younger members. Young parents, for example, reinforce the participation of their children when they continue the same rituals as their parents.

Cultures, and governments in particular, also often control their members through the use of aversive stimuli, either as negative reinforcers or as punishments for undesirable behavior. Citizens obey laws primarily to escape from or to avoid fines and imprisonment (Skinner, 1989b, p. 53).

Some cultural practices erode the contingencies available through operant conditioning (Skinner, 1987). For example, families no longer must grow their own food or weave the material for their clothing. Although some aversive consequences are avoided by paying someone else for goods and services, opportunities for reinforcement, such as pride in the finished product, are also lost.

In addition, the degree of job specialization in contemporary society has reduced the opportunities for reinforcement. Although society gains from a division of work (more products are available), the assembly line worker who completes one part of the circuitry in a television set does not directly experience reinforcement from completing the final product.

Another problem in Western civilization is the abundance of things described as “interesting, beautiful, delicious, entertaining, and exciting” (Skinner, 1987, p. 23). Included are beautiful pictures, beautiful music, and exciting entertainments. However, the only behaviors reinforced by such easy access to beautiful and exciting things are the behaviors of looking and listening. However, this is only a very small sample of human behavior (compared with the vast range of behaviors that might receive reinforcement) (Skinner, 1987, p. 24). In other words, easy access to pleasing reinforcers creates a situation in which “the reinforcers are not contingent upon the kinds of behavior that sustain the individual or promote the survival of [either] the culture or the species” (Skinner, 1987, p. 24).

**The Nature of Complex Learning**

The law of effect specified the temporal relationship between a response and a consequence (Skinner, 1953, 1963b). However, most activities consist of complex patterns of behavior. Factors observed to function in the acquisition of sets of behavioral patterns are shaping, schedules of reinforcement, the concept of negative utility, and rule-governed behavior.
Shaping
The acquisition of new and complex patterns or “topographies” of behavior results from a series of subtle contingencies of reinforcement. For example, a child learns to pull itself up, to stand, to walk, and to move about through the reinforcement of slightly exceptional instances of behavior (Skinner, 1953). Later, this same process, referred to as shaping, is responsible for all the other complex patterns of behaviors of the normal adult (Skinner, 1953, p. 93).

An example of shaping is the process of teaching a pigeon to bowl (Skinner, 1958). The desired outcome is that of swiping a wooden ball with a sideways movement of the beak so that the ball is sent down a miniature alley toward a set of toy pins. The process involves a carefully designed series of discriminative stimuli and reinforcements for subtle changes in responses, referred to as a program (Skinner, 1963b, p. 506). Each step of the program evokes a response that also prepares the subject to take the next step in the behavioral sequence.

The shaping process begins by providing reinforcement for responses that indicate approaches to the ball. Then reinforcement is withheld until the pigeon’s beak makes contact with the ball. After initial reinforcements for contact, reinforcement again is withheld until further refinement of the behavior (i.e., the pigeon sideswipes the ball). The procedure of first reinforcing responses that only remotely resemble the desired response and then reinforcing only refinements in the response is referred to as reinforcing successive approximations (Skinner, 1953, 1968b, 1989b) or differential reinforcement. Shaping is effective because it is sensitive to the continuous nature of a complex act, and it illustrates the utility of constructing complex behavior by a continual process of differential reinforcement (Skinner, 1953).

The importance of shaping is that it can generate complex behaviors that have an almost zero probability of occurring naturally in the final form (Skinner, 1963a). Shaping also differs from the modifications of behavior that occur with puzzle boxes and mazes. In those situations, the subject is thrown into a problem situation and can only succeed through trial and error. Because the performance of appropriate responses has been left to chance in such situations, random, incorrect responses also occur.

Schedules of Reinforcement
Behavior that acts on the immediate physical environment, in general, is reinforced consistently (Skinner, 1953, p. 99). Standing and walking are examples. However, a large part of behavior generates only intermittent reinforcement, such as writing.

In the laboratory, intermittent reinforcement may be delivered precisely according to different schedules or combinations of schedules (see Ferster & Skinner, 1957). The basis for some schedules is the number of responses emitted by the subject, known as ratio reinforcement. An example is reinforcing every fifth correct response. Other schedules are determined by the clock, such as reinforcing correct responding every 5 minutes (interval reinforcement) (Skinner, 1953, p. 100) (see Table 4.5).

Within these two categories, reinforcement may be either fixed or variable. Under a fixed schedule, whether ratio or interval, responding typically slows down
### TABLE 4.5
Comparison of Ratio and Interval Schedules in Reinforcement

<table>
<thead>
<tr>
<th>Ratio Reinforcement</th>
<th>Interval Reinforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforcement delivery is based on number of responses emitted.</td>
<td>Reinforcement delivery is based on elapsed time.</td>
</tr>
<tr>
<td><strong>Fixed:</strong> A constant number of responses generates reinforcement (e.g., every fifth response)</td>
<td><em>Examples:</em> Reading books, going to the theater, watching television (Skinner, 1966a)</td>
</tr>
<tr>
<td><em>Examples:</em> Selling on commission; pay for piecework in industry</td>
<td><strong>Fixed:</strong> Reinforcement for a correct response at a constant time interval (e.g., every 15 seconds)</td>
</tr>
<tr>
<td><strong>Variable:</strong> Reinforcement delivered after a varying number of correct responses (e.g., every fifth, eighth, third, etc.)</td>
<td><strong>Variable:</strong> Reinforcement delivered for an appropriate response at varying time intervals (e.g., every 10 seconds, 4 seconds, 7 seconds, etc.)</td>
</tr>
<tr>
<td><em>Examples:</em> Payoffs from slot machines, roulette, horse races, other games of chance</td>
<td></td>
</tr>
</tbody>
</table>

Immediately after reinforcement and then the rate gradually increases. The slowdown can be avoided through the use of a variable schedule. The delivery of reinforcement is uncertain and the response rate is more nearly constant.

Intermittent reinforcement on any schedule can sustain behavior for long periods of time. One particularly effective schedule is the **variable-ratio** schedule. Reinforcement is frequent at first, but then it is gradually reduced. For example, a television program may become less reinforcing as jokes or story lines become less interesting. However, someone who has followed the program from the beginning may continue to watch the program for a long time (Skinner, 1966a, p. 164).

The variable-ratio schedule is useful because it maintains behavior against extinction when reinforcement is infrequent (Skinner, 1989b, p. 77). The behavior of dedicated artists and scientists, for example, is sustained by occasional, unpredictable reinforcements.

**The Concept of Negative Utility**

In some situations the variable-ratio schedule can lead to the long-term detriment of the subject. For instance, pigeons reinforced on a variable-ratio schedule for pecking a disc at a high rate will peck until their beaks become inflamed. Similarly, the compulsive gambler is reinforced periodically for betting at the roulette table or playing the slot machine. Every winning play is reinforcing, but they do not occur often and eventually the gambler exhausts his or her resources. These situations are examples of **negative utility** (Skinner, 1987, p. 24).

Gambling sustained by a variable-ratio schedule to the point of negative utility is one form of addiction. This process also occurs with substances such as alcohol, heroin, cocaine, and other drugs (Skinner, 1989b, p. 76). Although initially reinforcing, long-term use leads to the powerful negative reinforcers called withdrawal symptoms. The long-term condition is one of negative utility; greater amounts of the substance are required to provide escape from the symptoms of
withdrawal (negative reinforcers) while the general physical and emotional state of the individual deteriorates.

**Rule-Governed Behavior**

Shaping, by exposing the subject to changing contingencies of reinforcement, develops progressively more accurate behaviors. Examples of this process, *contingency-governed behavior*, include learning to stand and learning to walk (Skinner, 1969). However, people do not acquire all behaviors through direct exposure to response consequences. “Few people drive a car at a moderate speed and keep their seat belts fastened because they have actually avoided or escaped from serious accidents by doing so” (Skinner, 1953, p. 168). Instead, people often do what others tell them to do—they follow advice (Skinner, 1987, p. 21). Typically, the advice is in the form of verbal suggestions or instructions, such as “If you wish to avoid the gridlock near Sumner Tunnel on the way to Logan Airport, take McGrath Highway” (Vaughn, 1987, p. 260). The instructions are verbal stimuli that alter the listener’s behavioral repertoire. Such behavior is *rule-governed*.

In addition to informal advice, rule-governed behavior also may be acquired through formal statements of acceptable behavior, such as the rules of grammar and spelling, and the legal, ethical, and religious practices of a society. The laws and other codified procedures of a culture are important in two ways. First, they help the individual benefit from the experience of others. Second, they also help the group to commend and censure consistently (Skinner, 1989b).

Why do individuals follow advice or rules? The primary reason is that following advice in the past produced reinforcing consequences. We follow the directions for assembling a piece of equipment if similar behavior has produced the outcome of, for example, a properly assembled tricycle (Skinner, 1987, p. 180). Also, when parents have provided reinforcements for following directions and rules, children will do as they are told (Skinner, 1989b, p. 80).

Rule-governed and contingency-governed behavior differ in two ways. In the contingency-governed condition, behavior is more effectively executed. When learning to drive a car, for example, the actions executed by the learner in response to verbal instructions are awkward and halting (rule-governed behavior). However, the novice driver acquires skilled behaviors in the contingency-governed condition by experiencing the consequences of his or her actions. An example is the smooth forward motion of the car following the right amount of foot pressure on the gas pedal.

The second difference is that only the immediate response consequences for contingency-governed behavior alter the likelihood of future responses. In the rule-governed condition, the likelihood of a response is undetermined (Skinner, 1953, p. 147). “For example, having learned that ‘procrastination is the thief of time,’ we are probably no less likely to put off unpleasant tasks” (Skinner, 1989b, p. 41).

A particular problem in efforts to change behavior is advice based on probable adverse consequences, such as warnings about cigarette smoking. A person does not stop smoking as a result of the statistical probabilities of dying from a heart attack or lung cancer. In other words, statistical predictions are ineffective in establishing rule-governed behavior.
Summary
Four factors are found in the acquisition of patterns of behavior. They are shaping, schedules of reinforcement, the concept of negative utility, and rule-governed behavior. Shaping consists of a series of discriminative stimuli and reinforcements for subtle changes in responses. The process illustrates the development of complex behavior through differential reinforcement. Shaping is important because it generates behaviors that have an almost zero probability of occurring naturally in the final form.

In the laboratory, reinforcement may be delivered according to a ratio schedule (determined by the number of responses) or an interval schedule (determined by the clock). The timing for each schedule may be fixed or variable. One advantage of variable-ratio reinforcement is that it maintains behavior against extinction when reinforcement is infrequent. However, when a variable-ratio schedule leads to long-term detriment, the process is referred to as negative utility. Addiction to gambling is an example.

Reinforcement for executed responses is contingency-governed. However, not all behaviors are acquired through direct exposure to response consequences. Instead, people often follow advice, instructions, or directions (discriminative stimuli). Behavioral change occurs because they have been reinforced in the past for compliance with verbal directives. Such behavior, referred to as rule-governed, differs from contingency-governed behavior in two ways. Behavior is more effectively executed in the contingency-governed condition, and the future occurrence of the behavior is more likely.

PRINCIPLES OF INSTRUCTION
Skinner became interested in education when his daughters entered school, and he began in the 1950s to apply operant conditioning to the classroom. He devised techniques for developing step-by-step instruction, mechanical devices for instruction referred to as teaching machines, and a technology of classroom teaching. He also wrote essays on the problems in education.

Basic Assumptions
Skinner's beliefs about the nature of schooling and classroom learning established the parameters for his technology of teaching.

The Nature of Education
The educational system is extremely important because the welfare of any culture depends on it. A culture is no stronger than its capacity to transmit its skills, beliefs, and practices to the next generation, and this responsibility belongs to education (Skinner, 1953).

Public schools were established to provide a private tutor to groups of students (Skinner, 1989b). However, as the number of students increased, personal attention became "sporadic at best" (p. 86). At the same time, changes in the system
have consisted of only small adjustments to the existing situation. An example is
the creation of schools within schools in some large middle and high schools. In
this configuration, groups of teachers work with only a portion of the total stu-
dent body and, in some cases, they teach the same students for 3 years.

Such changes, however, do little to address a basic problem. It is that students
are placed in groups to read and hear about events rather than experience them.
In this situation, the individual student seldom does anything that is immediately
or visibly successful (Skinner, 1987, p. 91). The effects are indicated by declines
in student motivation and performance in middle school classrooms reported by
also described the domination of lectures and seatwork at a time when students
are capable of participating in more challenging activities.

One change implemented in some schools is the effort to make the prepae-
ration stage of learning to be more like daily life. However, this practice also is
problematic. An example is asking students to discover science facts themselves
(Skinner, 1989b, p. 103). First, by using methods and equipment prescribed in the
lesson, the student does not engage in real discovery. Students can only learn
about making discoveries through working out methods for themselves. (Also,
good research practice is a separate subject and should be taught as such; p. 103.)
Second, although conducting experiments may be more interesting than reading,
the science that can be learned with this approach is very limited (p. 103).

The basic problem is that education takes place in an artificial setting, and
much of the world cannot be made available to the student during 12 years of
schooling. Although “the computer can bring ‘real life’ into the classroom, at least
in schematic form” (Skinner, 1989b, p. 94), it has yet to be used to its full potential.

Faced with these problems, the school typically relies on aversive control, and
the result is that students complete their work primarily to avoid the consequences
of not doing so (Skinner, 1968b, 1989b). The division of the school day into class
periods measures the limits of successful aversive control, not the students’ capa-
city for sustained attention (Skinner, 1968b, p. 97). Moreover, in recent years, the
school also has become subject to aversive control through accountability stan-
dards that rely on student performance on standardized achievement tests. In
addition to reducing the time available for instruction, this practice generates
feelings of anxiety and guilt among teachers and does not exert a positive influ-
ence in the classroom (Smith, 1991).

Various recommendations to remedy educational problems include lengthen-
ingen the school year and providing national certification for teachers. However,
in Skinner’s view, no institution can realize progress and improvement until it
analyzes the basic processes for which it is responsible.

Learning in the Classroom Setting
The specific characteristics of the educational setting differ from those of the lab-
ory. The dynamics of behavioral change, nevertheless, are the same (Skinner,
1968b, 1987). In the laboratory, internal states such as “hunger” were redefined
as observable conditions or events. In the classroom, the state referred to as
“readiness” is defined as the set of skills already acquired by the student.
When a teacher is responsible for 20–30 students at one time, several problems for instruction arise. Included are (a) the infrequency of positive reinforcement, (b) the excessive lengths of time between behavior and reinforcement, and (c) the lack of programs that lead the child through a series of approximations to the final behavior (Skinner, 1954).

To correct these problems, programs of carefully selected stimuli and reinforcements are needed (Skinner, 1968b, 1987, 1989b). In basic arithmetic alone, approximately 50,000 reinforcements for each student would be needed to ensure that the skills are acquired (Skinner, 1968b). Because the teacher cannot provide the needed reinforcements, machines such as computers and other technology are necessary in the classroom. Appropriate applications of technology would then free the teacher to spend more time listening and talking with individual students as well as reading and discussing their writing and other projects (Skinner, 1987).

In summary, three assumptions support Skinner's approach to a technology of teaching. First, the experimental analysis of behavior also applies to the classroom. Second, sets of behaviors in the classroom may be shaped in the same manner as other behaviors. Third, technology is needed to provide the large number of reinforcements for behavioral responses.

The Components of Instruction

Skinner's analyses of behavior and his work on programmed instruction have provided several tools for both classroom management and designing instruction. Concepts introduced by Skinner to be considered in planning for the classroom include the following:

(a) **discriminative stimuli** (specific events to which students are to respond);
(b) **contingencies of reinforcement**, including arranging for students to experience success, considering student characteristics, and differentiating between contingency-governed and rule-governed behavior; and
(c) **classroom dynamics**, which includes reinforcing successive approximations, and reinforcing behaviors incompatible with disruptive behavior. Discussed in this section are selecting discriminative stimuli and issues in selecting potential reinforcers.

**Selecting Discriminative Stimuli**

Skinner (1989a) emphasized that teaching is more than telling. Teaching occurs when a response is evoked for the first time and is reinforced. A key element in this process is the discriminative stimulus. Through association with a reinforced response, the discriminative stimulus serves as a cue for a particular behavior. In the social environment of the classroom, a variety of verbal stimuli, such as “Look at this picture” and “Take out your pencils,” may serve as discriminative stimuli to direct student attention. In addition, good classroom management can make use of nonverbal stimuli and thus reduce the need for oral directions. In one classroom, for example, the teacher used colored name tags for the children. A
particular color indicated the work or study group to which the child was to report that day. This technique permitted the teacher to rotate group membership easily and without confusion. In addition, any child who needed help with seatwork set up a little red tent provided in each work folder. The tent served as a discriminative stimulus for the teacher’s behavior and eliminated hand and arm waving (Becker, 1973).

In subject-matter instruction, stimulus discrimination and stimulus generalization are important prerequisites for learning more complex verbal behaviors. In discrimination, for example, the student learns to respond “p” to the letter p, but not to r, d, b, and so on. Then the response is reinforced in the presence of different forms of the stimulus, such as P (stimulus generalization).

The Transfer of Stimulus Control. An essential aspect of successful instruction is the transfer of stimulus control. Often, the teacher models a particular behavior and induces the student to imitate it. However, inducing a response is only the first step. The student’s response must come under the control of new variables (Skinner, 1968b, p. 223). This process can occur in either of two ways: (a) the behavior becomes reinforcing in its own right, and/or (b) it comes under the control of internal stimuli. For example, writing may be initially undertaken in response to the discriminating stimulus of a blank page or an incomplete paragraph from the previous day’s writing. (The behavior, at first, is likely to be halting and awkward, but continuing to write is strengthened by the conditioned reinforcers of noting the number of sentences or paragraphs completed each day.) After a time, thinking of new examples when one is not writing or of the next points to be made become internal discriminative stimuli for the writing process. Also, during the process, finding the right word or phrase to complete the meaning of a sentence becomes reinforcing.

A similar situation is the association of pictures with words the child is to learn to read. Initially, the picture is the stimulus that controls the student’s response. A picture of a flag, for example, induces the student to respond “flag” to the four-letter word. Then the picture must be gradually withdrawn so that the word alone has control over the student’s response.

The failure to provide for the transfer of stimulus control is one of the major errors found in microcomputer instruction (Vargas, 1986). For example, a program that consistently highlights words that students are to type teaches them to copy whatever is highlighted rather than to think about the content on the screen.

Developing Behaviors Incompatible With Other Responses. Elimination of inappropriate behavior requires the reinforcement of behavior that is incompatible with it. This process begins by arranging alternative discriminative stimuli that can evoke different responses. For example, in a factory, the women hurrying along the corridor at the end of the day created a hazard. When the manager installed mirrors along the hallway, the pace slowed as women paused to adjust their clothing or apply cosmetics (Skinner, 1953, p. 316).

A current issue in discussions of classroom climate is the importance of teachers establishing mastery-oriented classrooms. One goal is to foster student effort in the direction of learning and mastery and to reduce students’ focus on
outperforming others (Ames, 1992). Essential in this effort is removing discriminative stimuli that evoke competition. Included are not posting only the “best” work on bulletin boards, grading for mastery instead of on an A to F scale, and not announcing test scores to the class. Other discriminative stimuli that can lead to a redirection of student effort are “Let’s see how many ways we can think of to approach this problem” (a focus on learning instead of performance) and providing reinforcements for effort and persistence.

**Issues in Selecting Potential Reinforcers**
To be effective, reinforcement must be immediately contingent on the emission of the correct response. The two types of reinforcers available in the classroom are natural reinforcers and contrived reinforcers. Also important is phasing out contrived reinforcers, the timing of reinforcement, and the problems with aversive control.

**Natural Reinforcers.** The events available in the setting that provide nonaversive feedback are referred to as natural reinforcers (Skinner, 1954). Examples include playing with mechanical toys, painting, and cutting with scissors. Others include finding the right word to describe something, resolving a temporary confusion, and having the opportunity to advance to the next stage of an activity (Skinner, 1958, p. 380). Furthermore, a child learning to read is reinforced when the material “makes sense.”

The research conducted by David Premack (1959) indicated that children’s preferred activities will reinforce their participation in their less-preferred activities. For the child who prefers playing with mechanical toys to painting, time with the toys may be used to reinforce participation in art activities. In two studies, high-priority academic activities were used to strengthen other academic behaviors. Gallant, Sargeant, and Van Houten (1980) made access to a highly preferred subject area, a science lab activity, contingent on accurately completing assignments in reading and mathematics. Moreno and Hovell (1980) used access to a language laboratory to reinforce a Spanish-speaking teenager for answering questions in English. However, care should be exercised in the use of academic activities so that students are not denied access to important methods of instruction.

An important reinforcer in the classroom is success. However, implementation of this reinforcer requires that instruction should not be presented in a confusing or too difficult way. Experienced teachers who have also tried writing instructional programs expressed surprise at their discovery of the number of essential steps they typically omitted as well as the number of “awkward and ineffective presentations they have permitted to stand” (Skinner, 1968b, p. 254).

**Contrived Reinforcers.** In many situations, the use of natural reinforcers alone is insufficient to change behavior. For example, people should consume lesser amounts of certain kinds of goods because the by-products of those goods irreversibly foul the environment (Skinner, 1989b, p. 118). However, such a consequence is too remote to have an immediate effect on behavior. Contrived contingencies are needed to alter behaviors of overconsumption.
In education, contrived reinforcers also are often needed to bridge the gap between the early stages of learning and the setting in which natural reinforcers can function. Teaching reading and writing are examples in which the behavior is too much a product of an advanced culture to rely on natural reinforcers such as reading for information or for pleasure.

In some of the learning centers in the United States, students listen to instruction on cassette recorders and respond on worksheets. A magic-ink effect immediately indicates whether their behavior is correct or incorrect. Although no natural contingency exists between correct responses to a word or a passage and the appearance of a reaction, children nevertheless learn to read quickly (Skinner, 1987, p. 176). Contrived reinforcers also include verbal comments, early dismissal, and free time.

**Phasing Out Contrived Reinforcers.** Important in planning the use of contrived reinforcers is (a) gradually stretching the ratio between responses and reinforcers, (b) pairing the contrived reinforcer with other reinforcers, such as approval and recognition, and (c) gradually withdrawing or fading the contrived reinforcers. For example, a teacher initially may implement concrete reinforcers, such as tokens, for socially appropriate behaviors in the classroom. The tokens later may be exchanged for a prescribed number of minutes of free time. The tokens also should be paired with verbal comments in the form of positive feedback for behavior. In addition, the teacher should teach the students to commend themselves for appropriate behavior as the tokens are gradually phased out.

The key to using contrived reinforcers effectively is to (a) restrict their use to early stages of developing complex behavior, (b) plan the use of discriminative stimuli to include transfer to internal or nonarbitrary stimuli, (c) plan for the emergence of natural reinforcers, and (d) gradually fade (phase out) the contrived reinforcers as the behavior develops and natural reinforcers are functioning. Step three can be aided by a respected teacher, for example, who reads several paragraphs when the student completes them and verbally confirms good points made or improvement in fluency or expression.

**The Timing of Reinforcement.** Particularly important in the effectiveness of reinforcement is timing the delivery of reinforcing stimuli. “A fatal principle is ‘letting well enough alone’—giving no attention to a student so long as he behaves well and turning to him only when he begins to cause trouble” (Skinner, 1968b, p. 180). Because the attention of the teacher often is reinforcing in the classroom, the careless teacher will unintentionally reinforce the attention-getter, and the show-off. Furthermore, at-risk students in a class who are not receiving attention for their academic behaviors will engage in nonacademic behaviors because nonacademic behaviors are producing reinforcement (Belfiore & Hornyak, 1998, p. 187).

Another example is that of dismissing the class early. If the class is dismissed when the students are loud or disruptive, the early dismissal reinforces inappropriate behavior. The teacher must time the dismissal to occur when the class is quiet and busy.

The mistiming of reinforcement also occurs with brightly colored and attractive learning materials. Bright colors, animated sequences, and other innovations
have a temporary effect—they induce the student to look at the materials (Skinner 1968b, p. 105). Computers also have used such techniques to attract the attention of students (Vargas, 1986). The same problem occurs with an attractive school building, which reinforces only looking at it, and a colorful classroom, which reinforces only the behavior of entering it (Skinner, 1968b, p. 105). The problem is that attracting the students’ attention is far from teaching the student to look and listen. In effective instruction, the student should attend to the situation because doing so in the past was reinforcing.

Equally important in planning reinforcement is to avoid the overuse of reinforcers. For example, teacher data indicate that excessive praise for right answers to teacher questions is both intrusive and counterproductive (Brophy, 1981).

Problems With Aversive Control. Classroom control often includes both the use of aversive stimuli and the withdrawal of positive reinforcement. Governments use punishment to suppress the behavior of troublesome individuals. However, punishing students for such things as “not studying” is different (Skinner, 1989b, p. 88). First, the aim of education is to strengthen behavior, not suppress it. Second, the use of aversive stimuli as negative reinforcers and punishments leads to unwanted by-products. Specifically, this practice generates unwanted emotional reactions and escapes behaviors. Escape behaviors include forgetting, inattention, truancy, and vandalism, as well as subtle forms of behavior, such as looking at the teacher while not paying attention (Skinner, 1968b, p. 97). The emotional side effects include reactions typically described as apathy, anxiety, anger, and resentment, all of which inhibit learning.

The third problem associated with the use of aversive control is that punishment does not generate positive behaviors. “We do not strengthen good pronunciation by punishing bad or skillful movements by punishing awkward” (Skinner, 1968b, p. 149).

Reprimands can be used effectively, if they are in the form of “gentle admonitions” for small units of behavior (Skinner, 1968b, p. 101). Slight reprimands to the child who is learning to tie a shoelace for holding the lace wrong or moving it in the wrong direction, for example, are acceptable. They provide the opportunity for the learner to select the correct response from a small number of possibilities.

Summary
The role of discriminative stimuli in instruction is to serve as cues for particular behaviors. In the classroom, both verbal and nonverbal stimuli direct students’ attention, begin academic activity, and are essential in developing the processes of stimulus discrimination and generalization. An essential aspect of successful instruction is the transfer of stimulus control from prompts and cues to stimuli within the learner, a characteristic that is often not present in computer instruction. Selection of appropriate discriminative stimuli also is essential in developing behaviors that are incompatible with inappropriate responses.

Essential in effective instruction is the appropriate use of natural reinforcers, events in the setting that provide nonaversive feedback, and contrived reinforcers, such as verbal comments and early dismissal. Contrived reinforcers may be used
effectively if restricted to the early stages of developing complex behaviors, paired with reinforcers such as approval and attention, and gradually phased out as natural reinforcers begin to function. Also important is to avoid the mistiming of reinforcement. Aversive control also is to be avoided because of the negative emotional by-products. However, gentle reprimands can be effective for small units of behavior.

**Designing Instruction for Complex Skills**

The development of complex skills should not be left to chance. One of the problems with Thorndike’s experiments is that the animal was placed in the cage and left to “discover” the correct methods of escape (Skinner, 1953). Similar situations occur in the school setting with the practice of “assign and test” or asking students to write a term paper without teaching them the subordinate skills. Skinner refers to these situations as placing the learner in a set of terminal contingencies. The situation is one in which the learner is left, through trial and error, to discover the complex skills or series of skills required for success.

**Shaping Human Behavior**

Developing complex skills in the classroom involves the key ingredients identified in teaching pigeons to play ping-pong and to bowl. The key ingredients are (a) inducing a response, (b) reinforcing subtle improvements or refinements in the behavior, (c) providing for the transfer of stimulus control by gradually withdrawing the prompts or cues, and (d) scheduling reinforcements so that the ratio of reinforcements to responses gradually increases and natural reinforcements can maintain the behavior. In other words, instruction first primes the appropriate behavior, then prompts it through brief cues, and then gradually withdraws the prompts (Skinner, 1989b, p. 89). This process also occurs between parents or caregivers and toddlers. An adult will say “Mama” or “Dada” and reinforce any recognizable approximation. The adult also induces the young child’s speech by, for example, holding up a spoon, saying “Spoon,” and reinforcing the child’s similar response. Subsequently, the adult waits for the child’s response to only the spoon (Skinner, 1989b, p. 91).

A classroom example is learning to pronounce new words in a foreign language. The teacher typically holds up an object or picture, pronounces the words or phrases, and the student is induced to repeat the words. Reinforcement is provided initially for sounds that only remotely resemble correct pronunciation. Then reinforcement is withheld briefly until the pronunciation improves slightly. The teacher continues to prompt the pronunciation of difficult syllables or sounds and to provide reinforcement for improved pronunciation. The prompts then are gradually withdrawn. Instruction is complete when the student can identify the new objects or pictures correctly without assistance.

The first step in planning instruction to shape behavior is to clearly specify the behavior that is to be learned (Skinner, 1989b, p. 122). For example, one mathematics teacher wanted the students to learn to follow a course of logical reasoning. This expectation is too vague to be of assistance in planning instruction.
However, examples of specific expectations (subskills) include identifying the “givens” in a word problem, determining what the problem is asking, and so on.

The second step is to identify the entry skills of the learners (Skinner, 1987). This step is important because any missing skills must be addressed in the instruction. The third step is to program the subject matter in carefully graded steps and teach first things first (Skinner, 1987). One temptation is to move too quickly to the final product (i.e., the terminal contingency). However, a well-designed program takes small steps and guarantees a great deal of successful action (Skinner, 1987, p. 125).

The purpose of the step-by-step instruction is to provide a series of reinforcements, contrived if necessary, for increasingly refined or complex behavior. However, the reinforcements are programmed so that eventually natural reinforcers in the environment come into play and/or the activity itself becomes reinforcing for the learner. In learning to read, for example, a magic-ink effect may indicate initial success, whereas later the student is reinforced when a sentence makes sense, answers a question, or solves a problem. The activity of reading becomes reinforcing when the individual reaches the stage of reading for pleasure.

Shaping often has been viewed as limited to highly specific skills, such as discriminating sounds, words, or colors. However, Glaser (1990) identifies elements of shaping in representative instructional programs for developing self-regulatory skills. All of the programs incorporate features to ensure student success and to minimize student errors. In addition, Brown (1994) noted that operant conditioning developed fading and scaffolding. Scaffolding refers to the supports provided to the student in the early stages of learning. As illustrated in Chapter 9, the method referred to as reciprocal teaching (Palinscar & Brown, 1984) uses priming, prompting, reinforcement, and the gradual fading of support.

The techniques of teaching new routines and procedures at the beginning of the school year by effective classroom managers also incorporate elements of shaping. Teachers spend considerable time in the early weeks of school teaching the routines for use of storage areas, the pencil sharpener, and the bathroom, step by step with encouragement for each step (Doyle, 1986; Emmer, Evertson, & Anderson, 1980). Effective classroom managers consistently use cues to signal appropriate behavior, carefully monitor the classroom, provide reinforcement for appropriate behaviors, and redirect student behavior when small errors occur.

In addition, the methods for developing appropriate behaviors have been expanded to the secondary school classroom (Emmer, Evertson, Sanford, Clements, & Worsham, 1984), the management of adolescent behavior (Gottfredson, Gottfredson, & Hybl, 1993), and the development of school-wide systems of positive behavioral support (Horner & Suqai, 2004; Suqai & Horner, 2002). Of importance in such implementations is to develop clear expectations for student behavior and to remove the environmental events that reinforce inappropriate behavior.

**Teaching Machines and Computers**

Teaching machines were designed to provide sequenced instruction and the reinforcing power of immediate consequences (Skinner, 1989b). The importance of a mechanical device is that it gives reinforcement only for correct responses. When
programmed instruction is implemented in a book format, students may look ahead, skip frames, or lose their places. The first teaching machine was developed in 1954, and Skinner (1989b) described it as a mechanical anticipation of the computer. The early mechanical teaching machines provided contingent reinforcement for right answers in the form of (a) confirmation for correct answers, (b) the opportunity to move forward to new material, and (c) the opportunity to operate the equipment. The machine functioned as a patient tutor with no reprimands for errors, and a student moved forward at his or her own pace.

Skinner (1989b) considered the computer as the ideal teaching machine. Computers can bring aspects of “real life” into the classroom. In addition, computer software can expand the range of potential reinforcers and can provide appropriate feedback for a variety of responses. Included in the potential reinforcers are opportunities to (a) change the screen display, (b) play simple games, and (c) develop one’s own games. One group of games to teach math skills embeds the games in fantasy themes (e.g., a scavenger hunt theme in San Francisco) and allows the children to choose the problem type, game piece, and level of game. The games use the contrived reinforcers of (a) verbal praise and (b) acquiring an item needed in the scavenger hunt to help a game character solve a problem (Azar, 1998).

Skinner cautioned, however, that computer programs that try to “jazz up” the material with fancy graphics often are doing the students a disservice. When programs seek to attract students’ attention through animation or color graphics, they may actually be distracting the student from learning (Skinner, in Green, 1984). According to Skinner, there is no substitute for discovering that one can learn and for experiencing increasing levels of success.

Summary
Shaping behavior in the classroom first requires the clear specification of the behaviors to be learned. Second, entry skills of the learner must be identified. Then the subject matter should be programmed carefully in graded steps so that the instruction guarantees a great deal of successful action. Programs that initially provide instructional support, gradually fade or withdraw the support, and use successive approximations are using operant conditioning techniques. Effective classroom managers also use the methods to teach appropriate classroom behavior.

Mechanical devices known as teaching machines were developed by Skinner to teach programmed subject matter. Computers are improvements over teaching machines because they can bring aspects of real life into the classroom and also expand the range of potential reinforcers that may be used. However, the software should not be overloaded with animation or fancy graphics to attract student attention because they may distract the student from learning.

EDUCATIONAL APPLICATIONS
Like Watson’s behaviorism in the 1920s, Skinner’s methodology has enjoyed wide popularity. Its rapid popularization, however, has led to a variety of misapplications of the principles. Many of the behavioral management programs that
emerged in the 1950s were a combination of operant conditioning and other methods (Kazdin, 1989). (See Belfiore & Hornyak, 1998, for a discussion of self-monitoring programs that combine operant and other principles.) For example, many programs use time-out and response cost procedures. Time-out is a brief period of removal of the individual from a setting that provides reinforcement. Response cost is the loss of a reinforcer for misbehavior and requires paying a penalty. Because both techniques involve loss of reinforcers, they are a form of punishment (Becker, 1973; Kazdin, 1989), and generate negative emotional by-products.

In addition, many of the individualized materials for verbal behaviors copied the stimulus–response-feedback format of programmed instruction but not the substance. Textbook materials subdivided into sentences with blanks do not shape verbal behaviors. The disillusionment of educators with these poorly developed programs and the clumsiness of the original teaching machines contributed to the rapid decline of the programmed instruction movement. Also, the token-economy programs developed for behavioral management in the classroom often focused on trivial behaviors, contributing to the view that the methodology has only limited applications.

DISTAR, a commercial program developed in the 1960s to teach reading, continues to be successful with at-risk children. Now known as SRA Reading Mastery, the program is a highly structured, scripted program in which children are taught according to skill level (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998).

Classroom Issues

B. F. Skinner’s approach to learning is in terms of the factors responsible for behavioral change. Therefore, the issues of importance to education are discussed either as behaviors or as stimuli that lead to behavioral change.

Learner Characteristics

In the Skinnerian framework, learner characteristics are particular behaviors that students bring to the learning situation, and they may influence the acquisition of new behaviors.

Individual Differences. According to Skinner (1953), individual differences in student behaviors result from (a) the organism’s genetic endowment and (b) a particular history of reinforcement. The behavior of mentally retarded individuals, for example, is primarily the product of a defective genetic endowment. However, planned programs can develop new skills (Skinner, 1968b).

In Skinner’s view (1968b), defective reinforcement contingencies in the individual’s experience result in the failure to acquire a variety of skilled behaviors. An example is rhythm (Skinner, 1958). Some individuals, such as skilled typists and musicians, are under the influence of reinforcers that generate subtle timing. However, the development of this and other skills that influence career choices, artistic interests, and participation in sports is typically unplanned. Yet,
important skills that presently contribute to such individual differences can be taught. A simple machine can teach a child first to tap in unison and then to echo more and more subtle rhythmic patterns that constitute a sense of rhythm.

**Readiness for Learning.** In the operant conditioning framework, “readiness” is the behavioral repertoire that the student brings to the learning situation.

The concept of readiness interpreted as age or maturational level is of little help in determining the presence or absence of important skills (Skinner, 1953, p. 156). Also, developmental studies may indicate the amount usually learned by a child of a given age; however, such studies do not indicate the extent of a child’s intellectual development under an appropriate schedule of events (Homme, deBaca, Cottingham, & Homme, 1968). For example, once a child can discriminately respond to objects, planned contingency management can advance the child’s reading levels in a systematic way independent of age.

**Motivation.** Behaviors that illustrate interest, enthusiasm, appreciation, or dedication are included in descriptions of motivation. The diligent and eager student, the individual who enjoys “reading good books,” and the scientist who works long hours in the laboratory are all said to be motivated (Skinner, 1968b).

Such sustained activity in the absence of observable reinforcement is not the result of natural contingencies. No child really learns to plant seeds because he or she is reinforced by the resulting harvest, nor do we learn to read because we enjoy interesting books (Skinner, 1968b, p. 154). These long-range natural consequences are insufficient to develop and maintain “dedicated” behavior. Instead, dedication is the result of exposure to a gradually increasing variable-ratio schedule of reinforcements. The individual first receives an immediate payoff for engaging in the activity (Skinner, 1968b). Then the reinforcements are gradually extended (referred to as stretching the ratio) until the activity itself acquires secondary reinforcing power. Ironically, the same reinforcement schedule produces both the compulsive gambler and the dedicated scientist. However, only the scientist is considered by society to be “dedicated” (Skinner, 1963b).

**Cognitive Processes and Instruction**
Transfer of learning, “how-to-learn” skills, and problem solving are cognitive processes that often are the focus of instruction.

**Transfer of Learning.** Thorndike and Woodworth’s (1901) experiments indicated that the degree of similarity between prior and current learning tasks contributed to student performance. An example is learning to play the piano, which is said to improve performance in playing other instruments. In Skinner’s (1953) perspective, when training in one area of skilled behavior improves performance in another area, common elements are being reinforced “wherever they occur” (p. 94).

**Learning “How-to-Learn” Skills.** The process commonly referred to as “thinking” often means behaving in a particular way with regard to certain stimuli (Skinner, 1953, 1968b). When a child responds to certain stimulus properties, his or her
response has come under the control of those stimuli. In the identification of a closed, three-sided plane figure as a triangle, the child's response is under the control of the figure. Little is gained in such situations by describing the learning as that of "forming an abstraction."

Certain behaviors typically identified with thinking must be analyzed and taught (Skinner, 1968b, p. 120). They are the intellectual self-management behaviors that Skinner (1953, 1968b) referred to as "precurrence." Defined as "behavior which affects behavior" (Skinner, 1966b, p. 216), precurrence responses either change the environment or change the learner so that an effective response becomes possible. They also are covert; they are private events that are not observable. Included are (a) reviewing the features of a particular problem or calculating a mathematical answer by speaking silently to oneself, and (b) visualizing a problem or situation in the "mind's eye" (covert seeing) (Skinner, 1968b). Other precurrence responses are (a) attending to stimuli, (b) underlining important ideas in the textual material, (c) using mnemonic devices or other cues to remember important ideas, and (d) rearranging the elements in a problem situation so that a solution is more likely.

Teaching Problem Solving. Formally defined, problem solving is "any behavior which, through the manipulation of variables, makes the appearance of a solution more probable" (Skinner, 1953, p. 247). The "difficulty" of a problem depends on the availability of a response in the subject's repertoire that solves the problem. If no response is immediately available, the problem is difficult. To maximize the likelihood of a response (solution), the individual must change the situation so that he or she can respond appropriately. Steps that may be taken include (a) reviewing the problem carefully and clarifying the difficulties, (b) rearranging or regrouping the components of the problem, and (c) searching for similarities between the problem and others that have been solved. In anagrams, for example, the player maximizes the chances of forming a word from the set of letters by regrouping the letters in logical sequences (i.e., vowels separated by consonants).

Individuals learn to solve problems effectively by manipulating stimuli and receiving reinforcement for the behavior. Reinforcement for the effective manipulation of the problem situation will reduce the occurrence of haphazard or trial-and-error responses to problems.

Implications for Assessment
The focus of operant conditioning is behavioral change, and in the classroom, this emphasis often means verbal behavior. In the early years of school, the child learns to read and to solve arithmetic problems, as well as to pronounce and state the meanings of new words, both in his or her native language and others. That is, the child is able to respond to different situations with appropriate verbal responses. In addition, the learner's verbal behavior must become independent of the cues and prompts that facilitated the initial stages of acquisition.

At least three implications for classroom assessment may be inferred from the above description. First, students' constructed responses are essential in determining behavioral change. Multiple-choice questions are not appropriate because...
recognition of a correct answer is not the same as constructing a response. Instead of stating, for example, which of the following is a definition of population density? followed by four options, the question should ask the student to define the term in his or her own words.

Similarly, items (often found on standardized tests) that provide one- to three-paragraph reading selections followed by multiple-choice questions are not adequate assessments of reading comprehension. Also, some test-takers go directly to the questions without reading the selections and then search for the answers in the paragraphs. In contrast, story or text retelling, in which the learner reconstructs and sequences the elements (and does not memorize words and sentences) is appropriate.

Second, the concept of shaping behavior from simple to complex implies at least informal assessments with feedback as learning progresses. For example, as children are learning to read, they should have ample opportunities to read to the teacher or teacher’s aide one-on-one.

Third, the transfer of stimulus control is a requirement for behavioral change. Either the behavior itself becomes reinforcing (such as reading) or discriminative stimuli different from the learning situation or within the learner acquire some control over the behavior. To determine behavioral change, assessment should reflect this requirement and be independent of learning cues. This requirement is the reason that multiple-choice questions are not appropriate. Problem-solving behaviors, therefore, should not be assessed in situations that are the same as those used during learning.

The Social Context for Learning
Reinforcers that require the mediation of another person are referred to as social reinforcers. This group includes the positive reinforcers of attention, approval, and affection (typically, positive reinforcers) and the aversive stimuli of disapproval, insult, contempt, and ridicule (typically, negative reinforcers). In the social setting, the relationships between stimuli, responses, and reinforcers are both dynamic and reciprocal. For example, two children alone in a room with few toys provide an ideal situation for the shaping of selfish behavior (Skinner, 1958).

Behavior in the classroom is also a product of ongoing and complex contingencies that include teacher and students reinforcing each other both positively and negatively (Skinner, 1968a, p. 252). If a student is not punished by his peers for answering the teachers’ questions and is reinforced by the teacher, he will answer as often as possible. If the teacher calls only on students whose hands are raised, the student will raise her hand. Similarly, teachers who are reinforced by right answers will call on students whose hands are raised. However, teachers who are reinforced by wrong answers are exercising aversive control, and they typically call on students who do not raise their hands (Skinner, 1968a).

Therefore, designing a classroom environment to modify behavior must take into account the reciprocal reinforcement characteristics of a social setting. Brigham (1978, p. 266) described one study in which special education children learned to reinforce the positive comments of other children and teachers. As their behavior changed, so did the environment, and they became skillful at
manipulating the environment. Furthermore, the children's behaviors changed the teacher's environment as well because the children became the source of social reinforcement for their teachers.

**Relationships to Other Perspectives**

Unlike cognitive approaches to learning, operant conditioning addresses behavior rather than knowledge or internal states; evidence of learning is behavioral change. Moreover, student actions such as contributing verbally to classroom discourse (constructivism), manipulating objects (Piagetian theory), or observing the reinforcement received by others (Bandura's social-cognitive theory) are not indicators of learning unless they are new behaviors.

The application of operant conditioning to the priorities of other theoretical perspectives lies in the implementation of reinforcement to develop complex behaviors. Examples include reinforcing children's explanations of their problem-solving steps and listening respectfully to the strategies of others (radical constructivism and cognitive theory), developing persistence in academic tasks (Weiner's attribution theory), and monitoring one's own learning (cognitive theory).

Operant conditioning would not support presenting open-ended problems or tasks to groups of children in the absence of prior teaching of required behaviors. This practice is conducive to trial-and-error learning, does not ensure the acquisition of essential behaviors, and can precipitate the learning of incorrect responses. Furthermore, not all children in the group situation may receive reinforcement for appropriate responses.

**Operant Analysis of the Intrinsic/Extrinsic Discussion**

In the early 1970s, two experiments explored the effect of giving a reward to nursery school children for engaging in an activity that they had previously engaged in spontaneously during free-choice time—drawing with magic markers (Lepper & Greene, 1973, 1974). Each child was brought to the experimental room individually and asked if he or she would like to draw some pictures for an important person who was to visit the school. In the 6-minute experimental condition, some children also were told they would receive a Good Player certificate. In the other situations (also 6 minutes in duration), children simply received the certificate or were simply thanked. The researchers stated that post-session observations indicated that the average percentage of free-choice time spent in drawing by children who were told of the expected reward was significantly less than that of the other two groups. However, in the absence of baseline data on the free time spent drawing by the children, inferences about decreases or increases cannot be made. The researchers erroneously concluded that offering and providing the certificate "undermined" the children's interest in the activity, and schools should avoid the use of extrinsic rewards (Lepper & Greene, 1973, p. 136).

First, from the operant conditioning perspective, the offer of the certificate and acceptance of that condition by the children for the drawing activity constituted a pre-experimental contract between the assistant and the child. Second, in the absence of baseline data on the free time spent coloring, conclusions about whether
post-experimental drawing time increased or decreased cannot be made. Third, the example was a one-shot implementation of particular outcomes, whereas behavioral change typically involves more than one discriminative stimulus–response–outcome sequence. Moreover, subsequent analyses of studies of extrinsic rewards suggest that negative effects are produced only when the rewards connote failure or are not directly linked to behavior (Cameron & Pierce, 1994a, 1994b).

Fourth, a persistent behavior that is executed in the absence of observable reinforcers is under the control of internal discriminative stimuli and/or natural reinforcers. Finally, teachers do not implement concrete reinforcers for activities in which students already have demonstrated interest.

Developing a Classroom Strategy

The classroom teacher can make use of Skinner’s technology in any of three ways. They are (a) the appropriate use of discriminative stimuli and reinforcement in classroom interactions, (b) implementing the steps in shaping in instruction, and (c) developing individualized instructional materials.

Developing a Positive Classroom Climate

An important application of Skinner’s technology is that of developing a positive classroom climate. This goal differs from that of implementing an extensive behavior modification program. Skinner (1973) noted that an obvious approach, such as a token economy, may indeed be necessary in a totally disruptive classroom. However, a teacher can make the transition from punishment to positive reinforcement with one simple change—merely by responding to student successes rather than to student failures (Skinner, 1973, p. 15). Instead of pointing out what students are doing wrong, point out what they are doing right. The result, in Skinner’s view, will be an improved classroom atmosphere and more efficient instruction.

Applying the technology developed by Skinner in the classroom can make use of the following steps:

Step 1: Analyze the current classroom environment.

1.1 What are the positive student behaviors currently receiving reinforcement in the classroom? What are the undesirable behaviors that are receiving reinforcement? For example, withholding help so that the child has an opportunity to demonstrate his or her knowledge and then providing help when the child shows discouragement may be reinforcing behavior that indicates discouragement (Skinner, 1968b, p. 252).

1.2 For which behaviors is punishment currently dispensed in the classroom? (Recall Skinner’s definition of punishment: removal of a positive reinforcer or introduction of an aversive stimulus from which the individual seeks escape.)

1.3 What is the frequency of punishment? Have the punished behaviors been suppressed but other, related behaviors appeared?
Step 2: Develop a list of potential positive reinforcers.

2.1 What are the students’ preferred activities? (Students can rank their preferences on a list; young children can identify pictures.)

2.2 Which of the punished behaviors identified in step 1.2 may be used as reinforcers? For example, if talking with peers currently is punished, consider incorporating it occasionally as a reinforcer for less-preferred activities, such as completing seatwork assignments quietly.

2.3 Which activities that you have observed in the natural setting may serve as positive reinforcers for other behaviors? One reading teacher, for example, expressed difficulty in keeping children on task because they constantly interrupted to discuss the progress of their favorite TV shows that aired the previous evening. Discussing the TV programs for 10–15 minutes is a potential reinforcer in that setting.

Step 3: Select the behavioral sequences to be initially implemented in the classroom. Include discriminative stimuli and reinforcers.

3.1 Which of the punished behaviors identified in step 1.2 may be restructured in the form of positive behaviors? For example, use positive reinforcement for promptness instead of punishment for tardiness. Becker (1973) suggested that instead of punishment for fighting, a student may earn 1 minute of recess for no fighting.

3.2 Which of the positive student behaviors from the list in step 1.1 are occurring infrequently? Examples may include demonstrating independence in learning by getting and putting away needed materials on time, attending to relevant characteristics of stimuli during instruction, and so on.

3.3 What are the initial discriminative stimuli to be used? To which stimuli is the transfer of behavioral control to be made? For example, the verbal statement “Time to begin” may be replaced by a signal, such as a bell, and then by the students’ observations of the clock time.

Step 4: Implement the behavioral sequences, maintaining anecdotal records and making changes when necessary.

4.1 Are the rules for classroom behavior clear and consistent?

4.2 Is the method for earning reinforcement clear, and is reinforcement provided for improved behavior?

4.3 Does every child have the opportunity to earn reinforcement for behavioral change? If reinforcement is provided only for one or two behaviors that must meet a high standard, some children have no means of earning reinforcement in the classroom and are likely to seek attention in disruptive ways (Resnick, 1971).

4.4 Following initial behavioral change, are reinforcements provided after longer intervals (stretching the ratio), and are other reinforcers also implemented?
Programming Instruction

Programs to develop verbal behaviors should be designed to lead the student from a state of no knowledge to proficiency in one or more skills. A program is a series of items (frames) in which the student constructs a response. The following steps are recommended in the development of a constructed-response program:

**Step 1:** Identify the terminal skill to be acquired and analyze the subject matter to be learned.

1.1 What is the nature of the terminal behavior? Is it a discrimination skill, such as learning color names, or is it the application of a rule, such as carrying in addition?

1.2 What terms or definitions must be learned to acquire the skills?

1.3 What types of examples should the student respond to during learning (e.g., color bands, simple and complex addition problems)?

**Step 2:** Develop the initial sequence of frames and response confirmations.

2.1 What information should be placed in the first frame to induce a response (referred to as a *copying frame*)?

2.2 What is a logical sequence of responses (behaviors) that can be expected of the student?

2.3 What sequence of discriminative stimuli that progress from simple to complex can provide for the transfer to stimulus control?

**Step 3:** Review the sequence of frames, reordering if necessary.

3.1 Does the sequence progress from simple to complex?

3.2 Are the prompts gradually vanished in the sequence?

3.3 Does the student respond to meaningful rather than trivial content?

**Step 4:** Implement the instruction with a few students and revise if necessary.

4.1 Do any students experience difficulty with any of the frames? Such frames may need to be rewritten.

4.2 Do the students race through any of the frames, getting the right answer by only reading part of the frame? The frame may be superfluous or it may be asking for trivial information.

4.3 Does the program lead to mastery performance on the criterion posttest?

**Example of Programming**

Skinner originally developed programmed instruction for teaching machines, but recommended the use of microcomputers (Skinner in Green, 1984). A partial program to teach the concept "morpheme" to advanced high school students is illustrated in Figure 4.2. The terminal skills are that (a) the student can define morpheme and (b) the student can identify examples of free morphemes and bound morphemes. After a brief introduction to the lesson on morphemes (including lesson objectives), the next screen and the computer feedback is programmed as follows:
One aspect of linguistics is the analysis of words into the smallest units that carry meaning. The study of such word parts is an area of study in

Computer feedback for correct answer:
The correct answer is linguistics. Good. Continue with the program. When you enter the correct answer, the program will display it on the screen. For a wrong answer, you will be asked to try again.

Computer feedback for wrong answer:
Sorry your answer is not correct. Try the question again.

The first frame is a copying frame because essentially it involves the student's copying or repeating basic information in the stimulus. In Figure 4.2, frames 2 and 3 present the definition of a morpheme, later followed by the definition of bound and free morphemes. The cues, or prompts, for the correct answers are gradually withdrawn so that stimuli within the learner or other external stimuli are generating appropriate responses (see frame 15).

The advantage of several short units of programmed instruction on specific skills is to provide remediation targeted to specific deficiencies. Students who enter a grade lacking some essential skills or students who experience difficulty with the initial instruction for a topic may be given the material while the teacher works with other students on other problems.

Review of the Theory

B. F. Skinner's principles of operant conditioning continued the tradition established by John Watson. That is, for psychology to become a science, the study of behavior must become the focus of psychological research. Unlike the other stimulus–response (S-R) theorists, Skinner avoided the contradiction posed by Pavlov's classical conditioning model and Thorndike's instrumental conditioning. He proposed a paradigm that includes both types of responses and analyzed the conditions responsible for emitted responses or operant behavior (Table 4.6).

Skinner's analyses yielded a parsimonious system that was applied to the dynamics of behavioral change in both the laboratory and the classroom. Learning, represented by increased response rate, was described as a function of the three-component sequence \((S^D)-(R)-(S^{einf})\). Skinner described the typical practice of placing experimental animals in puzzle boxes and mazes as that of placing the subject in a "terminal contingency"; that is, the animal must either sink or swim in the
1. One aspect of linguistics is the analysis of words into the smallest units that carry meaning. The study of such word parts is an area of study in linguistics.

2. The smallest word parts that carry meaning are morphemes. In the word “unhappy,” the part “un-” means “not.” Therefore, “un-” is a morpheme.

3. Some words are composed of only one morpheme or unit of meaning. An example is cat. In this case, the morpheme making up the word is cat.

4. Sometimes morphemes may be added to existing words, for example, the letter “s.” When added to some words, “s” means “more than one.” In such a situation, the “s” is a morpheme.

5. Of course, some letters do not carry any meaning in words, such as the “s” in “slide.” In this case, “s” is a morpheme.

6. Some words are composed of two or more morphemes. An example is “biology,” which includes “bio-” (life) and “-logy” (study of). Biology, therefore, is composed of two morphemes.

7. The word “morpheme” itself may be analyzed as follows: “Mor ph-” = unit or form and “-erne” = small. The complete word is composed of two morphemes.

8. Prefixes and suffixes are word parts that frequently function as units of meaning. An example is “pre-” (before or prior) as in “preview.” In this example, the prefix is also a morpheme.

9. In the earlier example, “un-” in “unhappy” was identified as a morpheme. This prefix is a morpheme because it is a unit of meaning.

10. Language includes two kinds of morphemes, one of which is “free morphemes.” They are the smallest unit of meaning that can stand alone. For example, in the word “cats,” the word part “cat” is a free morpheme.

11. Some words are composed only of free morphemes. The word “cowboy” is composed of two free morphemes. They are cow and boy.

12. The other type of morpheme is a “bound morpheme.” It is a unit of meaning that cannot stand alone. For example, the morpheme “s” in the word “cats” is a bound morpheme.

13. The letter “s” in the word “cats” is a bound morpheme because it is a unit of meaning that can/cannot stand alone. (cannot)

14. Some words may be composed of only bound morphemes. An example is the word “biology,” composed of “bio-” and “-logy.” This word includes two bound morphemes.

15. Still other words, like “cats,” may be composed of both bound and free morphemes. Another example is the word “unhappy,” which includes one free morpheme(s) and one bound morpheme(s).

16. The study of morphemes can be a means for building vocabulary. We have learned, for example, that “-logy” means “study of.” Further, “psycho-” is a morpheme that means mind or mental life. Therefore, “psychology” means “study of the mind or mental life,” based on the two bound morphemes.
### TABLE 4.6
Summary of Skinner's Technology

<table>
<thead>
<tr>
<th>Basic Elements</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumptions</td>
<td>Behavioral change is a function of environmental conditions and events.</td>
</tr>
<tr>
<td>Learning</td>
<td>A change in behavior represented by increased response frequency.</td>
</tr>
<tr>
<td>Learning outcomes</td>
<td>New responses (behaviors)</td>
</tr>
<tr>
<td>Components of learning</td>
<td>((S^D)-(R)-(S^{reinf}))</td>
</tr>
<tr>
<td>Major issues in designing instruction</td>
<td>Transfer of stimulus control, timing of reinforcement, avoidance of punishment.</td>
</tr>
</tbody>
</table>

#### Analysis of the Technology

- **Disadvantages**
  1. Technology for complex situations is incomplete; successful analysis depends on the skill of the developer.
  2. Response frequency is difficult to apply to complex behaviors as a measure of probability.

- **Contributions to classroom practice**
  1. Analysis of states such as "readiness" and "motivation."
  2. Analysis of aversive classroom practices and interactive classroom situations.
  3. Individualized learning materials: teaching machines, microcomputers.

Search for escape or food. Instead, the appropriate procedure is to shape the animal's behavior through carefully established stimulus–response–reinforcement sequences. Approximations to appropriate responses are reinforced on intermittent schedules until the behavioral repertoire is acquired, such as pigeons playing ping-pong.

In the classroom, Skinner cited the practice of "assign-and-test" as one example of placing the human learner in a terminal contingency. Instead, Skinner recommended the practice of reinforcing the component behaviors, such as attending to stimuli and executing appropriate study behaviors. Punishment should be avoided because it produces unwanted emotional side effects and does not generate the desired positive behaviors.

Included in Skinner's analyses are the role of conditioned and natural reinforcers, positive and negative reinforcers, and generalized reinforcers. Also included is the development of programmed learning for verbal behaviors. Individual differences in entry skills and rates of learning may be accommodated by such materials.
Disadvantages
Some have criticized Skinner's principles because they do not address mental events. However, mental events are outside the requirements for developing a science of behavior. Within the parameters Skinner established for his work, two major problems in the application of his recommendations may be identified. One is that the technology for the experimental analysis of complex human behaviors is incomplete. Some students respond well in highly structured situations in which objectives and the steps to be taken are clearly specified. Others, however, are reinforced by the opportunity to explore on their own and to relate ideas without external directives. The procedures for identifying these and other differences in the variety of potential reinforcements is yet to be developed.

Second, in the classroom, response frequency as a measure of learning may be applied to simple behaviors, such as naming colors or adding two-digit numbers. Complex behaviors, however, such as diagnosing an illness or calculating one's taxes, are not conducive to response frequency as a measure of learning.

Contributions to Classroom Practice
Three major contributions to educational practice are illustrated in Table 4.6. First, the search for conditions and behaviors that represent states such as “unmotivated” is an important step in the identification of an appropriate course of action. Second, observations of contemporary classrooms reveal many inconsistent and noncontingent uses of reinforcement that contribute to classroom discipline problems. An analysis of these interactive situations in terms of discriminative stimuli, responses, and reinforcements is an important step in correcting the problems. Third, programmed learning materials, if properly designed, can provide for individual differences in the classroom.

CHAPTER QUESTIONS

Understanding Concepts
1. Skinner (1989b) stated that governments make use of aversive situations both as punishment and as negative reinforcers. His examples are having to pay a fine for parking in a “no parking” zone and the directive “Pay your taxes and avoid a fine.” Identify the type of consequence in each example.
2. Which reinforcement concept is most likely to explain a person’s involvement with the Sunday crossword puzzle?
3. One of the concerns about Internet use is that of individuals spending hours and days in computer chatrooms, to the exclusion of eating and sleeping regularly and engagement in face-to-face-interactions. Which concept in operant conditioning describes this phenomenon?
4. Skinner would likely view the availability of iPods as another erosion of contingencies of reinforcement. Why?
5. The American Academy of Pediatrics (Committee on Public Education, 1999) has reissued an earlier policy against television for the “under 2” set. The rationale is that research on early brain development indicates a critical need for babies and toddlers to interact with parents and caregivers. In terms of operant conditioning, what would Skinner likely say is the problem with the lack of interaction between adult and toddler?
Applying Concepts to Instructional Settings

1. Some educators advocate putting smiley faces or gold stars on children's homework papers or worksheets before the teacher returns them. However, in this situation, smiley faces and gold stars cannot serve as reinforcers. Why not?

2. Good and Power (1976) have identified five types of students in the classroom. Three are briefly described below. Name some potential reinforcers that may be effective for each type.
   a. *successful*—does not require structure or praise from the teacher
   b. *social*—is more person-oriented than task-oriented
   c. *dependent*—seeks teacher structure and teacher support

3. For the dependent student, which behaviors should the teacher seek to reinforce? What problems should be avoided in the use of reinforcement with this type of student?

4. A social studies teacher ignores a minor disruption in the back of the classroom until it becomes louder and louder. She or he then stops the class and reprimands the culprits. The other students giggle, but the talkers do become quiet. However, during the next class session, it begins again and increases in frequency over the next few days.
   (a) For the culprits, the other students' giggles function as ______.
   (b) For the teacher, the loud talking serves as ______ and (c) stopping the students' conversation serves as ______ for the reprimands.
   (d) A reasonable assumption is that, for the culprits, getting the teacher's attention serves as ______.
   (e) For the culprits, being in the social studies class becomes ______ for initiating a conversation.

REFERENCES


CHAPTER 5

Robert Gagné’s Conditions of Learning

*Human skills, appreciations, and reasonings in all their great variety, as well as human hopes, aspirations, attitudes, and values, are generally recognized to depend for their development largely on the events called learning.* (Gagné, 1985, p. 1)

The early psychologists, from Pavlov to Skinner, began with research in the laboratory and applied the findings to human learning. Their efforts identified important factors that influence learning (e.g., stimulus pairing in emotions, perception, discriminative stimuli, reinforcers, and shaping). Then the involvement of the United States in an all-out mechanized war (World War II) and post-war research on the effectiveness of training posed a very different question to psychologists: What are the conditions essential to developing expertise in positions such as radar operator, pilot, bombardier, aircraft gunner, and others?

Serving as the director of a laboratory researching the training of electronic maintenance personnel, Robert Gagné (1962b, 1987b) reported that the traditional principles of learning (e.g., contiguity, the law of effect) were not helpful in improving training. Regardless of the unquestionable validity of such principles as “arrange new contingencies of reinforcement,” they did not contribute to planning instruction for different kinds of learning outcomes (Gagné, 1974c, p. 12).

Three principles of effective instruction identified by Gagné in the analysis of training tasks were to (a) provide instruction on the set of component tasks that build toward the final task, (b) ensure that each component task is mastered, and (c) sequence the component tasks to ensure optimal transfer to the final task (Gagné, 1962a, 1962b). In electronic maintenance, for example, tasks included adjustments, part replacements, and troubleshooting skills (Gagné, 1987b). Later assignments included analyzing man-machine systems and forecasting training requirements for weapons systems yet to be built (Gagné, 1987b, 1989).
Convinced that analyzing learning tasks into simpler components also was applicable to school learning, Gagné began to analyze problem solving in mathematics. Observations of students indicated that lack of success resulted from gaps in knowledge of prerequisite procedures, such as finding multiples of numbers and simplifying fractions (Gagné, 1987b, p. 398). Identification of subcomponents of the final learning task led to the concept of a learning hierarchy, or a progression of prerequisite skills (Gagné, 1968a, 1968b). Various research methods applied in the verification of learning hierarchies (see Airasian & Bart, 1975; White, 1974) indicate that properly identified prerequisite skills contribute to the learning of more complex capabilities. Gagné’s concepts of analyzing learning tasks into subcomponents and identifying needed prerequisite skills were adapted for instructional programs with different goals (see, e.g., Griffin, Case, & Siegler, 1994; Jonassen, Tessmer, & Hannum, 1999). Included are activity analysis and job analysis. In addition, Gagné’s principles of systems design are found in a framework that combines instructional design with research (see Bannon-Ritland, 2003). The most recent development is cognitive task analysis, which extends traditional task analysis methods to describe the knowledge that experts use to perform complex tasks (Clark, Feldon, van Merriënboer, Yates, & Early, in press; Schraagen, Chipman, & Shalin, 2000).

After his military service, Gagné continued research in classrooms and other educational settings on the question, What factors can really make a difference in instruction? (1985, p. xiii). First, his analysis of human learning led to the identification of five distinct domains or varieties of learning outcomes that represent the range of human accomplishments. Second, he identified the internal states and information-processing steps required for learning in each domain or category, and third, the requirements for instruction that support learning. Finally, the guidelines for designing instruction also include criteria for media selection.

**PRINCIPLES OF LEARNING**

Human beings engage in a vast variety of activities that are primarily the result of learning—activities from executing the ballet steps in Swan Lake to piloting space vehicles. The problem with prior theories that addressed learning is that they failed to grasp the diversity and complexity of the activities that set humans apart from other species (Gagné, 1977a). Instead of beginning with laboratory research, Gagné (1972, 1977a) maintained that the key to the development of a comprehensive theory was to begin with an analysis of the variety of performances and skills executed by humans.

**Basic Assumptions**

The basic assumptions of Gagné’s theory describe the unique nature of human learning and his definition of learning.
The Unique Nature of Human Learning
Important elements in Gagné’s analyses are the relationship of learning to development, the complexity of human learning, and the particular problems with prior views.

The Relationship of Learning to Development. In the growth-readiness model (often referred to as the Gesellian model), body growth is closely related to mental growth. One suggestion was that the appearance of the child’s permanent teeth indicates the appropriate developmental age to begin reading instruction (see Gredler, 1992, for a review). However, equating learning and growth as natural events overlooks a major difference between them: the factors that influence growth are primarily genetic, and the factors that influence learning are primarily determined by events in the individual’s environment (Gagné, 1977a, p. 2).

The dependence of learning on environmental events places a major responsibility on human society. The question is whether the growing person will be placed in situations that will encourage the development of disciplined thinkers, great artists, and innovative scientists or discourage the full realization of human thought (p. 2).

The Complexity of Human Learning. Two characteristics of learning account for its importance in development. One is that much of human learning generalizes to a variety of situations (see Table 5.1). Addition, for example, is one skill

<table>
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<th>TABLE 5.1</th>
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<tr>
<td>Basic Assumptions of Gagné's Conditions of Learning</td>
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<tr>
<td>Assumption</td>
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<tr>
<td>1. Learning and growth should not be equated to each other.</td>
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<tr>
<td>2. Learning is an important causal factor in the individual's development.</td>
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<tr>
<td>3. Much of human learning generalizes to a variety of situations.</td>
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<tr>
<td>4. Human learning is cumulative; the learning of complex skills builds on prior learning.</td>
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<tr>
<td>5. Learning is not a single process.</td>
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</table>
with thousands of applications. The other characteristic is that complex skills build on prior learning. In many new situations, individuals are not required to learn a completely new set of responses. For example, the student who learns to write clear, descriptive paragraphs builds on his or her knowledge of writing sentences and choosing words. Within the broad limits established by growth, “behavioral development results from the cumulative effects of learning” (Gagné, 1968a, p. 178). In other words, learning is an important causal factor in the individual’s development (Gagné, 1968a, 1977a).

Problems with Prior Views. First, the ideas presented by the early theories are tied to specific situations, such as dogs salivating at the sight of food (Gagné, 1984, p. 388). Second, because the early theories were derived from laboratory studies of learning they could not account for the human capacity to learn complex skills and abilities (Gagné, 1977a).

Some laboratory-based theories do describe subcomponents of human learning, but these subskills are not the major objectives of learning. An example is Pavlov’s model, which Gagné (1977a) described as signal learning. That is, the conditioned stimulus “signals” emotional or other reactions, such as the feelings of well-being generated by a favorite stuffed toy or a favorite melody. Other perspectives are the stimulus–response (S-R) theories of Thorndike and Skinner. Examples of S-R connections are the infant learning to hold its own bottle, reaching for and clutching toys, and vocalizing utterances (p. 88). As the child acquires an increasing number of S-R connections, they begin to form chains. Examples include buttoning, tying, using scissors, printing, and, subsequently, verbal sequences such as the Pledge of Allegiance. In the early 20th century, verbal memorization was a priority in American schools (p. 100). Currently, however, such tasks are not the major goals of education.

Like S-R theorists, Gestalt psychologists also attempted to explain the “true” nature of learning. They maintained that learning occurs when a subject “sees” a new relationship in a problem situation (Gagné, 1977a). However, the Gestaltists did not assess the subject’s prior learning, which, at least in some cases, could explain problem-solving behavior. For example, a chimpanzee could stack boxes on top of each other to reach the bananas because he had previously done so in another situation (p. 13). Also, “when children are led to ‘see’ relations, such as those . . . between weight and the ‘pull’ of gravity, they often display insight” (p. 14). However, the major problem with the Gestalt view is that it, too, does not explain all learning. For example, learning to speak a foreign language and learning to read are not the result of insight.

In the 1960s, other research trends introduced a new perspective into the discussions of learning. They were (a) communications research, which viewed the learner as a complex information-processing system; (b) the appearance of high-speed computers, which followed sets of processing instructions; and (c) the rule-following description of how individuals process language. The major change in thinking about learning initiated by these developments was that individuals do not simply react to stimuli. Instead, they process the stimulation received from the environment. For example, the young child may see a small rabbit in her backyard,
recall the animal pictures in one of her storybooks, and call out "Bunny!" to her mother. Although the information-processing models did not address specific outcomes of learning, the concept of acting on stimuli in the environment in various ways had implications for instruction (Gagné, 1977a, p. 17).

**Definition of Learning**

Gagné’s (1970, 1972, 1977a) analyses led to his identification of the requirements for a comprehensive definition of learning and his description of human learning.

**Requirements for an Adequate Definition.** The focus on force-fitting all learning into a single description was one error in the prior development of learning principles. One problem is that neither the learning of word associations nor the problem solving described by Gestalt psychologists can be reduced one to the other. The learning of associations cannot be explained by insight, nor can problem-solving behavior be explained by the pairing of stimulus elements (Gagné, 1977a). These findings indicate that learning is more than a single process. Another problem is that neither of these views accounted for the diversity of human learning. The human capacity for learning makes possible an almost infinite variety of behavioral patterns (Gagné, 1977a). Given this diversity, no one set of characteristics can account for such different activities as learning to operate a computer, write an essay, or lace a shoe.

In the early 1980s, cognitive psychologists began to broaden the situations used to study learning; an example is a study of the learning of elementary arithmetic (Gagné, 1984, p. 377). Although a positive change from laboratory-based research, the danger was that research “become frozen into narrow channels of learning” (p. 378), such as the principles of science learning and principles of computer-repair learning. The problem is that this focus overlooks important generalities in learning outcomes between geometry and composition, for example, or between the procedures of office management and those of aircraft maintenance (p. 378).

Finally, an adequate conception of human learning must not be restricted to only the laboratory or the school. Instead, an adequate perspective should apply also, for example, to masons, carpenters, astronauts, politicians, housewives, and word-processing operators (p. 378). Therefore, the task for learning theory is to identify a set of principles that (a) accommodates both the complexity and variety of human learning, and (b) generalizes to all the various situations and circumstances in which learning occurs.

**The Concept of Capabilities.** If human learning is indeed a complex, multifaceted process, how is it to be defined? First, learning is the mechanism by which an individual becomes a competently functioning member of society (Gagné, 1977a). Learning is responsible for all the skills, knowledge, attitudes, and values that are acquired by human beings. In the most general sense, learning is a change in human disposition or capability that persists for a long time and is not the result of growth (p. 3). The evidence that learning has occurred is an observed change in behavior, typically based on a comparison of pre- and post-instructional performance.
Formally defined, learning results in a variety of retained dispositions that are reflected in different kinds of behaviors. They are the outcomes of learning that Gagné (1972, 1977a) referred to as capabilities. In Gagné’s perspective, capabilities consist of both a mental component (the retained disposition) and a behavioral component (performance). Second, these capabilities are acquired by human beings from (a) the stimulation from the environment and (b) the cognitive processing undertaken by the learner that transforms the stimulation from the environment into a new capability (Gagné & Briggs, 1979, p. 43).

Summary
The key to the development of a comprehensive learning theory is to account for the complex nature of human learning. First, unlike the growth-readiness model in which maturation governs learning, Gagné maintained that learning is an important causal factor in development. Second, human learning is cumulative. The learning of certain skills contributes to the learning of more complex skills. The result is an ever-increasing intellectual competence.

Third, human learning is both complex and diverse. The process cannot be reduced to either S-R associations or the insight experiences described by the Gestalt theorists. In addition, studies of learning should not focus on developing principles that apply to only one subject area. Instead, an adequate description of human learning must apply to a variety of human activities in the various settings and circumstances in which learning occurs. Also, learning results in retained dispositions that are evidenced by particular performances. Referred to as capabilities, they are the outcomes of learning. The process of learning is the set of cognitive processes that transforms information in the environment into the various capabilities.

The Components of Learning
Discussed in this section are the learning framework in Gagné’s theory, the domains or varieties of learning that he identified, and the internal events of learning.

The Learning Framework
Typically, theories of learning began by developing principles of learning that theorists or others translated into guidelines for instruction. Gagné’s approach differed in two ways from that course of action. The first step, in his view, is to develop an understanding of the diversity of human capabilities because the nature of the learning outcome sets broad parameters on the process of learning. Second, learning and instruction are not separate concerns; they should be developed in tandem. As a result, Gagné’s framework for learning consists of three major components. They are (a) a system for accounting for the diversity of human capabilities, (b) the processes by which the capabilities are acquired, and (c) the steps in instruction that support each of the steps in learning.

Criteria for Identifying Different Varieties of Learning. In the 1960s, efforts to identify objectives for instruction led to an awareness that different kinds of behaviors are acquired through learning. Initial efforts identified some behavioral
categories that consistently would indicate particular requirements for instruction (Gagné, 1965a, 1965b). For example, learning concepts, in which a common response is made to a class of objects, differs from learning verbal associations, such as the words in "The Star Spangled Banner." However, accounting for the diversity of human learning in a systematic and comprehensive way is a difficult task. Some approaches attempted to reconcile descriptions of learning in the laboratory and the behaviors taught in the classroom (Melton, 1964). For school subjects, Gagné (1972) noted that categories such as cognitive learning, rote learning, discovery learning, and concrete versus symbolic learning were often used. The difficulty, however, is that these designations do not generalize to different settings. Examples may be classified as rote learning in one context and conceptual in another (Gagné, 1972).

Any set of categories intended to describe the outcomes of learning must avoid the above problems. To do so, the classification system should meet at least four major criteria (Gagné, 1984, p. 2). First, each category should

(a) represent a formal and unique class or human performance that occurs through learning;
(b) apply to a widely diverse set of human activities and be independent of intelligence, age, race, socioeconomic status, classroom, grade level, and so on; and
(c) require different instructional treatments, prerequisites, and internal processing requirements.

In addition, factors identified as affecting the learning of each category should generalize to tasks within the category but not across categories (with the exception of reinforcement).

The Varieties of Learning. The five varieties of learning identified by Gagné meet the stated criteria. They are verbal information, intellectual skills, motor skills, attitudes, and cognitive strategies (Gagné, 1972, 1977a, 1985). Like the S-R associations and the insight experience, none of these categories may be reduced to the other. However, unlike associations and insight, they represent the range of human learning.

These five varieties of learning represent the outcomes of learning. They are capabilities because they make possible the prediction of many instances of performance by the learner (Gagné & Briggs, 1979, p. 51). For example, an individual who can state the names of things, state facts, or paraphrase the main and subordinate themes or ideas in connected discourse is functioning at the level of verbal information (Gagné, 1977a, 1985). This capability, which involves simply "reporting out" information, differs in major ways from intellectual skills. Composing sentences, adding two-digit numbers, solving algebra problems, and identifying colors are all intellectual skills. Each involves manipulating information and interacting with the environment using symbols.

Cognitive strategies, in contrast, includes the capabilities that control learning, remembering, and thinking. An example is making $3 \times 5$ note cards on key topics to study for an examination. Finally, motor skills include physical sequences or actions such as demonstrating the butterfly stroke, and attitudes influence a person's positive or negative actions toward people, objects, and events. Choosing to attend a rock concert or to go to the beach rather than study is an example.
**Internal and External Conditions of Learning.** In addition to the kinds of learning, Gagné (1977a, 1985) identified the internal states and processes that are essential in achieving each type. They are the *internal conditions of learning*. For example, in developing attitudes, the person must notice and attend to models who are behaving in appropriate ways. In contrast, for motor skills, the learner mentally rehearses the steps in the routine or subroutine, such as the moves in the butterfly stroke.

However, the conditions for acquiring new skills or capabilities are not all within the learner. Also important are the stimuli in the environment that interact with the learner’s internal processing. For example, a text may include diagrams that emphasize important features of the topic that focus the learner’s processing of information. Also, for example, in learning concepts, the teacher presents both examples and nonexamples for students to identify. These environmental supports are the *external conditions of learning* (Gagné, 1974a, 1977a, 1977b, 1985). They also are the events of instruction and are designed to support learning (they are discussed in the second part of this chapter). As indicated in Figure 5.1, the events of instruction (external conditions of learning) interact with the internal conditions to bring about the achievement of a particular type of capability.

**Cognitive Outcomes of Learning**
Three varieties of learning identified by Gagné are cognitive capabilities. They are verbal information, intellectual skills, and cognitive strategies.

![Diagram of internal and external conditions of learning](image)

**FIGURE 5.1**
Essential components of learning and instruction
**Verbal Information.** Perhaps the most familiar category of learned capabilities is verbal information (Gagné, 1977a). It begins in early childhood when toddlers begin to learn the names of objects, animals, and events, such as Halloween, and continues throughout life as people learn about the world around them. Two essential characteristics of verbal information are (a) it is *verbalizable* (can be written or told), and (b) at least some of the words have meaning for the individual (p. 182). Verbal information is not simply the repetition of words.

The capability represented in this category includes acquiring (a) labels and facts, (b) meaningfully connected selections of prose or poetry, and (c) organized bodies of information. Verbal information is also *declarative knowledge*, implying the capability to “declare” or “state” something (Gagné, 1984, 1985). In learning labels, for example, a consistent verbal response or name is applied to an object or an object class, such as *rose* or *tiger*.

After learning a fact, the student’s response typically is an oral or written statement, such as “Columbus discovered America in 1492” and “Rectangles have four sides.” Recalling selections such as the salute to the flag or Hamlet’s soliloquy are longer verbatim reinstatements of particular words and phrases.

Larger bodies of knowledge also are learned as information. Examples include the biblical story of creation and the contents of a local ordinance on littering. The performance is slightly different from briefer forms of verbal information, which often are stated verbatim. For a larger body of knowledge, the individual typically paraphrases or reports a summary of the information.

**Intellectual Skills.** Included in intellectual skills are “...distinguishing, combining, tabulating, classifying, analyzing, and quantifying objects, events, and even other symbols” (Gagné, 1977a, p. 27). Simple examples are mentally translating 24 ounces into pounds and making a singular verb agree with a singular subject (p. 27). Also included in this category are applying the rules that govern speaking, writing, and reading and, in mathematics, using the rules for computation, interpreting word problems, and verifying problem solutions (Gagné, 1984). Intellectual skills may be described as “the basic and, at the same time, the most pervasive structures of formal education” (Gagné & Briggs, 1974, p. 24). Intellectual skills also are found in a host of occupations from nursing to computer programming. They are the capabilities that make human beings competently functioning members of society.

Unlike verbal information, intellectual skills cannot be learned simply by hearing them or looking them up (Gagné, 1974a, p. 55) (see Table 5.2). Instead, the learner responds to situations by manipulating symbols (e.g., letters, numbers, formulas, words) in various ways. Another unique characteristic is that, unlike the other types of learning, intellectual skills consist of four discrete skills. From simple to complex, they are (a) discrimination learning, (b) the learning of concrete and defined concepts, (c) rule learning, and (d) higher order rule learning (problem solving). (These four skills are discussed in the section on hierarchies of learning.)

**Cognitive Strategies.** Intellectual skills form the basic structures for the learning that occur in schools (Gagné, 1977a, p. 167). As students progress in learning both verbal information and intellectual skills, they also begin to develop ways to
### TABLE 5.2
Overview of the Five Varieties of Learning

<table>
<thead>
<tr>
<th>Category of Learning</th>
<th>Capability</th>
<th>Performance</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal information</td>
<td>Retrieval of stored information (facts, labels, discourse)</td>
<td>Stating or communicating the information in some way</td>
<td>Paraphrasing a definition of patriotism</td>
</tr>
<tr>
<td>Intellectual skills</td>
<td>Mental operations that permit individuals to respond to conceptualizations of the environment</td>
<td>Interacting with the environment using symbols</td>
<td>Discriminating between red and blue; calculating the area of a triangle</td>
</tr>
<tr>
<td>Cognitive strategies</td>
<td>Executive control processes that govern the learner's thinking and learning</td>
<td>Efficiently managing one's remembering, thinking, and learning</td>
<td>Developing a set of note cards for writing a term paper</td>
</tr>
<tr>
<td>Motor skills</td>
<td>Capability and &quot;executive plan&quot; for performing a sequence of physical movements</td>
<td>Demonstrating a physical sequence or action</td>
<td>Tying a shoelace; demonstrating the butterfly stroke</td>
</tr>
<tr>
<td>Attitudes</td>
<td>Predisposition for positive or negative actions toward persons, objects, or events</td>
<td>Choosing personal actions toward or away from objects, events, or people</td>
<td>Electing to visit art museum; avoiding rock concerts</td>
</tr>
</tbody>
</table>

self-regulate their mental processes associated with learning. Specifically, cognitive strategies “are learning how to learn, how to remember, and how to carry out the reflective and analytic thought that leads to more learning” (p. 167). Prior to the extensive development in information-processing theories and cognitive theory, Gagné (1972) identified those capabilities that control the management of learning, remembering, and thinking as cognitive strategies. (Currently, cognitive theory refers to these strategies as metacognition.)

Unlike verbal information and intellectual skills, which operate with particular content (e.g., defining chlorophyll, adding two-digit numbers), the object of cognitive strategies is the learner’s own thought processes. Cognitive strategies that assist students in managing their learning and remembering include constructing images for words to be learned, underlining key sentences in written text, and checking one's understanding of text through self-questioning.

Cognitive strategies also assist individuals to manage their thinking by helping them determine when and how to use their verbal information and intellectual skills (Gagné, 1984). An example in troubleshooting equipment is weighing the difficulties and potential benefits of tests prior to their use (Gagné, in Twitchill, 1991). In problem solving, for example, cognitive strategies that assist thinking include creating a mental map of the elements of the problem, reviewing and testing problem-solving plans, and searching long-term memory for new...
information, if necessary. At the highest level, individuals can review, select, and reject their available cognitive strategies, and persist in the search for the best strategy for a given stage of problem solving (Gagné, 1980a, p. 89). Evidence of the types of strategies used and their implementation is the reports or protocols of learners about their methods of processing (Gagné, 1984, p. 381).

The importance of cognitive strategies is illustrated in the research on disadvantaged students in chapter one programs. These students, in particular, are in need of extensive strategy training (Brophy, 1988). Low-achieving students tend to rely primarily on rote memorization and other inefficient strategies. They fail to organize their learning and tend to skip over material they do not understand (p. 263).

**Motor Skills and Attitudes**

Verbal information, intellectual skills, and cognitive strategies all reflect outcomes that are some type of mental capability. In contrast, motor skills and attitudes are different from both those outcomes and each other.

**Motor Skills.** To a certain extent, all performances are “motor” in that they require an action of some kind (e.g., stating something, pushing a button, or pointing at something) (Gagné, 1984). A student may use his hands and fingers to manipulate a pencil so that he can write the answer to a problem such as \(6 \times 9 = ?\). However, this action is the demonstration of an intellectual skill; it is not a motor skill (Gagné, 1977a, p. 212).

Given that motor skills learning cannot be determined simply by observing some overt motor performance, what criteria are to be used? The key is to determine the student’s entering behavior in the situation (Gagné, 1977a, p. 212). In the case of multiplication problems, the student already knows how to print numbers; the focus of the task is demonstrating an intellectual skill. Of course, at some earlier time, the child had to learn the motor skills that make printing the answer possible. Nevertheless, identifying newly learned motor skills depends on recognizing that a motor performance was not present before the learning (p. 213). Examples include fly casting, lariat twirling, and executing a serve in tennis.

The common characteristics of motor skills are (a) the requirement to develop smoothness of action, precision, and timing, and (b) quality of performance can be attained only through repetition of the exact movements (with feedback from the environment) (Gagné, 1977a, 1984, 1985). Continued practice of the specific movements, in other words, is essential.

The three major phases in learning motor skills are (a) learning the sequence of the movements in the skill, the executive subroutine, (b) fitting the parts of the skills together through practice, and (c) improving the timing and smoothness of the performance through continued practice. The third phase, over time, leads to automatization of the skill so that it can be executed in the presence of potentially interfering activities, such as the roar of the crowd at an athletic event (Gagné, 1984). When learning the skill is completed, the individual is able to respond to the kinesthetic cues that signal the differences between inaccurate and error-free performance.
Attitudes. The fifth kind of learning differs from the others in three major ways. First, the relationship between attitudes and behavior is less direct (Gagné, 1977a, 1984). Attitudes are inferred states that influence or modulate behavior, but they do not directly determine performance in the way that verbal information, intellectual skills, cognitive strategies, and motor skills do. Attitudes only make classes of individual actions more or less likely (Gagné, 1977a, p. 231).

Second, telling students what they are to learn can be an effective aspect of instruction in any of the other categories. However, efforts to establish attitudes by persuasive logic or emotional appeal is not effective (Gagné, 1984, p. 382). Reading a printed message, such as “Avoid harmful drugs,” is not expected to have any effect on a learner’s attitude (Gagné, 1974b).

Third, attitudes generally are described as consisting of three aspects (Gagné, 1977a, 1985). One is cognitive, which expresses relationships such as “automobiles burn too much gasoline” (Gagné, 1977a, p. 234). The second aspect is affective, the feelings that accompany the cognitive belief. Third is the behavioral aspect that pertains to the readiness or predisposition for action (Gagné, 1985, p. 222).

Various institutions in society, including the school, the church, and the family, have a vested interest in developing students’ attitudes. The school, for example, typically emphasizes attitudes such as respecting others, observing safety rules, reacting positively to a given subject, and taking responsibility for one’s actions (Gagné, 1977a, p. 233). However, the medium that is most involved in influencing attitudes is television (Gagné, 1984). In addition to commercial messages, soap operas, and other programming, such as fictional criminal investigations, television programs produce and reinforce attitudes about various aspects of everyday life (p. 382).

Summary
Gagné’s approach to understanding human learning differed from prior efforts in two ways. One is that the first step should be to analyze the diversity of human learning. Second, learning and instruction should be developed in tandem. The framework of learning described by Gagné consists of (a) the five varieties of learning, (b) the internal conditions of learning, and (c) the external conditions of learning.

The five varieties of learning are verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. Each category represents a unique class of performance that is learned, applied to diverse activities and contexts, is independent of individual characteristics, and requires different instructional treatments, prerequisites, and internal processing requirements.

Verbal information refers to the acquisition of labels, facts, meaningfully connected selections of text, and organized passages. The outcome of verbal information is simply stating the information. In contrast, intellectual skills involve responding to different situations by manipulating symbols such as letters, numbers, formulas, and words. The category of intellectual skills also consists of four discrete skills. From simple to complex, they are discrimination learning, learning concrete and defined concepts, rule learning, and higher-order rule learning (problem solving). The third kind of cognitive learning is cognitive strategies. The object
of these strategies is the learner’s own thought processes. Cognitive strategies assist students to manage their learning and remembering and also their thinking.

The category of motor skills refers to newly learned physical actions that were not present before the learning, such as executing a serve in tennis. This definition prevents situations in which students write answers to questions from being classified as motor skills. Common characteristics of motor skills are that they require smoothness of action, precision, and timing, and depend on practice with feedback.

The fifth category, attitudes, is unique in three ways. The relationship between the inferred state influences behavior but does not directly determine performance, telling students what to do is ineffective, and attitudes have three aspects. They are cognitive, affective, and a predisposition for action. Various social institutions have an interest in developing attitudes. Also, television is a pervasive influence on attitudes.

**Internal Conditions of Learning**

The second component in Gagné’s framework of learning is the internal conditions of learning. They consist of (a) the internal prerequisites for learning particular capabilities and (b) the set of cognitive processes involved in learning.

**Internal Prerequisites.** The two types of internal states required for learning are essential and supportive prerequisites (Gagné & Briggs, 1979; Gagné, Briggs, & Wager, 1988). Supportive prerequisites are the capabilities that facilitate learning in either all five categories of learning or across the board in one category. An attitude of confidence in approaching learning is an example that is relevant for all five categories of learning.

An example that applies to all outcomes in verbal information is that the learner should have an organized set of ideas into which the new information can fit. Cognitive psychologists refer to this knowledge as a schema (Gagné, 1980b, p. 8). If such information is lacking, then the teacher must spend some time establishing a meaningful context for the new learning.

In discussing the learning requirements for attitudes, Gagné (1984, 1986) referred to Bandura’s (1977) concept of human models of behavior. That is, individuals learn appropriate or inappropriate actions from observing models. An internal supportive prerequisite for learning attitudes is the observer’s acceptance of the model as credible. In contrast, cognitive strategies that assist the individual in thinking through problems require the availability of relevant verbal information and intellectual skills in the learner’s schema.

In contrast to supportive prerequisites, essential prerequisites are particular skills that become an integral part of the new learning (Gagné & Briggs, 1979, p. 106). They are the component tasks that Gagné first identified in his analysis of the training of electronic personnel; these essential prerequisites are “folded into” the more complex skill when it is learned. For example, in learning to add mixed numbers (e.g., \(9\frac{3}{8} + 11\frac{5}{16}\)), an essential prerequisite (component task) is being able to simplify fractions (in this case, changing \(\frac{3}{8}\) to \(\frac{6}{16}\)). In general, when students can recall the prerequisite (component) skills, learning the new complex skill occurs rapidly (Gagné, 1980b, p. 7).
The Concept of Cognitive Processing. Prior approaches to learning either focused on the new behaviors that are acquired or the influence of the learner’s perceptions in developing solutions to problems. Then developments in cognitive psychology in the late 1960s and 1970s indicated that the learner’s cognitive processes interact with the environment in several ways during learning. Included in these processes are the learner’s perception of stimuli in the environment, the transformation of these perceptions into codes to be remembered, and the later recall of stored information. Also introduced to this work were the concepts of long-term memory and working memory. The memory system in which all our memories and learning are stored is long-term memory. Working memory is responsible for processing stimuli from the environment. It also is referred to as short-term memory because it has a limited capacity for holding information.

Gagné (1977a, 1985) applied the cognitive processing concept to his analysis of learning. He identified nine stages of processing that are essential to learning and that must be executed in sequential order. He referred to these stages as phases of learning (Gagné, 1985), and they are enacted in different ways for the different varieties of learning.

The Nine Phases of Learning
The nine phases of learning are presented in Table 5.3, and they are categorized as three broad stages. They are (a) preparation for learning, (b) acquisition and performance, which are the “core events” in learning the new capability, and (c) transfer of learning, which provides for the application of the new capability in new contexts.

Preparation for Learning. The purpose of the preparatory phase is to set the stage for learning. Included are attending to the stimuli for learning (which may be spoken or printed words, still or moving pictures, objects, or a human model), establishing an expectancy for the learning goal, and retrieving relevant information and/or skills from long-term memory to working memory. Typically, this phase only requires a few minutes.

The learner’s expectancy is important because it leads to selecting appropriate output at each subsequent stage of processing information. For example, if the individual expects to learn ways to find the resistance of electric circuits, characteristics of the circuit relevant to that goal will be processed and others will be ignored (Gagné, 1985, p. 78).

Retrieving relevant capabilities from long-term memory is also essential to the new learning. In learning the concept triangle, for example, the child must first recall that three-sided figures differ from other geometric shapes (discrimination learning).

Acquisition and Performance. The four phases of selective perception, semantic encoding, retrieval and responding, and reinforcement are here referred to as the core phases of learning. The three information-processing phases involve selecting and recognizing relevant stimuli from the environment (selective perception), assigning meaning and transferring the information to long-term
Table 5.3
Summary of the Nine Phases of Learning

<table>
<thead>
<tr>
<th>Description</th>
<th>Phase</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation for learning</td>
<td>1. Attending</td>
<td>Alerts the learner to the stimulus</td>
</tr>
<tr>
<td></td>
<td>2. Expectancy</td>
<td>Orients the learner to the learning goal</td>
</tr>
<tr>
<td></td>
<td>3. Retrieval (of relevant information and/or skills) to working memory</td>
<td>Provides recall of prerequisite capabilities</td>
</tr>
<tr>
<td>Acquisition and performance</td>
<td>4. Selective perception of stimulus features</td>
<td>Permits temporary storage of important stimulus features in working memory</td>
</tr>
<tr>
<td></td>
<td>5. Semantic encoding</td>
<td>Transfers stimulus features and related information to long-term memory</td>
</tr>
<tr>
<td></td>
<td>6. Retrieval and responding</td>
<td>Returns stored information to the individual’s response generator and activates response</td>
</tr>
<tr>
<td></td>
<td>7. Reinforcement</td>
<td>Confirms learner’s expectancy about learning goal</td>
</tr>
<tr>
<td>Transfer of learning</td>
<td>8. Cueing retrieval</td>
<td>Provides additional cues for later recall of the capability</td>
</tr>
<tr>
<td></td>
<td>9. Generalizability</td>
<td>Enhances transfer of learning to new situations</td>
</tr>
</tbody>
</table>

memory (encoding), then retrieving the information and responding. Of these phases, encoding is the central and critical stage in learning (Gagné, 1977a, p. 66). Without it, learning has not occurred. The stored code may be a concept, proposition, or some other meaningful organization (see Gagné & White, 1978). In learning the concept triangle, for example, the child encodes various examples of triangles of different textures and colors. For motor skills, however, the learner encodes a visual image of the skill and the executive routine required to enact the parts of the performance.

The core events of learning conclude with performance and confirmation of the new learning. The learner retrieves the newly stored code from long-term memory and executes a response. If the child is learning the concept triangle, he or she identifies examples of triangles that include various sizes, colors, and materials. For a motor skill, the student demonstrates the physical performance.

Feedback about the achievement of the learning goal is the next step. The feedback may be provided by the environment, or it may result from the learner’s observation of his or her performance (Gagné, 1977a). The importance of the feedback, according to Gagné (1985, p. 79), is derived from Estes’s (1972) concept of reinforcement. That is, feedback is reinforcing to the learner when it confirms
that the goal has been attained or is close to being accomplished. In other words, feedback acquires reinforcing power by confirming the learner’s expectancy.

**Transfer of Learning.** The new learning should not be limited to only the situations introduced in the core events of instruction. The final phases of learning include opportunities to apply the learning in new situations and to construct additional cues for later recall. The generalizability to new situations is known as lateral transfer (Gagné, 1985). For example, the learner should be able to pick out the triangles in a geometric painting as well as those drawn on a sheet of paper.

Acquiring additional cues for retrieval and generalizability may not immediately follow the other phases of learning. Short delays of a day or two may intervene between the initial learning and opportunities for transfer (Gagné, 1974a).

**Summary**

The internal conditions of learning consist of the internal prerequisites for learning particular capabilities and the set of cognitive processes of learning. Supportive prerequisites are the capabilities that facilitate learning in either all five categories of learning or across the board in one category. Examples of supportive prerequisites are an organized set of relevant ideas (verbal information), acceptance of appropriate models of behavior (attitudes), and relevant verbal information and intellectual skills (cognitive strategies). In contrast, essential prerequisites are capabilities that are “folded into” and become a part of the new learning.

In applying information-processing concepts to learning, Gagné described nine phases of learning. Initially, the learner attends to the stimuli for learning, establishes an expectancy for the learning goal, and retrieves relevant information and/or skills from long-term memory. In the core events of learning, the learner selectively perceives the relevant information in the environment, encodes the information in long-term memory (the critical event in learning), and then retrieves the code and executes a response. Then feedback about achieving the goal reinforces the learner by confirming his or her expectancy. Processing concludes with the learner applying the new learning in new contexts and situations. This phase also leads to developing additional cues for later recall of the capability.

**The Nature of Complex Learning**

Gagné’s analysis of learning includes two organizations of capabilities that represent complex learning. The two organizations are **procedures** and **learning hierarchies**.

**Procedures**

A procedure is (a) a set of different actions that must be executed in a sequential or steplike fashion, and (b) an organization of skills that includes both motor and intellectual skills (Gagné, 1985, p. 262). Examples are writing a check, balancing a checkbook, and parking a car. A far more complex example is nuclear
power production. Physical actions often involve only the manipulation of switches, but knowledge of the internal dynamics and physical layout of the system is essential to identifying problems early (Annett, 2000). Failure to do so leads to disastrous outcomes—as illustrated by the major nuclear accident at Chernobyl.

The procedure of parallel parking a car illustrates the mix of motor and intellectual skills. The motor skills include positioning the vehicle appropriately, backing at low speed in a certain direction, and turning the wheels straight from the turn (Gagné, 1977a, 1985). The intellectual skills include identifying the correct angle of approach, identifying alignment with the other car, and so on. Learning the procedure involves learning to perform the discrete motor skills as well as learning the essential concepts and rules.

Some procedures, such as parallel parking, require learning the step-by-step actions that constitute the total sequence. Others, however, require decisions about alternative steps at certain points in the procedure, referred to as a conditional procedure. In this situation, the outcome of one step provides clues to the choice to be made in the next step (Gagné, 1977a, p. 271). When balancing a checkbook, for example, an individual must determine if the checks are in numerical order. If not, the next step is to arrange the checks in sequence by date of issue.

**Learning Hierarchies**

Procedures are organizations of both motor and intellectual skills. In contrast, a learning hierarchy is “a set of specified intellectual capabilities that have an ordered relationship to each other” (Gagné, 1968b, p. 1). That is, each skill or capability is essential to the learning of the next higher skill in the set. Discussed in this section are the types of component skills and constructing a learning hierarchy.

**Types of Component Skills.** The category of intellectual skills consists of four discrete capabilities: discrimination learning, concept learning (both concrete and defined concepts), rule learning, and higher order rule learning (problem solving). Beginning with discrimination learning, each capability is a prerequisite (component task) of the next higher skill. These capabilities are summarized in Table 5.4.

Acquiring discriminations is important in both everyday life and in school learning (Gagné, 1977a, p. 105). At a young age, children learn to differentiate among various aspects of the environment. Included are shapes, sizes, textures, colors, brightness, and many others. In school, children begin to learn different sounds for printed letters, and many other discriminations. Adults also acquire discriminations, such as the locations of houses and streets, new faces, and the taste of different wines (p. 105).

Discriminations are often prerequisite to learning concrete concepts, such as triangle, table, and book. Concepts are identified as concrete when they can be learned through direct observation. An example of a discrimination that is prerequisite to learning the concept triangle (and other categories of geometric figures) is distinguishing different geometric shapes. Then at the level of learning
TABLE 5.4
Summary of Intellectual Skills from Simple to Complex

<table>
<thead>
<tr>
<th>Type of Capability</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrimination learning</td>
<td>Responding differently to characteristics that distinguish objects, such as shape, size, color</td>
<td>Differentiate between three-sided closed figures and other geometric figures</td>
</tr>
<tr>
<td>Concept learning/concrete concepts</td>
<td>Identifying object or event as a member of a concept class, learned through direct encounters with concrete examples</td>
<td>Identify various examples of triangles, from icicle-shaped to short and wide</td>
</tr>
<tr>
<td>Defined concepts</td>
<td>Learning the classifying rule (concept is abstract; lacks concrete examples)</td>
<td>Learning that patriotism refers to situations that reflect love or zealous support of one's country</td>
</tr>
<tr>
<td>Rule learning</td>
<td>Responding to a class of situations with a class of performances that represents a relationship</td>
<td>Responding to $5 + 2$, $6 + 1$, and $9 + 4$ by adding $2 + 5$, $1 + 6$, and $4 + 9$</td>
</tr>
<tr>
<td>Higher order rule learning (problem solving)</td>
<td>Selecting from memory subordinate rules to solve a problem and applying them in the appropriate sequence</td>
<td>Solving linear equations with one unknown</td>
</tr>
</tbody>
</table>

Concrete concepts, the individual can (a) put objects into a class and (b) respond to any example as an instance of that class (Gagne, 1977a, p. 111).

In contrast, defined concepts have no concrete examples; therefore, they cannot be learned by observing particular instances. They are sometimes described as abstract, and are learned through the concept definition. Examples are cousin (the son or daughter of an aunt or uncle) and transportation (a means or system of conveyance). Defined concepts typically express relationships among other concepts, and the learner needs to know those concepts prior to the new learning. For cousin, for example, the concepts aunt, uncle, son, and daughter are essential.

The next higher level capability is rule learning. “A rule is an inferred capability that enables the individual to respond to a class of stimulus situations with a class of performances” and these “performances are related to the stimuli by a specific class of relations” (Gagne, 1977a, p. 134). The rule illustrated in the example in Table 5.4 is that adding the first number in the problems to the second number is independent of the order in which they appear. The student can demonstrate that the sum of $5 + 2$ may be obtained by adding $2 + 5$ and the student can respond to other simple addition problems in the same way.

Rules are found in all subject areas; included are rules for spelling and forming sentences in language and for all numerical operations in mathematics (Gagne, 1977a, p. 135). An example in language is pronouncing the words mate and sane with a long a and mat and ram with a short a (p. 135). The rule expresses the relationship of the pronunciation of a to the presence or absence of the letter e at the end of the word.
A potential problem in teaching rules is that they may be learned only as verbalizations. However, the capability of stating the rule is only verbal information. This capability is no indication that the student can demonstrate the rule or apply it in various situations.

Higher order rule learning (problem solving) is an extension of rule learning. This process consists of two parts: (a) discovering a combination of previously learned rules that can be applied to solve a novel situation, and (b) when the problem is solved, the new learning is a higher-order rule (p. 157). An example is asking the student to demonstrate that the statement \((a + b)^2 = a^2 + 2ab + b^2\). To do so, the student applies the commutative and distributive properties of multiplication (Gagné, 1977a, p. 157). When the student has solved the problem, he or she can then repeat the process rapidly many times (p. 158).

In summary, each of the capabilities in intellectual skills is a discrete capability. Also, each capability is prerequisite to the next higher skill because it is "folded into" the learning of that skill. For example, learning triangle and related concepts is essential to learning rules about triangles and solving problems involving triangles.

**Constructing a Learning Hierarchy.** Developing a learning hierarchy begins with a clear statement of the terminal objective of instruction, such as subtracting whole numbers. The objective is then analyzed into subordinate skills such that the lower level skills can be predicted to generate positive transfer to higher skills in the hierarchy (Gagne, 1968b, p. 1). The process of constructing a learning hierarchy, **learning task analysis**, begins by asking the following question about the terminal objective: What would the learner have to be able to do to accomplish the objective if given only verbal instructions?

For example, for the terminal objective, "subtracting whole numbers of any size," the answer to the question indicates three subordinate rules. They are subtracting when several borrowings are required in nonadjacent columns, when successive borrowing is required in adjacent columns, and when "double borrowing" is required (across 0) (Gagné, 1979). They are skills VIII, IX, and X in Figure 5.2. Then the same question is asked about each of those skills, which yields the prerequisite skill of subtracting when a single borrowing is required in any column. The questioning is continued until no more prerequisite skills can be identified. In other words, in a valid hierarchy, a connection exists between two skills if the higher element cannot be learned without first learning the lower element (Gagné, 1977a, 1985).

An essential characteristic of learning hierarchies is that they are psychological organizations of skills. A learning hierarchy is neither a logical ordering of information nor a description of the ways in which verbalized knowledge is acquired (Gagné, 1968b). Also, as indicated in Figure 5.2, learning hierarchies do not necessarily consist of a single progression of one each of the four levels of capabilities. In the example in Figure 5.2, the prerequisites to the superordinate rule involve the learning of less complex rules.

One limitation of constructing learning hierarchies is that they do not necessarily indicate the sequence in which new learning should be introduced in the classroom. For example, mathematics instruction does not teach subtracting whole
Subtracting whole numbers of any size

(VIII) Subtracting when several borrowings are required in nonadjacent columns

(IX) Subtracting when successive borrowing is required, in adjacent columns

(X) Subtracting when “double borrowing” is required (across 0)

(IV) Subtracting in successive columns without borrowing

(VII) Subtracting when a single borrowing is required, in any column

(V) Subtracting a one-digit number with borrowing

(VI) Identifying where borrowing is to be done

(II) Subtracting in successive columns where each requires a simple subtraction (no “bringing down”)

(III) Subtracting when a 0 is understood (“bringing down”)

(I) Simple subtraction (“facts”)

FIGURE 5.2
A learning hierarchy for subtracting whole numbers

numbers of any size in a series of connected lessons. Children first are taught to subtract single-digit numbers. Then, later in the curriculum, they learn to subtract larger numbers.

Nevertheless, learning hierarchies can benefit curriculum development in two ways. One is that careful attention to prerequisite skills may reduce the need for remedial instruction. When remediation is necessary, the case often is that some basic skill or set of skills has not been learned. When remedial students attempt problems using basic math operations, they typically make use of rules they have developed themselves—the wrong rules. Similarly, one of the major differences between good and poor readers is the lack of essential prerequisite skills (Gagné, 1982).

The second contribution to curriculum development is that curricula may be designed to reflect process as opposed to content. In the development of "Science—A Process Approach," emphasis was on the skills involved in classifying, measuring, and predicting, rather than that of verbalizing the accomplishments of science (Gagné, 1968b). The application of learning hierarchies in other curriculum areas, in addition to math and science, also can redirect the emphasis from content to process. Examples include the rules of syntax in English and areas within the social sciences, such as classifying family relationships and comparing and contrasting systems of government (p. 144).

Summary
The two organizations of capabilities that represent complex learning are procedures and learning hierarchies. Procedures are sets of actions that are executed sequentially and they consist of both motor skills and intellectual skills. An example is parallel parking a car.

In contrast to procedures, learning hierarchies are organized sets of intellectual skills in which each capability is an essential prerequisite to the next higher skill. A hierarchy is a psychological organization of skills, not a logical sequence of information. The four discrete levels of capabilities possible in a hierarchy are discrimination learning, concept learning (concrete and defined concepts), rule learning, and higher order rule learning (problem solving). Discriminations include distinguishing different forms of objects and events, such as geometric figures. Discriminations also are often prerequisite to learning concrete concepts, which are learned through direct observation.

In contrast, defined concepts have no concrete examples. Often referred to as abstract, they typically express relationships among other concepts, and they are learned by definition. Rule learning, the next higher skill, involves responding to an entire category of situations with a class of performances. Examples of a category of such situations is adding two one-digit integers. The most complex capability in intellectual skills is higher order rule learning (problem solving). The learner is able to select from memory and accurately apply the correct combination of rules to solve a novel situation. When the problem is solved, the learner has acquired a higher order rule (the solution).

Constructing a hierarchy begins with a terminal objective for instruction, and then asks what the learner would have to be able to do to accomplish the
objective, given only verbal instructions. The answer indicates the next highest subordinate skill(s). The question is then repeated for each identified skill in turn until no more prerequisites are identified. The identifications are accurate if a higher level skill cannot be learned without first learning the connected lower skill.

A limitation of learning hierarchies is that they do not necessarily represent the presentation sequence of new learning in the classroom. Nevertheless, a learning hierarchy, by identifying prerequisite skills, can reduce the need for remediation and can provide for process outcomes in the curriculum.

**PRINCIPLES OF INSTRUCTION**

Robert Gagné framed his analysis of the conditions that affect human learning from the perspective of identifying the factors that can make a difference in instruction. As a result, the transition from the principles of learning in the theory to principles of instruction requires no translation. The five varieties of learning as outlined in Table 5.4 are capabilities that are the outcomes of instruction and the internal states required for learning are important prerequisites in instruction. Finally, each of the nine phases of learning is supported by a particular type of event during instruction.

**Basic Assumptions**

Gagné’s assumptions about classroom instruction include the nature of instruction and the process referred to as instructional design.

**Definition of Instruction**

Learning can occur whether or not instruction is present (Gagné, 1987a, p. 400). However, each of the phases in learning identified by Gagné may be influenced in some way by events external to the learner. When deliberately planned to support learning, they are instructional events. These external events do not produce learning; instead, they can only support the learner’s internal processing (Gagné, 1974b).

A second characteristic of instruction is that it does not have a single unitary purpose. Instead, instruction fulfills several functions that match the different information-processing phases of learning. This characteristic means that an external event appropriate for one phase may be inappropriate or irrelevant for another phase (Gagné, 1974b). An instructional event to arouse attention, for example, is different from one needed to support the transfer of new learning.

Third, decisions about instruction must be made in the context of the skill or skills to be learned. Instruction for information, for example, is not the same as instruction for motor skills. Therefore, the question, Is this example of instruction good?, cannot be answered. Instead, the relevant question is, Is this instruction good for learning (information, intellectual skills, motor skills, attitudes, cognitive strategies)? (Gagné, 1974a).
The Nature of Instructional Design

The focus in Gagne's principles is on instruction rather than simply teaching. The intent is to address all the events that may directly influence an individual's learning (Gagne & Briggs, 1979). In addition to teaching, instruction may be delivered by print materials, pictures, television, computer software, and other media. Gagne's principles for the design and development of instruction are an aspect of the larger enterprise known as instructional systems design.

Five assumptions support Gagne's recommendations for designing instruction (Table 5.5). First is that instruction should be designed for the individual student because learning takes place within the individual. The other four assumptions establish the foundation for the systematic design of instruction with provisions for testing and redesign, if necessary. They are to situate daily planning for instruction within long-range planning, do not plan haphazardly, and use the systems approach, which incorporates knowledge about learning and data from tryouts of instruction. (Systems design is discussed later in this chapter.) This approach to developing instruction supports Gagne's emphasis on the major responsibility of society to educate the next generation.

The Components of Instruction

The various kinds of capabilities and the different learning requirements for each were combined by Gagne (1985) into a theory of instruction. The cornerstone of

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Instruction should be planned to facilitate the learning of the individual student.</td>
<td>1. Although students often are grouped for instruction, learning takes place within the individual.</td>
</tr>
<tr>
<td>2. Both immediate and long-range phases should be included in the design of instruction.</td>
<td>2. The teacher or instructional designer plans daily lessons, but the lessons occur within larger segments of units and courses, and they should be congruent.</td>
</tr>
<tr>
<td>3. Instructional planning should not be haphazard or simply provide a nurturing environment.</td>
<td>3. Haphazard planning can lead to adults who are not competent. Therefore, as much as possible, instruction should be developed systematically (Gagne &amp; Briggs, 1979, p. 5).</td>
</tr>
<tr>
<td>4. Instruction should be designed using the systems approach.</td>
<td>4. The systems approach is an organized, sequential selection of components that (a) makes use of information, data, and theoretical principles as input at each planning stage (Gagne et al., 1988, p. 15), (b) tests and crosschecks the output from each stage of development, and (c) makes changes, when necessary.</td>
</tr>
<tr>
<td>5. Instructional design should be based on how human beings learn.</td>
<td>5. Data from research findings and tryouts of instruction can provide information about what works.</td>
</tr>
</tbody>
</table>
the theory is the five varieties of learning. They function as the frame of reference to identify the capability or capabilities that are the outcomes for a particular lesson. Instructional outcomes in the form of performance objectives are developed first. Then instruction is planned by drawing on the instructional events that each support a phase of learning.

**Designing Performance Objectives**

The function of performance objectives is that they are unambiguous statements of the capabilities to be learned. Terms such as *understand, comprehend,* and *appreciate* should be replaced with more precise terms that clearly communicate the skill or attitude to be learned. The source for the wording in performance objectives is the five varieties of learning. Motor skills are found in physical education and dance and also are subcomponents of other school subjects. Examples in kindergarten and the early grades are the physical skills in printing and writing. In contrast, cognitive strategies and attitudes include hoped-for outcomes: developing effective management skills for learning, remembering, and thinking and developing positive, self-confident attitudes toward learning. However, the curriculum, for the most part, emphasizes the learning of information and the acquisition of intellectual skills. An example in mathematics is “The student demonstrates, by solving verbally stated examples, the addition of positive and negative numbers” (rule learning).

Because each of the five categories of learning represents a different class of performances, the verbs used in performance objectives also will differ. For example, *states* or *defines* are appropriate for verbal information that does not involve manipulating information to achieve some outcome. However, these verbs are not appropriate for intellectual skills that require learner interaction with the subject matter. Instead, depending on the level of intellectual skill, verbs such as *selects, classifies, demonstrates,* or *solves* are needed. (See Table 5.6 for a listing of sample verbs.)

Stating the capabilities to be learned in the form of performance objectives fulfills two important functions in the school setting: (a) the needs of instruction are identified, and (b) the requirements for testing are determined. In other words, different capabilities are both taught for and tested in different ways. Verbal information may be tested by asking the student to state a particular item of information or the set of ideas in a text passage. The testing of intellectual skills, in contrast, requires that the student (a) interact with the stimulus situations using symbols to manipulate the information, and (b) respond to a new set of situations that is not the same as that used in instruction.

**Selecting Instructional Events**

Gagné identified nine instructional events to use as a guide for planning instruction. Their function is to support the learner’s cognitive processes during learning. For example, saying “Today we are going to learn to figure earned run averages of baseball players” (stating the objective) assists the student to establish the purpose and key elements of the events that are to follow (expectancy for learning). Similarly, providing hints or cues can facilitate the encoding and storage of the new learning in long-term memory. Table 5.7 lists the instructional events for each of the nine learning phases.
TABLE 5.6
Suggested Verbs for the Varieties of Learning

<table>
<thead>
<tr>
<th>Capability</th>
<th>Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>States, defines, paraphrases</td>
</tr>
<tr>
<td>Motor skill</td>
<td>Executes, performs, enacts, pronounces</td>
</tr>
<tr>
<td>Attitude</td>
<td>Chooses to . . . , free elects to . . . , selects (a preferred activity)</td>
</tr>
<tr>
<td>Cognitive strategy</td>
<td>Originates (a strategy)</td>
</tr>
<tr>
<td>Intellectual skills</td>
<td></td>
</tr>
<tr>
<td>Discriminate</td>
<td>Selects (same and different)</td>
</tr>
<tr>
<td>Concept</td>
<td>Identifies (examples), classifies (into categories)</td>
</tr>
<tr>
<td>Rule</td>
<td>Demonstrates, predicts, derives</td>
</tr>
<tr>
<td>Higher order rule</td>
<td>Generates (a problem solution), solves</td>
</tr>
</tbody>
</table>

Preparation for Learning. Gaining attention, informing learners of the objective, and stimulating the recall of prior learning are three instructional events that set the stage for new learning. Gaining the learner's attention may be accomplished by asking a provoking question, depicting an unusual event, or appealing to a child's particular interests. For example, a lesson on the Earth's atmosphere may begin with a question, such as "Did you know that one of the things we

TABLE 5.7
Relationships Between Learning Phases and Instructional Events

<table>
<thead>
<tr>
<th>Description</th>
<th>Learning Phase</th>
<th>Instructional Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation for learning</td>
<td>1. Attending</td>
<td>Gain learner's attention through unusual event, question, or change of stimulus</td>
</tr>
<tr>
<td></td>
<td>2. Expectancy</td>
<td>Inform the learner of the objective</td>
</tr>
<tr>
<td></td>
<td>3. Retrieval (of relevant information and/or skills) to working memory</td>
<td>Stimulate recall of prior learning</td>
</tr>
<tr>
<td>Acquisition and performance</td>
<td>4. Selective perception of stimulus features</td>
<td>Present distinctive stimulus features</td>
</tr>
<tr>
<td></td>
<td>5. Semantic encoding</td>
<td>Providing learning guidance</td>
</tr>
<tr>
<td></td>
<td>6. Retrieval and responding</td>
<td>Elicit performance</td>
</tr>
<tr>
<td></td>
<td>7. Reinforcement</td>
<td>Provide informative feedback</td>
</tr>
<tr>
<td>Transfer of learning</td>
<td>8. Cueing retrieval</td>
<td>Assess performance</td>
</tr>
<tr>
<td></td>
<td>9. Generalizing</td>
<td>Elicit performance with new examples</td>
</tr>
</tbody>
</table>
breathe every day is sulfuric acid?” (Gagné & Driscoll, 1988, p. 73). The teacher may say, “Today we are going to learn why leaves change colors and fall from the trees” or “Let’s find out why the liquid changes color when certain drops are added.” The answer to the initial question or the response to the unusual event provides closure and informs the learner of the new objective (event 2).

The importance of informing students of the objective should not be underestimated, particularly for elementary school children. Most are unable to determine the skills and concepts to be learned from their academic tasks (Peterson, 1988). Typically, they report that the goal, particularly for seatwork, is to get the task finished (p. 323).

Next, to prepare the student for a new level of learning, the instruction should stimulate the recall of important prerequisites (event 3). Relevant information, concepts, and rules, such as how plants make food, may be needed. Recall is stimulated through the use of questions such as Do you remember . . . ? or What did we do yesterday that might help us answer this question?

However, the teacher faces a particular problem in whole-class instruction. A typical method is to question the class and call on a volunteer or another student to answer (Gagné, 1980b, p. 2). The problem is that the answers of one or two students are no guarantee that the same prerequisites are accessible to the others. However, the teacher cannot call on every student. One teacher addressed this problem by involving the children in a pre-lesson exercise. In a unit on linear measurement, she gave the children sticks of different lengths. They then were asked to think about using the sticks to measure the height of a box (Gagné & Briggs, 1979, p. 167). Recall of the skill of counting numbers was initiated as each of the children used a particular length of stick to determine the height.

**Acquisition and Performance.** The core events of instruction are presenting distinctive stimulus features, providing learning guidance, eliciting performance, and providing feedback. The stimulus characteristics, or situations with which the learner is to interact during instruction, are presented first. Next, the instruction provides learning guidance by presenting specific situations accompanied by hints or prompts as needed. The communications to the learner should stimulate a particular direction of thought and therefore prevent the learning from getting off the track (Gagné & Briggs, 1974, p. 129).

Providing learning guidance is a critical event in instruction (Gagné, 1980b). First, it helps the learner transform the new capability into a code for later recall. Second, it can make a difference as to whether the new learning is relatively easy or hard, and whether instruction will be effective or ineffective (Gagné, 1980b, p. 6).

To determine the effectiveness of encoding, the teacher asks the student to demonstrate the new capability. Feedback is then provided that indicates either necessary corrections or provides reinforcement by confirming that the objective has been achieved.

The core events should be flexibly implemented for different kinds of learning. For example, instruction for the concept “circle” may include a variety of circles of different colors or sizes (presenting the stimulus). Examples made of string or rope also may be used (Gagné & Briggs, 1974, p. 129). In addition, the children
might be asked to join hands and form a circle. Then the children may be presented with a variety of pictures and other examples that include different geometric figures. They may be asked to look carefully at each picture in the set and to decide which ones represent circles. Hints or prompts concerning the characteristics of circles may be provided by the teacher as each picture is introduced and included in the set (providing learning guidance).

After identification of several circles, with teacher assistance, the children may be asked to point to examples in a new set of geometric figures or pictures (eliciting performance). Incorrect identifications are followed by reminders about the characteristics of circles and comparisons with the examples already identified (providing informative feedback).

The Role of Guided Discovery. The objective in rule learning is that the student can respond to an entire class of situations with a class of performances that reflects a particular relationship to the stimulus situations. For example, having learned to simplify fractions, the student can apply the rules for that task in any situation.

To ensure that the learner actually has acquired a generalizable rule, and not simply a verbal statement, effective instruction cannot rely on simply telling the learner the rule. (The only outcome that can be guaranteed with this strategy is that the learner can state the rule.) Also, according to Katona’s (1940) research on the matchstick problems, showing the learner the specific solutions to several problems was not effective (Gagne, 1977a, p. 158). Gagné (1977a) concluded that presenting the solutions was ineffective because this strategy did not require the learners to acquire the rule.

Effective instruction for the matchstick problems consisted of the researcher illustrating the necessary structural changes by using a rule (a matchstick that forms the sides of the two squares can be changed to form the side of one square), but not stating the rule. The researcher shaded drawings of the matchstick square to create “holes” in the configuration, illustrating, for example, how five squares can be reduced to three by moving only three matches. The learners’ subsequent performance indicated that they had discovered the rule. Gagné (1977a) described this approach as guided discovery (p. 159), and replicated the findings in math (Gagné & Brown, 1961). A review of 30 years’ research comparing expository, discovery, and guided discovery on various tasks by Mayer (2004) found that guided discovery was the only effective method.

An example of guided discovery in rule learning is discovering the rule of prime numbers (they are divisible only by the number itself and 1). The student first may be asked to recall that any number can be expressed as the product of various factors (e.g., $4 = 2 \times 2; 4 \times 1$). The distinctive stimulus for learning is a succession of numbers from 1 to 10, and asking the student to write out the various factors for the set. Hints to assist the student to notice the unique characteristic of prime numbers are to ask (a) do the factors for any of the numbers vary in any way, and (b) what are the differences between the numbers 3, 5, 7 and 4, 8, 10 (Gagné & Briggs, 1974, p. 129).
**Retrieval and Transfer.** The concluding segment of instruction provides for assessment of the new learning followed by additional cues for retrieval and transfer. For assessment, new situations or examples should be presented to students to be certain that learning is not restricted to the examples introduced in the core events of instruction. Instruction should then conclude with stimuli specifically designed to enhance retention and transfer. This phase may take the form of spaced reviews after a reasonable delay of a day or more after the initial instruction (Gagné, 1974a). For example, if the student has learned to define legislative with regard to the U.S. Congress, spaced reviews may include the meaning of the term at the level of city and state government (p. 116).

In summary, teachers and instructional designers select verbal statements, questions, objects, diagrams, and other stimuli to stimulate the learner's internal processing of information. These stimuli are selected to meet the requirements of particular instructional events.

**Applicability to the Varieties of Learning.** The set of nine instructional events is executed in somewhat different ways for each of the five varieties of learning. Table 5.8 illustrates the unique external conditions (requirements for instructional events) for the five types of capabilities. For example, in introducing instruction for attitudes, the teacher does not inform students of the objective, but first should establish respect for the model who is to execute the appropriate behavior. In contrast, introducing instruction for intellectual skills requires stimulating the recall of prerequisite skills that are subcomponents of the new skill to be learned.

Also important is that the set of instructional events should not be treated as an iron-clad sequence. Learning a complex concept, for example, may require cycling through the core events two or three times, given the number of criteria essential for identifying concept examples. The instructional plan at the end of this chapter is an example.

Although the instructional events were developed for teacher and other media-directed instruction, Flynn (1992) observed them in a fourth-grade cooperative learning environment. The teacher set the stage (preparation for learning), and the core events of instruction occurred in peer interactions in small groups. Flynn suggested that these events contribute to the effectiveness of the cooperative learning model over large-group instruction because the group interactions provide enhanced opportunities for their occurrence.

In summary, instructional events are selected for performance objectives based in large measure on the variety of learning represented by the objective. However, events are included as needed for the types of students and complexity of the information, skill, strategy, or attitude to be learned.

**The Role of Media in Instruction**

The term "media" typically conjures up images of computer-assisted instruction, instructional television, videocassette and CD/DVD recordings, and similar mechanized delivery systems. However, instructional media also include the teacher's voice, printed text, and real objects—in short, any physical means that communicates an instructional message (Gagné & Briggs, 1979; Reiser & Gagné, 1983).
### TABLE 5.8
Unique External Conditions of Learning for the Five Varieties

<table>
<thead>
<tr>
<th>Preparation for Learning</th>
<th>Core Instructional Events</th>
<th>Transfer of Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal information</td>
<td>Provide meaningful context of information for encoding. Provide elaborations, imagery, or other encoding cues. For bodies of knowledge, present information so that it can be learned in chunks.</td>
<td>Give cues for effective retrieval and generalization.</td>
</tr>
<tr>
<td>Intellectual skills</td>
<td>Stimulate recall of prerequisite skills.</td>
<td>Provide varied concrete examples and rules. Provide opportunities for interacting with examples in different ways. Assess in new situations.</td>
</tr>
<tr>
<td>Cognitive strategies</td>
<td>Elicit recall of necessary intellectual skills.</td>
<td>If task-specific, describe the strategy; if general, demonstrate the strategy. Provide opportunities for strategy practice with support and feedback.</td>
</tr>
<tr>
<td>Motor skills</td>
<td>Show performance of skill to be learned. Stimulate recall of part-skills, if appropriate.</td>
<td>Establish executive sub-routine and provide for mental rehearsal. Arrange several repetitions of skill with corrective feedback.</td>
</tr>
<tr>
<td>Attitudes</td>
<td>Learner is not directly informed of the objectives. Establish that learner respects the model.</td>
<td>Provide respected model(s) who enact positive behavior and reinforce the model. When learner enacts the behavior, provide reinforcement.</td>
</tr>
</tbody>
</table>

The typical approach to media selection is to choose a media form and then plan the instruction. However, this approach is deficient in two ways. First, research on media utilization indicates that no one medium is universally superior to all others for every type of learning outcome for all learners (Gagné et al., 1988, p. 204). Therefore, to choose arbitrarily computer software or some other medium for a lesson is to ignore factors such as learner characteristics and task
variables that can influence the effectiveness of a particular delivery system. Computer-assisted instruction, for example, can provide the interactive tutoring capability for the core events in intellectual skills for some learners. For example, in mathematics and the natural sciences, interactive computer-based representations can provide both concrete, graphic representations of difficult concepts and opportunities for students to interact with the situations. Numberspeed, for example, illustrates motion, velocity, and acceleration through the movement of two turtles racing on a track that students manipulate.

Second, the arbitrary selection of media can result in the omission of essential instructional events. A film or audiotape, for instance, may provide content but exclude instructional events such as providing learning guidance or pauses for student responding and feedback (Gagné et al., 1988, p. 199). Also, with a few notable exceptions, many of the computer materials developed for the public school classroom are inadequate examples of instruction. For example, the majority of computer exercises labeled “simulations” are either competitive games or drill-and-practice exercises accompanied by animated graphics (Gredler, 1986). Like other models of media selection, the model developed by Reiser and Gagné (1983) first provides the identification of a range of appropriate choices and then narrows the choices to one or two.

Criteria to be considered first are the nature of the learning outcome and the characteristics of the learners. For example, self-directed learners may be successful with hypertext, which includes several paths that users may select. However, other learners may become confused and lose their way.

The next step is to review the choices for the capability of providing the required instructional events. The final selection is based on practical factors, such as cost, size of the group to be accommodated at one time, and ease of implementation.

The media selection model is useful for expanding one’s thinking about the various types of media for instruction. It is particularly useful when the same unit of instruction will be replicated several times with similar groups of students.

**Summary**

Performance objectives are unambiguous statements of the capabilities to be learned in a unit. The source for writing objectives is the five varieties of learning. Performance objectives that state the capabilities to be learned identify both the needs of instruction and the requirements for testing.

The guide for planning instruction for the objectives is the nine instructional events identified by Gagné. Developed to support the internal processing phases of learning, the nine events reflect three stages of instruction. In the first stage, preparation for learning, instruction should gain the learner’s attention, inform the learner of the objective, and stimulate recall of prior learning. One problem faced by teachers in whole-class instruction is that the responses of a few students do not indicate whether the remainder of the class also has recalled relevant information. One solution is to involve the class in a pre-lesson exercise.

The core events of instruction are presenting distinctive stimulus features, providing learning guidance, eliciting performance, and providing feedback.
Providing learning guidance is a critical event because it helps the learner transform the new capability into a code to be remembered. The purpose of eliciting student performance is to determine the effectiveness of the encoding. Then feedback provides either needed corrections or reinforcement by confirming accurate responses. For rule learning and higher order rule learning, instruction should implement guided discovery. Building on prior learning, instruction provides hints to assist the learner to infer the rule.

The concluding segment of instruction consists of assessment of the new learning in the form of new situations. Additional cues for retrieval and transfer also are generated.

Application of the instructional events to the five varieties of learning leads to differences in instruction for the different learning outcomes. Elaboration, imagery, and methods of encoding chunks of information are sufficient core events for verbal information. However, they are not appropriate for intellectual skills. Instead, students must interact with situations and examples in a variety of ways. Attitude change, in contrast, depends on respected models and reinforcement for positive behaviors.

Also important in the use of instructional events is that they are not an ironclad sequence. Once the instructional events are identified, media may be selected. In other words, one does not first select media, such as television or the computer, and then design instruction. Instead, media are selected to fit the requirements of particular instructional events.

**Designing Instruction for Complex Skills**

Defining each capability to be learned in the form of a performance objective and selecting appropriate instructional events are the basics in the design of instruction. However, the goal is to address the cumulative nature of human learning. As described earlier, the two sets of capabilities are procedures and learning hierarchies.

**Instructional Design for Procedures**

The first step in developing instruction for complex skills is to determine the set of skills to be taught. For a procedure, each separate step is identified first. For example, for the procedure of parallel parking a car, the identified sequential skills are positioning the car about a foot away from and even with the car in the next forward space, backing at an angle of 35-40 degrees, turning the front wheels so the car will be near the curb, moving the car forward, and then straightening the front wheels (Gagné, 1977a, p. 215).

The motor skills in the sequence are then analyzed into part-skills that also may need to be taught. An example is the skill of backing up a car, which is an essential step in parallel parking. Stopping the car at the right point so that it is neither too close nor too far away from the curb is a part skill in backing up the vehicle. Also prerequisite to backing the car is the intellectual skill of judging the appropriate angle of approach (35-40 degrees).

For some procedures, choices between alternative steps may be required. For example, one step in reconciling a bank statement with check records is to
determine if the checks are numbered. If the answer is yes, the checks are arranged in numerical order. If the answer is no, the checks are arranged by date of issue (Gagné, 1977a, p. 262). Both alternatives must be included in the instruction.

After the skills, part-skills, and intellectual skills are identified, the type of capability of each skill is identified. Performance objectives then are written for each, and instruction is planned for the set of objectives.

**Instructional Design for Learning Hierarchies**

The section in this chapter on the nature of complex learning introduced learning task analysis, the method of constructing a learning hierarchy. The question, What simpler skill is essential to the present skill?, is first applied to the most complex skill to be taught, and then to the other skills so identified. Correct identification of subordinate skills requires the identification of component mental operations, not the identification of items of information (Gagné & Briggs, 1974, p. 113). Also, the key word is essential. Many simpler skills may be identified that are not integral components of the skill to be learned. The prerequisite skill is the one that must be recalled by the student if the learning is to proceed rapidly and without difficulty. An example is the skill “subtracting a one-digit number with borrowing” in Figure 6.2. An immediate prerequisite skill is “subtracting when a zero is understood (bringing down).” Learning to subtract zero from a one-digit number is essential to learning to subtract one-digit numbers that do not require borrowing.

The importance of learning task analysis is illustrated by the objective “converting Fahrenheit to Celsius temperature readings” (Gagné & Briggs, 1974, p. 113). One might be tempted to identify a prerequisite as “knowing that $C = \frac{5}{9} (F - 32)$.” This statement, however, is an item of information. In contrast, the prerequisite skills include “finding numerical values of an unknown variable by solving equations” and “substituting numerical values of variables in equations to yield a single numerical value for a variable” (p. 113).

Each skill identified by the questioning procedure also is subjected to the same question to determine the next simpler set of prerequisites. This analysis by questioning is repeated until a logical endpoint is reached for the particular group of learners. The logical endpoint is the set of prerequisite skills that the students already have learned. These skills are identified as the entry capabilities for the unit or course of instruction.

Each skill to be taught is then categorized as to type of capability and is written in the form of a performance objective. The relevant verbal information and attitudes also are identified and written as performance objectives. Instruction is developed for each objective, using the instructional events described earlier.

**Cognitive Task Analysis**

Learning hierarchies are sets of intellectual skills in which learning a higher capability, such as simplifying fractions, is dependent on learning the prerequisite skills. A learning hierarchy, in other words, is a set of directly observable capabilities.
However, the introduction of high-speed computers into a variety of situations introduced the need to go beyond traditional task analysis to adequately describe human performance. For example, the physical acts of pushing buttons in the command center of a modern ship are not the most important aspect of steering the vessel. It is the mental decisions that guide the button pushing (Chipman, Schraagen, & Shalin, 2000, p. 3).

Cognitive task analysis, an extension of traditional task analysis, emerged to address the goals, knowledge, mental processes, and decisions that underlie observable actions (p. 3). The methods are needed because evidence indicates that experts are only dimly aware of 70% of their mental analyses of tasks and their decisions (Clark & Elen, 2006). For example, cognitive task analysis applied to monitoring newborns by experienced neonatal nurses indicated that their recall omitted 25 of the 70 important diagnostic cues (Crandall & Getchell-Leiter, 1993, in Clark et al., in press). Moreover, experts cannot completely explain their thinking even when their intention is to contribute to the design of job training or the assessment of performance.

As indicated in Table 5.9, the first three steps in cognitive task analysis are to collect preliminary information about the task, identify essential subtasks, and use interviews to identify the needed conditions and cognitive processes essential for the tasks. Then the instructional designer categorizes and summarizes the data and presents the results to experts for review and refinement. The final step is to format the results for use.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collect preliminary information</td>
<td>Use unstructured interviews, documents, questionnaires, and observations to determine the importance, representativeness, and frequency of tasks.</td>
</tr>
<tr>
<td>2. Identify knowledge representations</td>
<td>Examine tasks to identify subtasks and types of knowledge required to perform them.</td>
</tr>
<tr>
<td>3. Implement knowledge-elicitation techniques</td>
<td>Use structured and unstructured interviews to identify the conditions and cognitive processes essential for complex problem solving.</td>
</tr>
<tr>
<td>4. Analyze and verify the data</td>
<td>(a) Code the data obtained in step three to categorize, summarize, and/or develop a synthesis of the data.</td>
</tr>
<tr>
<td>5. Format the results for use</td>
<td>Translate the results into models that portray the underlying skills, problem-solving strategies, and mental models that experts implement in highly complex tasks.</td>
</tr>
</tbody>
</table>

Table 5.9
Major Steps in Cognitive Task Anaysis\(^1\)

\(^1\) Compiled from Clark et al. (in press) and Chipman et al. (2000)
Currently, cognitive task analysis is used to analyze job components in various situations (Clark, 2006; Dubois & Shalin, 2000). Included are developing optimal human–computer interactions, the development of training and tests to certify job performance, and the design of expert systems (Chipman et al., 2000, p. 5).

EDUCATIONAL APPLICATIONS

Programs in several areas have implemented the concepts of component subtasks and prerequisite skills. For example, Reading Recovery, a program for the poorest readers, has found that understanding basic concepts about print is essential to success in reading instruction. Among the basic concepts are identifying the front of the book, indicating that print (not pictures) carries the message, identifying the purpose of the spaces between words, and so on (Clay, 1999). In arithmetic, Griffin et al. (1994) found that a significant number of low-income inner-city children lack central essential prerequisites for beginning formal arithmetic. They also use maladaptive strategies, such as counting up from either addend in a simple addition problem. The essential capabilities, which most middle-income children acquire prior to school, include counting reliably, quantifying sets, matching sets of numbers, and correctly identifying the larger and smaller numbers in a particular problem (p. 37).

Classroom Issues

Gagné’s approach to the analysis of learning is from the perspective of the needs of instruction. As a result, his work addresses several issues of importance in the classroom.

Learner Characteristics

Individual differences, readiness, and motivation are issues for both the systems approach to designing instruction and the classroom teacher. Gagné (1974a, 1980a) and Gagné and Briggs (1979) discuss these issues with regard to both instructional design and the delivery of instruction.

Individual Differences. The effectiveness of instruction is influenced by several kinds of individual differences among students. Included are differences in cognitive strategies and rate of learning. Particularly important, however, are differences in student entry capabilities (Gagné, 1974a) (see the “Readiness” section below). Entry capabilities are “the raw materials with which instruction must work” (Gagné, 1974a, p. 125). They may be assessed at several beginning points within the curriculum, such as the beginning of a school year or the start of a new course or unit.

Methods of compensating for individual differences in the delivery of instruction include small-group instruction, the tutorial mode, independent learning (Gagné, 1974a), and individualized instructional systems (Gagné & Briggs, 1979). The advantage of individualized systems is that they are delivery systems for adjusting instruction to the individual student in a group of 25 or more (Gagné & Briggs, 1979, p. 261).
Readiness. For Gagné (1968a, 1977a), developmental readiness is viewed as the individual's relevant capabilities. Readiness is not a matter of maturation in which certain growth changes must take place before learning can occur (referred to as the growth-readiness model; Gagné, 1968a). Nor is readiness a matter of the gradual internalization of logical forms of thought, as Piaget (1970) suggested. Both of these models, Gagné notes, have assigned a secondary role to the influence of learning in human development. However, because learning is cumulative, readiness for new learning refers to the availability of essential prerequisite capabilities. As discussed earlier, readiness includes the lower skills in the hierarchy of intellectual skills and the essential rules, concepts, and part-skills in procedures.

Motivation. Designing effective instruction includes the identification of student motives and the channeling of those motives into productive activities that accomplish educational goals (Gagné, 1977a, p. 287). Although often treated as a single characteristic, motivation includes both general and specific types. General motivational states include David McClelland's (1965) achievement motivation and R.W. White's (1950) competence motivation (Gagné, 1977a). More specific types include incentive motivation and task motivation, both of which may be developed through the careful use of reinforcement contingencies. That is, reinforcement for the activities of working with other children, relating to school tasks, and for mastery and accuracy can establish incentive motivation (Gagné, 1977a).

Cognitive Processes and Instruction
Gagné's analysis of learning is conducted from the perspective of the factors that make a difference in instruction. Therefore, the issues of transfer of learning, the students' self-management skills, and the teaching of problem solving are integral components of the conditions of learning.

Transfer of Learning. The concept of learning transfer is the heart of Gagné's model of cumulative learning. First, Gagné describes essential prerequisites for each of the five varieties of learning. Second, the essential prerequisites within intellectual skills provide for transfer in two ways. They contribute to the learning of the next higher order skill, and they also generalize to other situations. Examples include the skills of adding, subtracting, multiplying, and dividing whole numbers and fractions.

The sequence of nine instructional events also includes attention to transfer of learning. At the conclusion of learning, new situations or examples are presented to the students to ensure that the new learning is not limited to the situations used in the core and instructional events. New cues for retrieval also are developed.

Learning "How-to-Learn" Skills. These skills are the cognitive strategies identified by Gagné (1972, 1977a). They are the ways that the individual manages his or her learning, remembering, and thinking. Gagné notes that improving students' how-to-learn skills so that each student is "working up to potential" is one of the most challenging problems for education (Gagné, 1977a, p. 36).
Teaching Problem Solving. Higher order rule learning or problem solving involves generating a solution to a problem that is new to the learner. Required of the learner is the recall of relevant rules and their application in the correct sequence. Required of instruction are that (a) the learner has already acquired the necessary rules, (b) a problem situation is presented to the learner that he or she has not encountered before (Gagné & Briggs, 1979, p. 71), and, at a minimum, (c) guidance is in the form of informing the learner of the objective.

Problem solving, although it includes discovery learning, differs from the solving of novel problems suggested for cognitive strategies. In cognitive strategies, the learner is originating a solution that may require the selection of information from a variety of sources and the combining of information in novel ways. In the problem solving included in intellectual skills, the learner is generating a solution that requires the recombination of previously learned related rules. The result is a higher order rule.

Implications for Assessment
Gagné's interest in the diversity of human activities led to his identification of five kinds of capabilities, and each type is a unique class of human performance. They are verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. They can contribute to developing assessments in at least three ways. They are (a) pretests on essential capabilities to be learned during instruction, (b) posttests at the end of instruction to determine whether learning was successful, and (c) during teaching, as informal assessments. For example, the capability of noting that triangles, circles, and rectangles are different (discrimination learning) is an important component of learning the concept triangle, and would likely be assessed informally prior to instruction about triangles.

In terms of the format for an assessment, each variety of learning requires a different type of assessment. Verbal information requires stating or paraphrasing information and may be assessed with either short-answer items for definitions or requiring brief paragraphs for information that is to be summarized (e.g., What are the major points of the Kosovo Dayton Accords?). Multiple-choice items, however, are not adequate for assessing verbal information because they involve the recognition of information, not the production of information.

Intellectual skills, which require the manipulation of symbols in interacting with the environment, cannot be assessed adequately by simply asking learners to state information. Instead, assessments must require the manipulation of symbols in a way that meets the conditions of the particular intellectual skill. For example, for defined concepts, a modified matching question is appropriate. For example, in a course on assessment, the question may state as follows: Identify which of the following brief scenarios are examples of test validity, test reliability, or neither (validity or reliability). The items to be identified then must include a range of situations for each concept, as well as items that may superficially resemble the concepts, but are not concept instances. In kindergarten, for example, the teacher may use pictures or drawings of concept instances and nonexamples to informally assess the children's acquisition of concrete concepts.
Higher order rule learning typically involves problem situations that require the students to select from memory and then apply the appropriate rules in sequence to solve the problems. Assessment situations should not be the same situations used in instruction or the same situations with only minor tweaking. Instead, the context of the problem scenarios should be different to ensure that the students have acquired the essential capabilities independent of context cues.

Verbal information and intellectual skills are applied to selected content and may be assessed with paper-and-pencil tests. In contrast, the focus of cognitive strategies is one’s own thinking. Included are problem approach strategies that involve mentally searching for relevant information, and dividing a problem into parts. Assessment of cognitive strategies may implement verbal protocols—the student’s “talk-aloud” about his or her mental planning and monitoring activities during problem solving. However, this added responsibility does alter the particular processes somewhat. Another mode of assessment for cognitive strategies is student self-report on a questionnaire or survey. However, individuals typically overestimate the extent to which they implement such strategies.

Assessment of motor skills requires observation of the student, in either a live or videotaped performance. A checklist of essential moves and actions can assess the extent of mastery. In contrast, the domain of attitudes in the school setting refers to interests, appreciations, and values, as well as self-esteem and self-concept. Methods of assessment include rating scales and classroom observations. Rating scales typically are constructed in a Likert scale format in which response options typically range from “strongly agree” to “strongly disagree.” Classroom observations also may use rating scales, narrative descriptions, checklists, or coding systems that record particular behaviors.

The Social Context for Learning
The methods recommended by Gagné (1977a) and Gagné and Briggs (1979) focus on the design of instructional systems rather than on the development of models of teaching. A major difference between the two is that models of teaching place the teacher or the individual in the role of conducting and/or managing instruction for some identified group of learners. Instructional systems, in contrast, often include sets of materials and activities for which the pacing and management of instruction may reside in the learner. As a result, the context for learning with regard to instructional design is discussed in terms of the effects on the management of instruction (Gagné & Briggs, 1979). That is, the differences in the implementation of instructional events among the tutoring situation, small-group instruction, and large-group instruction are described. Gagné and Briggs also discuss the implications of different entry capabilities of students for each of these contexts.

Relationships to Other Perspectives
Unlike prior theorists, Gagné began his analysis with the various skills and capabilities that humans enact in diverse situations. Noting that some theories had identified at least part of the complex picture of human learning, his conditions of learning incorporate the Gestalt concept of partial insights and guided discovery in the description of intellectual skills, and the modeling
plus reinforcement component from Bandura’s theory in the description of attitudes.

Gagné’s conditions of learning also is a bridge between the behavioral focus of operant conditioning and the cognitive approaches to learning. That is, learners acquire responses, and environmental events (the events of instruction) are essential to learning (behavioral principles). However, the responses reflect different kinds of internal capabilities and require different internal states (mental events). Furthermore, the variety of learning referred to as cognitive strategies is also reflected in the information-processing concept referred to as metacognition.

Like operant conditioning, in the classroom, the sequence of instruction in the conditions of learning is teacher-directed and managed, and moves toward a predetermined outcome for learners. It differs from social constructivism in which the community of learners, with input from the teacher, largely determines the direction and depth of learning. It also differs from the cognitive perspectives, which, although discussing internal processing activities of the learner and instructional supports, often do not specify the learning outcome.

Developing a Classroom Strategy

According to the systems approach, the design of a classroom lesson is one component of a total process that includes both curriculum and instruction. Therefore, ideally, developing particular lessons is preceded by design at the curriculum and course levels.

The Systems Design Model

Systems models for instructional design are characterized by three major features. First, instruction is designed for specified goals and objectives. Second, the development of instruction utilizes media and other instructional technologies. Third, pilot tryouts, materials revision, and field testing of the materials are an integral part of the design process. In other words, systems models specify objectives, design the instruction, and try out the materials with students, revising the instruction until the desired achievement is produced. The design, tryout, and revision process is the major characteristic of systems models; the development is a “closed-loop” process.

The systems model designed by Gagné and Briggs (1979) includes all the stages in the design of curriculum and instruction (Figure 5.3). It begins with needs assessment and the development of goal statements. The model also entails the development of end-of-course objectives, specific performance objectives, instructional events, selection of media, and field testing of the final product.

One important feature of the model is that it places lesson development within the total context of curriculum design. In so doing, it extends the concept of cumulative learning beyond instruction to the curriculum level. The relationship between learning at the instructional and course levels is illustrated by the following set of objectives:

1. Course Objective. The student can critically analyze events and situations in a country’s judicial, governmental, economic, and political systems, consistent with that country’s identified priorities.
2. Unit Objective. The student can demonstrate the relationships between political and economic systems.

3. Specific Subskill. The student can classify systems as "political" or "economic."

In the design model, the term formative evaluation (step 11) refers to materials tryout with small groups of students. The purpose is to identify areas in the instruction that are not working effectively and to revise them. After these changes are made, field testing is undertaken with a large group. Minor changes in the materials may be required after the field test (step 12). Finally, summative evaluation (step 13) assesses the materials with a typical population. This evaluation certifies the objectives that are met by the instruction and identifies the population for which the materials are effective.

Designing the Lesson. The complete systems model is designed for curriculum development that includes both courses and units of instruction. However, the principles are applicable to the design of individual lessons.

Step 1: Write or select performance objectives.

1.1 What is/are the culminating skill(s) to be learned at the end of the lesson?

1.2 What are the related subordinate skills? If learning to use a rule is the end-of-lesson skill, what are the supporting concepts? If a
cognitive strategy is to be learned, what are the related intellectual skills?

1.3 Determine which of the supporting skills are entry skills to the lesson and which are to be taught as part of the lesson.

1.4 Select appropriate verbs for the skills to be taught and write in the form of performance objectives.

Step 2: Select instructional events for each of the performance objectives.

2.1 Identify the variety of learning for each objective. If intellectual skills, identify as to discrimination skill, concept learning, rule learning, or higher order rule learning.

2.2 Identify entry skills and particular characteristics of the group to be taught (e.g., average or poor reading ability).

2.3 Given 2.1 and 2.2, select instructional events to meet the unique learning conditions for each objective.

Step 3: Select media for instructional events.

3.1 Identify several choices that meet the requirements for the particular learning outcome.

3.2 Eliminate media inappropriate for the age and/or reading level of the learners.

3.3 Make final media choices for instructional events based on cost, size of the group, and ease of implementation.

Step 4: Develop tests for objectives.

4.1 Write four to eight items per objective that reflect the performance stated in the objective. For example, for "identifying the main idea," select several short paragraphs with a set of possible choices for each.

4.2 Assemble the items for each objective into a test and check for length and item difficulty.

Classroom Example

The lesson in Table 5.10 is an example of instruction designed for the objective of identifying the main idea. The lesson builds on a concept learned previously, that of topic (who or what a story is about). The lesson illustrates the use of the nine instructional events in specific classroom activities.

Note that in step 4, present distinctive stimulus features, the teacher presents core information that illustrates the defining rule of the concept of the main idea. This information is applied first by the teacher and then by the students in the identification of concept examples.

The use of the game in step 5 provides a chance for the children to try out their new skills prior to assessment of their performance. The game thus provides a source of feedback other than the teacher.

During the lesson, instructional events 5, 6, and 7 are repeated to give the children experience with two types of statements often confused with the main idea. The two types are general statements that do not describe the topic and
### TABLE 5.10
Classroom Example

**Capability to be learned:** The students can identify statements that represent the main idea for short selections (fourth and fifth graders).

<table>
<thead>
<tr>
<th>Instructional Event</th>
<th>Medium for Instruction</th>
<th>Classroom Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gain attention</td>
<td>Teacher communication</td>
<td>Teacher asks students to name their favorite TV show or story.</td>
</tr>
<tr>
<td>2. Inform learner of the objective</td>
<td>Teacher communication</td>
<td>Teacher asks the children if they know how to tell someone what the show (story) is about without retelling the story. Teacher explains that they are going to learn how to find the main idea of story so they can tell a friend what the story is about.</td>
</tr>
<tr>
<td>3. Stimulate recall of prior learning</td>
<td>Teacher communication</td>
<td>Learners asked to recall the term <em>topic</em> (who or what a story is about).</td>
</tr>
</tbody>
</table>
| 4. Present distinctive stimulus      | Transparency and teacher communication  | **Transparency:** TOPIC + SOMETHING SPECIAL ABOUT THE TOPIC = MAIN IDEA  
Example: Three Little Pigs  
Main idea: The three pigs (topic) built houses, and the wolf blew down all except the brick house.  
Teacher explains why the statement is the main idea. |
| features                             |                                         | **Transparencies:**  
Brief situations plus set of three statements about each. In each set, one choice is the main idea; others are specific details. Teacher and students discuss options and reasons for correct choices. |
| 5. Provide learning guidance         | Transparencies and group discussion      | Students are divided into groups and play the game “Natural Topics” (Bell & Weikert, 1985, pp. 78–83). Students take turns drawing game cards, each of which has three statements, and select the main idea. Tokens are moved on a game board—one space for easy answers, two for more difficult choices. |
| 6. Elicit performance                | Print material                           | Children are given brief situations, each with several choices from which they select the main idea.                                                                                                                   |

Example: Movie *E.T.*
Choices: The main idea is
A. E.T. rode on the handlebars of Elliott's bicycle.
B. E.T. was left on Earth and wanted to go home, although he had friends on Earth.
C. E.T. hid in a closet full of toys in Elliott's house and was hard to tell apart from the toys.

7. Provide feedback  Group discussion and teacher communication  Class discusses the answers.

Instructional events 5, 6, and 7 are then repeated, with the difference that the other statements about the story are not details; they are general statements. However, they do not describe "something special" about the topic.

Example: A short selection describes edible grasses and includes wheat, rice, hay, and their uses as food.

Choices: The story is about
A. how to eat grass.
B. how grass grows.
C. the uses of grass.

Instructional events, 5, 6, and 7 are then repeated, using a wide selection of statements that may represent the main idea.

Example: A short selection describes tree rings (topic), how they are formed, and what they tell us about a tree's growth.

Choices: The story as a whole is about
A. tree rings that are close together.
B. how rain makes trees grow.
C. how tree rings tell about trees.

8. Assess performance  Print material  Children are given several short reading selections with choices for main ideas (general and specific), and they select the sentence that tells what the whole story is about.

9. Provide retention and transfer  Group discussion  Children talk about the stories and the TV shows mentioned in instructional event 1. The teacher introduces several choices for the main idea of each, and the children as a group make a decision about the main idea during a class discussion.
specific details. Each type is contrasted separately with examples of the main idea so that the children may clearly understand the differences.

Retention and transfer is provided a few days after the initial instruction using a discussion of the children's favorite television programs. The children receive additional clues for later recall at this time.

**Review of the Theory**

The behaviorist and Gestalt theorists developed explanations of the learning process in the laboratory and extended the findings to the human situation. Robert Gagné, in contrast, began with the complexity and variety that characterizes human learning and developed a system to account for that variety.

Gagné's analysis yielded five categories or varieties of learning that are distinguished by different performances and different requirements for learning. The five varieties are verbal information, intellectual skills, cognitive strategies, attitudes, and motor skills. In addition, intellectual skills include four discrete skills that form a hierarchy from discrimination learning to higher order rule learning (problem solving). Unlike other designations, such as "rote learning" or "conceptual learning," the five varieties cut across school subjects, ages of learners, and grade levels.

Each learning variety requires a different set of internal and external conditions for acquisition of the particular capability. Internal conditions include (a) the necessary prerequisite skills and (b) the nine phases of cognitive processing required for learning. External conditions are the events of instruction that support the learner's cognitive processes (see Table 5.11).

A major goal of Gagné's theory is the planning of effective classroom instruction. The teacher or instructional designer writes the skills to be learned in the form of performance objectives, and identifies the variety of learning. Task analysis is then used to identify prerequisite skills, and instructional events are selected for each objective to be taught.

**Disadvantages**

Gagné developed the conditions of learning to account for the range of psychological processes observed in prior research on learning and to specify precisely the sequence of instructional events for the identified processes. Thus the theory is easier for a curriculum design team to implement than for the classroom teacher to use.

**Contributions to Classroom Practice**

The best-known contribution of the theory is that it operationalizes the concept of cumulative learning and provides a mechanism for designing instruction from simple to complex. The concepts of cumulative learning, task analysis, and the identification of component skills have become accepted curriculum components.
TABLE 5.11
Summary of Gagné's Conditions of Learning

<table>
<thead>
<tr>
<th>Basic Elements</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumptions</td>
<td>Within the parameters established by growth, development is the result of the cumulative effects of learning. Learning is characterized by more than a single process, and these processes cannot be reduced or collapsed into one.</td>
</tr>
<tr>
<td>Learning</td>
<td>The phases of information processing supported by stimulation from the environment executed for the different kinds of learning</td>
</tr>
<tr>
<td>Learning outcome</td>
<td>An internal capability manifested in a particular performance for each of the kinds of learning</td>
</tr>
<tr>
<td>Components of learning</td>
<td>Five varieties of learning: verbal information, intellectual skills, cognitive strategies, attitudes, and motor skills</td>
</tr>
<tr>
<td></td>
<td>Internal conditions of learning: prerequisite skills and the nine phases of information processing</td>
</tr>
<tr>
<td></td>
<td>External conditions of learning: the events of instruction</td>
</tr>
<tr>
<td>Designing instruction for complex skills</td>
<td>Provides instructional events for the sequence of skills in procedures and learning hierarchies</td>
</tr>
<tr>
<td>Major issues in designing instruction</td>
<td>Identification of capabilities to be learned; task analysis of objectives; selection of appropriate instructional events</td>
</tr>
</tbody>
</table>

Analysis of the Theory

Disadvantage                      | Difficult for the classroom teacher to implement without special training |
Contributions to classroom practice | Provides a mechanism for designing instruction from simple to complex; identifies the psychological process in cumulative human learning |
|                                  | Accounts for the diversity of human learning |
|                                  | Links instructional events to specific phases in information processing |

CHAPTER QUESTIONS

Understanding Concepts

1. State at least two differences between verbal information and intellectual skills.
2. Essential prerequisites occur only in intellectual skills. Why?

3. What is the typical trap that must be avoided in constructing a learning hierarchy?
4. One form of Skinner's transfer of stimulus control is that the learner's response comes under the control of stimuli within the
learner. Describe a similar situation in Gagné’s transfer of learning.
5. For a large-scale curriculum design project, what are the advantages of the systems design model?

Applying Concepts in Instructional Settings

1. Art appreciation courses often focus on providing information about different periods and styles, and assess cognitive outcomes. If Gagné’s recommendations on changing attitudes were followed, what would be different?
2. Discussions continue as to whether Head Start and other preschool programs are successful in reducing subsequent school failure. From Gagné’s perspective, what key question should be asked in this debate?
3. Classify the following objectives as to the variety of learning. If the objective is an intellectual skill, identify the type.

4. Identify at least two prerequisites for skills (b) and (d).
5. A teacher begins a lesson on solving for the areas of plane geometric figures by presenting the formulas $A = lw$ and $A = w \times \frac{1}{2}l$. She uses the formulas to find the areas of two rectangles and two triangles, and gives the students several problems for homework. According to Gagné’s theory, what are some of the teacher’s errors?

REFERENCES


CHAPTER 6
Cognitive Perspectives:
I. The Processing of Information

The brain is not a passive consumer of information. . . . The stored memories and information-processing strategies of our cognitive system interact with the sensory information received from the environment, selectively attend to this information, relate it to memory, and actively construct meaning for it. (Wittrock, 1990, p. 348).

The initial cognitive perspective, Gestalt psychology, addressed changes in perception as the key to learning in problem solving. Specifically, forming an accurate representation of the problem indicates the nature of the solution. Examples include the X-ray problem (thick, bundled rays must be replaced by scattered rays sent from various angles) and the matchstick problem (the configuration of matchsticks must be visualized with a hole in the center).

Limitations of the Gestalt findings are (a) they apply only to problems that can be portrayed visually, and (b) they do not address cognitive processes in other situations. There matters remained until September 11, 1956, at a “Symposium on Information Theory,” at the Massachusetts Institute of Technology, in Cambridge. Presenters that day included Noam Chomsky (theoretical linguistics), Alan Newell and Herbert Simon (computer simulation of cognitive processes), and George Miller (human experimental psychology). Miller (2003) later recalled his conviction on that day—the papers, he thought, were parts of a larger whole that the future would progressively elaborate and coordinate (p. 143). And so it did, in the form of a cognitive psychology that examined the nature, extent, and depth of mental processes in various areas. In psychology and educational psychology, initial research addressed the sequence of mental operations and the products (information) in the performance of cognitive tasks (Anderson, 1990). Subsequently, research expanded to include the ways that learners develop meaning from text and other information sources, and the ways that learners organize knowledge. Theorists and researchers also address the development of metacognition and problem solving, the complex skills addressed by the cognitive perspective; they are discussed in Chapter 7.
CHAPTER 6  Cognitive Perspectives: I. The Processing of Information  

PRINCIPLES OF LEARNING

Information-processing theory, which addresses the basic steps in the ways individuals obtain, code, and remember information, differs from the other learning-process theories (Skinner's operant conditioning, Gagné's conditions of learning) in two ways. First, information processing is not the conceptualization of only a single theorist. One result is a variation in the descriptions of the ways that long-term memory stores information. Second, because the basis of the theory is simply information processing and not learning, the theory does not specify the outcomes of learning. Different studies of basic cognition assess different activities, from learning new vocabulary to learning to summarize information. Nevertheless, researchers who adopt the cognitive perspective share the broad assumption that individuals transform much of the information impinging on their senses from the environment into memory codes that are stored for later use. Essential components of learning are the organization of information to be learned, the learner's prior knowledge, and the processes involved in perceiving, comprehending, and storing and retrieving information.

Basic Assumptions

Two key assumptions support information-processing research. They are (a) the memory system is an active, organized processor of information, and (b) prior knowledge plays an important role in learning. Related to these basic assumptions are beliefs about (a) the nature of the human memory system, (b) the ways that specific knowledge items are represented in long-term memory, and (c) the organization of bodies of knowledge in long-term memory.

The Nature of Human Memory

The early conception of human memory was that it served simply as a repository or passive collector of information over long periods of time. In the 1960s, however, researchers began to view human memory as a complex system that processes and organizes all our knowledge. Instead of passively recording information, human memory actively selects the sensory data that are to be processed, transforms the data into meaningful information, and stores much of that information for later use.

Types of Memory. Table 6.1 illustrates the views of human memory. Three conceptualize human memory in terms of states or levels. They are the memory system concept, the state concept, and levels of processing. The system concept describes semantic memory (word meanings and facts), procedural memory, and episodic memory. The unique characteristic of episodic memory is that it allows individuals to travel mentally into their past and reexperience personal events. Required are a sense of subjective time in which personal events occurred and an awareness of self (Tulving, 2002, p. 2). Some psychologists criticized the idea of an episodic memory that is separate from semantic memory neurologically. However,
<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
<th>Limitations</th>
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| The multistage model            | 1. Assumes that information is processed in stages linked to memory systems  
2. Structures are the sensory register, short-term storage, working memory, and executive control processes  
3. Structures are not locations in the brain | 1. Lack of research confirmation of the capacity of the structures  
2. Does not incorporate the variations in brain functioning that can occur (Edelman, 1987)  
3. Mindful procedures are brain products, not processes (Iran-Nejad, Marsh, & Clements, 1992) |
| The memory system concept       | 1. Systems are episodic (personal or autobiographic) information; semantic (general knowledge); procedural (steps that help in responding adaptively to the environment) (Tulving, 1985) | Differences in processing in semantic and procedural memories are not clear                           |
| The state concept               | Conceptualizes memory in terms of the state of information (active or inactive)                                                                                                                                 | Does not address processing steps in acquiring information                                              |
| Levels of processing            | 1. A memory is a by-product of perceptual analysis in a series of sequential, hierarchical levels  
2. Levels are sensory analysis, pattern recognition, and semantic association (Craik, 1979; Craik & Lockhart, 1972) | Depth of processing cannot be measured independently of the amount of information that is remembered (Neath, 1998) |
| The global workspace concept    | 1. Assumes that adaptive networks of the brain are controlled by particular contexts and aims.  
2. Focal consciousness is a spot on the stage of working memory that is directed by the spotlight, attention. | 1. Does not address the actual workings of neuronal networks                                           |
Connectionist networks, also known as neural networks or parallel distributed processing (PDP)

1. Consists of nodes or elements and links or connection weights in a network structure
2. Described as a Frisbee/rubber band (elements/connection weights) network (Bereiter, 1991)
3. Oscillations of the rubber bands represent input signals traversing a portion of the network
4. The extent of tightness in the rubber bands (connection weights) represents learning

1. The need for a physical agent to alter the connection weights disqualifies these models as explanations of autonomous learning by the brain (Bereiter, 1991)
2. In the computer simulations, the initial connection weights must be mechanically set by the designer (Iran-Nejad et al., 1992)
3. There is no guarantee that the network structure of the models represents the brain's network (Iran-Nejad et al., 1992)
clinical studies of neurological impairment identified individuals who are unable to remember ongoing experiences or recall personal events from their past, but retain semantic memory (p. 15). Brain imaging studies also indicate that retrieval from semantic memory primarily activates the left hemisphere, whereas retrieval of episodic memories activates the right frontal lobe (p. 18).

The state concept (identifying information as active or inactive) accounts for such activities as memorizing a poem, repeating a telephone number, and carrying on a conversation with a friend while driving. The levels of processing concept, in contrast, describes three types of processing involved in identifying words or phrases, but it does not address more complex processes (Craik, 1979).

The other three conceptualizations of human memory include information on the ways that the memory system operates. They are the connectionist perspective, the multistage model, and the global workspace concept of consciousness. In terms of planning instruction, the dominant perspective is the multistage concept.

**Connectionist Networks.** These networks differ from Thorndike’s connectionism, which consists of stimulus–response pairs. William James (1890) first proposed the idea of networks in which nodes (thoughts) fire impulses through connections to other nodes (Neath, 1998). James was intrigued by the “restless flight” of one idea before another and conceptualized a network to account for the rapid generation of different thoughts.

In the current models, knowledge is stored in connection weights (links) that also modulate the transfer of activity from one unit to the next (Schneider & Graham, 1992). Developers of connectionist models (e.g., McClelland & Rumelhart, 1986) emphasize that many activities, such as interpreting language, require processing information from several sources at once. In reading, for example, letter and word recognition and recognition of constraints are interacting simultaneously. Referred to as *parallel distributed processing*, this activity, according to the models, accounts for the instant recognition of “the cat.”

Advocates of connectionist networks maintain that multiple processing can occur simultaneously because information is stored in the links between the connections instead of in the form of static patterns.

Some models, referred to as “symbolic connectionist” models, use elements (Frisbees) that represent concepts or propositions (Holyoak, 1991; Thagard, 1989). These models sidestep the issue of how the symbolic representations are acquired initially. However, they function as people often do by illustrating the gradual change from vagueness (or imprecise impressions) to clarity of thought (Bereiter, 1991, p. 13).

**The Multistage Model.** Broadbent’s (1958) description of a multistage memory influenced the current general model derived from a computer metaphor. Figure 6.1 illustrates the sequential memory stages that are managed by an executive control. According to this model, an array of physical signals impinges on the sensory registers, primarily visual and auditory. Many signals are not processed and some are retained only briefly (0.5–2.0 seconds). Other signals,
EXECUTIVE CONTROL PROCESSES

Short-term store. Data are briefly maintained (0.5 – 2.0 seconds) for preliminary analysis.

Short-term (working) memory. A limited amount of data is maintained for approximately 20 seconds.

Long-term memory. Transformed or coded data become part of the knowledge system.

Data lost from the system

FIGURE 6.1
Generalized conceptualization of the human memory as a structural system

selected for further processing, enter working memory. Here, many of the signals are encoded into some meaningful form and transferred to long-term memory for permanent storage. Some information, such as a little-used telephone number that is looked up, is retained only until the particular action is completed.

As indicated in Figure 6.1, the multistage model illustrates a single path from step one (physical signals impinging on the sensory registers) to the storage of new learning in long-term memory. Also, the model shows a central command center managing the process, beginning with the brief period (0.5–2.0 seconds) of preliminary analysis in the short-term store. However, subsequent brain research indicates that processing occurs somewhat differently. In the early stages of visual processing, for example, physical signals entering the two eye retinas travel to the dorsal lateral geniculate nucleus (LGNd) of the thalamus, where they remain segregated. This area translates the visual input into a form that the visual cortex can read, and sends the input to some of the six layers of neurons in the primary visual cortex, V1. From V1, the information is sent on multiple pathways to some 30-plus visually responsive cortical areas (all of these early steps take place without any external executive control). Each cell in the visual cortex is receptive to particular characteristics of the visual stimulus, and analysis includes motion perception and tracking as well as object recognition and coding. At this stage, direct and indirect projections (axons and dendrites) carry signals in and out of the primary visual cortex (V1) and other areas of the brain as the stimulus is identified and subsequent action, if any, is identified.

Despite the differences between the information-processing model and the above steps, the processes associated with the information-processing model (perception, encoding, and storage in long-term memory) are useful for instruction.
The Global Workspace Concept. Baars (1996, 1997a, 1997b, 2003) introduced the global workspace concept to explain human consciousness. Briefly, consciousness is an important biological adaptation that allows the brain to "interpret, learn about, interact with, and act upon the world" (Baars, 1997b, p. viii). A basic assumption is that the neurons of the brain are not controlled by a centralized command. Instead, adaptive networks of neurons are controlled by particular contexts and aims. Also, a network of neural "patches" cooperate to display conscious events (p. ix). Included are the sensory projection areas of the cortex, which receive input from the senses. An example is the processing of visual input described in the prior section.

The global workspace concept describes consciousness in terms of a theater model. In the theater metaphor, the entire stage corresponds to working memory and focal consciousness is a bright spot on this stage. It is directed by attention, which is the spotlight (see Table 6.2). Attention is controlled by the frontal executive cortex and an automatic interrupt control that emanates from certain areas (e.g., the brain stem, pain systems, and emotional centers like the amygdala; Baars, 2003).

The bright spot (consciousness) is surrounded by "vital but vaguely conscious events" in working memory "in which we talk to ourselves, visualize places

<table>
<thead>
<tr>
<th>TABLE 6.2 Components of Baars’ Theater Metaphor of Consciousness</th>
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<tr>
<td><strong>Theater Component</strong></td>
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<tr>
<td>Stage</td>
</tr>
<tr>
<td>Spotlight on the stage</td>
</tr>
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</table>
| Actors onstage competing for the spotlight in working memory | Outer senses: seeing, hearing, feeling, tasting, smelling (Baars, 1997b, p.42)  
Inner senses: inner speech, visual memory, dreams, imaginal feelings (p. 42)  
Ideas: imagible and verbal  
On the fringe: conscious intuitions (p. 42) |
| Behind-the-scenes influences (unconscious) | Context: Largely unconscious expectations and intentions (but can become consciously accessible)  
Contextual beliefs, assumptions, and attitudes |
| Director | Executive functions in the frontal cortex. Automatic routines, autobiographical memory, semantic networks, declarative memory (facts), spatial relationships, social inferences, reading, and other skills |
| Audience (in the dark, unconscious) | |

Note: Summarized from Baars (1997b, 2003)
and people, and plan actions" (Baars, 1997a, p. 292). We may, for example, be walking down the street talking silently to ourselves about the items we need to get at the grocery store, dimly aware, if at all, of the buildings, people, and other characteristics of the scene that we pass by. In other words, the stage (working memory) receives both sensory and abstract information, “but only events in the spotlight shining on the stage are completely conscious” (p. 301).

Table 6.2 illustrates the internal and external stimuli that compete for attention in consciousness. However, when incoming sensory information and internal conceptual processes are compatible with each other, they may coexist in consciousness. For example, reading a moving poem involves processing visual stimuli, inner speech, and constructing meaning (Baars, 1997b, p. 63).

The remainder of the theater is dark, and therefore, unconscious. In the darkened theater are (a) behind-the-scenes influences that shape conscious thoughts, (b) the director, and (c) the audience. Behind-the-scenes influences include largely unconscious expectations and intentions, belief systems, methods of action control, and approaches to solving problems (Baars, 1997a, p. 303). An example is the functional fixedness described by the Gestalt theorists, in which particular assumptions about a problem prevent the solution.

The director, also behind the scenes, is the executive functions in the frontal cortex that manage the spotlight (unless there is a major interruption from a pain center or other part of the brain). The director shapes the actions carried out in the theater. However, some of the decisions by the director may not be totally conscious, such as to rehearse a telephone number (p. 303). The audience in the darkened theater includes the individual’s automatic highly practiced skills, such as routines that recognize words, make syntactic inferences, and interpret semantic information (Baars, 1997b, p. 17).

A primary functional role of consciousness is to permit this theater architecture to provide access, integrate, and coordinate the functioning of many specialized networks that otherwise function autonomously (Baars, 2003). In other words, an important characteristic of consciousness is that it is the gateway to the vast amount of the person’s unconscious specialized knowledge (represented in some models by long-term memory). This access is manifested in at least three ways. First, for example, consider the word set, which has a variety of meanings. In a fraction of a second, the meaning accessed from the unconscious changes, depending on the words or phrases that are paired with it. Set in tennis differs from a set of tools or silverware, glamorous people belong to the jet-set, and unlucky individuals are “a set of fools” (Baars, 1997a, p. 296). We can also build a stage set, the sun sets, and mathematicians deal with set theory. In other situations, information in consciousness can trigger unconscious information that helps to interpret subsequent conscious events (p. 305). Prior to a unit on viruses, for example, an instructor initially compared them to alien invaders from outer space to tap into the students’ related information.

Second, consciousness establishes access to unconscious problem solving—the incubation process described in Chapter 2. The “actor” on the stage states a question and certain problem solvers in the “audience” (the unconscious) go to work on it (p. 305). Also, several audience members may monitor and edit any conscious
goal or plan (Baars, 1997b, p. 133). An analogy is NASA engineers sitting at their computers and monitoring rocket launches for temperature, coolant pressure, signs of leakage, and so on. Any controller can abort the launch if the indicators go outside acceptable boundaries (p. 134). Third, consciousness establishes access for the self—access to vivid memories, as well as other personal information, such as one’s name, family members, aspirations, and so on. In other words, “consciousness gives us vast access to billions of neurons in the brain and body” (p. 298).

Finally, another major premise of global workspace theory is that the contents of consciousness are “globally available” to unconscious systems in the brain (Baars, 1996, p. 12). Reading a sentence, for example, makes it available to interpretative systems that analyze syntax and meaning and emotional and motivational impact, as well as the implications for thinking and action (p. 12).

**Summary.** Basic assumptions of information processing are that (a) human memory is actively involved in the construction of knowledge and (b) the learner’s prior knowledge plays an important role in learning. Human memory is a complex system that actively seeks sensory data, transforms the data into meaningful information, and stores the information in long-term memory. Three conceptualizations of the nature of memory are the state concept (information is either active or inactive), the memory system concept (episodic, semantic, and procedural systems), and levels of processing (sensory analysis, pattern recognition, and semantic association).

Perspectives that address the operation of the system are connectionist networks, the multistage model, and the global workspace concept. Connectionist networks approximate the neural networks found in the brain. Memory consists of interacting connection nets composed of elements or units and links known as connection weights. Learning involves modifying the connection weights among certain units to produce output patterns. The multistage model, in contrast, identifies structures that reflect stages involved in processing information and their associated processes. The structures are the sensory registers, short-term store, working memory, and long-term memory. Research on the brain indicates that the memory system is not divided into separate “bins.” Nevertheless, the stages and the related processes are useful for instruction.

In contrast to the other views, the global workspace concept addresses human consciousness. Described in terms of a theater, consciousness is a bright spot in working memory that is illuminated by attention. Influences on conscious processing of information are behind-the-scenes factors, including executive functions, one’s belief systems, language, methods of action control, and approaches to solving problems. An important characteristic of consciousness is that it establishes access to the huge amount of one’s unconscious knowledge. Consciousness helps to interpret information by accessing related unconscious information, and establishes access to unconscious problem solving, as well as to the self.

**The Representation of Knowledge in Long-Term Memory**

The stimulus input received and acted on by the senses and cognitive processing is in the form of physical signals. To be remembered, these signals are transformed
in some way for storage in long-term memory. One view, the dual-code model, maintains that information may be stored in verbal or nonverbal form (Paivio, 1971, 1983, 1986). The other view maintains that information is stored only in verbal form (Anderson, 1983, 1990). According to the verbal perspective, imagery is important in processing information, but the ultimate representation in long-term memory is verbal. The two types of verbal representation are declarative knowledge and procedural knowledge.

**The Dual-Code Model.** The dual-code model describes two functionally independent, although interconnected systems for processing and storing information. Abstract objects and events that do not refer to concrete, tangible objects or events are stored in verbal form. Examples are *success*, *soul*, *truth*, and *ability*. Nonverbal representations include environmental sounds, actions, and other non-linguistic objects and events. Examples include the sound of church bells, drawing lines, or pressing keys, and a clenched jaw or racing heart (Clark & Paivio, 1991). Some events and objects that have both concrete and abstract characteristics may be coded in both systems. An example is *house*. The house that one lives in would likely be stored as a nonverbal code. However, *house* in the sentence, “A house divided against itself cannot stand” would be coded in verbal form.

One basis for the nonverbal encoding view is the performance of individuals on memory tasks. Subjects in experiments recalled more concrete items in list memory tasks than abstract items (Clark & Paivio, 1991; Paivio, 1983). According to the model, subjects processed two characteristics for each concrete item. If one characteristic was unavailable at the time of recall, the other was retrieved. Also, when separate elements are integrated into a compound image, a partial cue can later reactivate the total representation (Clark & Paivio, 1991).

Critics of the dual-code model maintain that information storage in picture form would exceed the storage capacity of the brain. Also, it would require a “perceiver” in the brain to “read” the pictures (Pylyshyn, 1973). However, visual encoding theorists maintain that the stored codes are not pictures. Rather, they are analog representations or analog memories. That is, the nonverbal codes are structurally related to the real objects in the same sense that keys and locks are related (Shepard, 1978). Physically, keys and locks are quite different; however, only the correct key will open a particular lock. Similarly, only particular objects will activate the neural codes that represent the object. Nevertheless, Pylyshyn (2002) maintains that reasoning with images uses the same mechanisms and the same forms of representation as general reasoning; only the content differs (p. 158). For example, if told to imagine a baseball thrown into the air, we can easily imagine the curved trajectory of the ball because we recall having seen a ball follow such a path (p. 159).

**Declarative Knowledge.** The term *declarative* refers to information that (a) can be discussed or declared, and (b) is descriptive. Examples include “Sacramento is the capital of California” and “I got food poisoning last week.” As indicated by
these examples, declarative knowledge contributes to both semantic and episodic memory.

Verbal networks consisting of nodes and links represent declarative knowledge in memory. An early network model (Collins & Quillian, 1969; Quillian, 1968) used nodes to portray concepts and superordinate concepts with links or pointers that attached properties to the particular concept. Examples include “has fur” and “is a predator” for the concept “wolf.”

In contrast, the best-known current network consists of propositions, which are the smallest unit[s] of meaning that can be judged true or false (Anderson, 1990, p. 123). Examples are “The Cadillac is beautiful” and “Mary is my sister.” In other words, propositions are “atomic units of meaning” (p. 143).

**Procedural Knowledge.** Briefly, procedural knowledge is knowing how to execute a particular task or activity, such as parallel parking a car. Procedural knowledge may range from simple tasks, such as unlocking a door, to complex activities, such as using word processing software on a computer. According to the theorists, procedural knowledge is encoded in the form of condition—action pairs that are if—then statements (Anderson, 1993; Newell & Simon, 1972). For example, if a plural subject, then the present tense of the verb “to be” takes the form “are.”

Declarative memory and production memory are two of the internal components of the model of cognition, ACT-R, developed by John Anderson (2005; discussed in Chapter 7).

**Organizations of Knowledge**

In addition to the representations of particular items of information in memory, educators and others investigating school learning are interested in the ways that students acquire and make use of bodies of knowledge. Among the terms in the research literature are prior knowledge, domain knowledge, schema, content-specific knowledge, and topic knowledge. Reviews of the uses of this terminology indicated that explicit definitions typically are missing (Alexander, 1992; Alexander, Schallert, & Hare, 1991). However, analyses of implicit uses by Alexander et al. (1991) indicated two broad categories of knowledge: tacit and explicit. The broad components of explicit knowledge are conceptual and metacognitive knowledge.

**Tacit and Explicit Knowledge.** Much of an individual’s knowledge is tacit (Alexander, 1992; Alexander et al., 1991). Briefly, tacit knowledge (a) is implicit and (b) operates below the level of conscious awareness. Sociocultural knowledge, such as appropriate dress for a wedding, is an example.

Much of tacit knowledge consists of scripts, which contain the general information found in familiar, frequently experienced events (Schank & Abelson, 1977). For example, included in a “going to the movies” script are going to the theater, buying the ticket, buying refreshments, finding a seat, seeing the movie, leaving the theater, and going home. In the elementary grades, teachers spend time in the first few weeks ensuring that the children learn the scripts for major events in the school day.
When asked to state the important events in an episode such as going to a restaurant, individuals tend to name the same major events (Anderson, 1990). However, once learned, scripts tend to operate below the individual’s level of conscious awareness, that is, as tacit knowledge. Research also indicates that babies, by 7 months of age, show recall of caretaking scripts, such as teeth brushing and bath and peek-a-boo games (Ashmead & Perlmutter, 1980).

Explicit knowledge, in contrast, is easily available to consciousness, and is the object of thought (Prawat, 1989). Two broad categories of explicit knowledge are metacognitive and conceptual. Metacognitive knowledge includes information about specific and general strategies for learning new information, knowledge of plans, goals, and specific tasks, and knowledge of oneself as a learner (Alexander et al., 1991) (see Chapter 7).

**Conceptual Knowledge.** One type of conceptual knowledge is content knowledge (see Table 6.3). As learners acquire concepts, rules, and other information organized about a definite area, they are developing domain knowledge. Examples include baseball and first-semester biology. Some areas of knowledge, such as biology, chemistry, and physics, are referred to as disciplines. They are extensive fields of study that are defined by sets of rules or generalizations and have a history of developing new knowledge. Students who are becoming proficient in these areas are acquiring discipline knowledge. Examples are a student who is majoring in biology and a third-year medical student.

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<thead>
<tr>
<th>TABLE 6.3 Two Broad Categories of Explicit Conceptual Knowledge</th>
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<tbody>
<tr>
<td><strong>Content knowledge</strong>—information about some aspect of one’s physical, social, or mental world (corresponds roughly to the abstract structure referred to in the literature as content schemata)</td>
</tr>
<tr>
<td>May be informal or formal</td>
</tr>
<tr>
<td>May be organized and integrated at either of the following two levels:</td>
</tr>
<tr>
<td><strong>Domain knowledge</strong>—organized knowledge (1) about a defined area (such as baseball or computer programming) or (2) related to a discipline (such as biology)</td>
</tr>
<tr>
<td><strong>Discipline knowledge</strong>—extensive academic knowledge that is organized around the fundamental principles defining a particular field that is a discipline (such as biology or chemistry)</td>
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*This category and the subtypes consist of declarative and procedural knowledge.
Discourse or linguistic knowledge also is important in learning because it interacts with content knowledge. Discourse knowledge includes knowledge of text, syntax, and rhetoric of language. For example, recognizing signal words, such as “on the other hand” and “nevertheless,” alert the learner to important points that qualify or run counter to the concepts already discussed.

**Schemas.** Frederick Bartlett (1932) first defined *schema* as an “active organization of past reactions” that is assumed always to be operating in an individual’s response (p. 201). However, recall of prior information is not simply the retrieval of a fixed amount of information. Instead, schemas continue to develop over time (Brewer, 2000, p. 38).

In a now-classic experiment to illustrate the influence of schemas, Bartlett gave the first subject a folk story from an unfamiliar culture to read. The individual then reproduced the events and gave this accounting to the second individual. This person read the first subject’s version, laid it aside, reproduced the events, and handed that account to the third subject, and so on. By the time the story reached the 10th subject, it was no longer a story about mythical visitors (“The War of the Ghosts”). Instead, it had become a fishing trip. The individuals in the experiment dropped unfamiliar information as they repeated the story and retained a few details. Each reproduced version became more like the reader’s expectations (Bartlett, 1932). In other words, each reader’s schema influenced his interpretation of the story.

A more recent definition of schema is “an organized structure that reflects an individual’s knowledge, experience, and expectations about some aspect of the world” (Neath, 1998, p. 328). Also, schemas can represent knowledge at any of several levels, from a schema of an office to a schema of social structure. For example, cognitive load theory defines schemas in problem solving as categorizing problems that require similar solutions (Sweller, 1994, p. 296).

Three functions of schemas are to (a) provide a framework to assist in comprehending new information, (b) serve as a guide for goal-directed activities and searches of the environment, and (c) fill in gaps in information received from the environment (Alba & Hasher, 1983; Neisser, 1967). An experiment on the influence of schemas on visual perception and memory used a room designed as a graduate student’s office (Brewer & Treyens, 1981). After waiting in the room 35 seconds, the subject was escorted to a conference room and asked to write his or her recollections of the room. Some subjects recalled 88 objects, of which 19 were objects not in the room. Among the absent items named by the subjects were books, a filing cabinet, a coffee cup (a coffee pot was in the room), pens, and a lamp—objects that are highly relevant to the schema “office.” The researchers concluded that schema knowledge became integrated with actual information about the room (p. 228). In other words, although schemas can aid in recall, they also can introduce errors (Neath, 1998).

A limitation of the term “schema” is that it has no fixed definition (Alba & Hasher, 1983; Hampson & Morris, 1996). Two of the problems are (a) knowing how much information to include and (b) deciding how much information should be optional (Hampson & Morris, 1996). For example, the schema of a room would
include walls, a floor, and a ceiling. Then the question arises, should minimum dimensions be included (to differentiate room from closet)? In other words, the most common criticism is that the term is not useful because it explains everything, but predicts nothing (Neath, 1998, p. 331).

**Summary.** Conceptualizations of the form of specific items in long-term memory are the dual-code model (which describes verbal and nonverbal codes) and verbal representations. According to the verbal model, long-term memory stores declarative knowledge in the form of propositional networks and procedural knowledge is in the form of if–then statements or condition–action pairs.

The nature of the bodies of information stored in long-term memory include both tacit and explicit knowledge. Tacit knowledge, which operates below the level of consciousness, includes sociocultural knowledge and scripts for behavior in different situations. In contrast, explicit knowledge is easily available to consciousness and is the object of thought. Included are metacognitive and conceptual knowledge. The larger category, conceptual knowledge, consists of content knowledge (organized into either domain or discipline knowledge) and discourse knowledge (text-structure and syntactic knowledge). The term schema also refers to organized knowledge, experience, and expectations about some aspect of the world. Although useful for educators, the vagueness of the concept limits its use in research.

**The Components of Learning**

The major components of learning are (a) the framework for learning, which includes the prior knowledge of the learner and the organization of the information to be learned, and (b) the processes identified in the multistage model of memory and their interactions. These processes are perception, encoding and constructing meaning, interactions between working memory and long-term memory, and retrieval.

**The Learning Framework**

Effective and efficient learning depends on both internal and external factors. The internal factors are the types of knowledge in the individual’s cognitive framework (tacit, conceptual, and metacognitive knowledge). This knowledge is a component of the “darkened theater” described by Baars (1997a, 1997b), or unconscious knowledge. An important external factor is the nature and organization of the knowledge to be learned.

**The Role of Learner Knowledge.** The extent and variety of knowledge that the individual brings to the learning situation influences all aspects of processing. First, the learner’s tacit and content knowledge base serves as the framework for identifying incoming information. It provides the information for recognizing familiar objects, symbols, faces, and events. For example, a child may perceive a four-legged animal that barks to be a dog, whereas an adult recognizes it as a golden retriever.

Second, both tacit and content knowledge are major determinants of the inferences that individuals make about new information. For example, if your
friend tells you she has a big dog named Brutus, you infer that the animal has four legs and hair, barks, and is likely to be protective of his home territory (Adams, 1989). Prior knowledge also minimizes the potential confusion among similar types of information. In reading about John Dean in All the President's Men, for example, one does not confuse him with King John, Pope John, or a former classmate John (Adams, 1989).

Research also indicates that individuals' prior knowledge predicts both the rate of learning and retention scores for factual learning, general topics, and word meanings (Bors & McLeod, 1996). In other words, the extent of prior knowledge has serious implications for learning.

Third, an extensive knowledge base can enhance the capacity of short-term memory by making it possible to chunk new information into large units (see the section on encoding). That is, schemas become more elaborate and incorporate more information into a single chunk (Sweller, 1988, in Feldon, 2007). For example, an art historian reading a detailed description of a particular type of Chinese porcelain can rapidly process the technical terms in the discussion because of his or her prior learning.

**Organization of the Information to be Learned.** Two formal organizations of information to be learned are teacher presentations, including lecture, and text passages. Research on the nature of texts indicates that the ambiguity or complexity of the text influences the extent and nature of the learning. Even expert readers, when faced with obscure or ambiguous text, briefly experience the same difficulties in constructing meaning as novice readers (Alexander et al., 1991).

An analysis by Garner (1992) indicated that many textbooks are difficult to read, include information that is irrelevant to the topic, seldom focus learner attention on important information, and contain long digressions (p. 53). This situation is particularly problematic for younger or less-skilled students with inadequate text-structure knowledge. They are likely to acquire trivial details instead of important generalizations (p. 54).

Several studies have investigated so-called seductive details. They are highly interesting segments that are irrelevant to the main ideas in the text (Lehman, Schraw, McCrudden, & Hartley, 2007). The findings indicate that seductive details do not have a strong positive effect and may not exert a strong negative effect on texts that are narratives. However, they do interfere with the comprehension and processing of scientific text (p. 583). They draw the reader's attention away from main ideas in the text or break up the coherent flow of information that the reader must then attempt to remedy (p. 583).

In summary, the learner's tacit and content knowledge interact with text and other sources of information to influence learning. A poor match between learner knowledge and complexity of text or inaccurate or incomplete learner knowledge contribute to faulty learning.

**Perception**

Perception is the process that selects and recognizes the physical signals that are impinging on the senses. The sensory system (vision, hearing, touch, smell, and
taste) detects the signals as physical energy, which are sent to an area in the thalamus and then on to the appropriate area in the cortex for further processing. Following preliminary recognition, the information is available for up to 2 seconds. This brief availability of visual images is referred to as *iconic memory*, and the brief auditory store is known as *echoic memory*. Incoming signals that are not attended to at this time are lost. The preliminary meaning assigned to stimuli is referred to as pattern recognition; it is responsible for the identification of thousands of specific sensations and images, from the scent of a rose to the faces of one’s friends.

**The Role of Attention.** Processing incoming information requires selectively addressing particular events, objects, symbols, and other stimuli if they are to be learned. Attention is essential in this processing, but it is not an unlimited resource. Instead, it is similar to energy, fuel, or other resources that must be allocated among competing alternatives (see Grabe, 1986). As already indicated, when vivid text details distract learner attention, important generalizations in the material may not be attended to. Learner attention may be described as a “front-line manager” that is instrumental in determining the information that will be available for further processing (Kulhavey, Schwartz, & Peterson, 1986). One solution to the problem of the limited capacity of attention is to practice some essential tasks until they become *automatic*. Then they can be executed with little or no conscious attention. For example, the child’s task of learning the shapes and names of letters requires concentration and effort. At this stage, the task requires *deliberate* or *controlled processing*. However, after extended practice and use, letter identification becomes an automatic perceptual task. Later, for good readers, word identification also becomes largely automatic, freeing attention for the tasks of understanding meaning and developing connections among major concepts in the material.

**Learner Knowledge.** As already stated, the individual’s knowledge plays an important role in perception. Someone who has lived in the city all of his life, for example, may identify a large plant with a central trunk as a tree. In contrast, another individual who has lived in the country and majored in forestry in college may indicate that she has seen a hybrid American elm grafted onto a Chinese elm stock (Bruning, Schraw, & Ronning, 1995).

**Encoding and Constructing Meaning**  
**Encoding** acts on perceived information so that it can be retained in long-term memory and retrieved later when needed. This process occurs in the state referred to as working memory. However, the capacity of working memory is limited. Miller (1956) originally described the capacity as “seven plus or minus two.” This analysis refers to the number of items or “chunks” that can be held at any one time unless the learner takes action to retain the information. However, the number may be as few as four chunks, plus or minus one (Cowan, 2000). Also, a chunk varies in the amount of information it contains. For example, the letters *bkj* may be three chunks, but the three letters in *cow* are only one chunk for a fluent reader (DiVesta, 1987, p. 210).
Maintaining information in working memory is similar to the circus act of spinning plates on a reed (Anderson, 1990, p. 153). The performer must get each plate spinning in turn and then get back to the first one before it slows down and falls off. If we try to keep too many items in working memory, the first item, like the spinning plate, will fall off.

Accessibility of information at a later point in time from long-term memory depends primarily on the way it is originally encoded (Hampson & Morris, 1996). Also, the more ways a learner encodes information, the greater the chances of later retrieval.

**Encoding Specific Items.** Depending on the encoding method, specific items and facts may be forgotten, stored as isolated fragments, or integrated into a larger framework. The two major types of encoding strategies are maintenance, or primary rehearsal and elaborative rehearsal. Primary rehearsal is simply repeating information, such as names, dates, and definitions, over and over. However, the information is quickly forgotten (McKeown & Curtis, 1987) because primary rehearsal does not relate the information to the student’s knowledge.

Elaborative rehearsal, in contrast, transforms the information in some way. It may be (a) modified so that it relates to the learner’s prior knowledge, (b) replaced by another symbol, or (c) supplemented by additional information to aid in recall. The process of forming additional connections to material already learned and additional recall cues leads to the construction of elaborated structures in memory. Redundancy of the information to be stored is increased and alternate routes for later retrieval are developed (Anderson, 1990, p. 182).

The techniques known as mnemonics facilitate learning by making use of initially extraneous material (Turnure & Lane, 1987, p. 331). An example of a verbal mnemonic is the acronym ROY G BIV for the seven basic colors (red, orange, yellow, green, blue, indigo, and violet). An example of imagery is associating the term “roseola,” a common viral disease of childhood, with the image of a spray of red rosebuds. Some have suggested that bizarre and vivid images are more effective than mundane images in enhancing recall (e.g., Bower, 1970). However, a review of studies comparing the two types of images indicated the bizarre images are effective in tests administered after only short delays (Epstein & McDaniel, 1987). Moreover, the use of bizarre images does not meet the requirement that new information should fit into the learner’s scheme of reality in some way (Bellezza, 1996, p. 365).

Some mnemonic methods serve as organizing frameworks for new information. A well-known technique is the method of loci. The method supposedly originated with the Greek poet Simonides, and was used by the early Greek and Roman orators to remember the main points in their lengthy speeches. Implementation involves first selecting a familiar setting, such as the rooms in a house or the pathway of a customary walk. Then, using mental images, the individual associates each image with a particular location.

A variation of the method of loci appropriate for collections of important facts is to visualize a course of study or an area of content as a filing cabinet. Each drawer is mentally labeled by major topics, periods of time, or some similar designation. Each folder in a drawer may represent a subtopic, a major event,
a person, or some other important designation. During learning, the student visualizes the label on a particular drawer, the opening of the drawer, and the insertion of particular information into the relevant folder. For example, for a course in human development, a student may visualize the drawer labeled *early childhood* and mentally place information about children's types of play experiences in a folder labeled *play*.

To be effective as mental cues for the retrieval of information, mnemonic devices should meet three criteria (Bellezza, 1996). First, these cues should be reliable; that is, they can easily be generated at the time of recall. Second, the mnemonic must be linked easily to the new information to be learned (p. 353); visual images are more appropriate choices than abstract words. Third, the cues must be dissimilar from each other and easily identified as different. Otherwise, more than one item of new information will become attached to basically the same cue. The result is confusion or forgetting (p. 354).

**Encoding Concepts, Principles, and Ideas.** Two methods address the encoding of content knowledge that consists of concepts, principles, and ideas. They are (a) additional spaced presentations or reviews of the material, and (b) Wittrock's (1990, 1992) generative learning model. Research on verbal learning tasks, addition facts, science concepts, and the processing of text materials indicates that presentations spaced over a period of time are almost twice as effective as two massed presentations separated by only a few hours (see Dempster, 1996, for a review). The second reading or review provides the learner with an opportunity to retrieve the information from long-term memory and encode additional facts or details.

In contrast, the generative model maintains that comprehension and understanding are the result of generating two types of relations (Wittrock, 1990, 1992). They are (a) relations among concepts and (b) relations between the student's prior experiences or knowledge base and the new information. Teaching for comprehension involves leading students to construct these two types of relations (Wittrock, 1992, p. 532). In one study, students who answered one to three inferential questions after reading paragraphs recalled a greater number of idea units than students who read declarative versions (rote recall) of the questions (Benton, Glover, & Bruning, 1983). Furthermore, ninth-grade students taught a prior knowledge activation strategy had higher comprehension scores than students who were taught a strategy for identifying the main idea (Spires & Donley, 1998).

**Retrieval**

The term *retrieval* refers to accessing information that has been stored in long-term memory. Although computer models may imply that retrieval is rapid and effortless, it is often reconstructive and effortful. For example, if asked to recall when a particular chair in one's living room was purchased, the owner searches her memory and recalls that it was when she lived in apartment X in town Y. This information assists in recalling that she saw it at a sale at store W (Conway, 1996).

Until the 1970s, the failure to produce information when needed was viewed as either an encoding problem or the result of the deterioration of the memory of the event (Roediger & Guynn, 1996). Tulving (1974), however, introduced the
possibility that encoding and memory storage may be successful, but failure to recall an item of information occurs as a result of retrieval failure. Information may be available in long-term memory, but may be inaccessible through lack of a retrieval cue. In other words, remembering is similar to other familiar psychological events. For example, a star in the sky can be seen if its light reaches our eyes and if no light is reflected from the sky around it. Similarly, we recall an event if encoding developed a memory trace and if something reminds us of the event (p. 74).

The cue for retrieval may be external, internal, or a combination of the two. In the prior example, the friend’s question about the purchase date of the chair is an external cue that leads to the recall of the town and apartment lived in (internal cue), which then leads to the recall of the sale at store W. The rationale for using mnemonics for information that may be low in imagery or meaningfulness, for example, is to establish an internal mental cue that may be easily accessed at a later time.

Summary

Essential components of information processing that may be applied to learning are the learning framework and the processes of perception, encoding, and retrieving the learned information from long-term memory when needed. The learning framework consists of (a) the learner’s prior knowledge, both tacit and conceptual (content and discourse knowledge), and (b) the nature and organization of the information to be learned. The learner’s knowledge serves as the framework for identifying incoming information and influences the learner’s inferences about the new information. Extensive knowledge also can (a) enhance the capacity of working memory to encode information in large chunks, and (b) increase the speed of processing.

Two formal organizations of material to be learned are teacher presentations and text passages. However, many textbooks are difficult to read and often include irrelevant information. Some texts use irrelevant vivid details, which can distract student attention from important information.

Perception, the first step in comprehending information, selects and recognizes incoming information. Essential to this process are the knowledge and the attention of the learner. Attention functions as a front-line manager by selecting the information that will be processed further, and prior knowledge assists in identifying the incoming information. Encoding, which prepares selected information for storage in long-term memory and later recall, consists of two types of strategies. Maintenance rehearsal, reciting information over and over, is effective only for recall within a short time period. Elaborative rehearsal, which transforms information in some way and establishes links with prior knowledge, is an effective encoding strategy. Examples include mnemonic devices for facts and constructing meaningful links between new concepts or ideas and between the new concepts and the learner’s prior knowledge.

PRINCIPLES OF INSTRUCTION

Information processing is a particular perspective within the larger domain of cognitive psychology. Instruction can be planned to facilitate each of the processes identified by information-processing theory.
Basic Assumptions

The basic assumptions of information processing describe the nature of the human memory system and the representation of knowledge in memory. Classroom applications are derived from the assumption that human memory is an active system that selects, organizes, and encodes for storage the new information or skills to be learned. An important goal in the classroom is to develop in the learner a rich store of knowledge and effective strategies for understanding and comprehending information in different domains.

The Components of Instruction

Major components in instruction are (a) structuring the framework for learning, (b) facilitating learner attention, (c) facilitating the encoding of information, and (d) teaching students strategies for constructing meaning.

Addressing the Learning Framework

The learning framework consists of learner knowledge and the organization of the information to be learned. The role of instruction is to (a) contribute to the ways that learner knowledge interacts with new learning and (b) structure the information to be learned in meaningful ways.

Both discourse knowledge, particularly the knowledge of text structure, and the student's domain knowledge are important in the learner's comprehension of teacher presentations and text materials.

Knowledge of Text Structure. Knowledge of text structure, particularly organization, is important in assisting readers to differentiate important from unimportant information (Dole, Duffy, Roehler, & Pearson, 1991; Garner, 1990). For example, in two studies, 20% of seventh graders were unable to logically sequence seven randomly organized sentences into a coherent paragraph. Furthermore, one-third of the third and fifth graders were unable to identify the topic sentence in the set of randomly ordered sentences (Garner et al., 1986).

In addition to text organization, instruction on the recognition and understanding of signal words also is important (Mayer, 1984). Signal words are non-content words that emphasize the conceptual structure of the material. Examples include preview sentences, paragraph headings, and connectives such as "the problem is . . . .". Also included are "pointer words" such as unfortunately and more important.

Domain Knowledge. Across all ages and ability levels, readers use their knowledge base as a filter to interpret and construct meaning from text passages (Dole et al., 1991). When learner knowledge is incomplete, naive, or misleading, interpretations will be incomplete or faulty (p. 24). In addition, when the material to be learned conflicts with or contradicts the learner's knowledge base, learner knowledge typically prevails (see Dochy, Segers, & Buehl, 1999, for a discussion).

As the student moves through the educational system, the relationship between the learner's domain knowledge and text material becomes increasingly important (Alexander, Kulikowich, & Jetton, 1994). The main reason is that texts
become more important as information sources in the middle and high school grades. They become a primary mechanism for increasing the student’s domain knowledge. However, paradoxically, the student’s subject-matter knowledge is important in interpreting texts, which become lengthier and more complex in middle and high school (Alexander et al., 1991).

The relationship between the learner’s domain knowledge and text comprehension is described by Stanovich (1986) as Matthew effects. The term is derived from the biblical passage in Matthew 25:29, which states that those who have shall have abundance, but those who have not shall lose the little they have. Applied to school learning, those with more subject-matter knowledge are better able to process information from text and, therefore, acquire more domain-related information as they move from grade to grade. In contrast, students with weak domain knowledge become less able to address the more demanding texts and, thus, fall further and further behind (Alexander et al., 1994, p. 215).

A strategy to address this problem is to follow reading assignments with classroom discussions. The purpose is to clarify difficult or unfamiliar concepts. For example, statements in one elementary school passage were “Plains Indians lived mainly in tepees; some California tribes lived in simple earth-covered shelters,” and so forth. For children who did not know or who were unable to activate knowledge about the relationship of house style to lifestyle, climate, and availability of raw materials, the information is simply a list of arbitrary statements (Bransford, Vye, Adams, & Perfetto, 1989, p. 216). Classroom discussions in which students explore possible reasons for differences described in general statements provide experience in elaborating text and altering their prior knowledge about the topic.

**Organizing the information to be learned.** A few studies have restructured poorly organized text material, a strategy that enhanced both learning and interest in the subject matter (Alexander et al., 1994). However, in most situations, teachers face the responsibility of providing meaningful organization for text material. One suggested strategy is that of advance organizers. Discussed in the following section, advance organizers serve as umbrellas into which the student can fit more detailed information as he or she reads.

Another possible strategy is the development of materials using nonlinear or hypercard computer materials. In such an arrangement, the learner can access portions of the information as he or she chooses. The disadvantage is that many of the initial hypercard texts were quite lengthy (Alexander et al., 1991). This factor poses a problem for readers with poor processing strategies. Essential in designing hypercard materials is to assist the learner to develop a conceptual organization of information. Overview screens that display relationships among concepts at the choice points for selecting material can be helpful (Spoehr, 1994).

**Facilitating Learner Attention**
An important aspect of instruction is to first structure the environment so that student attention is focused on important tasks (Bruning et al., 1995) and then to informally assess learner perceptions. This step is important because the learner responds to the instruction that he or she actively apprehends, which is not
necessarily the instruction as presented (Shulman, 1986). One approach is to activate students’ relevant knowledge immediately prior to the lesson. For example, for a lesson on heat conduction and the relationship of an object’s density to its heat conduction, students generate examples of objects that conduct heat. One girl named the handle of a metal frying pan on a hot stove burner, another the outside-facing wall of a room on a cold day, and so on. A carefully controlled experiment in which several different materials of the same size were placed in a flame led to a discussion as to why some of the materials became warm quickly while others seemed to remain cool (Bruning et al., 1995).

**Advance Organizers.** David Ausubel, who introduced advance organizers, supported the use of direct instruction when bodies of information are to be learned. He cautioned, however, that instruction must foster meaningful learning, not rote memorization. To facilitate meaningful learning, instruction should link new ideas and concepts to the student’s existing knowledge through advance organizers. They are highly inclusive concepts that serve as “ideational scaffolding” (Ausubel, 1968). They must be carefully selected to serve as a link between the student’s existing store of information and the new learning. Advance organizers provide a conceptual framework as well as facilitating the encoding of new information.

The two types of organizers identified by Ausubel (1968) are expository (used with unfamiliar material) and comparative (used to facilitate the integration of new ideas in relatively familiar material with similar, previously learned concepts). Although some of the early research indicated no effects for advance organizers, Corkill (1992) noted that a variety of materials, such as prereading activities, paragraph headings, study objectives, and outlines, were mislabeled as advance organizers. However, advance organizers are neither previews of new learning nor organizations of the material to be learned.

Research has indicated that written organizers should be concrete and contain an example that illustrates the analogous relationship between ideas in the advance organizer and ideas in the new material (Corkill, 1992, p. 63). The reading level of the advance organizer also is important; students may require different advance organizers, depending on their prior knowledge and reading skills.

**Teaching Selective Attention Strategies.** The second major task for teachers in facilitating learner attention is to teach students to be strategic processors of information. The initial key step is focusing attention on important ideas, facts, concepts, and generalizations to be learned. However, particularly when reading text materials, the attention of both children and adults often is not strategic, conscious, or selective (Garner, 1992, p. 58). When individuals process meaningful materials, they often do so superficially (Pressley et al., 1992).

Teachers can provide instruction on focusing attention, using questions first to direct students’ attention to important material and then observing their use of these questions on their own. Appropriate questions to begin with are, Where should we look first for important information? (first or second sentence in the paragraph) and What other information do we need to include? (Garner, 1992).
Facilitating the Encoding of Specific Items

Laboratory research on the encoding of word lists indicates that a test prior to the final assessment enhances recall. In the classroom, this practice can apply to spelling and vocabulary in the elementary grades. Tests are not simply neutral events that provide evidence of the person's knowledge (Dempster, 1996). Instead, they require students to retrieve information from memory and interact with it again (Roediger & Guynn, 1996).

The method referred to as mnemonics is appropriate for arbitrary associations in different subject areas that must be learned. Sentences and acronyms, for example, are organizational mnemonics that assist in both learning the information and serving as retrieval cues for later recall. They are most effective for items that must be recalled in a certain order (Snowman, 1986). For example, a useful mnemonic in beginning music is the sentence, “Every good boy does fine.” The initial letters (e, g, b, d, f) are the notes printed on the lines of the treble clef. Similarly, the word face represents the notes printed in the spaces (f, a, c, e). An example useful for anatomy students is the rhyme, “On old Olympia’s towering top, a Finn, Visigoth, and German vault, skip, and hop” (Solso, 1988, p. 227). The initial letter of each word of the first line represents the cranial nerves (olfactory, optic, oculomotor, trochlear, trigeminal, and so on).

Both visual and verbal learner-generated cues can enhance encoding. A flexible mnemonic technique, originally developed for foreign-language learning, is the keyword method. The technique divides vocabulary learning into two major steps. The first step is for the learner to select an English word that sounds like some part of the foreign language word. This step is the acoustical link (Atkinson, 1975, p. 821). The second step is to form a mental image of the keyword interacting with the English equivalent of the foreign language word, referred to as an imagery link. For example, the Spanish word for duck sounds like “pot-o” (acoustical link). An interactive image is that of a duck hiding under an overturned flower pot. Another example is the use of the keyword wave for the Spanish word huevo (wave-o), which means “egg.” The visual image is that of a giant egg riding the crest of a wave (Jones & Hall, 1982).

Although designed for foreign language learning, the keyword method may be applied to other learning tasks. Examples include learning medical definitions, linking explorers with discoveries (Jones & Hall, 1982), enhancing memory for facts (Levin, 1986), and increasing learning from text (McCormick & Levin, 1984). Mnemonic imagery is also useful for learning information about totally unfamiliar concepts, such as information about unknown countries (Pressley, Johnson, Symons, McGoldrick, & Kurita, 1989, p. 12).

Mnemonic methods also may be useful in conveying both meaning and structure when terms are hierarchically organized. Levin and Levin (1990) developed a mnemonic system for plant classification terms in which (a) the particular terms were recoded into acoustically or orthographically similar concrete proxies (keywords), and (b) links between the terms were represented as pictorial semantic relationships. For example, angiosperm became an angel who is holding a pet leash attached to a monkey (for monocotylan) and the monkey is shooting an arrow (for arales) at a frying pan (for pandanales) (p. 302). The
subordinate relationships were illustrated in the picture by placing the images in sequence from the top to the bottom of the picture beginning with the angel at the top. Results indicated that the system, when compared to a taxonomy chart, significantly increased recall on both immediate and delayed tests (2 months later) for college students. The mnemonic group also was more fluent in accurately placing the plant terms within the taxonomy.

Imagery-based strategies can assist students with mental retardation or learning disabilities in learning and recall (see Mastropieri & Fulk, 1990; Turnure & Lane, 1987). However, to be effective, these mnemonics must be explained, demonstrated, and applied in many situations in which they are to be used.

**Strategies Instruction**

Strategies are operations over and above the processes that are involved in a task (Pressley, Borkowski, & Schneider, 1987). Teaching processes and strategies for learning concepts, principles, and ideas is important for two reasons. One is that students tend to overestimate their comprehension of text. Bradshaw (2000) found no relationship between the self-ratings of elementary school children on their text comprehension and their performance on specific comprehension questions. The second reason for instruction is that many students fail to use effective strategies.

Issues in strategy instruction are the types of strategies for constructing meaning and the steps in strategy instruction. Two specific strategies shown to be effective for constructing meaning from both text and orally presented material are summarizing and self-questioning. The purpose of these strategies is to assist students to construct a model of meaning from their prior knowledge, cues noted in the material, and the instructional context (Dole et al., 1991).

**Summarizing.** The purpose of summarization is to capture the gist of instruction while, at the same time, reducing the material. Effective summarization requires that the learner sift through large organizations of information, distinguish important from unimportant ideas, and then synthesize the key ideas into a new coherent organization that represents the original (Dole et al., 1991). Rules for developing useful summaries include (a) delete unnecessary material, (b) eliminate redundancy, (c) substitute a superordinate term for groups of terms and/or lists of events, and (d) invent a topic sentence if none appears in the text (Brown & Day, 1983).

Summarization often is recommended as a strategy for enhancing the meaning of reading passages. Summarization also may enhance understanding of orally presented material following notetaking (King, 1992). The topic of the lecture or presentation may be turned into a sentence that reflects the main idea and subtopics should be successively linked to the main idea.

As stated earlier, the effectiveness of summarization depends on the student’s ability to differentiate important from unimportant information (Dole et al., 1991). In reading, for example, research indicates that good readers use their general knowledge and domain knowledge as well as their knowledge of text structure to help them identify important information (Dole et al., 1991).
Garner (1990) differentiates strategically inefficient from strategically efficient summarizers on the basis of this capability. Inefficient summarizers copy ideas verbatim from text and do not paraphrase or combine ideas. In contrast, efficient summarizers select only the most important text, use rules for condensing text, and produce coherent summaries (p. 263).

**Self-Questioning.** Teacher-generated questions are a traditional practice in the teaching of reading. Current research, however, indicates that teaching students to generate their own questions stimulates their inferences and explanations about the material and, therefore, their understanding (Dole et al., 1991; King, 1991, 1992; Pressley et al., 1992).

The product generated in self-questioning is a set of questions and answers about the instruction. When the questions require inferences by the learner, that is, when they are high-level questions, they can assist the learner to organize the new material and integrate the information with existing knowledge. In addition, self-questioning is a metacognitive strategy because it is a way for learners to check their level of comprehension and understanding (King, 1992).

Researchers have identified several ways of implementing self-questioning for understanding. One approach, referred to as elaborative interrogation, involves asking “why” questions about factual statements in text passages. For example, for statements on Canadian provinces, Canadian university students asked questions such as, “Why would it make sense that the first radio stations were in Alberta?” (Pressley et al., 1992). For the students, the researchers hypothesized that the “why” questions activated the students’ prior knowledge related to the new facts (p. 98).

A second approach to generating thought-provoking questions is to teach specific stems (King, 1990, 1991, 1992). Two types are lesson-based questions and experience-based questions (King, 1994). Examples of lesson-based questions are “What does_____mean? Why is_____important? How are_____and_____similar? What are the strengths and weaknesses of_____?” (p. 341). Examples of experience-based questions are “How would you use_____to_____? What would happen if_____? How does_____tie in with_____we learned before?” (p. 341). Formulating such questions requires the identification of main ideas and the ways that the ideas relate to each other and to the students’ prior knowledge and experience. In one study, pairs or small groups of students asked each other the questions about the science information in teacher-led presentations and lessons (King, 1994). Combining the two types of questions was more effective than either the lesson-based questions or learner construction of cognitive maps of science concepts. The levels of elaboration in the types of questions are the essential components in Wittrock’s (1990) model.

A third approach to self-questioning addresses the identification of **story themes** by elementary school students (Williams et al., 2002). Children first are taught four organizing questions that assist them to identify important plot components that provide information for developing a theme. They are “Who is the main character? What is the main character’s problem? What did the main character do about the problem? And then what happened?” (p. 236). The teacher
should introduce these questions by both asking and answering them, providing a model for the students. After the students have demonstrated proficiency with these questions, four organizing items can lead to identification of the theme. They are “Was what happened good or bad? Why was it good or bad? The main character learned that he/she could _____. We should _____.” (p. 237).

A fourth approach that raised the reading scores of poor comprehenders combined instruction on looking for clue words in passages with answering “who,” “where,” “why,” and “when” questions (McGee & Johnson, 2003). Children between the ages of 6 and 9 identified as poor comprehenders participated in groups of five in two sessions per week (20–30 minutes each) for 3 weeks. For the children, looking for clue words was a novel activity; they had not deconstructed text in that way before (p. 56).

**Recommendations for Strategy Instruction.** A frequent criticism of strategy instruction is that students do not continue using the strategies without specific directions to do so (Pressley & El-Dinary, 1992, p. 86). However, implementing particular steps along with strategy instruction can promote transfer to other similar tasks. First, determine the particular activities undertaken by students and the underlying rationales for their actions. For example, students who skim a passage merely to get through it suggests an avoidance of school tasks and/or a sense that such tasks have no inherent meaning for life in the world outside of school.

Second, demonstrate the benefits of strategy use in both school assignments and other activities. For example, demonstrate how to construct meaning from one’s prior knowledge and the cues in the text and situational context (Dole et al., 1991). Also, ask students to compare their performance before and after using the particular strategy (Pressley & El-Dinary, 1992).

Essential steps in teaching a strategy are (a) describe and then model the strategy, (b) provide teacher-guided practice accompanied by praise and corrective feedback, and (c) teach when and where to use the particular strategy. This information is an important component of the student’s metacognitive knowledge (see Chapter 7). Finally, practice should begin with simple materials and progress to grade-level tasks (Pressley et al., 1989, p. 25).

Strategy instruction is not a “quick fix.” Strategies such as paraphrasing, summarizing, and self-questioning require time and practice to develop. Therefore, only one strategy should be taught at a time, and it should be learned well prior to the introduction of another strategy. In summary, successful strategy instruction should not be viewed as remediation. Instead, the goal is to develop sophisticated comprehension skills in all students (Pressley et al., 1989).

**Summary**

Major components in instruction from the information-processing perspective are enhancing prior learner knowledge, organizing the material to be learned, facilitating learner attention, encoding and the construction of meaning, and teaching students strategies to enhance their understanding of text and oral presentations.

Both discourse knowledge and the student’s domain knowledge are important in the comprehension of text materials and teacher presentation. Teachers
can assist students in developing text-structure knowledge by teaching them to recognize signals such as preview sentences, paragraph headings, and signal words. For students with poor background knowledge or for texts that are poorly written, small-group and class discussions can develop some of the missing links.

Essential in planning instruction is the fact that the student responds only to the instruction that he or she actively apprehends. Therefore, instruction should focus learner attention on important tasks and informally assess learner perceptions. One approach is to implement preteaching activities that activate prior knowledge and/or link prior knowledge to key concepts. Another approach is to use advance organizers. They are inclusive concepts that serve as a link between the student's present store of information and the new learning; they serve as a conceptual framework and also facilitate encoding. Another strategy is to teach students ways to find important information in text and other materials.

Methods for encoding specific items of information such as vocabulary words, dates, and facts include prior testing and various mnemonic techniques. Examples are rhymes, acronyms, sayings, and learner-generated cues, such as the keyword method. The two elements in the keyword mnemonic are an acoustical link to the word to be learned and an image of the acoustical link interacting with a semantic link to the new word. Imagery-based strategies also can aid students with learning disabilities with learning and recall.

Two strategies for the construction of meaning for complex information are summarizing and self-questioning. One summarization strategy involves turning the topic into a sentence that reflects the main idea and successively linking subtopics and related ideas together. Self-questioning can be useful for both facts and other types of information. In using "why" questions, the purpose is to activate students' prior knowledge related to new facts. Self-questioning to generate the meanings in a passage should involve application questions in which the learner generates new examples, explains how key concepts are used, and identifies relationships between major ideas. Teaching strategies for developing meaning from text and presentations requires demonstrating the benefit of the strategy, describing and modeling the strategy, and providing teacher-guided practice with praise and corrective feedback.

EDUCATIONAL APPLICATIONS

Information-processing theories began as a research effort to understand the cognitive operations undertaken by humans. Research then expanded to address the ways that students process information in various subject areas and to identify strategies to facilitate processing.

Classroom Issues

Classroom issues addressed by information-processing theory are those that are directly related to cognitive processes.
Learner Characteristics
Student characteristics that are important in the management of classroom learning are individual differences, readiness for learning, and motivation. Of these three, individual differences are addressed in relation to problem solving, which is discussed in Chapter 7.

Cognitive Processes and Instruction
The focus in information-processing theory is the variety of processes whereby individuals perceive, encode, remember, recall, and apply information or knowledge. The issues of transfer of learning and learning "how-to-learn" skills are also addressed.

Transfer of Learning. Typically, transfer of learning refers to skills or knowledge learned in one context or situation that later are applied to new contexts. Mnemonic techniques and other mechanisms to assist encoding are generalizable to a variety of settings, as are text comprehension strategies and others.

However, transfer will not occur unless the appropriate prior knowledge is activated. The failure to activate relevant knowledge is referred to as inert knowledge (Bransford et al., 1989; Whitehead, 1929). The problem of inert knowledge (i.e., lack of transfer) may be the result of (a) memorizing rather than learning the significance of new information, (b) acquiring concepts in a limited context, or (c) being unable to access acquired knowledge efficiently with minimal effort (Bransford et al., 1989, p. 214).

Learning "How-to-Learn" Skills. The term metacognition refers to the capabilities required to direct one’s learning, remembering, and thinking. They are discussed in Chapter 7.

Teaching Problem Solving. This topic is discussed in Chapter 7.

Implications for Assessment
A major contribution of information-processing theory is the recognition of the essential role of the student’s prior knowledge in learning. The implication for assessment is to determine students’ knowledge of facts and concepts essential to understanding an upcoming lesson. Assessment may consist of informal questioning and a brief class discussion or a formal pretest.

A major goal of information-processing theory is the construction of content knowledge in identified domains. In literature, social studies, and history, for example, multiple-choice and matching questions can address some facts, but cannot address comprehension and deep understanding. Instead, essay questions, properly constructed, can elicit students’ thoughtful explanations and interpretations of concepts.

An example in history is to ask the student to explain particular issues or problems at a point in history to a cousin visiting from England (Baker, Freeman, & Clayton, 1991). One assessment asked the student to imagine that he or she lived in Illinois in 1858. Then, based on the Lincoln–Douglas debates, the student
was to explain at least two important problems facing the country and proposed solutions to the English cousin. Events, laws, court decisions, and major principles of the U.S. government relevant to the issue were to be included in the essay (p. 146). Criteria for scoring the essays were the presence of problem focus, use of prior knowledge (principles, facts, and events) to explain or elaborate, avoidance of misconceptions, relevant text references, and demonstrating interrelationships using text and prior information (p. 150).

Questions that begin with the word discuss, as in “Discuss the Lincoln–Douglas debates” should not be used. First, the term is ambiguous and second, answers will be simply a regurgitation of information.

Comprehending information in teacher presentations and written text is a capability that begins in the early grades. A teaching and assessment method often used by elementary school teachers is retelling. This activity refers to telling a story or reporting informational text in one’s own words. It does not mean memorizing words and sentences from the written text (Morrow, 1989). The process involves reconstruction, which requires thinking about the particular story elements, relating them to each other, and arranging them in sequence. In this way, children build an internal representation of the story (p. 89).

As an assessment tool, retelling addresses the child’s recall of specifics, sense of story structure, and his or her abilities to organize, integrate, and classify information implied in the story. Retelling differs from answering questions about the text (Leslie, 1993). First, retelling is primarily dependent on the learner’s schema or understanding of the type of text. Second, direct questions frequently include clues that indicate the answer (p. 25). Prior to the retelling, the teacher should read storybooks several times and then ask children to retell them. In a variation of this procedure, after the teacher has read the story a few times, the child draws a picture that represents the story, and tells the teacher about the picture. Selections for use with children should have good plot structure with a clear story line (Morrow, 1989). Also, practice with prompting is essential in the classroom so that children feel at ease with the process.

The Social Context for Learning

Information-processing theory focuses on the cognitive mechanisms involved in the comprehension and retention of sensory data from the environment, as well as the application of learned information to solving problems. Although much of this learning occurs in a social environment, the theories have yet to address the influence of that environment on cognitive processing.

Relationships to Other Perspectives

Like Gestalt psychology, information-processing theory also addresses perception. However, Gestalt psychologists discussed perception only in problem-solving situations that require a reorganization of visual stimuli. In contrast, information-processing theory treats perception as one of the major steps in acquiring and remembering information.

Information-processing theory also discusses strategies for constructing meaning that operate within a context of predetermined knowledge to be learned.
Constructivists, however, maintain that such constraints prevent the "true" construction of knowledge, which, instead, must begin with the learner and does not build toward a specific outcome.

The comprehension of knowledge in a subject-matter area or domain is a major focus of information processing. Summarizing or restating information in a domain is referred to by Gagné as the capability of verbal information. Unlike Gagné's conditions of learning, the theory does not address the different types of cognitive capabilities that may be developed in relation to knowledge.

**Developing a Classroom Strategy**

Designing instruction for information processing should focus on transforming the logical meaning of knowledge into psychological meaning. Logical meaning is the relationship of the symbols, concepts, and rules of the subject area. Psychological meaning is the relationship of the symbols, concepts, and rules to the student's cognitive structure (Ausubel, 1968). Developing psychological meaning in the comprehension of knowledge and in solving problems depends on student interaction with the subject matter.

**Comprehension**

**Step 1:** Develop cues to guide the reception of the new learning.

1.1 What informal questions will access the learner’s existing knowledge?
1.2 Does the lesson include broadly written objectives or a statement of purpose that can direct the learner’s attention?
1.3 How will the new knowledge or skills enhance or build on the learner’s existing knowledge?

**Step 2:** Select or develop conceptual supports that facilitate the encoding of information.

2.1 What information should be included in advance organizers so that they bridge the student’s knowledge and the new learning?
2.2 What concepts, episodes, and images already acquired by the student may be used to illustrate the new terms, definitions, or concepts?
2.3 Are there adjunct questions in the text or major points in the text that can be used as a basis for secondary rehearsal by the students?
2.4 What are the logical points in the instruction for students to engage in secondary rehearsal (i.e., visual and/or verbal elaboration)? What are some examples of associative images and verbal codes that can be provided to students?

**Step 3:** Develop cues that aid in the retrieval of learned information.

3.1 What are some comparisons with related concepts, terms, or ideas that may be made? For example, if the concept is *morpheme*, it may be contrasted with *phoneme* and compared with the term *word*.
3.2 What inference questions may be used to conclude the lesson?
Comprehension Strategies

Step 1: Teach attention-focusing strategies.
   1.1 Use questions first to direct students’ attention to important material.
   1.2 Provide opportunities for students to apply the questions.

Step 2: Teach summarization and self-questioning strategies.
   2.1 Demonstrate turning topic sentences into a statement of the main idea.
   2.2 Demonstrate linking the main idea to subtopics.
   2.3 Provide opportunities for student application, feedback, and further opportunities for application.
   2.4 Demonstrate the use of generic question stems to generate information from text.
   2.5 Provide opportunities for student application, feedback, and further opportunities for application.

Classroom Example

The following strategy is a component of the story grammar strategy developed to assist students with learning and/or writing problems to write better stories. The strategy is a component in a program developed by Graham and Harris (1994) to teach writing and self-regulation skills to students with learning problems. The purpose is to provide students with an explicit, context-based strategy.

Initial conference. The purpose of instruction is explained. Teacher and students then discuss the common parts of a story and the goal for learning the story grammar strategy.

Part-skill development. Teacher and students discuss the common story parts (characters, place, time, setting) and story episodes (precipitating event, characters’ goals, action to achieve goals, resolution, and characters’ reactions).

Story grammar strategy. The following steps to help the students write stories are taught by the teacher:

1. Think of a story you would like to share with others.
2. Let your mind be free.
3. Write down the reminders of the story parts (W-W-W; What = 2; How = 2).
   W—Who is the main character? Who else is in the story?
   W—When does the story take place?
   W—Where does the story take place?
   What does the main character do or want to do and what do the other characters do?
   What happens with the other characters?
   How does the story end?
   How do the main character and the other characters feel?
   (Graham & Harris, 1994, p. 219)
4. Make notes of your ideas for the story parts.
5. Write the story. Use some parts and add, expand, or revise as you go
   (summarized from Graham & Harris, 1994).

### Review of the Theory

The communications research of World War II and computer simulations of human intellectual capabilities introduced a new paradigm to the study of mental operations. This paradigm is reflected in the information-processing descriptions of cognitive operations. According to this paradigm, the human memory is an active, organized system that selects the information to be processed and then transforms that information into meaningful codes for later use (see Table 6.4).

The core of the theory comprises the processes by which individuals perceive, encode, and then store information in long-term memory for later use. Theorists agree that codes are stored internally in some type of cognitive structure. The prevalent view is that subject-matter information takes the form of semantic networks.

### TABLE 6.4
Summary of Information-Processing Theory

<table>
<thead>
<tr>
<th>Basic Elements</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumptions</td>
<td>Human memory is a complex and active organizer of information; the memory system transforms information for storage (and later retrieval) in long-term memory</td>
</tr>
<tr>
<td>Learning</td>
<td>The processes by which information from the environment is transformed into cognitive structures</td>
</tr>
<tr>
<td>Learning outcome</td>
<td>Some form of cognitive structure; the prevalent view is that of semantic networks</td>
</tr>
<tr>
<td>Components of learning</td>
<td>The processes of perception, encoding, and storage in long-term memory</td>
</tr>
<tr>
<td>Designing instruction for complex skills</td>
<td>See Chapter 7</td>
</tr>
<tr>
<td>Major issues in designing instruction</td>
<td>Relating new learning to existing knowledge; teaching students to monitor comprehension; and structuring learning to facilitate processing</td>
</tr>
</tbody>
</table>

### Analysis of the Theory

| Disadvantages                        | Information-processing theory lacks a coordinated theoretical foundation; various perspectives are somewhat disjointed |
|                                      | Computer model of cognitive processes may or may not be valid |
| Contribution to classroom practice   | Identification of the importance of designing instruction for the cognitive processes in learning |
in which verbal elements are linked to each other. Personal items of information are described as being coded into episodic memory and procedural networks consist of "how-to" information. Large bodies of knowledge are categorized as tacit and explicit. Included in explicit knowledge are domain and discipline knowledge (content), discourse knowledge, and metacognitive knowledge. The term schema also refers to the learner's information about a particular topic, issue, or domain.

Key components in learning are (a) the learning framework, which consists of the learner's knowledge and the organization of the information to be learned, and (b) the learner's cognitive processes, learning strategies, and metacognitive decisions. Applications to education include specific recommendations for enhancing the learner's prior knowledge, the use of advance organizers, and the use of learner-generated cues for encoding and constructing meaning. Included are the use of images, combinations of images and words, and students' summarization and self-questioning strategies.

Disadvantages
Theories of learning focus on particular outcomes of the learning process and describe the essential conditions for attaining those outcomes. In contrast, information-processing theory began with the steps involved in the intake, encoding, and storage of information in long-term memory. Although some research targets particular tasks, such as encoding items of information, the theories lack a foundation of agreed-upon learning outcomes. Information-processing theory, in other words, is a collection of various approaches to the study of cognitive functions.

Contributions to Classroom Practice
Information-processing theory has described in detail the processes that Gestalt theorists were attempting to identify. For classroom learning, the processes identified in encoding and constructing meaning indicate the importance of structuring lessons to support these processes and to teach strategies to enhance comprehension.

CHAPTER QUESTIONS

Understanding Concepts

1. Why are the sentences in set A below easier to remember than those in set B?
   Set A: Benjamin Franklin flew the kite. George Washington hid the ax. Santa Claus walked on the roof.
   Set B: Jim flew the kite. John hid the ax. Ted walked on the roof. (Bransford et al., 1989, p. 204).
   2. What is the major difference between declarative and procedural knowledge?
   3. Why is elaborative rehearsal more effective than maintenance rehearsal in enhancing recall?
   4. Accurate interpretation of words and phrases such as "however" and "in contrast" is an example of what type of knowledge?
   5. Why is the state referred to as inert knowledge a problem in learning?

Applying Concepts to Instructional Settings

1. A science teacher showed the class a picture of Mendeleev in his laboratory and discussed
his contribution to the development of the periodic table before she presented the details of the table of elements. According to Ausubel, why is the preliminary information not an advance organizer?

2. A student is faced with the task of learning the following information stated in a biology textbook: Arteries are thick, elastic, and carry blood rich in oxygen from the heart. Veins are thinner, less elastic, and carry blood rich in carbon dioxide from the body to the heart.

(a) What are some visual imagery and/or mnemonic elaborations that the student may generate to facilitate learning this information?

(b) What information can the teacher provide about the significance or relevance of these facts that may assist the student in remembering the information?

3. Some educators who support writing across the curriculum have suggested that writing should be included in mathematics and science as well as other subjects. What are some essay questions that might be used in those subject areas?

4. A middle school science teacher suggests that the students use a 5 × 8 card for each concept in the course. The cards should include the definition and examples. Critique this suggestion from the perspective of schema development.

5. Prior to teaching a unit on viruses, the teacher begins with a brief description of alien invaders from space that land on Earth and begin to destroy the infrastructure (e.g., roads and bridges). Critique this introduction from the perspective of advance organizers.

REFERENCES


CHAPTER 7

Cognitive Perspectives: II. Metacognition and Problem Solving

The reconceptualization of thinking and learning that is emerging suggests that becoming a good thinker in any domain may be as much a matter of acquiring the habits and dispositions of interpretation and sense-making as of acquiring any particular set of skills. (Resnick, 1988, p. 58)

Learning to speak and understand a first language, recognize faces, engage in basic social interactions, and execute general problem-solving techniques are skills that children acquire in their daily experiences (Howe, 1988; Geary, 1995, 2002, 2005). Formal schooling is not needed for these capabilities, which Geary (1995, 2002, 2005) identifies as biologically primary abilities. They are cognitive abilities that appear to have been shaped during evolution from the early Hominids to Homo sapiens (Geary, 1995; Geary & Bjorklund, 2000; Pinker, 1997). An example is the capability to process and respond to the sounds of language, which is found in all cultures (Geary & Bjorklund, 2000, p. 62). (However, language will not develop unless the child engages in relevant activities with others.)

In contrast, secondary abilities are cultural inventions that build on the primary abilities. They are not universal and are rarely learned spontaneously. “Children are wired for sound, but print is an optional accessory that must be painstakingly bolted on” (Pinker, 1997, p. ix). In addition, the extent to which a secondary ability is removed from the related primary ability, the more difficult it is to learn. An example is the distance between pointing at objects as someone counts them (a primary ability) and the base 10 number system. The mastery of concepts and procedures in the base 10 system requires more explicit and formal instruction than mastering a formal counting method, but less than mastering the basics of algebra (Geary, 2002). Evolutionary psychology predicts that the extent to which formal explicit instruction is needed for secondary abilities is a direct function of the distance of the secondary ability from the associated primary ability.

Also, unlike needing to know the growing cycles of plants or which plants make the best poison for arrow tips, the reasons for acquiring some secondary abilities in contemporary society is not obvious (Owens, 2002). In addition, as the
child progresses through school, education changes in two ways. One is that tasks become complex and abstract. Some middle school textbooks in mathematics, for example, introduce the concepts of probability and statistics, topics formerly taught in high school.

The second is that students are expected to develop the capabilities of learning from text and applying their learning to solve problems in various knowledge domains.

The need for self-directed learning does not end with formal schooling. Rapid increases in knowledge in several disciplines, the explosion of technology into daily affairs, and technological advances are changing the workplace and placing new demands on individuals. Managing one’s learning and learning to solve problems are important capabilities in a variety of settings.

THE NATURE OF COMPLEX LEARNING

Cognitive theory has addressed the changing educational situation in two ways. One is the identification and assessment of the cognitive abilities that students should enact to guide their learning of complex tasks, monitor their progress, and change course, if necessary. These capabilities are referred to as **metacognition**. Second, psychologists and educational psychologists have extensively researched various forms of problem solving in different subject domains to inform educational practice.

**Metacognition**

In comparison to the development of other learning theories, the concept of a particular knowledge base that addresses the organization and management of learning is relatively new. In the early 1970s, learning to use comprehension strategies, such as self-questioning and summarizing text, was viewed as moving from nonuse to the spontaneous production of the effective strategy (Harnishfeger & Bjorklund, 1990). Theorists and researchers attributed the spontaneous production of strategies to the learner’s increased planning capabilities and the acquisition of component skills in the particular strategy (p. 9).

An alternative view of strategy use emerged in the late 1970s and 1980s. Specifically, there are higher order processes that control the use of specific strategies. The first higher order process to be identified was metamemory (Flavell, 1971). Included are the learner’s (a) verbalizable knowledge about memory storage and (b) the person, task, and strategy variables that influence the performance of memory (Flavell & Wellman, 1977). Then research interests expanded to include learner knowledge about his or her cognitive functioning in general (in addition to memory)—the capabilities known as metacognition (Harnishfeger & Bjorklund, 1990).

Discussed in this section are the nature of metacognition and differences in the use of metacognitive strategies between younger and older learners and between experts and novices.
Components
In general, metacognition involves thinking about thinking. Some perspectives emphasize the individual's knowledge about cognition and strategy use. Others emphasize both the knowledge and regulation of cognition (Brown, 1987; Son & Schwartz, 2003).

Knowledge of Cognition. Key components of metacognition are (a) knowledge about and awareness of one's own thinking and (b) knowledge of when and where to use acquired strategies (Pressley & McCormick, 1995, p. 2). Knowledge about one's thinking includes information about one's own capacities and limitations and awareness of difficulties as they arise during learning so that remedial action may be taken. For example, students are sometimes unaware that a difficult text for which they have little background knowledge should be read differently than a text on familiar topics (Pressley, Borkowski, & Schneider, 1987). Also, young children sometimes believe that the purpose of reading is to pronounce all the words without mistakes. They also believe that good reading involves verbatim recall of the text. They lack sufficient metacognitive knowledge about the purposes of reading (Alexander, Schallert, & Hare, 1991).

Regulation of Cognition. Cognitive researchers differentiate between metacognitive strategies and cognitive skills. For example, taking notes while reading a chapter on the Louisiana Purchase is a cognitive skill; it is undertaken to facilitate comprehension and learning (Flavell, 1979). Later, the reader is concerned about being prepared for an upcoming test. She then quizzes herself to evaluate her level of preparedness using the end-of-chapter questions and her own self-generated questions. This strategy both assists the learner in constructing meaning and is a metacognitive strategy for checking one's level of learning (evaluation).

Researchers have proposed somewhat different models of metacognition for different tasks. One model consists of the three components of planning, evaluation, and monitoring (Jacobs & Paris, 1987). Planning involves setting goals, activating relevant resources (including budgeting time), and selecting appropriate strategies. Determining one's level of understanding constitutes evaluation. In this model, monitoring involves checking one's progress and selecting appropriate repair strategies when the selected strategies are not working. Developing meaning from text while reading, which involves evaluation and monitoring, is referred to as comprehension monitoring. The term refers to one's awareness of the quality and degree of comprehension and knowing what to do and how to do it when the learner discovers he or she is not understanding the material (Dole, Duffy, Roehler, & Pearson, 1991). Garner (1990, p. 251) refers to identifying a failure to understand a portion of the text as a cognitive failure (information processing is impaired), but a metacognitive success (the reader notices the problem and addresses it). When readers fail to monitor and control comprehension, “triggering events” that can alert them to comprehension failure (such as realizing that they do not know the meaning of one or more of the words) simply do not occur. The result is that the reader erroneously believes he or she has comprehended the text.
A model of the metacognitive activities in studying describes four stages (see Table 7.1). They are defining the task, goal setting and planning, enacting study tactics and strategies, and adapting studying (Winne, 2001; Winne & Hadwin, 1998). If the study task is very familiar, stage one may be skipped.

Each stage generates a product that the learner evaluates (a metacognitive activity) and that updates the conditions of work in the next stage. The student’s perception of the learning task, for example, is the basis for setting goals in stage two. The student’s personal standards also influence the actions at each stage. For example, students with an orientation to “just get by” may, in stage two, select simplistic tasks, such as paraphrasing headings and noting boldface terms in the text. Available time for the task also influences students’ decisions. Students faced with a time limitation exerted more effort on simple rather than complex aspects of a task, perhaps from the view that the tasks that are too difficult to complete in the allotted time should be avoided (Winne & Jamieson-Noel, 2003).

In stage three, the internal feedback generated by monitoring the enactment of study strategies may lead to adjustments. However, if the student perceives no

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**TABLE 7.1**
A Model of the Metacognitive Activities in Studying

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining the task</td>
<td>Generate a perception of the nature of the studying task, available resources, and constraints.</td>
<td>Complete an assigned reading on volcanoes from National Geographic; language is complex for middle school students, but student has 1 1/2 hours to complete assignment.</td>
</tr>
<tr>
<td>Goal setting and planning</td>
<td>Select or generate goals and a plan for addressing the study task.</td>
<td>Read the article for deep processing to prepare for unit test; personal note taking and self-questioning are needed.</td>
</tr>
<tr>
<td>Enacting study tactics and strategies</td>
<td>Implement the activities selected in stage two, and fine-tune, if necessary.</td>
<td>Difficult vocabulary encountered during reading leads to pauses to look up term definitions and rereading.</td>
</tr>
<tr>
<td></td>
<td>(1) Make large-scale adjustments to the task, goals, plans, and engagement.</td>
<td>Major difficulties in understanding the article lead to searching for basic information about volcanoes on the Internet.</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>(2) Alter one’s conditions for future studying (knowledge, skills, beliefs, dispositions, and motivational factors).</td>
<td>Lower one’s standard of proficiency for difficult material to shallow processing.</td>
</tr>
</tbody>
</table>

Note: Stages and definitions are summarized from Winne and Hadwin (1998).
tactics are available to achieve the goals, the task may be abandoned. Stage four, a broad metacognitive activity, does not refer to fine-tuning ongoing strategies. Instead, the learner makes one of two adaptive decisions. One is to make large-scale adjustments to his or her understandings of the task, goals, plans, and strategies. The second is to make relatively permanent changes in future study conditions. An example is lowering one's personal standards for success (Winne & Hadwin, 1998, p. 285).

As these examples indicate, metacognitive strategies are considered to be conscious and intentional. They involve an awareness of one's thinking processes and decisions about the actions to be taken if progress is unsatisfactory. In some cases, however, metacognitive processes can be highly automated. For example, some study tasks may be so familiar that defining the task (stage one) is bypassed. Furthermore, expert readers process text fluidly and rapidly without conscious attention allocated to their level of comprehension until a contradiction or other difficulty occurs. They then take steps to resolve the difficulty.

Relationship of Metacognition to Other Internal States. At least three internal learner states interact with or influence the implementation of the learner's metacognitive skills. One is the learner's prior knowledge. Detailed knowledge about a topic or in a domain is important because it allows the learner to process information efficiently and with little effort (Bjorklund, Muir-Broaddus, & Schneider, 1990, p. 95). For example, a biology professor rarely has to monitor comprehension when reading about the effects of acid rain on the environment (Garner, 1990). However, when reading about Renaissance art, a domain in which he has little knowledge, he must use metacognitive strategies to generate knowledge from the text.

A second related internal state is achievement goal orientation. Students with a mastery goal orientation, for example, seek to demonstrate their ability through developing new skills (Ames, 1992). These students, given the opportunity, also develop effective and sophisticated metacognitive skills. In contrast, a student who is preoccupied with his or her image in the class focuses on avoiding responding in class and does not volunteer for difficult subtasks in small-group work (Midgley, Kaplan, Middleton, & Maeka, 1998). In terms of learning, this orientation fosters nonproductive strategies.

A third related internal state is the set of beliefs and judgments about one's competence. Learners typically form these beliefs intuitively and apply them in particular contexts (Zimmerman, 1995). An example is the belief that one "is terrible" at solving mathematical word problems. As a result, the learner is not motivated to attempt a solution or monitor his or her efforts (Hacker, 1998, p. 10). Such views, known as self-efficacy, are defined as beliefs in one's capabilities to organize and execute the actions necessary to manage and be successful in particular situations (Bandura, 1995, p. 2). They influence learner effort in applying metacognitive strategies. Models of effective learning that incorporate self-efficacy, goal setting, effort, and persistence, as well as monitoring and evaluation, are typically referred to as models of self-regulated learning (see Chapter 10).
Differences Between Younger and Older Children

Some have described the differences between younger and older children as the result of developmental changes. However, in large measure, metacognitive differences result from increasing knowledge as the child gains more experience with formal schooling. Metacognitive differences include the extent of awareness of the purposes of instruction and different task demands, monitoring one’s comprehension and understanding, detection of mathematical errors, and awareness of strategy flexibility.

Awareness of Instructional Purposes and Task Demands. Young children typically are aware of the peripheral lesson requirements, but not the broader purposes of instruction. Examples include that the goal of instruction is to finish seatwork on time and the purpose of reading is to pronounce all the words correctly. Lack of awareness of task performance is not universal, however. Some preschool children, when asked to dictate their favorite experience so that other children may read it, monitored and corrected their ongoing speech. Comments included, “What do I want to do here” and “I wanna change that word” (Fang & Cox, 1999).

A second difference is that younger children often are unaware of task demands. They are likely to believe, for example, that reading a story for fun and reading for science or social studies do not differ. In other words, they often have only a rough idea about the factors that influence task difficulty (Bruning, Schraw, & Ronning, 1995). Similarly, recognition of the need to remember as a purpose for working through instructional materials is a capability that develops slowly throughout childhood. One study asked young children what they would do to remember information (Jacobs & Paris, 1987). Options such as “to think hard and try to remember” and “to ask yourself questions about the ideas” were provided. However, many of the children selected the option that stated they would skip the parts they did not understand.

Monitoring One’s Comprehension and Understanding. Research indicates that children show little indication of monitoring their comprehension to determine whether it is successful (Kuhn, 1999, p. 21). Furthermore, although improvement accompanies development, mastery often is not attained even by adulthood.

One measure of comprehension monitoring is the error detection task in which learners read or listen to a text that contains inconsistencies. First graders in one study detected inconsistencies in text read to them when they were familiar with the topic (Vosniadou, Pearson, & Rogers, 1988). However, they did not identify errors in unfamiliar material, whereas third and fifth graders were successful. Other studies report similar differences in error detection, but noted that both younger and older children read the contradictory statements more slowly than other lines in the story (see Garner, 1990). One explanation for observed discrepancies between reading times and reported contradictions is that younger children are only momentarily aware of comprehension difficulties, which they dismiss as unimportant (Garner, 1990).
Detecting Mathematical Errors and Other Problems. Related to the concept of error detection in text is the identification of mathematical errors. One application is to check one's work on completing a problem. Another is the detection of logical inconsistencies in word problems. In one study, first graders typically checked their problem answers (a) using memorized addition and subtraction facts, or (b) counting on their fingers or with objects. Older children, however, applied a computational standard, such as adding in the opposite direction (Van Haneghan, 1986).

In another study, fifth graders found more errors in solutions to word problems than third graders (Van Haneghan & Baker, 1989). The problems required dealing with “more than” and “less than” relations among quantities. The presented problems ranged from correctly solved to computational or operational error, to unanswerable but “solved” anyway. (An unsolvable problem stated that Matt has 22 cents and Ken has 60 cents; how many more cents does Matt have than Ken?) Calculation errors were most likely to be found and unanswerable problems were least likely to be identified (p. 229).

One reason for the lack of identification of unsolvable problems is that children develop a “word problem” schema in which word problems are divorced from real-world problems. One group of third- and fifth-grade children, for example, stated that a legitimate problem was unsolvable because it differed from typical problems (Van Haneghan, 1986). The misjudged problem stated that Sam had 28 cookies and he had 13 more than John. The problem asked how many cookies John had. The two reasons given by the children as to the unsolvability of the problem were (a) the problem does not tell you how many John has, and (b) the problem says first that Sam has 28 cookies and then he has 13, and this does not make sense (p. 225).

A somewhat different problem detection skill is essential in writing. Specifically, revising one’s writing depends on detecting sentences or passages that do not communicate clearly. However, students often fail to revise their writing because they assume the text is clear and understandable (Graham & Harris, 1994). Beal (1989) found that third-grade children revised more ambiguous messages than younger children. The performance differences were largely the result of the level of skill in finding the problem in the passage.

Awareness of Strategy Flexibility. A fourth characteristic of children is that they often lack the knowledge about when and where to make use of different strategies. This component of metacognition is described by Paris, Lipson, and Wilson (1983) as conditional knowledge. Children’s inability to transfer learned strategies to new situations is an example of the lack of conditional knowledge.

Development of conditional knowledge is related, in part, to children’s reliance on primitive strategies that they have developed. These strategies, such as copying selected text sentences verbatim (used as a summarization strategy), hinder their development of more appropriate strategies. Moreover, these primitive strategies hinder their awareness of strategy flexibility. Although the lack of conditional knowledge is most noticeable in young children, it is found in other age groups as well. For example, beginning graduate students may focus on memorizing content from textbooks instead of integrating information and ideas (Garner, 1990).
**The Development of Cognitive Maturity.** Coming to cognitive maturity in complex societies is not an easy task, and it involves several factors. First, it depends on developing knowledge about the internal mental world. Basic information about this world includes the fact that people possess minds, mental processes are distinct from feelings and emotions, and a person can understand and react to his or her mental states (Wellman, 1985). Young children, however, have little knowledge of beliefs, certainties, illusions, mistakes, or deceptions (Garner, 1990). Thus, they are not skilled in identifying inconsistencies in text passages or monitoring their thinking. Older children, in contrast, have a more sophisticated theory of mind and also are able to treat language itself as an object of thinking. Thus, older children can use this knowledge to direct and manage their thinking.

Second, developing cognitive maturity is an aspect of developing secondary abilities and also involves mastering tasks that may not be of interest to the child. Kindergarten children can differentiate classroom activities into work and play and can state that “work” activities are more important to the teacher than play activities (Garner, 1990). However, they may expend less cognitive effort on tasks that represent work. The often-cited example is the student who can cite earned run averages, runs batted in, and other baseball statistics of major players, past and present. The student, however, has difficulty in history and other fact-loaded subjects.

**Expert–Novice Differences**

Experts and novices differ in both metacognitive skills and in their problem-solving capabilities. For example, in contrast to novices, experts in diagnosing X-rays tested and revised their diagnoses until they had accounted for all the characteristics of a particular situation (Lesgold et al., 1988).

In reading, the metacognitive skills of experts and novices differ in four major ways. First, experts are aware of the general goals of reading and studying and of the specific objectives of a particular task (Rohrer & Thomas, 1989). As a result, they allocate their time and effort differently to different tasks and typically expend greater time and effort on more difficult tasks. Also, in the rapid pace of the classroom, which often has an emphasis on task completion, experts weigh the costs of using different strategies against the benefits of the goals to be achieved (Garner, 1990).

In contrast, novices tend not to read for meaning. They do not adjust their reading behavior to different kinds of content or reading situations. Furthermore, they do not slow down for difficult passages (Rohrer & Thomas, 1989).

Second, experts are aware of and use “fix-it” strategies when problems occur (Dole et al., 1991). In this way, difficulties are addressed before they become major problems. Third, experts are more likely to use available resources, such as the strategy of looking back at prior text when a difficulty occurs as well as the pause-and-reflect strategy.

Finally, the strategy use of experts is more flexible than that of novices in at least two important ways. They are more likely to use different strategies in different circumstances, and they also adapt question-asking strategies to different kinds of texts and task demands (p. 248). Novices, in contrast, tend to
apply a single strategy across contexts. Moreover, although they may use strategies, such as context clues when directed to do so, they do not apply them spontaneously (Rohrer & Thomas, 1989).

Strategies applied by experts to articles in their area of expertise included anticipating and predicting information, testing predictions as they read, searching for information related to their reading purpose, looking backward and forward in the text to find particular information, and developing summary interpretations of the articles (Wyatt et al., 1993). A comprehensive catalog of the processes reported in verbal protocols of reading identified 15 common processes. Included were overviewing before reading, searching for and paying more attention to important information, and relating important points in the text to each other to understand the text as a whole. The authors concluded that skilled reading is constructively responsive reading (Pressley, 1995; Pressley & Afflerbach, 1995). That is, the reader exploits text clues, reflects on the text after reading, and monitors his or her reading extensively.

**Summary**

Initially, researchers thought that the spontaneous production of effective strategies resulted from increases in planning skills and learning the subskills in a strategy. The revised view is that higher order processes, referred to as metacognitive skills, control the learner’s use of strategies in cognitive tasks. Included in metacognition are (a) knowledge about cognition that includes knowledge about tasks, strategies, instructional plans, and goals, and (b) capabilities in managing one’s cognition. Included are setting goals, activating relevant resources, selecting appropriate strategies, evaluating one’s understanding, checking one’s progress, and redirecting effort, if necessary. Although conscious and internal, metacognitive processes can become highly automatic. Also, the greater the learner’s knowledge base in a particular area, the less need for metacognitive strategies.

Individual differences that can influence and interact with the execution of metacognitive strategies include the learner’s topic or domain knowledge, achievement goal orientation, and beliefs about self-efficacy. In addition, younger and older children differ in characteristics that influence their metacognitive strategies. Younger children typically lack awareness of instructional purposes and changing task demands, and do not monitor either their comprehension when reading or identify mathematical errors in problem solving. They also lack an awareness of strategy flexibility. These differences result, in part, from a lack of cognitive maturity in which children recognize and react to their mental processes. Furthermore, experts in metacognitive thinking allocate their time and effort differently for different tasks, use “fix-it” strategies when problems occur, and are more flexible in strategy use than novices.

**Problem Solving**

In general, problem solving involves dealing with new and unfamiliar tasks when the relevant solution methods (even if partly mastered) are not known (Schoenfeld, 1992, p. 354). Initially, the processes addressed by cognitive researchers are
those involved in solving problems that are not related to school subjects. Examples include Katona's matchstick problems and so-called "move" problems. One is the Tower of Hanoi, which has three "towers" (upright pegs). Four discs are stacked on one peg with the largest on the bottom and the smallest on the top. The goal is to transfer the discs, one at a time, from one peg to another without placing a larger disc on top of a smaller one. The rationale for studying these problems was the belief that simple domains permitted a focus on the development of strategies. Initially, researchers erroneously believed that this work could be expanded into semantic-rich domains (Schoenfeld, 1992).

Then, in the 1990s, a focus on the role of problem solving in the school curriculum led to a reexamination of problem solving. This focus examined the learner's interpretation, structuring, and adaptation of knowledge (both content and strategic) to new situations (Resnick, 1989). Discussed in this section are prior research, types of problems and major subprocesses, the differences between expert and novice problem solvers, and cognitive load theory.

**Prior Research**

Early developments include the General Problem Solver (GPS), discussions of heuristics, and artificial intelligence research. Then, in the 1990s, John Anderson and his colleagues developed the ACT-R model.

**The GPS.** Developed from tasks such as the Tower of Hanoi problem, the GPS identified three main steps in problem solving. First, represent the problem, the givens, and the legal operators. Second, establish goals and subgoals and begin solving for the subgoals. Three, use means–ends analysis to assess progress, and redefine subgoals, if necessary (Newell & Simon, 1972). Means–ends analysis involves assessing the differences between a present state and a desired state, searching for an appropriate operator to reduce the differences, and evaluating the results (Simon, 1980).

The Tower of Hanoi, described earlier, is an example of a move problem. A successful strategy requires solving for subgoals. The first subgoal is to free the largest disc so that it can be moved. This requires several steps, some of which require returning discs to the original peg at certain points.

GPS is particularly appropriate for well-defined problems for which subgoals can be clearly defined and which are solved in sequential steps. Many problems, however, do not fit this category. Another difficulty is that most problems require domain-specific information to solve them. However, individuals cannot derive domain-specific strategies from general problem-solving approaches.

**Heuristics.** A focus on well-defined problems led to discussions of heuristics. They typically refer to a rule of thumb for reducing uncertainty about a problem. In addition to means–ends analysis, examples are (a) working backward from the goal state, (b) hill climbing, and (c) dividing the problem into subproblems. Hill climbing involves taking any step that moves the problem solver closer to the goal. However, one difficulty with such strategies is that they may or may not result in a solution. For example, the rule of thumb "Always take the smaller
number from the larger number” in subtraction will result in errors some of the time (e.g., \(3 - 7 = -4\), not +4).

General heuristic strategies include searching one’s memory for similar problems and analogies. However, an experimental test of analogies did not support their use as an aid to problem solving. Prior to providing subjects with the medical problem discussed in Chapter 2, developed by Duncker (1945), the subjects read a brief analogous episode of a general dispersing his forces to invade a town. The results indicated that the presence of the analogous situation is insufficient for subjects to solve the target problem. Spontaneous transfer occurred in the majority of subjects (62%) only when they read two priming stories, wrote a summary of them, and then received an explicit statement of the solution principle (Gick & Holyoak, 1980, 1983).

Like the GPS, one difficulty with heuristics is that most problems require domain-specific information to solve them. Another is that heuristics do not address the key thinking processes required by the problem.

**Artificial Intelligence Research.** The scientific goal of artificial intelligence (AI) is twofold: (a) understand intelligence by building computer programs, and (b) study the problems that the world presents to intelligence. An example is PARRY, a program that simulated a paranoid patient so well that psychiatrists communicating by computer terminals were unable to determine whether the “patient” was real or a computer program (Bereiter, 1991). The rules incorporated into PARRY included rules for reacting emotionally to the psychiatrist’s language in addition to rules for interpreting the psychiatrist’s words.

Despite the success of PARRY and other programs, some concerns about this approach to analyzing problem solving have emerged (Bereiter, 1991). One major concern is that the easiest tasks to simulate on the computer are those that are most difficult for humans, that is, extended chains of reasoning (p. 11). Conversely, the tasks that humans complete easily are extremely difficult to program with rule-based systems. For example, construction of the checkers-playing program Chinook required sifting through 500 billion billion (the digit 5 plus 20 zeros) checkers positions (see Schaeffer, 1997). As of April 2007, the program cannot be defeated; it may only be played to a draw. However, such programs do not play board games in the same way as humans. A master program in chess, for example, considers 126 million moves in 3 minutes, whereas a human master player typically considers two moves.

**ACT-R Theory.** The theory Adaptive Control of Thought—Rational (ACT-R), describes an integrated cognition that includes several mental operations (Anderson & Lebiere, 1998). A basic assumption of the theory is that knowledge is represented in two memory systems: Declarative memory stores facts and procedural memory consists of rules (Taatgen, Lebiere, & Anderson, 2006). A second basic assumption is that cognition is the result of the interaction of several independent modules. As indicated in Table 7.2, the basic modules are visual, problem state, control (goal), declarative, procedural, and manual modules (Anderson, 2005, p. 314). In the most recent version, ACT-R 6.0, the production system that implements procedural memory plays a central role by connecting the modules together.
TABLE 7.2
Basic Modules in ACT-R 6.0

<table>
<thead>
<tr>
<th>Module</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>Identifies objects in the visual field</td>
</tr>
<tr>
<td>Problem state (imaginal)</td>
<td>Holds a current representation of the problem</td>
</tr>
<tr>
<td>Control (goal)</td>
<td>Keeps track of current goals and attention</td>
</tr>
<tr>
<td>Declarative</td>
<td>Retrieves information from memory</td>
</tr>
<tr>
<td>Procedural (production system)</td>
<td>Responds to information in the buffers of other modules and also puts information into those buffers</td>
</tr>
<tr>
<td>Manual</td>
<td>Controls the hands</td>
</tr>
</tbody>
</table>

Note: Summarized from Anderson (2005).

Modules can be acting on information at the same time. An example is processing the entire visual field (visual module) and searching through large databases (declarative module) (Anderson, 2005, p. 314). However, a limitation of the modules is that each can deposit only a little information at a time into the buffer associated with the module (Anderson, 2005; Anderson et al., 2004). For example, the problem state buffer holds a single problem state and the visual buffer a single object at a time.

The production system communicates with the modules through the buffers. For example, the control module may encode an intention to solve a linear algebraic equation. The production system then responds with a production rule. Specifically, if the goal is to solve the equation, then retrieve the first step of that process.

Research on ACT-R indicated that increased processing speed observed over time involves (a) reduced retrieval times of steps in the original instruction and (b) combining two production rules into one. For example, the first production rule (if the goal is to solve the equation, then retrieve the first step of the process) and the second production rule (if a number is on the right then simplify the right side of the equation) are combined. The new rule is if the goal is to solve the equation, then begin with the side with the number(s). In other words, in this process, referred to as production compilation, the retrieval step is replaced by the action to be taken as the first step. In other words, ACT-R defines learning in terms of retrieval times of information and the compilation of production rules.

A deficiency of ACT-R, however, is that it does not account for the learning of the individual production rules prior to their compilation (Taatgen et al., 2006, p. 44). For example, in a study on solving linear equations, the students received private tutoring on the “unwind” strategy for solving equations and practiced paper-and-pencil solutions with the tutor’s guidance on the first day (day 0; Anderson, 2005, p. 318). On the remaining 5 days of the experiment, the students practiced solving zero-, one-, and two-step classes of equations on a computer, completing 10 computer-presented blocks of equations each day. Each block consisted of 16 trials with four examples of the four equation types.
(the one-step equations include two subtypes) (p. 318). Brain imaging studies conducted in conjunction with solving linear equations and other tasks (e.g., Anderson, 2005; Qin et al., 2003) indicated that the prefrontal, parietal, and motor regions of the brain were involved in various aspects of the tasks.

Types of Problems

Problems in school curricula typically have specific components and may be classified according to the nature of the problem or the extent of the learner’s experience with particular kinds of problems.

Definition. Formally defined, a problem has three components: givens, a goal, and allowable operators. The givens are the elements, the relations among them, and the conditions or constraints that constitute the initial form of the problem (Anderson, 1985; Davidson & Sternberg, 1998). The goal is the desired outcome or solution and the allowable operators are the steps or procedures that will transform the givens into the goal (Mayer & Wittrock, 1996).

In addition, the problem situation also may include obstacles (Davidson & Sternberg, 1998). They are the characteristics of either the problem and/or the student that make it difficult for the student to transform the initial form of the problem into the desired outcome. The situations, referred to as functional fixedness and problem set by Gestalt researchers, are examples.

Well-Defined and Ill-Defined Problems. One classification of problems is the distinction between problems in which the elements are either clear or somewhat ambiguous. In well-defined problems, the givens, desired goal, and allowable operators are explicit. Computation problems, such as $2.69 \times 0.078 = \text{_____}$, are examples. Well-defined problems are the type that Edward Thorndike addressed in his research on the application of connectionism to school learning.

In ill-defined problems, the givens, desired goal, and allowable operators (procedures) are not immediately clear to the problem solver (Mayer & Wittrock, 1996). The problems investigated by Gestalt researchers are examples. In the school setting, an example is “Write a computer program that can serve as a teacher’s grade book” (p. 48). Although most educational materials address well-defined problems, most problems in the real world are ill-defined.

Routine and Nonroutine Problems. Categorizing a problem as well defined or ill defined addresses particular characteristics of the problem itself. In contrast, the labels routine and nonroutine refer to the experience of the problem solver. Routine problems are those that the individual has solved in the past and for which he or she instantly recognizes a solution (Mayer, 1992; Mayer & Wittrock, 1996). Nonroutine problems are those that the individual has not solved previously and for which he or she cannot generate a preexisting solution (Mayer, 1992, p. 4). These designations are similar to the processes identified by Gestalt researchers as reproductive and productive thinking (Katona, 1940; Wertheimer, 1945/1959). Reproductive thinking is the application of procedures used to solve similar problems, whereas productive thinking is the construction of a novel solution.
These categories, however, actually identify the endpoints of a continuum. Between these two extremes lie problems for which the individual does not have a ready solution but which also do not require a novel solution. Instead, they require the application of prior strategies in new ways or the restructuring of prior strategies for different goals. Examples include the problems devised by first-grade children who are learning to solve various types of simple word problems in mathematics. Among them are finding out how much older a book they are reading is than they are and how old the book is this year (Fennema, Franke, Carpenter, & Carey, 1993).

**Subprocesses in Problem Solving**

The shift in research focus in the late 1980s and 1990s to learner construction, interpretation, and adaptation of knowledge to new situations places primary importance on the thinking strategies of students. Furthermore, expertise requires knowledge of principles in a domain rather than general heuristic strategies (Chi, Glaser, & Farr, 1991). Important in these activities are the metacognitive skills of planning and monitoring and evaluating one's decisions.

The four major subprocesses of problem solving that all require metacognition are representing the problem, planning strategies, overcoming obstacles, and executing plans (Davidson & Sternberg, 1998; Mayer & Wittrock, 1996) (see Table 7.3). In addition to planning, the metacognitive skills of monitoring and evaluating decisions also are essential.

**TABLE 7.3**

<table>
<thead>
<tr>
<th>Subprocesses</th>
<th>Role of Metacognitive Skills</th>
</tr>
</thead>
</table>
| 1. Representing the problem (identifying the most relevant features and creating a mental map of the components) | 1a. Assist in accessing relevant information from long-term memory that can contribute to the identification of key problem components.  
   b. Assist in creating a "mental map" of the givens, the relations among them, the goal, and the constraints (Davidson & Sternberg, 1998).  
   c. Assist in selective recoding, selective combination, and selective comparison, when necessary (Davidson & Sternberg, 1998). |
   b. Initiate 1a above, when necessary.                                                                |
   b. Initiate 1c above.                                                                                 |
| 4. Executing plans (and overcoming obstacles)       | 4a. Monitor progress and modify plans when necessary.  
   b. Return to 3, if necessary.                                                                            |
Representing the Problem. This phase, often overlooked by students, is essential to successful problem solving for both well-defined and open-ended situations. In this phase, the learner should identify the key features of the problem and create a mental map of the relationships, making use of relevant information in his or her long-term memory. Some problem solvers, however, rely on inaccurate metacognitive knowledge in executing this step. For example, some schoolchildren thought that they need not read an entire math problem because the critical information was always in the last sentence (Briars & Larkin, 1984).

The purpose of the mental map is to assist the learner to organize the conditions, decide on appropriate steps, and also keep track of his or her progress (Davidson & Sternberg, 1998). Difficulties in constructing a mental map of the problem should lead to selective recoding, combining, and comparison. Selective recoding involves seeing elements that previously were unnoticed, followed by putting the problem elements together in a new way. Selective comparison is the discovery of a nonobvious relationship between problem elements and the learner's existing information (p. 53). These processes reflect the components of problem solving identified by Gestalt researchers. They include “the restructuring of the given material” (Köhler, 1969, p. 146); mentally redefining and clarifying the problem, such as redefining the goal (Duncker, 1945); or reformulating the functions of the givens (Maier, 1930).

Planning. Effective problem solvers review strategies and tactics prior to implementation (the structured exploration identified by Schoenfeld, 1992). This phase helps the problem solver anticipate the consequences of particular approaches and helps to avoid costly mistakes (Holyoak, 1995). Failure to identify a viable strategy may require review and possible reorganization of the learner’s mental map of the problem (phase one in Table 7.3).

Differences in the problem-solving behavior of a faculty member and a group of students faced with a difficult two-part problem illustrate the importance of representing the problem and planning before beginning to implement a strategy. The faculty member spent more than half of the allotted time in analyzing and structured exploring before implementing a solution (Schoenfeld, 1992). The students, however, began to immediately work on the problem. Although they had more of the facts and procedures readily accessible to them, few solved the problem. The faculty member generated a number of potential wild-goose chases, but he abandoned paths that did not bear fruit and solved the problem (p. 356).

Overcoming Obstacles and Executing Plans. One major obstacle that can occur during planning is the state referred to as stereotypy (Davidson & Sternberg, 1998), which consists of the problem set and functional fixedness identified by Gestalt researchers. The other is the inability to generate any plans or procedures; this difficulty occurs most often in insight problems. One strategy is to search long-term memory for models, analogies, and metaphors that may provide a new perspective on the problem. Another is to take a break from the problem to allow one’s thoughts to incubate (Davidson & Sternberg, 1998).
Students often fail to correctly solve problems because they do not monitor their execution of the selected strategy. Monitoring is important to keep track of the steps already executed and the actions yet to be completed. It also can prevent misapplication of routine steps in a strategy. For example, in solving a complex multistage problem, use of inappropriate data and calculation errors accounted for 13% and 2% of the errors, respectively, of sixth-grade students (Vye et al., 1997). In another situation, requiring middle-school students to monitor their strategies in solving computer-based problems reduced errors and decreased problem-solving time (Declos & Harrington, 1991).

**Summary**

The formal components of a problem are the givens, the goal, and the allowable operators or procedures that transform the given information. The situation also may include obstacles that impede progress in solving the problem.

Two categorizations of problems are well defined (information is explicit) and ill defined (information is implicit). Also, from the learner's perspective, problems may be described as routine (has an instantly recognizable solution) and nonroutine (involves developing a novel solution). However, between these two designations are problems that require the restructuring of prior strategies to fit a new goal.

Cognitive research in the 1970s primarily included development of the General Problem Solver (GPS), discussions of heuristics, and artificial intelligence research. A limitation of GPS and heuristics is that they do not provide for domain-specific knowledge. ACT-R theory, introduced in the 1990s, presents cognition in the form of procedural rules constructed by the production system, which coordinates the output from several independent modules.

Currently, research in other settings addresses the subprocesses of problem solving and the related metacognitive skills. Identified subprocesses are representing the problem, which includes identifying key elements and creating a mental map, planning, overcoming obstacles, and executing the plans. In addition to metacognitive knowledge about problems and strategies, the skills of planning, monitoring, and evaluation are essential in successful problem solving.

**Expert and Novice Problem Solvers**

Efforts to simulate human capabilities in computer programs in the 1960s have led to increased interest in expertise as a subject for investigation (Glaser & Chi, 1988, p. xv). Research in the ensuing period has identified several key characteristics of expert performance that are generalizable across knowledge domains (Glaser & Chi, 1988). First, expertise is developed over a lengthy period of time in a particular domain. Research indicated that around 5 years or approximately 10,000 hours are required (Hayes, 1988). Second, experts and novices differ in the nature of their knowledge about a domain. Third, in problem solving, they differ in problem representation, problem approach, and self-monitoring skills (Glaser & Chi, 1988).

**Knowledge Differences.** The knowledge differences between novices and experts are substantial. They occur both in the amount of knowledge and the
organization and accessibility of that knowledge. The knowledge structures of novices are organized around the main phenomena in a domain, such as the behavior of objects on inclined planes in physics. In contrast, the knowledge structures of experts represent the phenomena in a domain in relation to higher order principles, such as Newton's laws of force (Chi, Glaser, & Rees, 1982).

The organization of the expert's domain or discipline knowledge has implications for problem solving. Experts in the sciences use a different "problem schema" than novices to encode and represent problems (Glaser & Chi, 1988). That is, with experience, experts have encoded procedures for solving relevant problems and the conditions in which they apply, along with representations of higher order principles. Over time, problem and solution become entwined in the problem schema so that the activation of problem–solution strategies becomes more automatic. Thus, for the expert, strategies become one component of the knowledge base.

Knowledge differences also contribute to the more efficient use of short-term and long-term memory by experts. They are more efficient at searching solution space because their recall is chunked (Bruning et al., 1995). For example, in pattern recognition tasks using a chessboard, the knowledge base of the master chess player greatly simplifies recall. Both experts and novices were shown mid-game positions for a few seconds and were asked to replicate the configurations. Chess masters were able to construct 80–90% of the board positions. However, beginners were able to place only a few pieces. The chess expert has stored some 50,000 configurations in long-term memory, and new information is encoded in the form of these configurations. The beginner, however, depends on rote memory for the location of individual pieces (Chase & Simon, 1973).

As indicated in Chapter 6, the extent of the individual's knowledge base also influences his or her capability to process verbal information in large chunks. For example, the expression \((a + b)^2\) may be one chunk for a mathematics teacher and several chunks for the beginning student in algebra. Also, experts in physics recall the equations linked with a particular physics principle in a single configuration or "bundle" (Bruning et al., 1995, p. 352). Thus, although the short-term memory capacity of experts is no larger than that of other individuals, their chunking of information makes efficient use of short-term memory.

**Problem Representation.** For difficult or ambiguous problems, experts in mathematics and in the sciences often spend time in constructing representations of the problem (Rohrer & Thomas, 1989; Schoenfeld, 1992). For example, when Michael Faraday was attempting to solve the problem of electromagnetic induction, he spent considerable time in developing and representing the problem and subsequently proposed two possible solutions. Deductions then were made from these solutions and tested in the laboratory (Voss, 1989, p. 274).

Similar processes were observed in a study of expert radiologists diagnosing difficult X-ray films (Lesgold et al., 1988). Experts viewed each film, constructed a tentative mental representation of the problem, and then proceeded to test this schema. If disconfirmed, the schema was set aside and the film was examined for clues to another representation of the problem. Medical residents,
in contrast, were more likely to go with their initial perspective of the problem. They also tended to force-fit film features that should have signaled abnormality into their schemata for normal anatomy.

Experts also represent problems at deep structural levels in terms of basic principles in the domains, such as conservation of energy. Novices, in contrast, represent problems in terms of surface or superficial characteristics or objects state in the problem. Examples include rotating discs on inclined planes.

**Problem Approach.** For easy or moderately difficult problems, experts apply their well-developed problem schemas. They also work forward from information given in the problem. The expert has solved many such problems in the past, and similar problems and their solutions are recalled with little effort.

Novices, on the other hand, typically use “working backward” strategies and, sometimes, trial and error. As already indicated, because they lack sophisticated problem schema, they must begin with the unknown in the problem. In science, for example, novices often begin with an equation that contains the unknown and work backward in hopes of finding the variable they need (Anzai, 1991). (See Table 7.4 for a comparison of novice and expert problem solvers.)

**TABLE 7.4**
A Comparison of Novice and Expert Problem Solvers in Mathematics and Science

<table>
<thead>
<tr>
<th>Novices</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge structures are organized around</td>
<td>1a. Knowledge structures of experts represent phenomena in the domain in relation to higher order principles</td>
</tr>
<tr>
<td>the main phenomena in a domain</td>
<td>b. Knowledge is organized in the form of problem schema that include procedures for solving relevant problems</td>
</tr>
<tr>
<td>2. Inefficient use of short- and long-term memory because knowledge often is stored in unrelated items</td>
<td>2a. Efficient use of short- and long-term memory because recall occurs in chunks of related information</td>
</tr>
<tr>
<td>3. Little or no time spent constructing representations of problems; represent problems at surface or superficial levels</td>
<td>b. Automatization of sequences of steps within problem strategies</td>
</tr>
<tr>
<td>4. Reliance on working backward strategies and, sometimes, trial and error</td>
<td>3. Considerable time spent constructing representations of problems; represent problems at deep structural levels</td>
</tr>
<tr>
<td>5. Frequent lack of awareness of errors and the need to check solutions</td>
<td>4. Reliance on working forward from information given in the problem</td>
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<td></td>
<td>5. Use of strong self-monitoring skills that include testing and fine-tuning solutions</td>
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Expertise in mathematics and science typically involves bringing the appropriate problem schema to the task of solving well-structured problems. In contrast, expertise in the humanities depends more on constructing a context-specific schema tailored to specific events (Spoehr, 1994; Wineburg, 1991, 2000). That is, expertise requires searching for patterns of knowledge in the construction of explanations at abstract levels (Spoehr, 1994, p. 79). In one study, trained historians working with fragmented and contradictory historical documents (a) looked first to the source of the document as a framework for reviewing the text, (b) carefully validated and rejected various details by checking and cross-checking the documents (corroboration), and (c) constructed sequences and locales of events as a means to verify witness accounts (Wineburg, 1991). In other words, three heuristics implemented by the historians were sourcing, corroboration, and contextualization (Wineburg, 1991).

Novices, in contrast, tended to not notice discrepancies and rarely looked back at previous documents. They also struggled with interpreting accounts, in part through failure to identify the writer or construct sequences of events. The students read the documents in a linear sequence and took information at face value (Wineburg, 1991). They also attempted to remember facts, a frustrating task because different documents presented different facts. Similar studies also found that neither high school nor college students consistently and effectively used sourcing to evaluate various documents (Britt & Aglinskas, 2002; Rouet, Favart, Britt, & Perfetti, 1997). Wineburg (1991) concluded from his research that the reliance on a single textbook in high school history classes was a contributing factor to the inability of the novices to interact with different sources of information.

**Metacognitive Skills.** Experts and novices also differ in their metacognitive skills related to problem solving. First, experts spend more time in planning, and they routinely self-monitor their decisions. As already stated, experts in diagnosing X-rays, for example, test and fine-tune their tentative diagnoses until all the characteristics of a particular film are accounted for (Lesgold et al., 1988). Novices, however, test and self-monitor their conclusions less often and are often unaware of their errors.

Particularly interesting in the study of radiologists is that third- and fourth-year radiology residents, in general, perform worse than either the experts or the first- and second-year residents. One explanation is that the schemas of the "true" novices are bound tightly to the perceptual data, whereas the expert rigorously tests possible schemata. The third- and fourth-year residents, in contrast, are beginning to replace perceptual decision making with cognitive reasoning, and rigorous testing is not possible in early stages of this process. In other words, the development of certain complex problem-solving skills is not linear.

**Cognitive Load Theory**
A different perspective on problem solving is cognitive load theory, which targets the ways that learners focus cognitive resources during learning and problem solving (Chandler & Sweller, 1991, p. 294). A major purpose of the theory is to improve the effectiveness of instructional design in which materials alone provide the instruction.
Assumptions. Four assumptions support cognitive load theory. Two are (a) the limitations of working memory in processing information, and (b) a virtually unlimited long-term memory that can be used to overcome the limitations of short-term memory (Pollock, Chandler, & Sweller, 2002). The third assumption reflects the definition of learning prescribed by the theory. Specifically, the key functions of learning are the acquisition of schemas and the automation of schemas, which allows cognitive processing to bypass working memory (Sweller, 1994; Sweller & Chandler, 1994). The fourth assumption is that learners, when faced with novel problems for which they do not have schemas, rely on means–ends analysis (Sweller, van Merrienboer, & Paas, 1998). Although an efficient way to solve a problem, this strategy "bears little relation to learning" (p. 263).

Evidence of the importance of schemas is found in the novice–expert literature. This research indicates that access to a large number of schemas in long-term memory is an essential characteristic of skilled performance (Sweller, 1994, p. 298). The theory defines schemas as elements of information that are categorized according to how they will be used (Sweller, 1994). In problem solving, schemas serve to categorize problems that require similar solutions (Cooper & Sweller, 1987, p. 348; Sweller, 1994, p. 296). Schemas reduce the cognitive load on working memory by allowing the individual to ignore a great deal of the information impinging on his or her senses (Sweller & Chandler, 1994). For example, people can recognize trees because of a tree schema, which bypasses the need to process its particular features (trunk, branches, and leaves). Similarly, a schema in algebra is the procedure for multiplying out the denominator. For example, the equation \( \frac{a}{b} = c \) is recognized as \( a = bc \). Also, \( \frac{a}{b} = c + 2d - a \) is \( a = bc + 2bd - ab \). The schema of multiplying out the denominator allows individuals to solve such problems immediately (p. 187).

Although working memory can process only a limited number of elements at a time, the size, complexity, and sophistication of each element are not limited (Sweller, van Mérrienboer, & Paas, 1998, p. 256). Therefore, a schema, which can contain a large amount of information, functions as one element. An example is an adult's schema for the term restaurant. This schema contains a large amount of information about food and its role in human activities, the basic architecture of the building, the furniture, and many other facts and processes. The subelements or lower-level schemas do not require working-memory capacity because they are part of the higher-level schema (p. 256).

Developing a schema is not an all-or-nothing process. Instead, rules for solving particular types of problems are learned gradually and consciously through processing in working memory. As the learner becomes familiar with the domain, the need to attend to specific problem-solving rules decreases, and they gradually become automated (Sweller, 1994, p. 298). For example, when the schema for multiplying out the denominator in algebra becomes automatic, the learner can implement this operation while thinking about another aspect of the problem. In other words, automated schemas permit cognitive processes to occur without conscious control. In addition, cognitive load theory maintains that an intellectual skill can attain its full potential only when it requires minimal thought for implementation (p. 298).
Types of Cognitive Load. The theory has identified three types of load on working memory imposed by processing instructional materials (Paas, Renkl, & Sweller, 2003; Pollock, Chandler, & Sweller, 2002; Sweller et al., 1998). One type is intrinsic cognitive load, which refers to the extent of interaction among the individual elements to be learned. For example, in learning vocabulary words, the new terms do not interact; each can be learned without reference to the others. Learning syntax, in contrast, requires consideration of several vocabulary terms and their interrelationships (Pollock et al., 2002, p. 62). For the student who has little experience in the mechanics of language, learning syntax carries a high element interactivity—a high intrinsic load. However, simply determining the levels of element interactivity by analyzing instructional materials is insufficient to determine intrinsic load (Sweller et al., 1998). A large number of interactive elements for a novice may actually be one element for someone with greater expertise. Therefore, documenting the characteristics of the target population for the instruction is important (pp. 261–262).

A second type of cognitive load is extraneous load. It is (a) imposed by the ways that instruction presents the new information, and (b) does not contribute to the construction of schema (Paas et al., 2003; Pollock et al., 2002). For example, instruction that requires the learner to search for a solution imposes a high extraneous load on working memory. It is both time-consuming and does not alter long-term memory (Kirschner, Sweller, & Clark, 2006; Paas et al., 2003, p. 2).

The third type, germane cognitive load, refers to the aspects of instruction that enhance learning (Paas et al., 2003, p. 2). Germane load occurs when the resources in working memory are focused on the development and automation of schema.

Implications and Questions. The implications of cognitive load theory are that instruction should be designed to eliminate extraneous load and reduce intrinsic load (difficulty of the material due to high element interactivity) when possible. Reducing intrinsic cognitive load reduces the total load on working memory, which frees memory capacity (Paas et al., 2003, p. 2). One way to reduce intrinsic load is to identify simpler parts of tasks that may be learned separately and then gradually combined as one task (Ayres, 2006; van Merrienboer, Kirschner, & Kester, 2003, p. 7).

However, part-task approaches can result in fragmentation and the lack of transfer to new problem situations for tasks or problems that require extensive coordination between the parts. An example is the procedure for testing the installation of new wiring (Chandler & Sweller, 1991). Conventional presentations consist of diagrams with numbers that refer to explanatory statements in the text. Learner efforts to integrate the two incomplete sources of information, referred to as the split-attention effect, are an example of extraneous cognitive load. Research comparing restructured diagrams that incorporate identification of the steps with conventional presentations indicated a significant positive effect on performance in basic electrical procedures for the integrated diagrams. Chandler and Sweller (1991) concluded that when diagrams and text are each unintelligible without the other, instructional materials should be restructured so that either
(a) explanatory information appears on the diagram or (b) the text and diagram are each understandable without reference to the other (p. 331).

Much of learning consists of cognitive skills, which cognitive load theory designates as learner capabilities to solve problems in well-structured domains such as mathematics, physics, and programming (Renkl & Atkinson, 2003, p. 16). In some mathematics and mathematics-based courses, instruction for solving problems often is stereotyped (Sweller & Cooper, 1985). The steps are that the teacher or instructor (a) introduces principles and relations, often in the form of equations, (b) presents a few example problems that demonstrate the new information, and (c) provides several problems for the students to solve as homework (pp. 59–60). Experiments conducted in physics classes (the three rules that govern image projection with mirrors and lenses and procedures for solving simple linear motion problems) introduced worked examples into the students’ homework. One group received worked examples plus problems to solve and the other group received only problems to solve (conventional problems) (Ward & Sweller, 1990). Well-designed worked problems (no split sources of information) resulted in significantly higher performance on tests administered the following day. These findings supported laboratory-based studies of the effects of worked examples (e.g., Cooper & Sweller, 1987; Sweller & Cooper, 1985; Tarmizi & Sweller, 1988).

The research on worked examples indicates that they are effective in facilitating learning in situations involving highly structured tasks or problems (such as the nine-step procedure for determining insulation resistance and applying the three rules for determining image reflection in concave and convex mirrors). These situations address specific objectives and procedures in which variability in learner behavior is not expected (Gerjets & Scheiter, 2003). However, in other situations, teacher and learner variables are likely to interfere with the “one-to-one mapping between instructional design and a resulting pattern of extraneous and germane load” (p. 34). Teacher goals, for example, may include the acquisition of declarative knowledge or the application of procedural knowledge to similar and/or novel problem-solving situations, as well as time constraints (p. 35). Moreover, learner goals likely reflect personal interests and may not match the teacher’s expectation of student aspiration and different learners also may execute different processing strategies. Also, research on aspects of designing worked examples, such as requiring learner self-explanation (Atkinson, Renkl, & Merrill, 2003; Catrambone & Yusa, 2006), has yielded mixed results. Suggested adjustments to the theory include (a) uniform specification and measurement of key cognitive load constructs such as difficulty, expertise, prior knowledge, and the types of cognitive load, and (b) consideration of student characteristics in materials design and research (Moreno, 2006, p. 178).

Summary

Research on the differences between experts and novices in problem solving indicates the major role of knowledge and metacognitive skills in thinking. The extensive knowledge base of experts also makes possible the efficient use of short- and long-term memory.
In addition to a greater store of knowledge, experts in science and mathematics encode problems and procedures/solutions in schema organized around higher order principles in the domain. They also spend time in constructing a representation of the problem, apply well-developed schema, and test and monitor their strategies through the process. In the humanities, experts construct explanations of situations or events that reflect the search for and identification of patterns of knowledge, and they also check and cross-check their emerging deductions.

A different perspective on problem solving, cognitive load theory, addresses the limitations of working memory by identifying the features that make material difficult to learn. The theory addresses the influence of extraneous, intrinsic, and germane cognitive load in the acquisition and automation of schemas.

**PRINCIPLES OF INSTRUCTION**

Metacognition and problem solving are the complex higher order capabilities described by cognitive theorists. Although theorists have identified only a few definitive instructional principles, others may be inferred from the research.

**Metacognition**

Research on metacognition suggests areas that may be addressed by metacognitive instruction in the classroom. They are essential instructional conditions for any metacognitive instruction, teaching self-monitoring and evaluation, and addressing applications in particular situations.

**General Instructional Conditions**

Four general conditions are essential for successful instruction for metacognition (see Table 7.5). First, any instruction on strategies should be “cognitive training with awareness” or “informed training” as opposed to “blind training” (Brown, Armbruster, & Baker, 1986; Rohrer & Thomas, 1989). For example, transfer of comprehension strategies to new tasks is far from automatic. Extensive teaching about when and where to use strategies is essential (Pressley, El-Dinary, Wharton-McDonald, & Brown, 1998). For example, the initial steps in one program to teach writing skills are (1) develop the learner’s background knowledge about the criteria for good writing, and (2) introduce the strategy to be learned, the purpose, and when to use it (Graham, Harris, & Troia, 1998).

**TABLE 7.5**

<table>
<thead>
<tr>
<th>General Requirements for Teaching Metacognitive Strategies</th>
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<td>1. In addition to the strategy, teach when and where to use it.</td>
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<td>2. Ensure that performance assessments require the metacognitive activities addressed in instruction.</td>
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<td>3. Model use of the strategies in a variety of contexts with reinforcement.</td>
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<tr>
<td>4. Provide extensive practice in a variety of contexts with reinforcement.</td>
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Second, the performance criteria used to evaluate student achievement should require the kinds of metacognitive activities addressed in the instruction. If testing only includes low-level performances, students will have little incentive to engage in evaluating task demands, allocating resources carefully, evaluating performance, and monitoring progress. For example, students are unlikely to relinquish a summarization strategy that emphasizes rote recall if tests require only factual information. Instead, test items should be included that require the integration of disparate information to answer a novel question or solve a novel problem (Rohrer & Thomas, 1989, p. 113).

Third, in addition to explanations, teachers should model strategies in a variety of contexts (Pressley et al., 1998). The teacher also should demonstrate the use of self-reinforcement as he or she works through a strategy (e.g., “Great, this is a good reason”; Graham et al., 1998, p. 28).

Fourth, instruction should provide extensive practice in a variety of contexts with reinforcement. As implementation of the strategy continues, the teacher should schedule learner-driven discussions about the ways students are adapting the strategies to new contexts (Pressley et al., 1998, p. 53). Particularly important is that instruction should avoid providing compensations. They are the conditions that decrease the demand for cognitive and metacognitive activities (Rohrer & Thomas, 1989, p. 113). For example, a problem occurs when test items appear to require integrative processing, but students have received review materials that contain the integrated propositions needed for the test (p. 113). In other words, handouts and other aids should not provide the end product of metacognitive activities, and, instead, facilitate students’ construction of such products.

In addition to these requirements for teaching metacognitive strategies, instruction should provide training in the monitoring and evaluation of strategy use (Rohrer & Thomas, 1989, p. 113). Students often do not realize the importance of these skills. For example, research on computer-based instruction indicated that when students have control over their involvement in instruction, they often exit prematurely (Steinberg, 1989). The students were not adequately monitoring their understanding.

Attitudes also play a role. One student in a program to teach strategies believed that admitting he did not know something meant that he was admitting he was dumb (Gaskins, 1994, p. 151). Instruction should demonstrate that an important self-question is Do I understand this information? and taking action when needed. To illustrate the importance of explicitly noting lacking of understanding, a teacher modeled monitoring as she solved a problem or wrote an essay. Self-talk demonstrated by the teacher included comments such as, “There’s a lot of information in that last paragraph and I’m not sure I understand it. I’d better see if I can say it in my own words” (p. 151).

Because monitoring and evaluation activities require effort, instruction should include (a) teacher modeling with repetition when necessary, (b) opportunities to practice strategies in pairs and in groups, and (c) teacher reinforcement. These steps are important until the skills become less effortful for students and they begin to see the benefits of using them (Pressley et al., 1998).
Addressing Strategy Applications

Three problems in relation to students’ execution of strategies occur frequently (Butler & Winne, 1995). One is the failure to recognize task conditions that should cue strategy use, referred to as the lack of conditional knowledge. The second problem is the misperception of task conditions (cues). This error leads to selection of the wrong strategies as well as inappropriate criteria for judging performance. Third is the failure to recognize the relationships between task conditions and performance.

A fourth problem is simply the failure to execute the new strategic knowledge. One reason is that new concepts and strategies compete with old and, very likely, deeply ingrained procedures (Pressley, 1995). Also, applying newly learned information requires more effort than relying on prior concepts. Finally, many more connections exist in long-term memory between the old strategies and misconceptions than to the newly learned concepts (p. 209). Therefore, a few experiences with new concepts or new knowledge about tasks, conditions, and strategies are insufficient to develop use of the information. Instead, the self-monitoring use of newly learned strategies requires many experiences, and sophisticated use typically requires years (Pressley, 1995, p. 209).

One tool that can be helpful with adolescents is the Metacognitive Awareness of Reading Strategies Inventory (MARSI; Mokhtari & Richard, 2002). The 30-item instrument addresses global reading strategies (e.g., previewing text for content), problem-solving strategies (e.g., adjusting reading rate), and support strategies (e.g., taking notes while reading). It may be used to assist students in developing awareness of strategy use in reading.

Summary. Four general conditions for metacognitive instruction are (a) instruction with awareness of use, (b) performance criteria and assessments that require metacognitive activities, (c) modeling the strategy with reinforcement, and (d) extensive practice in different situations with reinforcement. Also, classroom handouts and other learning aids should not substitute or compensate for metacognitive strategies. During instruction, brief class discussions can explore the purposes of metacognitive strategies and explore the relationships between task conditions, strategies, and the products from different tasks. Self-monitoring and evaluation also should be included as part of the instruction for metacognitive skills.

Typical problems that prevent student implementation of strategies are (a) the failure to recognize task conditions that should signal use, (b) misperception of task conditions, and (c) the failure to recognize relationships between task conditions and performance. In addition, relinquishing old strategies, which are ineffective, is difficult for students. New strategies initially require additional effort and typically require extensive practice.

Problem Solving

The terms problem and problem solving in the school curriculum have had multiple and contradictory meanings over the years (Schoenfeld, 1992). Until the 1980s, problem solving had become a catch-all term for different views of education and schooling in general and mathematics in particular (Stanic & Kilpatrick, 1988).


School Curricula
In the late 1980s, the traditional view of problem solving as addressing routine problems began to undergo examination and revision.

Traditional Curriculum Approaches. College courses described as problem solving range across several perspectives. Among them are teaching students to think creatively and preparing students for competitions (e.g., the International Olympiads); providing instruction to potential teachers on some heuristic strategies; and providing a new approach in remedial mathematics (Schoenfeld, 1992, p. 237). Others, described as programs for thinking skills, aimed at general improvement in intellectual ability. However, they have not presented convincing evidence of transfer (Mayer & Wittrock, 1996, p. 51).

Traditionally, elementary and secondary education viewed problems as routine exercises. Problems or tasks introduced a technique, illustrated by the teacher and/or the text, and the students completed additional problems for practice. Given a stated goal and needed numbers, the only task for the students was to pick a suitable computation. The cultural assumption in mathematics was that (a) doing math means following the teacher’s rules, and (b) mathematical truth is determined when the teacher verifies an answer as correct. Typical student beliefs about mathematics include “Problems are always solved in 10 minutes if they are solved at all,” and “Only geniuses are capable of discovering mathematics” (Schoenfeld, 1985, p. 43).

In science, laboratory exercises often do not require problem solving. One analysis of laboratory exercises indicated three possible types (Mergandoller, Mitman, Marchman, & Packer, 1987). Explicit exercises pose the questions and prescribe the procedures and specify the solution. Implicit exercises pose the questions and prescribe the methods, and integrative exercises pose only the problem. An analysis of the laboratory exercises in seventh-grade science, however, revealed no integrative exercises. Instead, 45% of the assigned exercises were explicit and 55% were implicit (Mergandoller et al., 1987). In addition, 84% of the worksheet questions and 82% of the test questions required only verbatim recall.

In other words, instruction traditionally expected students to master, in a preordained sequence, sets of facts and procedures that represent the content domain. This view reflects an emphasis on getting the right answers for problems and experiments.

Some Current Approaches. Science curricula currently tend to focus on science as inquiry. That is, students approach situations with an inquiring, investigative mind and resolve issues through experimentation. (Chapter 8 addresses this perspective.) Other curricula focus on developing dispositions to use mathematics in the real world and address children’s strategies in the context of “doing mathematics” (Lester, Garofolo, & Kroll, 1989). Required are exploring various ways to address problems, showing and discussing solutions, and discussing alternative solutions. Whole-class discussions should be used to elicit ideas for possible ways to solve a particular problem. During team or small-group problem solving, early
finishers can present and discuss their different strategies, and the approaches can be extended or generalized to other situations. The teacher’s role is to serve as a facilitator to provide hints when students experience difficulties.

One curriculum approach derives the content of mathematical problems from other activities that the children are involved in. For example, when discussing a book or an author, the children determine how old the author’s book would be this year, how much older the book is than the child, and so on (Fennema et al., 1993, p. 565). Children also construct their own problems that they then solve, working in small groups, and discussing their strategies with each other, the class, and the teacher. Results indicated that all of the children solved problems that are more difficult than those typically found in first-grade textbooks. Strategies ranged from representing the problem concretely (with manipulatives) and counting to standard algorithms and complex invented algorithms (used by children in the middle and high performance ranges).

Other Approaches
Research on the interpretations of historical documents indicated that both high school and college students lacked skills in analyzing sources to evaluate documents (Britt & Aglinskas, 2002; Rouet et al., 1997), and high school students tended to try to remember facts (Wineburg, 1991). Also, both students and their parents refer to movies such as Forrest Gump and Schindler’s List to support their views of history (Wineburg, 2000, in Britt & Aglinskas, 2002).

However, high school students can learn the skills involved in sourcing documents without sacrificing learning content (Britt & Aglinskas, 2002; Nokes, Dole, & Hacker, 2007). Components of effective instruction include information about source features and heuristics, excerpts from different kinds of documents (e.g., letters, treatises, political speeches), author credentials and other information, document information (type, date, and publisher), and problems from economic, military, or social history (Britt & Aglinskas, 2002). Students also should receive instruction on making note cards for documents that include both basic and evaluative information about each.

Problem solving in other subject areas may involve well-defined and ill-defined problems. Cognitive load theory suggests that, for well-defined problems, instruction should avoid extraneous cognitive load and seek to minimize intrinsic load. Simple-to-complex sequencing of task elements or some other mechanism that clearly illustrates the relationships among highly interactive task elements should be implemented. In contrast, broader tasks, such as writing a computer program for a specific purpose, and determining travel logistics and costs for transporting the high school band to several out-of-town football games include subparts. For such problems, representing the problem and its subparts, planning, and overcoming obstacles during execution are essential.

Summary. Thinking about problem solving in the elementary and secondary school curriculum has moved from viewing problems as routine exercises to developing, for example, mathematical understanding. This focus involves developing rich, integrated knowledge structures that result from an emphasis on the
various strategies that may be used to solve basic representational problems. Other current approaches are teaching students to evaluate and critique historical documents, developing instruction for well-defined problems to eliminate extraneous cognitive load and minimize intrinsic load, and strategies for ill-defined problems. These broader tasks require representing the problem and its subparts, planning, and overcoming obstacles during implementation of the planned strategy.

EDUCATIONAL APPLICATIONS

Classroom Issues
The basic issues related to cognitive perspectives of learning are discussed in Chapter 6. Issues addressed by the research on complex cognitive processes are learning “how-to-learn” skills, recognizing learner differences, and teaching problem solving.

Learning “How-to-Learn” Skills
The term metacognition refers to the capabilities required to direct one’s learning, remembering, and thinking. Included are knowledge about and awareness of one’s own thinking and awareness of difficulties as they arise during learning so that remedial action may be taken.

Learner Differences
Younger and older children differ in metacognitive capabilities. Included are the extent of awareness of the purposes of instruction and different task demands, skills in monitoring one’s understanding and applying new strategies, as well as awareness of strategy flexibility. In problem solving, differences in both knowledge base and strategy use differentiate novice and expert problem solvers.

Teaching Problem Solving
Some current perspectives on problem solving maintain that students should acquire the same habits and dispositions to interpretations as experts in the domain. Therefore, problem solving in mathematics means “doing mathematics” and interpretation in history involves evaluating and critiquing historical documents. For well-defined problems, particularly in mathematics-based curricula, such as physics, cognitive load theory emphasizes the importance of avoiding extraneous cognitive load and minimizing intrinsic load for tasks with highly interactive elements.

Implications for Assessment
National U.S. standards for history emphasize the evaluation, interpretation, and comparison of textual information (National Center for History in the Schools, 1996, in Britt & Aglinskas, 2002). Such assessments can build on the type of assessment described in Chapter 6. In that assessment, students explain one or two
important problems in the country at a particular point in time, based on events, laws, court decisions, and other information. The related assessment may address documents about the historical events, which students evaluate for authenticity, and their interpretation of events.

In other curriculum areas, word problems that simply have different numbers (or other task elements) than the instructional problems should be avoided. Such problems produce numerically correct but “mindless” answers. An example is the problem in which 130 children must be assigned to buses that each hold 50 students. Responses often state that 2.6 buses are needed, an absurd answer.

Instead, problems should require the application of information and principles to situations that require mindful application. For example, following a unit on basic punctuation, the assessment may require that students edit a letter to the editor of the local newspaper. Similarly, a lesson on the three rules that govern the location of an image on a concave or convex mirror may be followed by one or two problems that state a particular image location. The students are asked to identify the misapplication of one or more rules.

**Relationships to Other Perspectives**

Metacognition includes (a) knowledge about and awareness of one’s thinking; (b) knowledge about the application of strategies to monitor, evaluate, and adjust one’s learning activities; and (c) the execution of these strategies. Gagné described the capabilities that control the management of learning, remembering, and thinking as cognitive strategies.

The goal setting, monitoring, and evaluation of one’s learning also are components of models of self-regulation (see Chapter 10). A key difference is that these models also address the motivational characteristics that influence the implementation of metacognitive strategies. In addition, Vygotsky’s cultural-historical theory addressed the self-regulation of attention and the conscious awareness and mastery of one’s thinking processes in the school years (see Chapter 9).

Prior theories and research typically conceptualized problem solving in terms of moves or changes in given conditions required to identify a solution. Gagné’s conditions of learning described problem solving as the search for and application of relevant rules. Current developments in cognitive theory describe the learner’s internal subprocesses during the problem-solving process. This focus, particularly the emphasis on the individual’s conceptualization of the problem, addresses the issues of problem organization and understanding raised by Gestalt psychologists about visual problems. In contrast, the issues of cognitive load refer to the development of schemas in long-term memory and bypassing working memory in the solution of well-defined problems.

**Developing a Classroom Strategy**

**Step 1:** Determine the nature of the problem the instruction is to address.

1.1a Does it require the implementation of prior strategies in new ways or the restructuring of prior strategies to fit new goals?
1.1b Or is the problem to be taught well defined and one that illustrates one or two discrete principles?

**Step 2:** Identify the prerequisite concepts and/or principles essential for addressing the problem.

2.1 Are the concepts/principles a part of students’ prior knowledge?
2.2 Is the instruction intended to introduce relevant concepts/principles?

**Step 3:** Determine the scope of the instruction.

3.1a If the answer to 1.1a is yes, are there situations for which the students can construct problems? Are there real-world situations the instruction can introduce?
3.1b If the answer to 1.1b is yes, can some form of worked examples supplement explanations of the principle(s)?

**Step 4:** Determine the mode of instruction.

4.1a For problems to be taught identified in 1.1a, which problems are to be solved by teams and which ones by small groups? What objects may be needed to assist students in developing their approaches?
4.1b For problems to be taught identified in 1.1b, how will basic explanations about concepts and/or principles be addressed? What number and type of worked examples are needed in addition to problems to be solved in student practice?

**Classroom Example**

*Subject:* Addition and subtraction in first-grade mathematics.

*Organization of subject matter:* Problems are organized by the following problem types: join, separate, part–part–whole, and compare.

*Example of a “join” problem:* Connie has 5 marbles. How many more marbles does she need to make 13 marbles altogether?

*Example of a “compare” problem:* Jim has 5 marbles. Connie has 8 more than Jim. How many marbles does Connie have?

The curriculum is an example of children learning to “do” mathematics. Beginning the first few days of school, the teacher asks children to solve word problems that he or she has constructed. Later, children also construct and solve their own problems.

Content of the problems is derived from other activities that the children are involved in. For example, when discussing a book or an author, the children determine how old the author or book would be this year, how much older the book is than the child, and so on.

A key focus in the curriculum is the various strategies that children use to solve problems. Children are expected to be engaged in mathematics—solving problems they, their peers, or the teacher has written. They also are expected to persist in their work, and to report how they solved the problem. In addition, they are expected to reflect on their own thinking by comparing it with someone
else's approach or on the difficulty of a particular problem for them (Fennema et al., 1993, p. 565). Finally, they are expected to listen to the solutions of others and to respect their solutions. The teacher encourages the use of multiple solution strategies and emphasizes the importance of children using a strategy that is most appropriate for them (p. 578).

Children often work in small groups, and they also present and discuss their work individually with the teacher and participate in whole-class sessions. In class discussions, the teacher often calls on children with less mature strategies first, challenging those with more mature strategies to think of alternative ways to solve the problem. For example, in response to the question, How many ways can you make 3?, strategies ranged from 6 – 3 and 1 + 1 + 1 to 3 + 3 + 3 – 3 – 3.

CHAPTER QUESTIONS

Understanding Concepts

1. What are some likely reasons for children's lack of implementation of metacognitive strategies following instruction on such strategies?
2. What are the major differences between the Gestalt view of problem solving and the information-processing perspective?
3. What are some of the potential advantages and disadvantages of having children construct their own problems in a subject area?
4. Why was the research on problem-solving situations such as the Tower of Hanoi inadequate for understanding problem solving in subjects in the curriculum?
5. Which phase of problem solving is most likely to be overlooked by students?

Applying Concepts to Instructional Settings

1. An instructor is attempting to reduce extraneous load in homework exercises on comma use. The practice exercise lists the sentences to be punctuated accompanied by a statement of the appropriate comma rule in parentheses after each sentence. What errors has the instructor made in attempting to implement cognitive load theory?
2. Children often approach writing tasks as simply writing down somewhat appropriate information with each new sentence stimulating the next idea. What type of metacognitive deficiency do they have?
3. ACT-R theory describes the use of declarative and procedural knowledge in the form of production rules (if, then) statements. For an area in which you plan to teach, what are some examples of production rules?
4. In the classroom example for this chapter, children found different ways to combine numbers to represent a particular total. They also constructed their own word problems. In what ways can these activities contribute to schema development?
5. Select a subject that you have taught or are interested in and identify examples of well-defined and ill-defined problems.

REFERENCES


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Unlike the prior theories, cognitive-development perspectives do not address the acquisition of knowledge or specific skills. Instead, they focus on the formation of the highest levels of human thinking, describing the events and conditions necessary to attain these levels.

The two cognitive-development theorists, Jean Piaget and Lev S. Vygotsky, describe different aspects of thinking. Jean Piaget, a Swiss psychologist, addressed the development of logical thinking in the form of causal reasoning about events. An example is the ways that children eventually set aside their perceptions about events (such as the moon walks along with me at night) and develop logical ways of dealing with complex hypothetical situations (formal operational thinking). Piaget grounded his investigations in the individual child’s manipulation of and interaction with objects in the environment.

Lev Vygotsky, in contrast, addressed particular higher psychological processes that he referred to as psychological or mental processes. Included are self-organized attention, categorical perception, conceptual thinking, and logical memory. The essential components of such development are the signs and symbols of one’s culture and interactions with adults, whom he described as the “ideal form” of behavior. Vygotsky grounded his analyses in experiments in which subjects demonstrated their understanding of the role of cultural signs (psychological tools) in addressing cognitive tasks.
CHAPTER 8
Jean Piaget's Cognitive-Development Theory

To present an adequate notion of learning one must first explain how the individual manages to construct and invent, not merely how he repeats and copies. (Piaget, 1970b)

In the 1920s, a young Swiss psychologist began his studies into the ways that young children think. Employed at the Binet Institute, Jean Piaget's responsibility was to develop French versions of questions on intelligence tests in English. However, he became intrigued with the reasons children gave for their wrong answers on the questions that required logical thinking. Using the open-ended interviewing techniques of psychoanalysis, Piaget probed for explanations of the children's errors.

From that beginning emerged Piaget's genetic (developmental) epistemology, a comprehensive analysis of the growth of intelligence. His work consists of richly detailed analyses of thinking and reasoning, which Beilin (1992a) maintained is unrivaled in developmental psychology in both scope and depth.

Prior to the introduction of Jean Piaget's work in the United States, American psychologists saw little difference in the thinking processes of the young child and the adult (Chandler & Chapman, 1991, p. ix). Piaget, often referred to as the giant in the nursery, changed that perspective by demonstrating the unique ways that young children organize their experiences and think about the world.

The aim of Piaget's work was to discover the characteristics of natural logic—the logic of the acting, speaking, reasoning individual in all of its various forms (Inhelder & deCaprona, 1990, p. 39). The areas he addressed include children's language and thought, children's understanding of causality and the world, moral development, arithmetic reasoning, stages in infant cognitive development, the components of logical thinking, and analyses of prelogical thinking. In addition, the researchers who collaborated with Piaget in Geneva at the Center for Genetic (developmental) Epistemology conducted hundreds of experiments on various aspects of children's reasoning and thinking.

One of Piaget's last writings revisited the issue of logical thinking; specifically, the role of the child's understanding of the possibility and necessity of events
(Piaget, 1987a, 1987b). His last work on the logic of meaning (Piaget & Garcia, 1991) identified the child's development of implications among actions as the basis for the later development of logical thinking. For example, when the infant's action of inserting an object into a small box is followed by the reverse action, emptying, the infant has begun to construct an implication between actions.

Understanding Piaget's work is hindered by at least three factors. One is that only some of his writings and the Genevan research are available in English. Second, Piaget, in his later writings, often did not restate the purpose and broad aims of his work, thus making it easier to misapply the theory to inappropriate questions (Chapman, 1988). Third, Piaget continued to revise and rework the theory based on continuing experimentation; he once described himself as its chief revisionist (Piaget, 1970b). For example, he originally used the term logico-mathematical to refer to the child's construction of classes and relations involving number and quantity (Piaget, 1952). He later expanded the category to include all the organism's intercoordinations of its activities (Piaget, 1971).

Finally, the framework of Piaget's thinking differed from the general framework of psychology. Primarily, that framework viewed knowledge as a thing (not a process) and also described knowledge and intelligence as different constructs. As a result, misinterpretations occurred when the English and American empiricist tradition attempted to assimilate Piaget's action-oriented model (Beilin, 1992b; Bickhard, 1997; Chandler & Chapman, 1991; Chapman, 1988; Dean & Youniss, 1991; Lorenço & Machado, 1996; Smith, 1991). In addition, some researchers incorporated Piaget's concepts into their framework of questions while excluding issues the theory addressed. The result was a distorted version of the theory (Chandler & Chapman, 1991: Chapman, 1988; Dean & Youniss, 1991; Lorenço & Machado, 1996). Moreover, some interpretations of Piaget's theory were so distorted that he was criticized for positions he had never taken (Bickhard, 1997; Chapman, 1988; Lorenço & Machado, 1996).

**PRINCIPLES OF COGNITIVE DEVELOPMENT**

The focus of Jean Piaget's theory was to discover the origins of natural logic and the transformations from one form of reasoning to another. This goal required investigating the roots of logical thinking in infancy, the kinds of reasoning that the young child engages in, and the reasoning processes of the adolescent and the adult.

**Basic Assumptions**

The basic assumptions of the theory are Piaget's conception of the constructivist nature of intelligence and the essential factors in cognitive development.

*A Constructivist View of Intelligence*

The introduction of Piaget's theory to the English-speaking community after World War II created a near-sensation with its bold theoretical claims and
counterintuitive experimental data (Beilin, 1992a, p. 191). Discussed in this section are differences with traditional views of knowledge, Piaget's research framework, and his conception of intelligence.

**Differences with Traditional Views.** Piaget (1970b) maintained that the traditional view of learning erred in three ways. First, psychologists and educators typically described knowledge as (a) some entity “out there” in objects and events that (b) consists of static objective information about that “real” world. Therefore, (c) the individual and the external environment can be separated into two entities in any definition of knowledge. Opposing this view is Piaget’s counterintuitive claim that intelligence and knowledge are not static quantities or things. Instead, knowing is a process; it develops through the individual’s adaptations to the environment, and it is ever-changing. “We must not take knowledge with a capital K, as a state in its higher forms, but seek the process of formation” (Piaget, in Bringuier, 1980, p. 7). Therefore, in the process of developing new knowledge [knowing], the individual and the environment cannot be separated.

Piaget’s second counterintuitive claim is that knowing (knowledge) and the actions of intelligence are one and the same process that changes through interactions with the environment. The role of the psychologist is to determine the nature of the changes.

**Piaget’s Research Framework.** Piaget’s approach to studying the development of intelligence was itself an innovation. He began with four questions to be answered. They are: What is the nature of knowledge? What is the relationship between the knower and reality? What is the nature of intelligence? and What are appropriate methods of investigation? As indicated in Table 8.1, he formed the framework for his research and theory from the disciplines of philosophy, biology, and psychology. For Piaget, the nature of knowledge and the relationship of the learner to reality are philosophical questions. Biology, in his view, provided the answer to the nature of intelligence, and psychology addressed the issue of the appropriate methods of study (observation and experimentation).

The process of knowing is created in the individual's interactions with the environment. “To know is to act, and, in the absence of action, the question of knowledge [knowing] becomes mute within Piaget’s system” (Pufall, 1988, p. 16). Knowing also contains many subjective components; therefore, it is a relationship and not some *a priori* given. For example, young children initially think that everything that moves or can be moved is alive, including rocks and clouds. First, children believe that a rock is alive because you can throw it. Later, they will say that it is *not* alive because you throw it. Eventually, children reconstruct their views about living and nonliving things by setting aside motion, and action as criteria for being alive. They gradually realize that other characteristics are important.

As indicated by this example, “the relationship between subject (knower) and objects is in no way determined beforehand, and what is more important, it is not stable” (Piaget, 1970b, p. 704). The infant, for example, first learns about the environment by putting objects into its mouth and later by shaking, dropping,
TABLE 8.1
Assumptions of Piaget’s Cognitive-Development Theory

<table>
<thead>
<tr>
<th>Question</th>
<th>Source</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the nature of knowledge?</td>
<td>Philosophy</td>
<td>Knowledge is knowing, and it is a process created by the activity of the learner.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowing derives from the experience of transforming reality by interacting with it (Chapman, 1999, p. 32).</td>
</tr>
<tr>
<td>What is the relationship between the knower and reality?</td>
<td></td>
<td>(a) In the creation of knowledge, the individual and the object are fused and cannot be separated.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) “The relationship between the learner and the object is in no way determined beforehand and what is more important, it is not stable” (Piaget, 1970b, p. 704).</td>
</tr>
<tr>
<td>What is the nature of intelligence?</td>
<td>Biology</td>
<td>Human intelligence and biological organisms function in similar ways. Both are organized systems that constantly interact with the environment. They also construct the structures they need in order to adapt to the environment (Piaget, in Bringuier, 1980, p. 3).</td>
</tr>
<tr>
<td>What are appropriate methods of investigation?</td>
<td>Psychology</td>
<td>Observation and experimentation</td>
</tr>
</tbody>
</table>

pushing, or pulling them. At the most sophisticated level of thinking, however, scientists and scholars build theories using abstract symbols that may have no concrete counterparts in the environment. Between the activities of the infant and those of the theoretical scientist lies a continuum of ever-changing development.

The Nature of Intelligence. First, intelligence is not a static trait that can be quantitatively assessed. Instead, intelligence is active, dynamic, and changing. A basic assumption of Piaget’s theory is that human intelligence and biological organisms function in similar ways. Intelligence, like a biological organism, is a living system that grows and develops. Also, both are organized systems that constantly interact with the environment, and they construct the structures they need in order to adapt to the environment (Piaget, in Bringuier, 1980, p. 3).

Piaget’s view that the organism is not a passive agent in cognitive development is supported by his earlier research on mollusks. He found that certain mollusks, transported from their calm water habitat to turbulent wind-driven waters,
grew an extra “foot” to maintain a hold on the rocks in the fast currents. Furthermore, these biological changes, constructed in response to an environmental change, were inherited by some descendants of the mollusks. For some of the organisms, this change persisted even when they were transported back to calmer waters (Piaget, 1980).

Similarly, intelligence constructs the cognitive structures that it needs in the process of adaptation to the environment. Cognitive structures, like biological structures, “are not given in advance, neither in the human mind nor in the external world as we perceive and organize it” (Piaget, in Bringuier, 1980, p. 37). An example is the infant’s coordination of his or her actions into the reaching–grasping–pulling scheme. This new structure enables the infant to pull a string to reach the object at the end of it (Piaget, 1967), to pull a blanket to get an out-of-reach toy, and so on. Other examples throughout childhood involve the gradual construction of logical ways of interacting with objects and events, instead of acting on perceptual cues.

In summary, genetic epistemology “above all sees knowledge as a continuous construction” (Piaget, 1972b, p. 17). Also, the term knowledge refers to natural logic, which is the child’s developing intelligence. Because knowledge [knowing] is constructed through the individual’s interactions with the environment and intelligence also is so constructed, the issues in understanding knowledge and intelligence are reduced to the same question. In other words, to answer the question about how the individual progresses from a state of less sufficient to more sufficient knowledge is to determine the ways in which intelligence is interacting with the environment.

**Essential Factors in Cognitive Development**

Four factors are necessary for the developmental transformations from one form of reasoning to another. They are the physical environment, maturation, social influences, and the processes referred to as equilibration (Piaget, 1977).

Contact with the physical environment is essential because interactions between the individual and the world are the source of new knowledge. However, such contact is insufficient for developing knowledge unless the individual can make use of the experience. Maturation of the nervous system is, therefore, important because it permits the child to realize maximum benefit from physical experience. In other words, maturation opens up possibilities for development. The emergence of hand–eye coordination in the infant, for example, is essential for the construction of the infant’s action schemes, such as reaching–grasping–pulling.

Although maturation is an important condition for cognitive development, particular developmental events are not predetermed. Development proceeds at different rates, depending on the nature of the child’s contact with the environment and his or her own activity.

The third factor, the social environment, includes the role of language and education and, particularly, contact with others. In the absence of social interactions, the child, subjectively certain in his or her beliefs, would be unlikely to initiate the actions required to change inaccurate ideas. Piaget (1926) stated, “Never
without the shock of contact with the thought of others and the effort of reflection which this shock entails would thought as such come to consciousness” (p. 144). Also, differences in social experiences, like physical experience, can accelerate or retard the development of cognitive structures (Inhelder, Sinclair, & Bovet, 1974).

These three factors are the classical influences on development described by other theorists. Piaget maintained, however, that these three factors (either singly or in combination) were insufficient to explain the emergence of new forms of thinking (Chapman, 1988, p. 388). Also essential is the fourth factor, equilibration. This factor consists of the set of processes that maintain a steady state in intellectual functioning in the midst of transformation and change. Equilibration (described in the following section) regulates the individual's interactions with the environment and permits cognitive development to proceed in a coherent and organized fashion.

**Summary**

The purpose of Piaget's work was to discover the characteristics of natural logic, which consist of the reasoning processes that the individual constructs at various phases during cognitive development. First, he did not support the view of knowledge as static information residing in objects and events that is separate from the individual. In Piaget's work, knowledge is the process of knowing through interactions with the environment, and intelligence is an organized system that constructs the structures it needs in adapting to the environment. Therefore, intelligence is an ongoing and changing process, and the activity of the learner creates the process of knowing. The key question for psychology thus becomes the ways that the learner progresses from one stage of knowledge construction to another.

The transformation from one form of reasoning to another depends on four essential factors. They are the physical environment, maturation, social influences, and the processes referred to as equilibration. The role of equilibration is to maintain the functioning of intelligence while it undergoes major transformation.

**The Components of Cognitive Development**

The focal point of the theory is the processes that account for progress from one level of reasoning and thinking to a higher level. Two major topics in Piaget's theory illustrate these processes. They are the psychological nature of logical thinking and the fundamental processes involved in interactions with the environment.

**The Psychological Nature of Logical Thinking**

Three key concepts that reflect the nature of logical thinking in Piaget's theory are the psychological structure of logical thinking, the role of possibility and necessity in understanding events, and the role of meaning.

**Psychological Structure.** The basic units of logical thinking are particular kinds of cognitive activity that Piaget (1928, 1970b) referred to as operations. They are the cognitive structures that govern logical reasoning in the broad sense (Piaget, 1970a,
Without this system of logical thinking, children are unable to differentiate reliably “between knowledge and desire, fact and fantasy, or among what is, may be, must be, or cannot be” (Furth, 1986, p. 39). However, operations are not static structures of information. Instead, operations are transformations performed on data or objects and they form a particular psychological structure. They are actions that are internalized, reversible, and coordinated into systems. In other words, cognitive structures are not the conscious content of thinking. Instead, cognitive structures impose one particular way of thinking instead of another (Piaget, 1970/1976a, p. 64; 1976b).

Three essential characteristics differentiate operations from other kinds of mental actions. As indicated in Table 8.2, the data or object transformation is one in which a change in one feature of the situation is exactly compensated by a change in another characteristic. For example, subdividing a pile of 40 pennies yields four equal piles (transformation), but the number in a pile decreases as the number of piles increases. However, the essential nature of the situation, 40 pennies, does not change (the invariant or the constant). Recognition of the unchanging feature of the situation by the child is referred to as conservation. Similarly, when balls of clay are flattened into sausage or pancake shapes, the amount of clay remains invariant; the quantity is conserved.

The third important characteristic of operations is that the transformation can be restored to the original by an inverse operation. The four piles of pennies, for example, can be recombined into the whole of 40 pennies. The capability of a child to simultaneously coordinate an operation and its inverse is referred to as reversibility. When a child develops the understanding that a transformation simultaneously and necessarily implies its inverse, he or she can manipulate the situation and analyze it correctly without becoming confused. At that point, the child has constructed a logical cognitive structure, an operation.

In other words, both the transformation and its inverse are essential elements of an operational structure. The inverse of adding $2 + 3 = 5$, for example, is subtraction (i.e., $5 - 3 = 2$). However, simply demonstrating the capability of adding numbers does not imply that the child has attained operational thinking. The child must view addition as the inverse of subtraction and vice versa; that is, the existence of one requires the presence of the other (Murray, 1990, p. 199).

**TABLE 8.2**
Examples of the Characteristics of a Psychological Structure

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Conservation of Number</th>
<th>Conservation of Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformation</td>
<td>Subdivide a pile of 40 pennies into four piles</td>
<td>Roll little balls of clay into sausage shapes</td>
</tr>
<tr>
<td>Balancing compensations</td>
<td>The number of piles increases while the number in a pile decreases</td>
<td>The shape become longer and thinner</td>
</tr>
<tr>
<td>The constant or invariant (conservation)</td>
<td>Total number of pennies does not change</td>
<td>Total amount of clay does not change</td>
</tr>
<tr>
<td>Reversibility (inverse action that restores the original)</td>
<td>Recombine the four piles into one</td>
<td>Roll the sausage shapes into little balls of clay</td>
</tr>
</tbody>
</table>
**Development of an Operational Structure.** Operational structures develop slowly, over months and years, and this development requires several reorganizations of prior thinking. Experiments on the conservation of quantity illustrate the phases involved in the child's invention of an operational structure. The experimenter shows the child balls of clay, and then rolls them into sausage shapes. When asked if the amount of clay is the same, children responded in ways that indicated four levels of development. Initially, the children centered on the length of the clay, ignoring other dimensions (Level I). At Level II, children center on the length, but begin to notice that the clay also becomes thinner. However, they do not coordinate these two observations. Instead, the observations alternate in an “unstable equilibrium” (Chapman, 1988, p. 298).

Then, at Level III, children note that lengthening the clay also makes it thinner at the same time. They see that rolling out the clay results in two **simultaneous** changes, but they do not understand that the two changes precisely compensate each other (p. 299). Also at this phase, children understand that the sausage shape can be restored to a ball. Piaget referred to this understanding as “the empirical return” (p. 299). Children do not yet understand the principle of operational reversibility. That is, transformations of length and width are compensatory relations (as the clay becomes longer, it becomes thinner, and as it becomes shorter, it also becomes thicker).

Construction of the operational structure of conservation of quantity develops at Level IV. At this level, children can predict in advance the compensatory changes in length and thickness that result from rolling out the clay. In addition, they are able to identify the constant or invariant in the process (the amount of clay). Figure 8.1 illustrates the totalities of an operational structure that is identified by its own transformational rules about relations (Inhelder & deCaprona, 1990, p. 53).

One factor in the lengthy development of conservation is that children register only positive observables perceptually. In contrast, negations are neglected.

![Figure 8.1](attachment:image.png)

**Figure 8.1**
Illustration of the psychological structure of conservation of quantity
or constructed slowly and laboriously after the development of positive observable characteristics (Piaget, 1985, p. 13). In other words, to create an operational structure, the child must invent the opposite of factors \(x\) and \(y\). Also, the child must determine exactly what non-\(x\) and non-\(y\) are, such that existence of one (\(x, y\)) requires the existence of the other (non-\(x\), non-\(y\)) (Murray, 1990, p. 199). For example, when the child sequentially orders a dozen sticks of different lengths, he or she must realize simultaneously that “big” means “not little” and vice versa. Also, “bigger” means “less little,” and a stick can be bigger or smaller than another depending on the comparison that is being made (Piaget, 1985, p. 104).

**The Role of Possibility and Necessity.** The interdependence of the factors and their inverses in Figure 8.1 illustrates a key concept in the construction of operational structures: necessity. That is, the child realizes that certain things he or she knows are true also must be true. Young children, and even adults, often are slow to appreciate the necessity that is inherent in situations (Murray, 1990, p. 192). For example, in two studies, children were able to accurately add numbers from one to three. However, from 30 to 70% of the children thought the answer also could be a different number (Cauley, Murray, & Smith, 1983; Murray, 1990).

The importance of distinguishing between necessary knowledge and “simply true” knowledge is that they differ in key characteristics. “Simply true” knowledge may be developed through induction, noting observable facts, probability, and contingent relations among events. In contrast, necessary knowledge (e.g., conservation of number) depends on deduction, universality (can be acquired by any individual), certainty, and causal relations between states and affairs. That is, necessity is inherent in causal explanations, in the relationship between identified “causes” and the effects or outcomes they are said to produce (Ferreiro, 2001, p. 216).

For example, at a certain point in development, the child knows, *without looking at a concrete set of examples*, that A is greater than C if he or she knows that A is greater than B and B is greater than C. The child also knows that this conclusion must be true. Similarly, he or she also knows that there are more Bs than As when A is included in B, and this belief is unwavering (Borel, 1987, p. 68).

Research by Piaget in his later years revealed the lengthy development by the child of possibility and necessity (1987a, 1987b). The child’s understanding of these concepts in problem-solving situations emerges late in the development of operational structures (the concrete operational period; Acredolo, 1997; Piaget, 1987a, 1987b). Beilin (1992b) views this work as one of the most important redirections of Piaget’s theory.

Prior to the child’s development of operational structures (the preoperational level of thinking), children cannot differentiate between reality, possibility, and necessity (Level I). Shown a partially hidden box, young children stated that the hidden sides must be the same color as the visible portion (Chapman, 1988). This phase, in which the child believes that only one choice is valid, is referred to by Piaget (1987a) as *pseudonecessity*.

At Level IIA, children think of a few concrete co-possibilities, such as the hidden sides could be “green, blue, violet, yellow, white — and that’s all” (Piaget, 1987a, p. 44). At Level IIB, when concrete operations are firmly established, each
possibility is treated as one among many others that are conceivable (Beilin, 1989, p. 115) (see Table 8.3).

Children at Level II also make some effort to rule out false possibilities on the basis of the data. In one experiment, the task was to arrange three animals in the same sequence as three animals hidden behind a screen. The six possible sequences of the sheep (S), the rabbit (R) and the chicken (C) are SRC, SCR, RSC, RCS, CSR, and CRS. The children were told the number of their correct positions after each attempt. This information can lead to the systematic elimination of certain possibilities until only one remains (the “necessarily” correct solution; Chapman, 1988, p. 320). However, Level II children were able to eliminate only a few possibilities after feedback; none recognized that getting only two of the three animals correctly positioned is impossible.

Level III children recognize unlimited possibilities and also systematically exclude possibilities until they arrive at the one that is necessary. In the animal sequence problem, for example, children at Level III systematically solved both the three- and four-animal sequences.

These transitions indicate that testing the development of operational thinking involves more than obtaining a correct answer to particular tasks. Genuine tests of operational thinking also must certify that the child’s response is a necessary conclusion (Murray, 1990). Children may be asked, for example, if the

<table>
<thead>
<tr>
<th>TABLE 8.3</th>
<th>Levels of Reasoning about Possibility and Necessity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level of Thinking</strong></td>
<td><strong>Possibility</strong></td>
</tr>
<tr>
<td>Level I (preoperations)</td>
<td>(a) Recognition of only a single possibility</td>
</tr>
<tr>
<td></td>
<td>(b) Later recognition of at least one other possibility</td>
</tr>
<tr>
<td>Level IIA (onset of concrete operations)</td>
<td>Formation of concrete co-possibilities; limited to those the child can imagine</td>
</tr>
<tr>
<td>Level IIB</td>
<td>Each possibility is one among many that are conceivable</td>
</tr>
<tr>
<td>Level III (hypothetico-deductive operations)</td>
<td>Indeterminate unlimited possibilities are completely deducible</td>
</tr>
</tbody>
</table>
outcome can be different, or if this outcome occurs only sometimes (p. 188). Equally important is eliciting the child’s reasons for his or her conclusions.

**The Logic of Meaning.** The logic of operational thinking is referred to as extensional logic. It involves the truth or falsity of a term or a statement based on its extensions or links to other terms or statements. Examples are part/whole and inclusion relations. For example, given a collection of both brown and white wooden beads, the statement, “There are more white beads than wooden beads” is false. The relative quantity of the white beads is determined by the other types of beads in the total collection.

Piaget’s last work, *The Logic of Meanings* (Piaget & Garcia, 1991), laid the foundation for his theory of intensional logic, or a logic of shared meaning. In Piaget’s view, the shared meanings in actions are the roots of operational or extensional logic.

1. **Knowledge always involves inference.** That is, a relation between actions is a logical implication. For example, some infants at 9–10 months, when given empty cubes, sticks, and small plasticine balls, will insert an object into a cube. However, the infants first put the object into their mouths. According to Piaget and Garcia (1991, p. 5), they have constructed the content-container action scheme from the “insert into the mouth” scheme. These schemes have, as a result, shared meaning. The infants then extend the content-container scheme to new schemes or subschemes, such as to insert and take out, to fill and empty, and so on.

2. The meaning of an object includes what can be done with the object as well as descriptions of it (p. 119). Therefore, meaning is an assimilation to an action scheme (whether overt or mental). For example, the meanings of objects for an infant include pushing, opening, pulling, closing, and so on.

3. Logic begins at the moment a child is able to anticipate a relation between actions, referred to as meaning implications or implications between actions (p. 155). When the infant’s action, such as inserting, is followed by the reverse action, emptying, the infant has begun to construct an implication between actions. In this example the implication is that “action implies the possibility of the reverse action” (p. 6).

With the appearance of language, children can express action implications as statements and begin to construct logical links that represent *and* and *or*. In one problem, two tunnels (A1 and A2) each branch into two B tunnels, which, in turn, branch into two C tunnels. The task is to open as few windows as possible on the tunnels to determine the path taken by the car, which is indicated by a ribbon. Although the problem consists of 12 branched tunnels, it is solved by opening three windows in the correct sequence. One 6-year-old first opened a window on an A tunnel. He correctly inferred that the ribbon must be in either A1 or A2 and that the absence of the ribbon implies the car’s path was through the other tunnel.

Although children can form logical connections that reflect *and* and *or*, as well as negations of the combinations, their constructions do not yet represent
operational thinking. Their constructions are context-bound fragments that later will become operational structures. Unlike the extensive research on concrete operations by Piaget and his colleagues, researchers have conducted only a few experiments on meaning implications (see Piaget & Garcia, 1991). Thus, this aspect of the theory remains incomplete. However, one analysis of this work maintained that it provides a foundation for explaining necessity in operational settings (Ricco, 1990).

**Summary.** Three essential characteristics differentiate operational (logical) thinking from other kinds of actions. First, a transformation is exactly compensated by a change in another characteristic. Second, the essential nature of the object(s) or data remains invariant. Recognition of the unchanging feature of the situation and being able to explain why it does not change is referred to as conservation. Third, the transformation or change can be restored to the original by an inverse operation. When a child understands that a transformation simultaneously and necessarily implies its inverse, the child has developed the concept of reversibility. The child has constructed an internal operational structure and can analyze the situation accurately without becoming confused.

Essential to operational thinking is the child’s construction of the concept of necessity. Young children cannot differentiate between reality, possibility, and necessity. At the onset of concrete operations, the child forms limited concrete co-possibilities but is only able to limit some of them in a systematic way. Eventually, the child is able to conceive of unlimited possibilities and systematically exclude them.

Piaget’s last work sketched the roots of operational thinking, which are found in the early actions of the infant and then the child. The basic principles are that knowledge always involves inference, the meaning of an object includes actions that can be carried out with it, and logic begins when a child is able to anticipate a relation between actions. Children’s early logical connections, however, are context-bound fragments that later will become operational thinking.

**The Fundamental Processes**

Like biological systems, intelligence interacts with the environment, adapts to it, develops new structures as needed, and maintains a steady state while change and growth are occurring. Piaget, therefore, used terms derived from biological concepts to describe the essential nature of the interactions between intelligence and the environment. They are the processes referred to as assimilation, accommodation, and equilibration.

**Assimilation and Accommodation.** The integration of external elements into the organism’s structures is referred to as assimilation. Examples include the digestion of food and the incorporation of chlorophyll in a plant’s growth (Piaget, 1970b, p. 307). In intellectual life, assimilation is “the incorporation of an external element, for example, an object or event, into a sensorimotor or conceptual scheme of the subject” (Piaget, 1985, p. 5). An infant grasping a tool, a child weighing an object in his hand, and a scientist reviewing experiments in light of a particular theory are examples.
Assimilation is not the process of passively registering a copy of reality, nor is it an association between some environmental stimulus and a response (S → R). Instead, it is the filtering of the stimulus through an action structure so that the structures are themselves enriched (i.e., S ⊃ R; Piaget & Inhelder, 1969, p. 6).

An essential requirement for assimilation is an internal structure that can make use of the information. Young children, for example, base many of their decisions about the environment on perceptual cues alone. Often they do not integrate new information because they lack an appropriate assimilatory structure. For example, when asked to draw a picture of a half-full bottle that is tipped to one side, young children typically draw the water line as always parallel to the bottom of the bottle (Figure 8.2).

When confronted with the physical situation, young children fail to see the discrepancy between their drawings and reality (Piaget, 1977, p. 4). They have not developed a coordinate spatial system that enables them to place the water in a frame of reference outside the bottle.

**Accommodation** is manifested in Piaget's theory in two ways. One is the adjustment of internal structures to the particular characteristics of specific situations. For example, biological structures accommodate to the type and quantity of food at the same time that the organism assimilates the food.

Similarly, in cognitive functioning, internal structures adjust to the particular characteristics of new objects and events. The child assimilates the familiar characteristics of a green felt triangle (closed, three-sided) while accommodating to its particular features (in this case, color and material).

Assimilation and accommodation function together in encounters with the environment at all levels of cognitive functioning. When the infant has discovered that he or she can grasp everything within reach, everything becomes an object to

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**FIGURE 8.2**
Young child's conception of the water line in containers placed at different angles
grasp (i.e., assimilation; Piaget, in Bringuier, 1980, p. 43). For a large object, however, both hands may be needed, and for a small object, the fingers may need to be tightened (accommodation). Similarly, the theories of the scientist and the scholar are assimilatory schemes that are adapted to diverse situations (p. 43).

In cognitive development, accommodation also refers to the modification of the individual's internal cognitive structures. When the learner realizes that his or her ways of thinking are contradicted by events in the environment, the prior ways of thinking are reorganized. This reorganization, which results in a higher level of thinking, is also a form of accommodation.

**The Role of Cognitive Conflict.** The child's reorganization of his or her thinking to higher levels is not easily accomplished. The child must “rethink” his or her view of the world. An important step in this process is the experience of cognitive conflict. That is, the child eventually becomes aware of the fact that he or she holds two contradictory views about a situation and they both cannot be true. This step is referred to as cognitive conflict or disequilibrium. For example, young children faced with two parallel rows of five pennies each have no difficulty in asserting that the number of pennies in the two rows is the same. However, when the pennies in one row are spaced farther apart so that the endpoints of that row extend beyond the endpoints of the other, the child's response is that the adjusted row has more pennies. However, the child can also agree, upon counting, that each row has five pennies; no conflict exists for the child. Holding the two contradictory views stems from the child's thinking, which has not yet separated the concepts of number and space. Eventually, after several encounters with number/length situations, children experience cognitive conflict associated with the two incompatible views. They are then ready to reorganize their thinking on a more logical level.

**Equilibration.** The processes involved in maintaining a steady state while undergoing continuous change is referred to as equilibration. However, equilibration is not a balance of forces (which would be an immobile state). Instead, it is the complex and dynamic processes that continuously regulate behavior (Piaget, in Bringuier, 1980, p. 41).

The three general forms of equilibrium identified by Piaget (1985) are (a) between assimilation and accommodation, (b) between schemes or subsystems (such as number and length), and (c) between the whole and its parts. Equilibrium between assimilation and accommodation is essential for the child's comparisons about the properties of objects. Equilibration balances assimilation and accommodation almost equally in most situations. However, the brief dominance of one or the other is sometimes necessary. Examples include symbolic play (the dominance of assimilation) and imitation (the dominance of accommodation). Symbolic play occurs when the young child is attempting to subordinate reality to his or her representational thought. For example, the child may make a playhouse out of boxes and boats out of matchboxes. These activities are “a deforming assimilation of reality to the self” (Piaget, 1967, p. 23). Through symbolic play, the child achieves an affective satisfaction missing in his or her daily efforts to understand a strange and confusing world (see Piaget, 1951).
Imitation, in contrast, is the accommodation of the individual to external models. These activities contribute to the child’s acquisition of functional social behaviors. Equilibration, however, regulates these two types of childhood activities so that each occurs when appropriate (Piaget & Inhelder, 1969, p. 58).

**Equilibration and the Construction of Operational Structures.** One of the sources of progress in the construction of both the action schemes of the infant and later logical operations is found in disequilibria (contradictions). Such events can force the individual to go beyond his or her current state and strike out in new directions (Piaget, 1985, p. 10). However, disequilibria do not always lead to progress. The various reactions to disequilibria described by Piaget (1985) are alpha, beta, and gamma reactions. Another important aspect of equilibration is the processes by which thinking is reorganized on a higher level. These processes are referred to as reflective abstraction.

The two types of alpha reactions are (a) ignoring or removing the disturbance, and (b) incorporating the conflict into one’s beliefs without changing them. Examples of ignoring conflict involve failing to recognize (a) the true water line in a tilted bottle and (b) the changes in width when a ball of clay is lengthened into a cylinder (Level I thinking in the example discussed earlier). An example of fitting a disturbance into core beliefs is the child who believes the Earth is flat and, when told the Earth is round, concludes that it is shaped like a disc (Vosniadou & Brewer, 1992).

In contrast, beta reactions involve a modification of thinking in order to accommodate the disturbance. For example, the child incorporates the thinning of the ball as it becomes longer into his or her thinking (Level III thinking). However, the child has not constructed a new cognitive structure that permits him or her to predict all the transformations in advance. This reorganization of thinking is an example of a gamma reaction (Level IV thinking). That is, the child can predict in advance that rolling out balls of clay into sausage shapes involves changes in both length and thickness and that the changes are compensatory. That is, the thinning of the ball as it is lengthened becomes logically necessary (Piaget, 1985, p. 100).

**Reflective Abstraction.** The equilibration process that accounts for the transition between relatively impoverished to richer cognitive structures is reflective abstraction (Piaget, 1987b, p. 142). This process consists of (a) projecting (reflecting) something borrowed from a lower level to a higher level and (b) cognitively reconstructing (“reflection”) what is transferred (Piaget, 1985, p. 29). An example is raising the step-by-step set of sensorimotor actions used to rotate an object, such as a cube, to the representational level (Piaget, 1980, p. 98). This process, although developed slowly over time, makes possible the visualization of the reverse side of the cube when only one aspect can be seen. Reflective abstraction is important because it is essential for the construction of concrete operations.

The subject matter in reflective abstraction is the individual’s thought process. (In contrast, empirical abstraction refers to focusing on the observable
At the level of formal operations, thought processes are independent of any reference to physical manipulation (unlike concrete operations). This pure form of developing rich cognitive structures is referred to as reflected abstraction (Piaget, 1980).

**Summary**

The components of cognitive development consist of (a) the psychological structure of logical thinking and (b) the fundamental processes involved in interactions with the environment. The individual has achieved logical thinking in a particular domain when he or she can simultaneously coordinate an operation and its inverse, can predict in advance the types of change that will occur, and can support his or her decision on the basis of necessity. In Piaget’s last work, he described the role of meaning implications as the root of operational logic. That is, logic begins at the moment a child is able to anticipate a relation between actions. It begins with such activities as separating a set of boxes that the infant has just stacked inside each other.

The fundamental processes in the development of logical thinking are assimilation, accommodation, and equilibration. Assimilation is the integration of external elements into the learner’s internal structures. Accommodation includes both adjustments in the learner’s internal structures and qualitative transformations in thinking. The child’s realization that two contradictory beliefs he or she holds cannot both be true (cognitive conflict) often precipitates a reorganization of the child’s thinking. Equilibration is the set of complex and dynamic processes that continuously regulate behavior. A major role for equilibration is that of maintaining intellectual functioning during development.

**The Levels of Complex Reasoning**

The early research conducted by Piaget (1967, 1970a) established the framework for his analyses of thinking processes. The framework consists of four broad periods or stages of cognitive development: sensorimotor, preoperational, concrete operational, and formal operational stages (see Table 8.4). Each one “extends the preceding period, reconstructs it on a new level, and later surpasses it to an even greater degree” (Piaget & Inhelder, 1969, p. 152). For example, the preoperational child focuses on perceptual cues and static states. Young children also combine a sense of quantity, weight, and volume into a fuzzy concept of size (Smith, 1991, p. 85). In addition, they use circular reasoning and the inconsistent application of criteria to justify their answers. In contrast, the child at the concrete operational level of reasoning understands transformations and the affirmations (changes) and inverses that compensate each other.

Contrary to early beliefs about Piaget’s theory, the stages were not the goal of his work. Instead, they represent the kinds of logical issues the child can deal with at a particular phase in his or her development.

In addition to qualitative changes in reasoning processes, the stages also reflect changes in the child’s awareness of his or her own thought processes. Piaget identified three levels (Pons & Harris, 2001). The first, practical consciousness, emerges in the sensorimotor period. It refers to the young child’s awareness of his or her activities (p. 221).
The second level, conceptual consciousness, is associated with concrete operational thinking. Specifically, the construction of new concrete operations, as in the example in Figure 8.1, is accompanied by a conscious process of conceptualization (Pons & Harris, 2001, p. 221). The third level is reflective consciousness and is essential for the development of formal operational thinking. Here, the individual reflects on his or her own functioning; the focus of reflective consciousness is the individual’s thought processes rather than the content of the problem. Piaget did not conceptualize consciousness as an entity to be filled by a particular content (Ferreiro, 2001, p. 215). Like his other major concepts, consciousness is a process—the developing awareness of one’s thinking (prise de conscience).

Of the four major stages of reasoning, concrete and formal operational thinking represent logical reasoning. However, they differ in qualitative ways.

**Concrete Operations**

Concrete operations include class inclusion operations, ordering relations (seriation), and the conservation constructs of number, length, matter, weight, and volume. An earlier section in this chapter describes two examples of concrete
operational thinking (number and conservation of matter). The child's construction of concrete operations is a gradual process that first includes cognitive conflict, then vacillation among possible choices, and finally, logical resolution of the conflict.

**Characteristics.** Concrete operations are linked to the direct manipulation of objects. The common characteristic of concrete operational structures is that they consist of an equilibrium between "affirmations" (direct operations) and their inverses (opposites) (Piaget, 1985). The concrete operational child focuses on the transformations and can predict in advance the affirmations (changes) and inverses that compensate each other. The child has invented a closed concrete operational structure when he or she has constructed the set of affirmations and their corresponding inverses.

**Class Inclusion Operations.** An understanding of part-whole relationships is the essential characteristic of class inclusion operations. An example is roses + tulips = flowers. Class inclusion also includes double classification. An example is classifying the flowers into red roses, red tulips, white roses, and white tulips. Preoperational children, in contrast, can only focus on one feature at a time (referred to as "centering" by Piaget). When asked to identify the red roses, they will choose either all the roses (white and red) or all the red flowers.

**Seriation.** The defining characteristic of seriation is transitivity or the "transfer" of relations. If A = B and B = C, then A = C and C = B = A (the inverse). Seriation also includes asymmetric relations ("greater than" [>] and "less than" [<]), such as A > B > C. Concrete operational children understand that some element B is both longer and shorter than some other elements. Unlike preoperational thinkers who proceed haphazardly to form a series, concrete operational children systematically search for the longest (or shortest) stick, then the next one in length, and so on. They also can demonstrate that the reverse of A > B > C is C < B < A.

**Formal Operations**
The concrete operational thinker can only reason from empirical data in developing an explanation of a situation (Inhelder & Piaget, 1958, p. 251), and inferences are limited to pairing characteristics two by two. This approach, however, does not take into account the possibilities that the variables are mixed. That is, one effect in a situation may be caused by several factors, or a single causal factor may be accompanied or masked by several varying factors that are not causes (p. 282). For example, the type of soil and amount of rainfall influence the height of water in a lake, but water temperature is not a causal factor.

**Characteristics.** A major feature of formal operations is that individuals can address multifactor situations (as opposed to only two-factor situations). The basis for this capability is that the formal operational thinker is able to conceptualize all combinations of the factors in a particular situation. For example, given four characteristics, such as red and white and tulips and roses, the formal operational thinker can generate the 16 possible combinations of these characteristics. Among
the possibilities are (a) white tulips and red roses, (b) red roses and red tulips, and so on. The concrete operational thinker can only generate the four subclasses (red roses, red tulips, white roses, white tulips).

This example illustrates three essential characteristics of formal operational thinking. One is that reality is subordinated to possibility in that the individual can generate all the likely possibilities. Second, the individual begins with a theoretical synthesis that implies certain relationships and then proceeds to test the hypothesized relationships (Karmiloff-Smith & Inhelder, 1975).

The third characteristic of formal operations is that the hypotheses are related to each other in a combinatorial system. However, the individual, when faced with a complex situation, does not actually construct the table of combinations. Instead, he or she begins by conceptualizing some of the possible combinations and systematically testing hypotheses in order to isolate the correct explanation.

The Colorless Liquids Experiment. An example of formal operational thinking is the strategy for resolving the colorless liquids experiment (Inhelder & Piaget, 1958). The experimenter adds a substance \( g \) to each of two beakers of colorless liquid(s). In one case, the new substance produces no change; however, in the other, the color yellow appears. The task is to identify which of four colorless liquids, singly or in combination, produces the yellow color (Figure 8.3).

![Figure 8.3](image)

Which combination of the colorless liquids in beakers (1), (2), (3), and (4) are in beaker (b) such that the addition of test tube (g) changes the liquid to yellow?

Possible combinations
- 1 only; 2 only; 3 only; 4 only
- 1 and 2; 1 and 3; 1 and 4; 2 and 3; 2 and 4; 3 and 4
- 1, 2, and 3; 1, 3, and 4; 1, 2, and 4; 2, 3, and 4
- 1, 2, 3, and 4

FIGURE 8.3
The colorless liquids experiment
Formal operational thinkers will identify the possible combinations, often jotting them down, and then proceed to test them. Individuals who are at the concrete level of thinking will proceed to test combinations, two by two. However, this approach results in omissions and errors.

**Related Issues.** Piaget (1972a, p. 10) noted that his research into formal operations had utilized situations likely to be understood by children in an academic setting. However, the applicability of such situations to professional environments is questionable. In other words, carpenters, locksmiths, or mechanics may well reason hypothetically in their specialty. Their unfamiliarity with structured school subjects, however, would hinder them from reasoning in a formal way with the experimental situations used in the research.

Similarly, research conducted by DeLisi and Stewart (1980) indicated that college students reason hypothetically in the area of their college majors. However, formal operational reasoning was not observed in other areas. Some reviews of the research on formal operations concluded that the empirical evidence supporting the construct is equivocal. However, Bond (1998) concluded that studies attentive to the definition of formal operations support inferences about formal operational thinking.

Piaget's use of propositional logic should not be confused with the standard view of logic. In the standard use, $p$ and $q$ are combined in various ways, using logical connectives. The task is to determine whether a particular statement such as "if $p$ then $q$" is true or false, given initial information about $p$ and $q$. Piaget's application of propositional logic, however, does not address truth or falsity in terms of the congruence of statements to given information. Instead, Piaget applied propositional logic as a description of the subject's experimental behavior in which the subject is testing hypotheses based on causal models (Müller, 1999, p. 28).

**Other Interpretations**
Research summarized by Berk (1989) indicated that infants attain some accomplishments in the sensorimotor stage, such as object permanence, earlier than Piaget had indicated. However, some researchers have used the infant's reaction of surprise on the disappearance of an object (rather than a search for the hidden object) as evidence of the concept of object permanence (Lorenço & Machado, 1996). The difficulty with the use of this reaction is that infants often display surprise at a change in a perceptual array of objects. Thus, the surprise reaction is not a reliable indicator of object permanence. Furthermore, as Piaget indicated, mental representations of hidden objects are rarely error-free until 18 months of age.

One line of theoretical development undertaken by Case (1985, 1992, 1993) has retained the broad perspective of Piaget's theory and introduced new concepts. This perspective (sometimes referred to as neo-Piagetian) has, according to Case (1992, p. 61), altered the Piagetian framework substantially. The work is not a simple extension of Piaget's concepts nor a revision that he would have sanctioned (p. 62).

The broad concepts retained from classic Piagetian theory in Case's revision are that children (a) create their own cognitive structures, (b) assimilate experience...
to existing cognitive structures, (c) pass through a universal sequence of structures, and (d) incorporate earlier structures into later ones. Elements developed by Case (1985, 1992, 1993) are that (a) the general factor in child development is the child's attentional or information-processing capacity (Case, 1992, p. 72), and (b) analysis of task performance should include children's goals and strategies and the information load required for the strategies.

Analysis of children's actions in different tasks led Case (1993) to conclude that children younger than 5 years approach computational tasks, such as telling time and making change with money, in a global fashion. In contrast, 5- to 7-year-olds have an integrated structure for such problems that includes counting and comparison. This integrated structure becomes automatic as children apply it in various situations and functional working memory increases (p. 225).

**Summary**

The periods of cognitive development identified by Piaget are the sensorimotor, preoperational, concrete operational, and formal operational stages. They are not the goal of Piaget's work, serving only to represent the kinds of logical issues the child can address at a particular period in his or her development. In the sensorimotor period, the infant constructs actions that allow him or her to act on the environment. An example is the "insert-in-the-mouth" scheme. In the preoperational period, the child makes decisions about events on perceptual cues and does not differentiate between reality, possibility, and necessity in problem-solving situations.

The concrete and formal operational periods both represent logical reasoning, although these periods differ qualitatively. Concrete operational thinking is limited to the direct manipulation of objects. However, the child does develop logical thinking in relation to number, class inclusion, and the conservation of continuous quantities. In formal operational thinking, the individual can solve multifactor situations because he or she can conceptualize all combination of factors in a particular situation. The individual systematically tests hypotheses about the situation in order to isolate the correct explanation.

**PRINCIPLES OF INSTRUCTION**

Deriving instructional principles from Piaget's developmental theory requires careful and thoughtful analysis and interpretation. The primary reason is that the theory describes the qualitative changes in reasoning about events that lead to logical thinking. The theory does not address the learning of specific facts, such as state capitals. Piaget believed that using one's intelligence involves the exercise of a critical spirit. Therefore, curricula should address the development of logical reasoning. This focus is consistent with the development of students' inquiry abilities and skills and scientific habits of mind (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996).
Basic Assumptions

One’s perspective of the nature of a child’s thinking has important implications for education (Piaget, 1970c). If childhood is believed to be simply a period that a child goes through to become an adult, then the relationship between the educational system and the child will be unilateral. The child will receive already finished products of adult knowledge and morality. Educational experiences will be organized and directed by the teacher and transmitted to the child. In such an educational climate, even individual tasks such as writing an essay will be directed toward obedience rather than autonomy (Piaget, 1970c).

However, if childhood is accepted as a necessary and important phase in the development of logical thinking, education will be viewed differently. The child’s thought patterns undergo qualitative changes essential to the development of logical hypothetical thought. Therefore, the relationship between the educational system and the child will be a reciprocal one (Piaget, 1970c).

Piaget recommended the use of active methods that require the student to engage in active inquiry of topics that interest him or her. However, a highly industrialized and technological society presents a problem in that it is not an ideal setting for exploration and spontaneous activity (Furth, 1980). How can a child apply his spontaneous curiosity to a television set, when only an expert knows how it works? Or to vegetables in a can when he has never seen them growing? The problem is that these children enter school with an intelligence that has not been well nourished. Thus, a “high-tech” society faces particular problems in developing individuals who are capable of constructing new knowledge.

The Components of Instruction

Instead of the verbal transmission of knowledge, education should rely on the use of methods that support the spontaneous research of the child or adolescent (Piaget, 1973). This approach is particularly important in the teaching of mathematics and science. Mathematics, for example, consists of actions and operations; therefore, understanding mathematics should begin with action (Piaget, 1973). Instruction should begin in nursery school with concrete situations related to lengths, surfaces, numbers, and so on, progressing to physical and mechanical experiments in secondary school (p. 104).

The basic need for education, according to Piaget (1973), is “to introduce both liberal arts and science students to experimental procedures and the free activity such training implies” (p. 35). The solution he recommended is to provide mixed curricula—science classes that focus on self-directed experimentation and courses that use experimentation where possible. Some psychology classes, for example, could be devoted to individual experimentation in psycholinguistics.

Of course, subjects such as history or Latin cannot be “reinvented” by the students. That is, individuals cannot verify explanatory hypotheses with regard to Greek civilization (p. 47). However, when research reveals some understanding
of the ways in which students acquire spontaneous operational thought in historical understanding, methods may change.

A requirement that must accompany experimentation is that of collaboration and interchange among the students themselves (Piaget, 1973, p. 108). The traditional school often excludes this interchange, recognizing only the social exchange between teacher and student. However, both independent and collaborative student activity should be included. Using one's intelligence, according to Piaget (1973), assumes the exercise of a critical spirit. Such objectivity, however, can be developed only in a group situation in which give-and-take with one's peers occurs. Therefore, spontaneous activity, with small groups of students brought together by means of their mutual interest in a particular activity, should be a major feature of classroom learning. The classroom should be “a center of real (and experimental) activities carried out in common, so that logical intelligence may be elaborated through action and social exchange” (p. 47).

Facilitating the Young Child's Construction of Knowledge

Organizing education around the child's spontaneous research implies an educational goal to develop the child's intelligence as an organized whole (Kamii, 1975). Important issues in preschool curricula are the problems with direct teaching, the role of make-believe play, the use of activities, and the teacher’s role.

Problems with "Direct Teaching." Children do not learn by internalizing knowledge in ready-made form (Kamii & Kamii, 1990). Therefore, abstract ideas or principles should not be taught through verbal transmission (Kamii & DeVries, 1978). First, a logical rule contradicts the child's spontaneous beliefs and, therefore, confuses the child. The preoperational child does not notice the contradiction in his or her own explanations. One child, for example, stated that a wooden blade floats because it is thick, and copper wire sinks because it is long (p. 32). The fact that the wooden blade was also long was irrelevant to the child. Therefore, because the child is unaware of the contradictions, a logical rule to fit all contingencies at this point is only a verbalization that introduces confusion.

In addition, direct teaching of ideas stifles children's initiative in the construction of knowledge (Kamii & DeVries, 1978). Children may lose confidence in their ability to figure things out and focus instead on picking up cues from the teacher that indicate the desired right answer.

Make-Believe Play. A major characteristic of preschool children, according to Piaget (1951), is that they manage to live in a world where the adult distinction between fiction and reality does not apply. The child accomplishes this feat, in part, through make-believe or symbolic play.

The importance of make-believe play is that it provides the child a temporary escape from the strange outside world. The child is free to accept from the environment whatever appeals to him or her and to ignore information or events that are beyond immediate interest or understanding. For example, the child can "bake a cake" without having to be careful about breaking or burning. Also, the anger of an adult about some misbehavior can be reenacted using rules that the
child understands. In other words, make-believe play provides a world of actions, symbols, and images where the child can feel free because it is under his or her own intellectual control (Furth, 1980, p. 67).

One of the current concerns about the use of VCRs, CDs, and television as baby sitters is the lost opportunities for creative play. The child is passive, instead of creating roles, actions, and thoughts through symbolic play. An important element in developing new ideas and ways of thinking is lost through reliance on these passive activities (Berk, 1989). Thus, an important activity to include in the preschool curriculum is some time in which children are free to engage in make-believe scenarios.

**Use of Activities.** Some early curriculum developments advocated the diagnosis of the child’s level of cognitive functioning and the provision of particular activities appropriate for the different levels in the classroom. However, in any one class of 30 children, various levels of development and breadth of understanding will be represented. Tailoring narrow exercises for individual children is both impractical and unnecessary (Duckworth, 1979). First, the time required to test the children’s level of cognitive development for different subsystems (number, space, length, etc.) is prohibitive. Second, logistical problems are generated by efforts to continuously provide a variety of activities and experiences for several different levels.

Third, activities or exercises that isolate and present one form of reasoning should not be used. They lack the element essential for progress, which is the dynamics of the conflict among modes of thinking (Inhelder et al., 1974, p. 265). Therefore, classroom activities should maximize the child’s opportunities to construct and coordinate many relationships that he or she is capable of exercising (DeVries, 1978, p. 85).

For preschool children, Kamii and DeVries (1978, p. 49) identified four criteria for physical activities. Objects should be included that can be acted on directly by the child and for which different actions by the child will produce different effects. In addition, the effects of the child’s actions on the object should be both immediate and observable.

Activities that meet these criteria can provide opportunities for the enrichment and clarification of the child’s awareness of object features, actions, and reactions (i.e., assimilation). Many such activities also can facilitate the process of accommodation that occurs when a cognitive structure adjusts to particular object characters and to the development of inferences about one’s actions (meanings) (Piaget & Garcia, 1991).

Table 8.5 summarizes an activity for 4- and 5-year-olds that is appropriate for different developmental levels. The nature of the activity is such that it provides numerous opportunities for children to determine the physical properties of objects in water. The interaction between blowing and speed of the objects contributes to the development of implications between actions.

**The Teacher’s Role.** Piaget (1973) indicated that no more difficult task exists for the teacher than that of becoming attuned to the spontaneous mental
TABLE 8.5
Summary of Classroom Activity for Young Children

<table>
<thead>
<tr>
<th>Activity</th>
<th>Blowing objects with a straw across the water surface in a water table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objects</td>
<td>A drinking straw for each child; assorted objects, including ping-pong balls, cotton balls, crayons, ivory soap, paper cups, styrofoam bits, a round Tinker toy, and others</td>
</tr>
<tr>
<td>Follow-up activity</td>
<td>Suggest a race with some objects or a hockey game with the ping-pong balls</td>
</tr>
<tr>
<td>Potential logico-mathematical knowledge</td>
<td>“Lighter than,” “heavier than,” “faster than”; relationship between angle and straw, blowing effort, and speed</td>
</tr>
<tr>
<td>Sample follow-up questions</td>
<td>“What happened when you used two straws?” and “What would you like to try next time?” (Kamii &amp; DeVries, 1978, p. 60)</td>
</tr>
</tbody>
</table>


activity of the child or adolescent. Yet intellectual development depends on that constructive activity with all its errors and all the extra time that it seems to consume (p. 107).

The teacher’s role is first to create and organize classroom activities. Second is to provide examples that lead students to rethink their hastily developed ideas. Third is to elicit children’s ideas through indirect questions such as, “Can you tell me about this?” or “What else feels (tastes, looks) like this?” (Copple, Sigel, & Saunders, 1979, pp. 231–232). Examples of questions that keep children engaged are, “Can you find any more like that?” and “What did you do that was different from what she did?” (Duckworth, 1990, p. 46). Prediction questions such as, “What would happen if . . .” encourage children to go beyond the immediate physical reality (Kamii & DeVries, 1978).

However, young children often are unaware of which of their own actions produced a particular effect. For example, 4-year-olds can twirl an object on a string and time its release to land it in a box several feet away. However, until the age of 9 or 10, their descriptions of the ways to accomplish this goal differ from their actions (Piaget, 1976b). Explanations of such effects by 4- and 5-year-olds, and their accompanying understanding of such causes, will not be accurate.

Facilitating Operational Thinking

True logical thinking, according to Piaget, is constructed by the learner in self-directed or peer-collaborative research on topics of interest to the students (Duckworth, 1978, 1990). As Piaget (1973) indicated, self-directed experimentation is particularly important in science and mathematics.
Applications in Science. In elementary school science, the material world should be the starting point (Duckworth, 1990). It is both accessible and contains complexities children have never dreamed of (p. 25). For example, in one second-grade classroom, some children were interested in crystals. They made a "crystal" museum of examples they collected, grew crystals, examined them under a microscope, and read books about them. One snowflake picture led to their building a 12-sided polygon with their pattern blocks. Some children were fascinated to discover that, within such a shape, patterns were found 1, 2, 3, 6, or 12 times. Their explorations to determine the basis for these numbers led to the factors of 12. Other children appreciated most the beauty of the patterns (p. 22).

Some science curricula in the 1980s focused on addressing students' misconceptions about scientific concepts, such as gravity, force, velocity, and others (e.g., Champagne, Gunstone, & Klopf, 1985; Gilbert, Watts, & Osborne, 1985; Osborne & Gilbert, 1980). In one study, students as old as age 19 held opposing beliefs and were unaware of their contradictions (Osborne & Gilbert, 1980). One student, for example, when asked if any force was acting on a man standing on the moon, replied, "There is no air up there, so there is no gravity" (p. 379). Later, in the same interview, the student indicated that there was some gravity, but no air. After identifying the misconceptions, students engaged in experimental activities to change their thinking (Osborne & Gilbert, 1980).

Research in science education then expanded to determine learners' experimentation skills, which include testing hypotheses about multifactor situations (see Zimmerman, 2000, for a discussion). In several innovations, the instruction poses the question to be addressed by the students. An example is the situation in which middle-school students must determine which combination of four variables—soil type (sand, clay), elevation (high, low), water pollution (high, low), and/or water temperature (hot, cold)—produce the least amount of flooding (five levels, 1-5 feet) along a series of lakes (Kuhn, Black, Keselman, & Kaplan, 2000).

In contrast, one curriculum is based on the belief that students should take a high degree of responsibility for investigations from start to finish (O'Neill & Polman, 2004). In the first quarter of eighth-grade earth science, the teacher presented an overview of the subject and introduced the Internet and computer tools in the classroom (spreadsheet, word processing software). The students, in self-selected groups of two or three, devised and researched three questions during the remainder of the year (one question each quarter). The students first gather background information on their topic, prepare a synthesis, and then draft potential research questions. The teacher then provides guidance in the selection of a final question. The questions in one project cycle included, Which of two "unidentified" regions of space, Cygnus X-J and Sagittarius A, is most likely a black hole? Are there any similarities between earthquake patterns in time and in magnitude on different continents? and How did plesiosaurs propel themselves through the water? (p. 243). The question on plesiosaurs emerged from contradictory descriptions in two different books and the students, in their project, evaluated the available evidence.
Students submitted initially collected data and initial data analyses to the teacher in written form. Teacher feedback on this milestone activity identified the occasions when students were relying on appeals to authority rather than relying on the data for their inferences. Also, on occasion, the students treated the data as self-explanatory. The teacher instructed the students who were studying hurricanes on ways to code their data so that they would be able to identify trends. In a final report of each project, the students described the research question, data collection and analysis, and discussed the results. Data from the study of the curriculum indicated that students were able to conduct legitimate scientific inquiry (O'Neill & Polman, 2004).

Constructivism in Mathematics. As indicated in Chapter 1, some developers have incorporated some of Piaget's concepts in curricula that also make use of classroom discourse. One perspective, individual or personal constructivism, is derived from Piagetian principles. Essential learning processes are assimilation and accommodation following cognitive conflict and reflective abstraction. A difference between Piaget's perspective and constructivist views is that he maintained the existence of an external verifiable reality. Another perspective, referred to as emergent (Cobb, 1995), advocates the Piagetian views that (a) learners actively create knowledge, (b) they create new knowledge by reflecting on their physical and mental actions, (c) substantive learning occurs in periods of conflict and confusion and surprise, over long periods of time, and (d) opportunities for learning occur during social interaction (Wood, Cobb, & Yaeckel, 1991, p. 591).

In one second-grade classroom, pairs of children first solve problems that may be resolved in more than one way. In the subsequent whole-class discussion, children are expected to justify and explain their answers and also to listen to other children's explanations (Wood et al., 1991). Important in this and similar implementations is the reconstruction of classroom social norms so that the children feel "psychologically safe" to explain their solutions to each other and the class (p. 598).

Role of the Computer. Some interactive computer software can introduce the implications of often-misunderstood concepts. For example, confronting student misconceptions about Newtonian mechanics is the goal of several process simulations in physical science (Flick, 1990; White, 1984). In one set of exercises, students perform several actions on a "spaceship" in a frictionless environment (space). In this way, they confront their misconceptions about force, velocity, and speed.

The developer of computer software, however, must not confuse interactive with constructive. This message is important because creating interactive environments is educationally appealing (Pufall, 1988). Interacting with the computer, however, is not sufficient for the child's construction of knowledge.

Facilitating Formal Operational Thinking
Placing students in multivariate problems before they have developed the conceptual structures to address such complex situations leads to difficulties (Lavoie & Good, 1988). One simulation included five variables that, in some combination, affected oxygen and waste concentration of the water in the situation. The
variables were temperature, waste type, dumping rate, type of treatment, and type of body of water. Problem-solving ability on prediction problems in the simulation was related to high or moderate initial knowledge and performance at the Piagetian stage of formal operational thinking. Unsuccessful students tended to have both low initial knowledge and to be at the stage of concrete operational thinking. Kuhn et al. (2000) noted that students often have an incorrect mental model that impedes the multivariable analysis required in science inquiry. They lack the concept of additive effects of variables on the outcome. In Piagetian terms, they lack the combinatorial propositional logic of formal operational thinking.

Obviously, formal operational thinking cannot be acquired through "prepackaged experiments" or by solving end-of-chapter problems for a predetermined answer. Any experiment that is not carried out by the individual with complete freedom is not an exercise; it is simply drill with no educational worth (Piaget, 1973, p. 20).

Situations that require students to confront their inaccurate ideas through exploration have reported changes in student thinking in science and physics (Champagne et al., 1985; Kuhn & Phelps, 1979). An essential characteristic of one intervention was "ideational confrontation"; it is the disequilibrium described by Piaget.

One study provided a rich problem environment with opportunities to explore the causes of different events to students who showed no evidence of formal reasoning strategies (Kuhn & Phelps, 1979). After 3 months of weekly problem-solving sessions, both fifth graders and adolescents showed changes in their reasoning strategies. However, the process was slow and uneven with setbacks along the way. "Conflicts and contradictions are encountered and resolved, not once, but many times over" (p. 54). Similar to another study (Kuhn, 1979), the most common difficulty seemed to be not the mastery of new strategies but the inability to relinquish inadequate strategies.

Some students begin by conducting experiments in such a way that their hypotheses cannot be disproved (Champagne, Klopfer, & Anderson, 1980; Kuhn & Phelps, 1979). Other students, faced with findings that contradict their hypotheses, simply ignore the conflicting data. Thus, open-ended exploration by itself is not sufficient to develop hypothetical reasoning. Probing questions and challenges to the student's thinking are essential.

Progress also requires that the instructor push students to formulate explanatory hypotheses and to test them repeatedly. Even so, "reconceptualization will be a slow tortuous process. It will come only after many alternative ideas and explanations have been tried and failed" (Champagne et al., 1980, p. 1078).

**Summary**

The focus of Piaget's theory is the development of logical thinking; therefore, it does not include specific guidelines for instruction. However, general guidelines for instruction to facilitate student thinking may be derived from the theory. First, knowledge, particularly in mathematics and science, should not be taught as though it were a set of truths that can be relayed through abstract language. The learner constructs knowledge through self-directed and peer-collaborative research. The teacher's role is that of organizing and creating situations that present meaningful problems, and asking thoughtful questions that provoke
children's thinking. Collaboration and interchange among the students also should accompany experimentation.

At the elementary school level, a variety of materials for measurement and experimentation can provide children with opportunities to construct knowledge. Experimentation in science also can help children to confront their intuitive beliefs about scientific concepts. Formal operational thinking also requires self-directed exploration. Students should be encouraged to formulate explanatory hypotheses, to test them, and to address conflicting data. However, reconceptualization will be a slow process.

EDUCATIONAL APPLICATIONS

The concepts developed by Piaget can be implemented in preschool and elementary school classrooms by providing rich activities for children's exploration. Some curriculum misapplications resulted from the failure to coordinate a developmental curriculum with the academic curriculum. Kamii (1981) suggested three general objectives compatible with school curricula. They are (a) the development of children's autonomy through interactive situations; (b) the decentering and coordination of various points of view by children; and (c) the development of alertness, curiosity, initiative, and confidence in learning (p. 24).

Classroom Issues

Piaget's theory is neither a theory of academic learning nor a teaching theory. Nevertheless, it does address several educational issues.

Learner Characteristics

Jean Piaget's theory addresses the broad issues involved in cognitive development. Individual differences, readiness, and motivation are therefore viewed in terms of their relationship to long-term cognitive development.

Individual Differences. Some educators have criticized the theory for omitting specific references to individual differences. Piaget's standard response to such criticisms was that his focus was the identification of the most general and universal in all people (Furth & Youniss, 2000, p. 123). Thus, individual differences are outside the realm of the theory; the goal was to identify and study the universal laws of cognitive development.

Nevertheless, research has indicated cultural differences in the rate of attainment of cognitive structures. Children in some rural settings are slower than urban children in the attainment of concrete operations. Furthermore, formal operations are not attained by all individuals, nor are they acquired in all areas of expertise (Piaget, 1972a).

Readiness. Readiness has two meanings in the interpretation of Piaget's theory. One is that of the individual's capacity to assimilate new information; a requirement is a cognitive framework that can make use of the new information.
The second way in which readiness is manifested is in relation to the construction of logical cognitive structures (i.e., operations). Specifically, logical constructions do not result until the subject experiences cognitive conflict and seeks to resolve it on a higher plane. Readiness, therefore, is the acknowledgment of conflicting statements coupled with the felt need to resolve two subsystems—for example, number and space.

Some have mistakenly viewed Piaget at times as a maturationist because he identified four sequential stages of development. However, only the ordering of the states is invariant; attainment requires learner experience with the environment, learner activity, and interaction with the social environment.

**Motivation.** Piaget (1973) identified two sources of motivation. One is a general motivating factor that functions at all levels of development—that of need. As in other theories, needs may be physiological, affective, or intellectual. Because intelligence seeks both to understand and to explain, an intellectual need often appears in the form of a question or a problem (Piaget, 1967, p. 5). In Piaget’s view, all action, whether movement, thought, or emotion, is in response to a need. Moreover, the theory describes need as a manifestation of disequilibrium (Piaget, 1967). When the need is satisfied, equilibrium is restored.

Disequilibrium represents the general factor of need at all levels of development. The second source of motivation is the specifics or content of need at a particular age or period of development. These specific needs depend on the system of ideas that a child has developed plus his or her affective inclinations. For example, a young child may engage in behavior to gain the approval of a parent, but a teenager is more likely to seek the approval of peers.

**Cognitive Processes and Instruction**

Three important classroom issues are developing “how-to-learn” skills, providing transfer of learning, and teaching problem solving. In the context of Piaget’s theory, these issues take on a different meaning.

**Developing “How-to-Learn” Skills.** The individual’s ability to organize his or her own behavior efficiently in order to extract meaning from a situation or initiate steps to solve some predetermined problem are typically defined as how-to-learn skills. In the context of genetic epistemology, however, manipulating and experiencing concrete objects in the environment is the foundation for knowledge construction. Children learn how to learn by generating problems, investigating questions, and examining their answers.

**Transfer of Learning.** The facilitation of new learning that results from similarities to prior learning is an important classroom issue. Transfer of learning implies some sequencing of learning tasks in order to take advantage of their common properties.

Cognitive development, however, differs from specific learning. The attainment of particular cognitive structures does not “transfer” to the development of the next stage in the sense of isomorphic elements. The cognitive structures attained in any period of development do, however, prepare the learner to undertake the next stage.
Teaching Problem Solving. According to Piaget (1973), the skill of problem solving cannot be directly taught. Instead, the rules of experimentation and, therefore, the rules for problem solution must be discovered or reinvented by each student. This experimentation and reinvention is essential to the development of problem-solving skills. In addition, Piaget maintained that the rules or theories that operate in any particular subject area must be reinvented by the individual; they cannot be conveyed verbally.

Implications for Assessment
The purpose of Piaget’s cognitive-development theory was to determine how new forms of reasoning developed from existing forms. The assessment tasks developed by Piaget and his colleagues revealed the nature of the child’s thinking. The focus of the assessments is the child’s organization of his or her thinking in addressing particular situations. For example, in rolling out a ball of clay, simply noticing that the material becomes thinner as it becomes longer indicates that the child is in transition from preoperational to operational thinking. Demonstrating an understanding of (a) the compensatory relationship between length and width, (b) the constant or invariant in the process, and (c) the reversibility of the transformation indicates operational thinking.

Some researchers developed psychometric measures of Piagetian concepts. First, this approach risks eliminating key constructs such as sequence, equilibration, universality, and generalization from the research agenda (Edelstein & Schroeder, 2000). Second, understanding inter-individual differences in the context of Piaget’s theory means a focus on inter-individual variability as both input into and the outcome of development. Required are experiential interactions between the individual and the environment that deeply affect development across the lifespan (p. 842).

Other American psychologists changed the administrative procedures of the tasks with the result that children appeared to demonstrate competence at earlier ages than those identified by Piaget. However, the altered tasks required different and less complex forms of thinking (Chandler & Chapman, 1991; Chapman, 1988; Montangero, 1991). For example, the typical Piagetian task on transivity (A > B > C) presented sticks A and B and then sticks B and C (A and C were not seen together). The child then inferred the relationship of A to C. The revision of the task, in contrast, presented the three sticks together, and young children concluded that A is greater than C on the basis of the far right position of C (Chapman, 1988, p. 352).

In other words, tasks that appear to have the same logical structure may actually differ when analyzed according to the ways that children infer their responses (p. 354). The implications for assessment are that the correctness of the child’s decisions about situations that require logical thinking is insufficient to determine different forms of reasoning (p. 355).

Teachers are not likely to be administering Piagetian assessments of reasoning in the classroom. However, the Piagetian tasks have implications for the classroom in two ways. One is that exploring students’ rationales for their answers is important to determine whether their thinking has actually changed. As already mentioned, children who were able to correctly add numbers from one to three thought the answers also could be other numbers.
Second, preschools are feeling pressured to teach academic skills as a result of the No Child Left Behind legislation (Stipek, 2006). The pressure stems from the view of policymakers that an early start on teaching academic skills can help children meet the standards set for elementary school (p. 455). For example, a typical standard is that children can count to 20. This standard will be interpreted literally, and children will learn to count by rote. However, they will have no concept of the relationship of 4 to 5, for example. Moreover, efforts to teach academic skills in preschool have the potential to undermine children’s confidence and their enthusiasm for learning. The “overly narrow” standards are merely laundry lists that can lead to fragmented learning (p. 457) and do not provide for the interesting and challenging situations for young children described earlier in this chapter. Assessments that address the level of thinking of preschool children should provide useful information in discussions of the kinds of information important in preschool curricula.

**The Social Context for Learning**

Unlike educational approaches that focus on teacher–student interaction, Piaget (1973) emphasized the importance of peer interactions in the context of self-directed experimentation. Only through this type of interaction does the student acquire the capability of viewing issues from other perspectives. Furthermore, in exchanges with others, students examine their own thinking, explore other alternatives, and reorganize their views and conclusions. The teacher, however, must create situations that promote exploration.

**Relationships to Other Perspectives**

Unlike operant conditioning, the conditions of learning, and the information-processing perspective, Piaget’s theory does not address the factual and conceptual information that constitutes subject domains. Instead, his principles address the characteristics involved in thinking and reasoning about events (i.e., natural logic) and the various changes across the lifespan. Like Vygotsky, Piaget was concerned with the individual’s development of the awareness of his or her own thinking. However, he conceptualized the process differently.

The activities and strategies recommended by Piaget for the classroom, therefore, target children’s spontaneous research in the development of reasoning and thinking skills. Although Piaget identified questioning and interaction among peers in the classroom as important, the teacher must create classroom situations conducive to a variety of student actions. Thus, in his view, the goal is not to become a community of learners, as is recommended by social constructivism. Furthermore, the individual student, not the group, is the locus of learning.

Piaget’s view of the role of make-believe play, children’s egocentric speech, and the role of society also differed from that of Lev Vygotsky. These differences are discussed in Chapter 9.

**Developing a Classroom Strategy**

The implementation of Piaget’s concepts at any level of the curriculum can be accomplished using the following four general steps and the subquestions for each step.
**Step 1:** Determine which principles in a course or curriculum typically taught by verbal means may be replaced by student-directed research.

1.1 Which aspects of the curriculum are conducive to experimentation?
1.2 Which principles are conducive to problem-solving activity in a group situation?
1.3 Which topics (or concepts) can be introduced using physical objects?

**Step 2:** Select or develop classroom activities for the identified topics. Evaluate the selected activities using the following list of questions.

2.1 Does the activity provide opportunities for a variety of methods of experimentation?
2.2 Can the activity lead to a variety of questions by the students?
2.3 Can the students compare various modes of reasoning in working through the activity?
2.4 Is the problem one that cannot be solved on the basis of perceptual cues alone?
2.5 Is the activity one that generates both physical activity and opportunities for cognitive activity? (Inappropriate activities include constructing a picture or diagram or building objects specified by the teacher.)
2.6 Can the activity enrich an already learned construct?

**Step 3:** Identify opportunities for teacher questions that support the problem-solving process.

3.1 What probing follow-up questions may be used (e.g., predictions, “what if” questions)?
3.2 What potential comparisons can be identified within the material that are conducive to spontaneous questions?

**Step 4:** Evaluate the implementation of each activity, noting successes and needed revisions.

4.1 What aspects of the activity generated the most intense interest and involvement? Are there ways that this may be capitalized on in the future?
4.2 What aspects of the activity, if any, “fell flat”? Did the activity fail to engage the efforts of one or more learners? What are some alternatives to try next time?
4.3 Did the activity provide opportunities to develop new strategies of investigation or to enhance already-learned strategies?

In summary, maximize the opportunities for students to construct knowledge for themselves through student-directed research. Discussions about research findings in which answers were developed through group interaction and that require consideration of a number of variables will enhance the student's construction of knowledge. Finally, whenever possible, provide direct student experience with constructs, rules, and theories prior to any verbalization. Otherwise, the information remains only verbalization and does not become knowledge.
Classroom Example

The following classroom lesson emerged as part of a research and development project in teaching conducted by Magdalene Lampert (1990). The goal was to determine in what ways the practice of knowing mathematics in the classroom could be brought closer to what it means to know mathematics within the discipline. The primary mechanism in this process is to alter the roles and responsibilities of both students and teacher during classroom discourse (p. 29).

The goal was not to create a Piagetian curriculum. However, the construction of knowledge undertaken by the fifth-grade students, the role of the teacher, and the nature of the peer interaction reflect classroom characteristics described by Piaget as essential for cognitive development.

Basic premise. “Doing” mathematics is not a matter of finding a right answer that is ratified by the teacher. Instead, mathematics develops as a process of “conscious guessing” about relationships that are examined and then tested through the use of counterexamples (Lakatos, 1976; Lampert, 1990).

Content. Exponents, fifth-grade class.

Purpose. One can determine aspects of the characteristics of unknown quantities by studying patterns in numbers one can observe (Lampert, 1990; Polya, 1954). Also, students can acquire the attitudes and skills to participate in a disciplinary discourse that is knowledge about mathematics (Lampert, 1990; Schoenfeld, 1985).

Prior activities. The use of mathematical discourse, and the rules for interchange, were already in use in the classroom (Lampert, 1990). When the class considered a problem, student conjectures and their names were written on the board. When students wanted to change a conjecture, they had learned to say, “I want to revise my thinking.” When proposing a possible answer (conjecture), they were expected to provide a rationale. All the students had prepared their own table of squares from $1^2$ to $100^2$ using calculators.

Constructing Knowledge. The teacher challenged the students to find patterns in their tables of numbers by examining the last digits of the numbers. They actively participated in this investigation for three 45-minute class periods. The key to the lesson was that “the mathematical content embedded in inventing the strategies that can be used to assert the answers without doing the calculations is mathematically significant and engages students in arguing about the key ideas behind how exponents work” (Lampert, 1990, p. 46).

The first assertion made by the students was that the last digits of the squares alternated between odd and even just as the base numbers did. Other assertions were that multiples of 10 would always end in 0, and the square of a number ending in 5 always ends in 5. They then began to explore further the hypothesis that “if the last digit is always $n$ when you raise $n$ to some power, the
last two digits will always be \( n^2 \) (Lampert, 1990, p. 49). Two students asserted that the powers of 6 should end in 36, but other students quickly identified a counterexample.

Students also determined that the strings of last digits always will be symmetrical around both 0 and 5. They used a chart to work out the symmetrical pattern of last digits. The students also proved that the pattern would go on forever because numbers ending in 9 or 1 have squares that end in 1, numbers ending in 2 or 8 have squares that end in 4, and so on.

The final segment of the lesson shifted to strategies for figuring out the last digit in a number raised to the \( 5^{th} \) power. In the discussion of \( 7^5 \), the students proposed several digits along with their accompanying rationales. One student thought the pattern of last digits would be 1, 7, 9, 1, 7, 9, and so on. However, after several assertions and discussions of each, the students determined that the pattern of last digits would be 7, 9, 3, 1, 7; therefore, \( 7^5 \) ends in 7.

During the discussion, one of the students stated that \( 7^5 \) should end in 1. The teacher’s role was to ask him to explain, to assert what some of the student’s assumptions were, and, later, to ask him to articulate the revision in thinking he had made. The purpose is not simply for the student to rethink his assumptions, but to help the other students see why those assumptions had led him to the conclusion that the last digit was 1. In other words, in this type of lesson, both students and teacher have a different relation to the subject than they would in a “knowledge telling exchange” (Lampert, 1990, p. 52).

**Review of the Theory**

Jean Piaget’s theory of cognitive development redefines intelligence, knowledge, and the relationship of the learner to the environment. Intelligence, like a biological system, is a continuing process that creates the structures it needs in continuing interactions with the environment.

The essential characteristic of logical thinking is the construction of a psychological structure with particular characteristics. Specifically, the learner (a) clearly recognizes the changing (transformation) and unchanging (conservation) features of a situation, (b) understands the inverse operation for each transformation (reversibility), and (c) identifies the problem solution as logically necessary.

The development of the individual’s different ways of thinking from infancy to adulthood includes the action schemes of the infant, preoperations, concrete operations, and formal operations. The process by which each of these more complex structures is constructed are assimilation and accommodation, regulated by equilibration (Table 8.6).

The role of education, in Piaget’s view, is to support the spontaneous research of the child. Experimentation with real objects and interaction with peers, supported by the teacher’s insightful questions, permit the child to construct both physical and logico-mathematical knowledge. The major requirements for the curriculum are rich opportunities for children to interact with the physical world in a variety of ways, to make their own mistakes, and to develop answers through interaction with their peers.
TABLE 8.6
Summary of Jean Piaget's Cognitive-Development Theory

<table>
<thead>
<tr>
<th>Basic Element</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumptions</td>
<td>Intelligence, like a biological system, constructs the structures it needs to function. Knowing is the interaction between the individual and the environment. The growth of intelligence is influenced by four factors (physical and social environment, maturation, and equilibration).</td>
</tr>
<tr>
<td>Cognitive development</td>
<td>The growth of logical thinking from infancy to adulthood</td>
</tr>
<tr>
<td>Outcomes of cognitive development</td>
<td>The construction of new structures from prior structures (i.e., action schemes, concrete and formal operations)</td>
</tr>
<tr>
<td>Components of cognitive development</td>
<td>Assimilation and accommodation, regulated by equilibration</td>
</tr>
<tr>
<td></td>
<td>Physical experience and logicomathematical experience</td>
</tr>
<tr>
<td>Facilitating logical thinking</td>
<td>Providing rich opportunities for experimentation with physical objects supported by peer interaction and teacher questions</td>
</tr>
<tr>
<td>Major issues in designing instruction</td>
<td>Maintenance of reciprocal relationship between child and education: avoidance of direct teaching and correction of children's &quot;errors&quot;</td>
</tr>
</tbody>
</table>

Analysis of the Theory

Disadvantages
Understanding of basic terms and definitions is difficult.
Piagetian curriculum is difficult to implement and maintain.
Perspective excludes the relationship between logical thinking and basic learning, such as reading.

Contributions to classroom practice
Provides a rich description of the world through the child's eye.
Identifies problems in curricula, particularly the teaching of mathematics and science as "socialized knowledge."
Operationalizes the often-cited concept, "discovery learning."

Disadvantages
A major problem in the implementation of Piaget's ideas arises from the different perspective he cast on intelligence, knowledge, and learning. Considerable effort is required to alter one's perspective from intelligence and knowledge as products to treating these concepts totally as process.
The development of curriculum, according to Piagetian concepts, requires, as Piaget himself indicated, considerable work and effort. Implementation of a Piagetian curriculum also is complicated by the fact that his theory excludes the relationships between logical thinking and curriculum basics, such as reading and writing.

**Contributions to Educational Practice**

A major contribution of Piaget's work is that he changed the view of a child from that of a little adult to one with distinctive and changing patterns of thinking. Another is that he identified the shortcomings of directly teaching some parts of the curriculum. In Piaget's view, science classes should focus on self-directed experimentation and other courses should use experimentation where possible. He delineated the problems and effects of teaching mathematics and science, for example, as “socialized knowledge.” In addition to providing a rich description of the world from the child's eye, he has operationalized the often-cited concept “discovery learning.” Table 8.6 summarizes Piaget's cognitive-development theory.

**CHAPTER QUESTIONS**

**Understanding Concepts**

1. A child feels the rush of air on his face made by fanning a paper. Later, on a windy day, he feels the wind and decides it is caused by the swaying trees (Wolfgang & Saunders, 1981, p. 117). Which stage of thinking does this notion of causality represent? Why?

2. Preschool children, who typically reason at the preoperational level, are asked if there are more birds or sparrows in the woods. The children reply that they do not know without counting. Which concrete operation have they not yet mastered?

3. How would the Gestalt psychologists describe the child's drawings of the water in Figure 8.2?

4. A researcher states that children younger than the age identified by Piaget can separate number and spatial relations if only two rows of two pennies each are used. What errors has the researcher made?

5. From Piaget’s perspective, what essential developmental activities are being replaced by television and video games?

**Applying Concepts to Instructional Settings**

1. A student is using a computer software program to write an essay. She is required to use certain symbol keys to direct the computer to double-space, number the pages, and so on. In Piaget's view, what is this process?

2. The teacher asks a group of middle school students to predict which of two objects, dropped at the same time, will fall faster. Most of the students predict that the heavier object will reach the floor first. When given several objects to experiment with, they are puzzled that they cannot determine any difference in the rate of descent. Some of the students conclude, in error, that the heavier object falls faster but the difference is too small for them to observe. According to Piaget, what has happened in this situation?

3. Waight and Khalick (2007) describe a science classroom in which (a) student activities require searching through information to answer questions, and (b) the teacher views computer technologies as a means to retrieve information or as repositories for information (p. 169). Critique this situation in terms of Piaget's suggestions for curricula.

4. Standards for science curricula typically suggest the use of “hands-on” activities in which students actively engage in manipulation of materials. Determine in what ways such activities may be consistent with or in conflict with Piagetian principles.
5. Proponents of direct instruction tend to consider that inquiry-oriented instruction is inefficient. Refute this statement from Piaget’s perspective.

REFERENCES


Waight, N., & Khalick, F. (2007). The impact of technology on the enactment of “inquiry” in


CHAPTER 9

Lev S. Vygotsky’s Cultural-Historical Theory of Psychological Development

All of the higher psychological functions [cognitive processes] have a common psychological characteristic that differentiates them from all other mental processes: They are processes of mastering our own reactions by different means. (Vygotsky, 1982–1984/1997, p. 207)

In the same decade that Piaget began his studies of children’s ways of reasoning, a young Russian scholar, Lev S. Vygotsky, formally entered Soviet psychology. Seven years earlier, in 1917, he had earned degrees simultaneously from two universities, according to his daughter Gita (Valsiner & van der Veer, 2000). (The degrees were in law from Moscow University and humanities from the Shanyavsky People’s University.) Returning to his native province in southwestern Russia after his university studies, Vygotsky engaged in a variety of activities. They ranged from heading the theater section of the Gomel Department of People’s Education and writing theater reviews to co-founding a publishing house and teaching in several venues. Included was Gomel Teacher College where he set up a psychological laboratory for simple experiments (Valsiner & van der Veer, 2000; van der Veer & Valsiner, 1991, p. 10).

Vygotsky’s entry into psychology in 1924 was, in several ways, an accident of history. A humanist scholar with no formal training in psychology, he happened to present three papers at a 1924 psychological conference that previously had not permitted widespread participation (Joravsky, 1989). One paper discussed problems with then-current research methods, and it attracted the attention of the new director of the Institute for Experimental Psychology, Konstantin Kornilov. Vygotsky’s presentation raised questions about Pavlov’s reflexology (a rival approach to Kornilov’s views) and also expressed the need for a unified and objective study of the human mind — a position that Kornilov supported (van der Veer & Valsiner, 1991, p. 43). Kornilov also was hiring new personnel, and he offered Vygotsky a position. (The government had dismissed the previous director and several of his staff for supporting “idealism,” a view that differed from the Bolshevik philosophical perspective; Joravsky, 1989; McLeish, 1975; van der Veer & Valsiner, 1991).
Under ordinary circumstances, Vygotsky would not have obtained an academic position in psychology. However, in the reorganization of society under the Bolsheviks, old professional hierarchies had broken down, and educated individuals who did not oppose the Bolsheviks were in short supply in the largely illiterate country (Fitzpatrick, 1992). Valsiner (1988) noted that, 10 years earlier, psychology would not have been interested in Vygotsky, and 10 years later, psychology would not have interested him.

Vygotsky's primary goal was to reformulate psychology as part of a unified social science (Joravsky, 1989; van der Veer & Valsiner, 1991). He considered understanding the human intellect to be the most critical and central problem for psychology (Vygotsky, 1930/1997n, p. 190; Vygotsky, 1960/1997p, p. 13), and this problem required studying the whole of human consciousness (Vygotsky, 1925/1997d, 1930/1997k). Moreover, psychology would fail as a discipline if it could not explain the formation of human behaviors (Vygotsky, 1924/1979a; 1926/1997j).

In addition to working toward this goal, Vygotsky, like other psychologists in the war-ravaged country, fulfilled multiple roles. He addressed the problems of mentally retarded, blind, and deaf-mute children; became a skilled clinician; and was involved in organizing child study in the Soviet Union (van der Veer & Valsiner, 1991). He also organized medico-pedagogical conferences in which doctors, psychologists, special education teachers, and others observed his examinations of special needs children with their parents (Vygodskaya, 1998).

This schedule led to periodic life-threatening bouts of tuberculosis, a disease he had contracted as a young man while caring for his ill brother (van der Veer & Valsiner, 1991). He was unable to defend his dissertation, The Psychology of Art, in the summer of 1925, and it was accepted for the PhD degree without a public defense. Although ill, Vygotsky mustered a Herculean effort to accomplish his goals, often writing late at night when he had a few quiet hours. Needless to say, his tuberculosis worsened and, in June 1934, he died at the age of 37.

Vygotsky's major theoretical writings include the role of cultural signs and symbols in the development of attention, abstraction, language, memory, numeric operations, and reasoning (Vygotsky, 1929, 1960/1997a, 1930/1999a, 1960/1997b; Vygotsky & Luria 1930/1993); his identification and discussion of the outcomes of cognitive development, the higher psychological or mental functions (Vygotsky, 1960/1997b, 1931/1966, 1930–1931/1998b); the key role of scientific (subject-matter) concepts in developing thinking (Vygotsky, 1934/1987a, 1934/1987b, 1930–1931/1998c); and the relationship of thinking and speech (Vygotsky, 1934/1987c, 1934/1987d). In the last two years of his life, Vygotsky had begun to address the possible hierarchical relationships among mental functions and the development of affect and its role in intellectual processes (Bozhovitch, 1977, p. 15; Vygotsky, 1999d). However, that work is incomplete.

An understanding of Vygotsky's work is hindered by at least three factors. First, following his death, his work was unavailable in Russia until the mid-1950s. Beginning in 1930, the Communist Party criticized his discussions of the ideas of non-Russian psychologists (Thorndike, Gestalt psychologists, and others). Then, in 1936, the Party banned psychological testing and works that discussed individual differences in mental functions; included were several of Vygotsky's writings.
Second, when Vygotsky’s work began to be noticed in this country in the 1980s, only a few of his concepts taken out of context appeared in the literature. One result is the erroneous belief that the zone of proximal development is a major concept in his theory. However, in all of Vygotsky’s collected works, only a few pages discuss that concept.

Third, the popularity of a few concepts from Vygotsky’s theory is accompanied by a lack of attention to his broader principles. This situation is an example of the observation that the understanding of a theory is inversely related to its popularity (Valsiner, 1988). At present, the majority of Vygotsky’s ideas, although currently available in English translations of his collected works, have yet to be discussed by psychologists and educators in the United States.

PRINCIPLES OF PSYCHOLOGICAL DEVELOPMENT

Vygotsky’s goal was to create a psychology that was theoretically and methodologically equal to the task of investigating uniquely human characteristics.

Basic Assumptions

Three areas form the foundation for Vygotsky’s analysis of the development of human mental capabilities. They are (a) the nature of human intelligence; (b) the two different lines of psychological development, biological and cultural-historical; and (c) the design of an experimental method for the investigation of dynamic psychological processes.

The Nature of Human Intelligence

Vygotsky’s description of the nature of human intelligence includes four related topics. They are (a) the differences between animals and humans, (b) the philosophical foundations that formed the basis of his theory, (c) the concept of psychological tools, and (d) the influence of symbol systems (psychological tools) on human development.

Animal/Human Differences in Mental Activities. At the time Vygotsky entered psychology, researchers primarily based their theories on research with animals. Pavlov’s research on the salivation reflex was well known, Thorndike had developed connectionism, and Gestalt psychologists advocated mental restructuring as a major principle in human learning.

Vygotsky took issue with these approaches to human cognition (e.g., Vygotsky, 1930/1997l, 1926/1997o). He pointed out that “man is not a skin sack filled with reflexes” (Vygotsky, 1925/1997d, p. 66). And the stimulus–response model reflects associations that occur only on the basis of “a purely external coincidence in time” (Vygotsky, 1960/1997q, p. 31).

Furthermore, the major Gestalt principle, in which understanding depends on mentally restructuring a situation, is not the same for chimpanzees and children (Vygotsky, 1934/1997m, 1930/1997n). First, a structured action is not necessarily an
intellectual act (Vygotsky, 1934/1997m p. 205). The ape's goal-directed action is meaningful only within the experimental situation, but is meaningless beyond those boundaries (p. 209). In contrast, the child can develop the idea of a tool as functioning in a variety of contexts (p. 214).

Second, the Gestaltists claimed mental restructuring of a situation as a universal principle of learning. However, this pronouncement means that "the perception of a chicken [animal used in some Gestalt experiments] and the actions of a mathematician, which represents the most perfect model of human thinking, are equally structured" (Vygotsky, 1934/1997m, p. 225). If this is so, then the structural principle "is insufficiently dynamic to bring out the novel phenomena that arise in the course of development itself" (p. 225).

**Philosophical Foundations.** Three philosophers influenced Vygotsky's thinking in the development of his theory. One was Benedict Spinoza, his favorite philosopher (van der Veer & Valsiner, 1991, p. 15; Yaroshevsky, 1989). Spinoza believed that, in principle, everything can be known through reasoning. Also, humans learn to control their passions through the development of rational thinking. Vygotsky's theory describes the ever-increasing mastery of one's behavior through the development of rational mental capabilities (mental functions).

A second philosophical influence was the description of change as dialectical synthesis, proposed by G. W. F. Hegel. Briefly, dialectical synthesis involves (a) the negation of a thesis by its oppositive, antithesis, followed by (b) a resolution of that interaction in the form of a qualitatively new formation—a synthesis. For example, matter, which is the foundation of existence, is not viewed as absolute and unchanging. Instead, the world of matter is "a combination of processes, eternally changing or developing" (Kornilov, 1930, p. 250). Light, heat, electricity, magnetic currents, chemical transformation, life, and psychological processes are examples.

Vygotsky (1930/1997k) described the processes of cognitive development as both (a) uninterrupted, "accompanied by leaps or the development of new qualities" (p. 112), and (b) "a complex dialectical process" (Vygotsky, 1960/1997g, p. 99). Included are a disproportionate development of separate intellectual functions, qualitative transformations of some forms of thinking into others, and complex interactions of external and internal factors. For example, perception is "the dominant function [process]" in early childhood (Vygotsky, 1982–1984/1998e, p. 264). The 2-year-old does "only what surrounding objects urge him to do" (p. 263), and attention is bound up with perception. A ladder, for example, entices the child to climb it. In contrast, at school age, attention has already separated from perception and memory becomes dominant. The school-age child often answers questions intended to require thinking by remembering a concrete example (Vygotsky, 1930–1931/1998b, p. 88).

A third philosophical influence consisted of some general concepts from Karl Marx and Frederic Engels. They built on Hegel's concept that humans create diverse cultures in which work provides the means of perceiving the world as independent objects and acting subjects. Marx and Engels maintained that the tools of work are the essential factor in changing human nature (Marx & Engels,
Tool invention by pre-humans led to the emergence of humans because it led to labor, the need for cooperation, and speech (Engels, 1925/1978). Also, through tool use, humans transform both nature and themselves, and the particular social organizations that result from tool use determine human mental life (Engels, 1940). The discovery of fire, the invention of simple agricultural tools, and the discovery of electricity are examples.

**The Concept of “Psychological Tools.”** Two questions for psychology were left unanswered by the designation of tools as instruments of change. First, how does a relatively simple activity, tool use, account for such sweeping developments as the emergence of the human species and advanced cognitive development? Second, what are the relationships among tool use, social organizations, and differences in cognitive development?

Vygotsky (1960/1997q) bridged the gap between tool use and cognitive development with his designation of cultural signs and symbols as psychological tools. Likely sources for this concept were (a) Wolfgang Köhler’s references to “the priceless tool of speech,” and (b) Emile Durkheim’s discussions of the collective representations of society as “clever instruments of thought” (van der Veer & Valsiner, 1991, pp. 206, 302).

According to Vygotsky, psychological tools (signs and symbols) rather than the tools of work bring about the transformation of human consciousness. Technical tools change an external situation but psychological tools direct the mind and change the process of thinking (Vygotsky, 1960/1997q, p. 62). Moreover, these psychological tools differ throughout human history and across cultures. Vygotsky referred to his theory developed from this perspective as the cultural-historical theory of the psyche (Leont’ev & Luria, 1968).

A common misunderstanding about Vygotsky’s work is that he identified culture per se as the key influence on individual development. Instead, he included only the signs and symbols of a culture and the ways they are used in thinking. The reason is that only cultural symbols, such as language, have the potential for the self-regulation of cognition and, therefore, the transformation of behavior (van der Veer & Valsiner, 1991).

**Biological and Cultural-Historical Lines of Development**

Analysis of the differences between animal and human behavior led to the identification of two qualitatively different lines of psychological development (Figure 9.1). One line is that of the biological factors that were a part of the evolutionary process. Included are the development of the central nervous system and physical growth and maturation. In the human species, biological factors dominate the early months of life, accounting for simple perception, natural or direct memory, and involuntary attention. The emergence of these elementary mental functions is also referred to as natural or primitive development (Vygotsky, 1929/1977a).

**Signalization and Signification.** Part of the biological heritage of both animals and humans is the process referred to as signalization. This process is the
recognition of co-occurring stimuli in the environment (Vygotsky, 1929/1977a; 1960/1997q, p. 55). For example, the young gazelle learns to recognize the appearance of a lion as an indicator of danger. Similarly, a young child puts his hand on a hot stove and feels pain. On approaching the stove again, the child recalls the pain and exercises caution.

The essential difference between animal and human behavior is that humans progressed beyond their biological heritage. At some point in development, primitive humans began to master and control their memory through artificial symbols that they created. An example is the so-called "messenger's wands" found in Australia (Leont'ev, 1959). They are large sticks or rectangular wooden slabs marked by a series of cuts that the messengers used to deliver communications to distant tribes. However, the notches were not arbitrary symbols of syllables or words. Instead, they designated certain persons and objects and their number and localities to the extent that they occurred in the particular message. With the aid of this simple device, the messenger reconstructed the message at the time of delivery.

The uniquely human events associated with the use of these wands is that (a) new connections are established in the brain through the act of perceiving the external reminders and returning to the ideas they represent, and (b) the construction of the process of memorizing is accomplished by internally forcing an external object to remind the individual of something (Vygotsky, 1929/1977a, p. 69).
Another early culturally based sign system was the knot-tying system (quipu) used in ancient Peru. It was a method of recording ownership of property and other economic events (Clodd, 1905, in Vygotsky & Luria, 1930/1993).

Vygotsky (1960/1997q; Vygotsky & Luria 1930/1993, p. 101) designated these artificial symbols as signs because of their role in redirecting memory. They are the psychological tools that enabled early humans to progress beyond a dependence on their natural memory.

The process of the creation and use of signs is referred to as signification (Vygotsky, 1929/1977a; 1960/1997q, p. 55). This process differentiates human behavior from that of other animals; the signs created by early humans initiated cultural-historical development. Also, as indicated in Figure 9.1, cultural-historical development plays a key role in the cognitive growth of the individual child. Children inherit the symbol systems of their culture and learn to use them to master their thinking.

**Cultural Differences.** At the time Vygotsky entered psychology, anthropologists, sociologists, and others were expressing various views about the relationship between culture and individual development. Among them were that complex forms of memory originate in the concrete history of society and primitive individuals generalize information differently from people in technological societies (Luria, 1979, p. 58), and different cultures imply different kinds of cognitive growth (Thurnwald, 1922).

Analyzing these writings, Vygotsky (1929; Vygotsky & Luria, 1930/1993) concluded that cultural diversity in symbols leads to differences in the level of mental functions. For example, in one village in Papua New Guinea, people count using body parts (Saxe, 1981). Counting begins with the right thumb, progresses around the hand, arm, shoulder, right ear, eyes, and then down the left side to the left forearm and fingers. Because the maximum number that may be counted using this method is 29, villagers have great difficulty with even simple addition and subtraction problems. Furthermore, the counting system limits the quantities that can be added and subtracted.

In contrast, cultures with advanced mathematical systems can produce individuals who think about differential equations in calculus. Therefore, the complexity of symbol use in a culture sets broad parameters for individual development.

**Differences in Individual and Species Development.** Although cultural-historical factors influence both the development of the species and of the child, there are three important differences. First, childhood does not repeat the stages that occurred in the development of civilization. (One early psychologist, G. Stanley Hall, maintained that childhood included the same stages as civilization [i.e., ontogeny recapitulates phylogeny]. The theory, however, was found to be scientifically unsound.)

Second, in the development of the culture, humans create and elaborate on sign systems, whereas the child masters the available sign systems. Third, when cultural development began for the human species, biological factors, in terms of influencing species development, were displaced. However, in the cognitive
development of the individual child, biological factors become subordinated to cultural development in a complex transformative process.

In summary, the behavior of a modern cultured adult is the result of two different processes of mental development. One is the biological evolution of the animal species that gave rise to the species *Homo sapiens*. The second is the process of historical development that transformed primitive humans into humans who use signs and symbols to change their mental functioning (Vygotsky, 1931/1966a).

**The Experimental-Genetic (Developmental) Method**

Vygotsky (1931/1966a) described the processes of cognitive development as complex and ever-changing but researchers had failed to study these processes (p. 21). Instead, they had implemented only one model—the stimulus-response situation. Although psychologists had studied different constellations of stimuli and various reactions, they had not taken one fundamental step beyond that basic model (p. 21).

**Components.** To discover the dynamics of the development of human mental functions, Vygotsky (1929/1979b) and his coworkers devised an experimental approach referred to as the experimental-genetic method. The researchers modeled their experiments on those that Köhler conducted with anthropoid apes (Vygotsky, 1929). The apes were placed in problem-solving situations with a means to the solution nearby. Similarly, Vygotsky and his colleagues presented children with tasks that were above their natural capacities, such as remembering a long list of words. Objects were available nearby, such as pictures. The tasks consisted of object stimuli (focus of the task) and other materials (potential auxiliary stimuli). The researchers observed whether the additional stimuli ceased being neutral and became part of the child's efforts to be successful in the task, thereby changing the nature of the cognitive processing. Vygotsky referred to the experimental model as the functional model of double stimulation because the individual's behavior is organized by two sets of stimuli (Vygotsky, 1929, p. 430; 1982–1984/1999b, p. 59; Vygotsky & Luria, 1994, p. 154).

Ages of the subjects in the experiments ranged from preschool to adulthood. The purpose of this age range was to explain the origins of the higher mental functions as well as developmental differences in cognitive functioning (see Vygotsky & Luria, 1930/1993, pp. 175–182). In addition, by including young children, the research avoided addressing a complex reaction only in its “finished and dead form . . . in its automatized form” (Vygotsky, 1930/1977a, p. 75). Processes in their finished form have become a sort of fossil (p. 71).

**Experiments on Memory and Attention.** The objective in the memory experiments was to remember a list of 15 words or a series of numbers. In the experiments on remembering words, unrelated pictures were available as potential auxiliary stimuli (potential psychological tools). (See Table 9.1.) The experimenter read each word aloud and the subject selected a picture. After presentation of the words, the experimenter collected the pictures and rearranged them. Then, holding up each picture, the experimenter asked the subject for the associated word.
The experiments on attention took the form of a familiar children’s game—the “forbidden colors” game. The goal is to answer the experimenter’s rapid-fire questions without (a) naming the forbidden color, or (b) naming any color more than once. Examples of the 18 questions included Do you go to school? What color are the desks in school? Do you like to play? What color is grass? (Vygotsky, 1929/1979b; Vygotsky & Luria, 1930/1993, p. 191). To assist in answering the questions about colors, the subject received a set of cards, each a different color (the second stimulus set). The goal was to determine whether the subject directed his or her attention with the cards.

The experiments on the use of auxiliary stimuli to master one’s memory and attention indicated four developmental stages, which are described in the next section.

**Summary**

First, Vygotsky maintained that psychology should study humans rather than animals. Second is the Spinozan perspective that humans are rational and gradually gain control of their own thinking. Third, cognitive change can be characterized as the dialectical syntheses described by G. W. F. Hegel. Fourth, psychological tools, the symbols of one’s culture, serve as instruments of thought essential in the development of higher cognitive processes. They set broad limits on the level of higher cognitive thinking that the child can attain. That is, biological principles account for primitive or elementary functions, whereas the signs and symbols of one’s culture contribute to the development of complex ways of thinking (see Table 9.2).

Fifth, because cognitive processes are dynamic and ever-changing, they must be studied using research methods that reveal their dynamic nature. Research should focus on (a) process analysis rather than object analysis; (b) an accounting that reveals real, causal, or dynamic relations; and (c) an explanation of the origins of cognitive processes (Vygotsky, 1931/1997a).

**The Components of Cognitive Development**

Key principles describe the transformation of the primitive or elementary mental functions (involuntary attention, simple perception, and natural memory) into complex mental processes, such as logical memory. These principles are the
TABLE 9.2  
Basic Assumptions of Vygotsky's Cultural-Historical Theory

1. Research on animal behavior cannot explain human behavior.
2. Humans are rational beings who gain control of their behavior through the development of complex intellectual capabilities.
3. Cognitive development is a complex dialectical process that includes qualitative transformations of some processes into others and complex interactions of external and internal factors.
4. a) Through the development and use of tools, human beings transform both nature and themselves.  
   b) Psychological tools that influence cognitive development are the signs and symbols of a culture that are used for thinking.
5. Cognitive processes should be studied in ways that can reveal their dynamic and changing nature.

The Natural History of the Sign
Signs are the created or artificial stimuli introduced into a psychological task that change the nature of the mental activity. In this role, signs are functioning as psychological tools. The Vygotskian experiments on memory and attention indicated four qualitatively different stages in the learning to master one's thinking using signs. Vygotsky (1960/1997s) referred to this lengthy process as the natural history of the sign.

The Stages of Sign Use. The four stages of sign use are natural or primitive, the stage of naive psychology, external sign use, and internal sign use. For most mental functions, the stages begin in early childhood and extend through adolescence. Table 9.3 illustrates the reactions of subjects in the memory and attention experiments that reflect each of the stages. In the natural or primitive stage, the child relies on his or her elementary mental processes, but is unsuccessful.

Then, in the naive psychology stage, the child also is unsuccessful because he or she is unaware of how to use the auxiliary stimuli. This situation is analogous to the performance of a man who is able to press on a lever, but is unable to use the skill to move a heavy rock (Leont'ev, 1959, p. 141). In the memory experiments, the child sometimes produced a different word than the word originally linked to the selected picture (Vygotsky, 1929; Vygotsky & Luria, 1994). In other words, the mere presence of an association is insufficient to guide the child's memory. For example, one child selected notebooks for the word study, but his later recall was "one goes to school" (Leont'ev, 1959). In the attention experiments, for example, one young child focused on the white card and repeated "white" to all the questions (Leont'ev, 1932/1994, p. 300).

The behavior of the school-age children differed qualitatively from the efforts of the younger children. In the memory experiments, word and picture were combined into an integrated structure, which indicates the conversion of natural history of the sign, of which the development of speech is an example, the role of imaginary play, the two branches of cognitive development, the general law of genetic development, and the role of imitation.
TABLE 9.3  
The Stages of Sign Use in Memory and Attention

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Memory</th>
<th>Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Natural or primitive</td>
<td>Child relies on elementary mental processes</td>
<td>Child tries to remember all the words</td>
<td>Child tries to control attention directly</td>
</tr>
<tr>
<td>2. Naive psychology (preschool)</td>
<td>Child makes an effort to use the available auxiliary stimuli, but is unaware of the psychological links needed between the stimuli and the task</td>
<td>Some children choose pictures randomly; others form links with the pictures, which were forgotten and/or did not aid future recall</td>
<td>Children look at the cards at inappropriate times, sometimes naming the very color when setting aside the card</td>
</tr>
<tr>
<td>3. External sign use (school age)</td>
<td>Children carefully select or arrange external stimuli in terms of the needs of the task</td>
<td>Children select pictures through which they could establish a logical link with the particular word</td>
<td>Children arrange the cards in front of them and remove a card when naming the color</td>
</tr>
<tr>
<td>4. Internal sign use (adults)</td>
<td>Subjects rely on internal, self-created stimuli</td>
<td>Subjects form internal verbal links</td>
<td>Subjects only occasionally glance at the cards, primarily keeping track of the named colors internally</td>
</tr>
</tbody>
</table>

Note: Compiled from Leont'ev (1959); Vygotsky (1929, 1960/1997d)

simple memory into an intellectual operation. One child, for example, selected a chair to represent the word *house* because one can sit in a house. Another child selected the picture of a crab at the shore to recall the word *theater* because the stones on the bottom are a theater for the crab (Vygotsky, 1982–1984/1997f, p. 181). In the forbidden colors game, the children typically arrayed the cards in front of them, and put aside the corresponding card when naming the color.

At the highest level of development, individuals internalize the process of directing memory and attention through the use of self-generated stimuli. In one experiment, for example, one subject remembered the words *beach, hail,* and *dress* by creating the sentence, “A lady walked on the beach; it began to hail and ruined her dress” (Leont'ev, 1959, p. 94). In another experiment, an individual selected *candle* to represent fire and devised the sentence, “Moscow burned up from a candle worth a kopek” (Leont'ev, 1959). Also, in the recall phase, adults typically relied only on their sentences or phrases, not external stimuli.

*An Example.* One mental process that develops prior to adolescence is the quantitative concept of number. First, the young child can only determine differences between groups of objects by sight, such as three apples and seven apples. The process is limited to “the immediate perception of given pluralities
and number groups” (the primitive stage; Vygotsky & Luria, 1994, p. 139). The child is unable, for example, to differentiate between groups of 16 and 19 apples. In the second stage (naive psychology), the child attempts to count on his or her fingers, but makes many errors and is unaware of the one-to-one correspondence in counting. However, in stage three, the child can count accurately, often using both speech and fingers (external regulation). He or she can also subtract single-digit numbers (e.g., 2 from 7). In stage four, internal regulation, the child easily counts accurately in his or her head.

The Laws of Sign Use. The first law of sign use formalizes the transformation in mastering one’s thinking through the integration of signs into the completion of cognitive tasks (Vygotsky, 1930–1931/1998g). It is “the law of the transmission from direct, innate, natural forms and methods of behavior to mediated, artificial, mental functions [processes] that develop in the process of cultural development” (p. 168). This law indicates that the use of the symbols of one’s culture is not simply an “add-on” to existing mental processes. Integrating signs into one’s thinking is essential to develop higher forms of cognition.

The other law emphasizes the transition from stage three to stage four in sign use. It is “the law of transition of a function from outside inward” (Vygotsky, 1930–1931/1998g, p. 170). As an operation, such as mastering one’s attention, becomes firmly established in the general structure of thinking, it moves inward. The mental process is restructured in this transition and begins to operate through internal means (Vygotsky, 1930–1931/1998b, p. 104).

Summary. Signs are the artificial stimuli introduced into a psychological task that change the nature of the mental activity. The Vygotskian experiments identified four different stages in learning to use signs to master one’s thinking. In the first stage, the child relies on his or her natural mental processes, but is unsuccessful (the natural or primitive stage). Then, in the stage of naive psychology, the child attempts to use the auxiliary stimuli, but is unaware of their psychological role. In the third stage, external sign use, the school-age child creates verbal links between the auxiliary stimuli and the object of the task. Finally, at the highest level of development, individuals construct internal verbal stimuli to master their thinking.

Vygotsky identified two laws that relate to sign use. The first law states the importance of the transmission from direct or natural forms of behavior to the use of signs in cognitive tasks. The other law emphasizes the restructuring in thinking that takes place in the transition from a reliance on external signs (auxiliary stimuli) to internal verbal thinking.

The Development of Speech
Speech begins as a means of communication and socializing and later becomes a tool of thinking (Vygotsky, 1960/1997p, p. 4). Vygotsky (1934/1987d) viewed the analysis of thinking and speech as a major task for psychology, and the central issue was “the relationship of thought to word” (p. 43). One problem with prior views is that they had oscillated between two extreme poles: (a) the complete
fusion of thought and word, and (b) the complete separation of thought and word. However, neither view was correct (p. 43). Instead, speech begins to develop independent of thought. Then, “at a certain point, the two lines cross: thinking becomes verbal and speech becomes intellectual” (Vygotsky, 1934/1987c, p. 112).

In one discussion of the development of speech in relation to thinking, Vygotsky described four stages that also correspond to the stages of sign use. Then, in a later discussion of development in the first year of a child’s life, he described the role of the child’s invented words, which precede the child’s words in adult speech (Vygotsky, 1982–1984/1998f). The complete sequence includes preintellectual, autonomous speech, naive psychology, communicative and egocentric speech, and internal speech.

**Preintellectual and Autonomous Speech.** The development of the child’s speech begins with the infant’s affective cries. The cry is emotional, expressing, for example, hunger or discomfort. Soon the infant begins babbling, laughing, and gesturing—actions that function as a means of social contact (Vygotsky, 1934/1987c, p. 110). This is the preintellectual stage of speech.

At about 12 months of age, the child begins to invent words, the stage referred to as autonomous speech (see Table 9.4). The child’s invented syllables are an effort to communicate with adults. However, a particular syllable may indicate a particular object in one situation and another object in a different situation. For example,

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preintellectual</td>
<td>A means of social contact in the first year of life; includes laughter, babbling, pointing, and gesture</td>
</tr>
<tr>
<td>Autonomous speech</td>
<td>“Words” invented by the child to refer to concrete objects in sight; however, they are not used consistently</td>
</tr>
<tr>
<td>“Naively” psychological</td>
<td>Speech and thinking begin to coincide in the second year of life when the child discovers things have names; many words are used without grasping the true meaning (e.g., because, but, when)</td>
</tr>
<tr>
<td>Dominance of external speech: Communicative Egocentric</td>
<td>Speech fulfills a social function Speech first accompanies child’s actions in planning and problem solving, then it becomes essential in planning; the “middle link” between external and internal speech</td>
</tr>
<tr>
<td>Inner speech (Intellectual stage)</td>
<td>External operation moves to the internal plane and undergoes profound change; speech becomes soundless</td>
</tr>
</tbody>
</table>

one child’s word _ka_ referred to a yellow stone, egg soap, and then stones of any color or shape (Vygotsky, 1982–1984/1998a, p. 253). Autonomous speech is useful only in concrete situations with adults who are around the child, and when the object is in sight. Nevertheless, autonomous speech is the child’s first effort to use the speech sounds in adult language.

**Naive Psychology.** This stage begins between 18 and 24 months with the child’s first use of simple adult words. The child learns that everything has a name (Vygotsky, 1929, p. 429; 1934/1987c). However, initially, the child treats the name as simply another characteristic of the object (Vygotsky, 1934/1987c, p. 118). The child can connect the word to a concrete object, but is unaware that the name is an arbitrary designation (Vygotsky, 1982–1984/1998e, p. 270). For example, when asked if a cow could be called ink, young children stated that the name could not be changed. Their rationale was that a cow gives milk and ink is used for writing (Vygotsky, 1939, p. 36). The child does not develop the symbolic function of words (the representation of a finite set of characteristics) until much later (Vygotsky, 1934/1987c, p. 118).

Despite these limitations, learning the names of many objects helps the child form a picture of the external environment (Vygotsky, 1982–1984/1998e, p. 277). During this stage, the child “begins to actively expand his vocabulary by asking the name of each new thing he encounters” (Vygotsky, 1934/1987c, p. 111).

**Communicative and Egocentric Speech.** At about age three, the child’s speech differentiates into two types: communicative and egocentric (Vygotsky, 1934/1987e, p. 74). Communicative speech is speech for others, and the child at age three is able to use simple sentences, such as “I want milk.”

In contrast, egocentric speech is speech for oneself. It begins at about age three and continues until about age seven. Egocentric speech involves talking aloud; it initially accompanies the child’s practical activity, and it often occurs in the presence of other children. In the second phase, the child’s utterances begin to shift to the beginning of the activity (Levina, 1968/1981; Vygotsky, 1930–1931/1998b; Vygotsky & Luria, 1994). For example, in attempting to get a piece of candy from the top of a cupboard, the child pulls a chair beside the cupboard, saying “Get the chair.”

Then, in the third phase, egocentric speech takes on a planning function (Vygotsky, 1934/1987c). When the child uses speech for planning, the structure of the visual field no longer determines the child’s activity. Instead, behavior is guided “by a new form of activity—verbal thinking” (Vygotsky, 1930–1931/1998b, p. 115). Between the object of the activity and the child’s actions stand “stimuli of the second order [speech] now directed not immediately at the object but at the organization and personal planning of the child’s behavior” (Vygotsky & Luria, 1994, p. 121).

Naturalistic observations of low-income Appalachian children supported Vygotsky’s views (Berk & Garvin, 1984). The researchers found that the major function of private speech is self-guidance and that it is greater during cognitively demanding academic tasks. Research also indicated that children who use private speech in conjunction with challenging tasks are more attentive and show
greater improvement than their peers (Berk, 2000; Berk & Stuhl, 1995). Also, the rates of private speech are higher over a longer development period for children with learning problems (Berk, 2000).

**Intellectual (Internal) Speech.** The final stage of speech and intellectual development is the internalization of egocentric speech. The structure of egocentric speech mastered by the child becomes inner speech as well as the basic structure of the individual's thinking (Vygotsky, 1934/1987c, p. 120). However, inner speech is carried out almost without words because it is speech for oneself (Vygotsky, 1934/1987f, p. 277). In addition, it is not fully developed until adolescence.

The implication of the importance of egocentric speech is that children with impoverished vocabulary and a limited sense of word meaning will have difficulties in planning and problem solving. In other words, developing inner speech is not a guarantee that individuals reach the levels of advanced thinking (the higher mental processes). An example is the speech of the illiterate peasants in the cross-cultural studies of Vygotsky and Luria (Luria, 1976). An example is the generalization tasks that required the identification of one object that did not belong in a group of four objects. People with some education removed the log from a group of four objects that also included a hammer, a saw, and a hatchet, classifying the remaining objects as tools. However, the peasants insisted that no object could be removed from the group. The log was necessary, because people need wood for building houses, fences, and so on.

**Summary.** Prior efforts to explain the relationship of speech to thinking were inadequate, according to Vygotsky. Researchers did not recognize them as separate capabilities that merged at a particular stage of development. The first stage of speech development is preintellectual; it includes the infant's cries, then babbling and other sounds to make contact with others. The second stage, autonomous speech, occurs at about the child's first birthday, and consists of the young child's invented words. However, they function only in concrete situations with family members and others close to the child.

The stage of naive psychology involves the child's use of simple adult words. Although the child understands the naming function of words, he or she does not yet understand their symbolic function as categories. At about age three, the child's speech separates into communicative (speech for others) and egocentric (speech for oneself). Egocentric speech initially accompanies the child's practical activity and then takes on a planning function. This is the beginning of the child's verbal thinking. The final stage, intellectual or internal speech, begins at about age seven but is not fully developed until adolescence. The basic structure of the child's egocentric speech has turned inward and becomes internal speech.

**The Role of Imaginary Play**

Vygotsky (1982–1984/1998f) designated the years from three to seven as the preschool period. Egocentric speech develops during this period. It is also the period in which the child's imaginary play fulfills an important role in the child's cognitive development. Imaginary play is the main source of the development of

Vygotsky (1982–1984/1998e) did not view activities such as riding a hobby horse or tending to a doll or a teddy bear as meeting the criterion for play. The reason is that these activities lack an extended imaginary situation. To qualify as play, the child must (a) take on a clearly defined role, and (b) change the property or properties of a thing in clearly visible ways (p. 268). For example, the child may state that she is a surgeon and must operate on a sick patient (her doll). She uses a small scarf to cover her nose and mouth (surgeon’s mask) and takes the plastic knives from her toy place settings to “operate” on the patient.

In “true” play, the object in the situation is the focal point that leads to changes in constructed meanings. For example, when the stick that the child uses as a horse actually becomes a horse for the child, meaning then determines the role of the object. The child begins to act in a cognitive rather than a visual domain (Vygotsky, 1931/1966b), as in the example of pretending to be a surgeon.

**The Two Branches of Cognitive Development**

Vygotsky (1931/1966a; 1931/1997p, p. 14) maintained that the development of higher mental functions encompasses two sets of processes that, initially, may seem to be unrelated. Instead, the development of higher cognitive functions consists of

...two inseparably connected but never confluent streams of development of the higher forms of behavior. These are, first, the processes of mastering the external means of cultural development and thinking—language, writing, counting, and drawing, and secondly, the processes of development of the special higher mental functions. (Vygotsky, 1931/1966, p. 16)

Most approaches to learning and/or cognitive development consider symbol systems as an “add-on” to internal cognitive processes (Vygotsky, 1982–1984/1999a, p. 37; Vygotsky & Luria, 1994, p. 136). However, Vygotsky maintained that symbol systems are essential to the internal development of attention, perception, memory, and conceptual thinking (Vygotsky, 1982–1984/1999a, p. 37; 1982–1984/1999c, p. 40; Vygotsky & Luria, 1994, p. 137). Complex cognitive functions develop in the process of subordinating symbol systems to human control to carry out cognitive tasks (Vygotsky, 1929/1979b). Using colored cards to monitor the color names that one has used in a game is an example. Constructing a hierarchy of related concepts in a subject area is another.

The logical inference is that learning to communicate with language is a necessary but not sufficient condition for the development of higher cognitive functions. This inference is supported by Vygotsky’s description of signs and symbols as only potential psychological tools. Specifically, “a stimulus becomes a psychological tool not by virtue of its physical qualities ... (but) by virtue of its use as a means of influencing the mind and behavior” (Vygotsky, 1982–1984/1997h, p. 85). Examples of psychological tools and their complex systems include “language, different forms of numeration and counting, mnemotechnical techniques, algebraic
symbolism, works of art, writing, schemes, diagrams, maps, blueprints, all sorts of conventional signs, etc.” (p. 85).

**The General Law of Genetic Development**

Vygotsky referred to the “general genetic law of cultural development” (Vygotsky, 1960/1997e) as the second law of cognitive development (Vygotsky, 1930–1931/1998d, p. 170). The basis for this law is the social–behavioral relationship described by French psychologist Pierre Janet (van der Veer & Valsiner, 1988). Specifically, all higher psychological processes develop through the application of aspects of social relationships to oneself, and words are the most powerful social stimuli because they originated as commands (Janet, 1926, 1929, cited in van der Veer & Valsiner, 1988; Vygotsky, 1931/1966a).

Vygotsky stated the general genetic law as

> every function in the cultural development of the child appears on the stage twice, in two planes, first, the social, then the psychological, first between people as an intermental category, then within the child as an intramental category. (Vygotsky, 1960/1997g, p. 106)

In other words, every higher mental function “was formerly a social relation between two people” (Vygotsky, 1960/1997g, p. 105). Vygotsky’s reference to the “two planes” in which mental functions appear—social and then psychological—identifies the source of these functions. This perspective differs from other theories that identify the psychological plane as the locus for learning and development. Vygotsky’s perspective, stated another way, is that “all basic forms of social intercourse between the adult and the child later become mental functions” (p. 105).

The higher mental functions are voluntary (self-organized) attention, categorical perception, conceptual thinking (verbal and mathematical), and logical memory (see the section “The Nature of Complex Thinking”). The roots of these functions are found in the relationships between the very young child and his or her caregiver(s). For example, the child does not develop articulate speech on his or her own. Cooperation with adults leads the child to master speech, which is essential for thinking (Vygotsky, 1982–1984/1998e, p. 272). Caregivers should establish functional connections between words and the objects they represent. The child then internalizes these meanings, which is the first step toward eventually developing conceptual thinking (Vygotsky, 1960/1997g, p. 105). These interactions lead to the child’s awareness that things have names and the stage when the child begins to rapidly expand his or her vocabulary (the stage referred to as naive psychology).

In other words, “through others we become ourselves,” and this rule refers to “the history of each separate [mental] function” (p. 105). A simple example is the child learning the pointing gesture (Vygotsky, 1931/1966a, 1931/1997g, p. 104). First, when the child tries to grasp an out-of-reach object, her hands are stretched toward the object and are left hanging in the air. The movement objectively indicates an object. The situation changes substantially when the mother comes to
help. She, not the object, responds to the child's unsuccessful movement. Later, the child links her unsuccessful movement to the whole situation, and begins to understand the action as a pointing gesture. Here the function of the movement changes. Instead of being directed at an object, it becomes a form of communication, a movement directed toward another person. The child then uses the gesture as a signal or indicator to others. In other words, the conscious use of the gesture is late in its development (pp. 104–105).

The Role of Imitation

The process of the internal acquisition of the role of signs or symbols is not automatic. Instead, the transition from the external social plane to the internal psychological plane is one in which the child begins to practice the same forms of behavior that others formerly practiced with respect to him (Vygotsky, 1960/1997s, p. 88). For example, the school-age child typically solves problems “on the basis of a model he has been shown in class” (Vygotsky, 1934/1987a, p. 216).

In other words, a basic path in the individual’s mastery of his or her behavior is imitation (p. 95). However, it is not a simple mechanical transfer from one person to another (Vygotsky, 1960/1997s). Instead, imitation requires “a certain understanding of the significance of the action of another” (p. 95). For example, if the individual knows nothing of chess, she cannot play a game even if a chess master shows her how (Vygotsky, 1934/1987a, p. 209). Vygotsky restricts the meaning of imitation to refer to “operations that are more or less directly connected with the mental activity of the child” (Vygotsky, 1930–1931/1998g, p. 202).

Development in Children with Disabilities

In the early 20th century, psychologists and educators viewed a sensory defect, such as being blind or deaf, as a biological problem. Also, a heightened sensitivity in another function could compensate for the defect. Examples are the senses of hearing and touch in the blind and vision in the deaf (Kozulin, 1990). According to this view, training should focus on the “compensatory” functions, such as acuteness of hearing in the blind.

Vygotsky’s (1925/1994c) perspective differed in two ways from the prevailing view. First, the problem of the disabling condition is not biological, it is social. “Blindness or deafness, as a psychological fact, is not at all a misfortune, but, as a social fact, it becomes such” (p. 20). Vygotsky noted that self-reports from individuals with these disabilities indicated that the defects were not perceived as “abnormalities” until they were brought into the social context (Gindis, 1995, p. 78).

The second difference between Vygotsky’s perspective and the accepted view is that he believed the basic principles of his cultural-historical theory applied also to children with disabilities. That is, cognitive development occurs in the context of the social activities of the children with adults. Therefore, instead of training other sensory functions, such as acuteness of hearing for blind children, Vygotsky (1925/1994c) maintained that physical or mental defects could be compensated for through alternative, yet equivalent, means of cultural development. Where necessary, symbolic systems should be changed while preserving the basic meaning of social communication. Examples are the Braille system,
sign language, lip-reading, and finger spelling. Furthermore, societies should continue developing special psychological tools that can provide the social and cultural interactions essential for development. Many of today’s computer developments, such as activating a keyboard through a breathing apparatus for paralyzed individuals, are examples.

**Summary**
Cognitive development depends on developing capabilities in using artificial stimuli or signs to master one’s thinking. The stages in this lengthy process are the natural or primitive stage, naive psychology, external sign use, and constructing internal verbal stimuli (internal sign use). The young child, for example, is unable to use pictures as cues to recall a set of words. However, adults construct complex verbal relationships as memory aids.

The developing relationship between speech and thinking is an example of learning to use signs for thinking. Preintellectual speech (infant cries and babbling) and the child’s invented words (autonomous speech) precede the link between speech and thinking. The rapid expansion of the child’s vocabulary in adult words follows (the naive psychology stage). Then, at about age three, egocentric speech, the child’s speech for him- or herself, separates from communicative speech, and the child also engages in imaginary play. Both developments free the child from the visual domain. At about age 7, egocentric speech begins to turn inward into internal speech, a development that is not completed until adolescence.

The importance that Vygotsky assigned to cultural symbols is illustrated by his designation of the two branches of cognitive development. They are mastering language, writing, counting, and other symbols and relying on those symbol systems to master cognitive tasks. Through influencing thinking, symbol systems become psychological tools.

Essential in cognitive development is the social–behavioral relationship that Vygotsky described as the general law of genetic development. That is, every mental function in the development of the child appears first in the social plane, between two people. These social relations are then internalized within the child. This process begins with the interactions between the young child and his or her caregivers in the opportunities for communication and learning. The child accomplishes the transition from the social plane to the internal psychological plane through imitation.

**The Nature of Complex Thinking**


**The Higher Mental Functions**

Vygotsky (1931/1966a, 1960/1997q) identified three primitive or elementary processes that are innate or inborn. They are involuntary attention, simple perception, and direct or natural memory. Unlike the elementary functions, the higher
mental processes are a product of historical and cultural development. They are involuntary (self-organized) attention, categorical perception, conceptual thinking, and logical memory. Individuals learn to control their attention internally through verbal thinking or other means; categorical perception is a blending of visual experiences and concrete and/or abstract concepts; and conceptual thinking relies on connections and relationships among concepts. Also, logical memory reflects the individual's analysis and systematic organization of concepts (Vygotsky, 1930–1931/1998b).

Table 9.5 illustrates the characteristics of elementary and higher mental functions. As indicated they occur under completely different circumstances; biological factors account for elementary mental processes, and cultural-historical development accounts for higher levels of thinking. In other words, higher mental functions are not simply a linear extension of the elementary functions. Other characteristics that differentiate these two levels of mental functions are source of control, dynamics, defining characteristics, and relationship to thinking.

A Comparison. Table 9.6 describes the three elementary mental functions—simple or natural memory, simple perception, and involuntary attention—and compares them to the higher mental functions. As indicated, the higher forms of thinking involve the integration of symbols in mental processes, primarily in the form of concepts in categorical perception and logical memory. For example, the child's memory relies on visual images and concrete experience, whereas the

<table>
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<th>TABLE 9.5</th>
<th>Characteristics of Primitive and Higher Mental Functions</th>
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<td><strong>Primitive Functions</strong></td>
<td><strong>Higher Mental Functions</strong></td>
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<tr>
<td>1. Processes</td>
<td>Simple perception, natural memory, involuntary attention</td>
</tr>
<tr>
<td>2. Source of control</td>
<td>Stimulation from the environment</td>
</tr>
<tr>
<td>3. Dynamics</td>
<td>Co-occurrence of two stimuli</td>
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<tr>
<td>4. Defining characteristics</td>
<td>Immediacy; bounded by concrete experience</td>
</tr>
<tr>
<td>5. Thinking and reasoning</td>
<td>Determined by natural memory; limited to reproducing established practical situations</td>
</tr>
<tr>
<td>6. Origin</td>
<td>Biological factors</td>
</tr>
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memory of the adolescent (who has mastered the higher functions) relies on concepts with all the connections and relations with other concepts. Similarly, categorical perception is governed by conceptual thinking, and voluntary attention is organized through symbols. In other words, unlike the elementary functions, in which natural memory dominates throughout, the relationship is reversed in the higher mental functions. For the young child, “intellect is a function of memory, then, in the adolescent, memory is a function of intellect” (Vygotsky, 1930–1931/1998b, p. 96).

**The Role of Conscious Awareness and Volition**

Vygotsky (1934/1987a) identified two broad psychological functions that are essential to developing the higher mental functions. They are conscious awareness and volitional (self-directed) control of one’s mental activities (p. 208). He viewed these two cognitive processes as two halves of the same coin. In the absence of awareness of one’s cognitive activities, the learner cannot master higher mental functions. He or she will not be able to organize and direct his or her attention (voluntary attention), analyze and relate concepts to each other (conceptual thinking), and so on.

The two foundational functions only begin to emerge at school age. In the experiments on memory, for example, the preschool children were unaware of the actions they should take to be successful. The school-age children, however, knew that they must choose a picture for each word and establish a meaningful link that ensured later recall of the word. However, the child’s awareness of his or her thinking is imperfect initially (Vygotsky, 1934/1987a, 1930–1931/1998b). For example, in a study on using the words *because* or *although*, one child wrote “‘Kolya decided to go to the theater because although he didn’t have any money’” (Vygotsky, 1930–1931/1998c, p. 66).
In summary, the forms of complex thinking identified by Vygotsky are voluntary (self-organized) attention, categorical perception, conceptual thinking (verbal and mathematical), and logical memory. They differ in major ways from the innate elementary functions—involuntary attention, simple perception, and natural or indirect memory. The two psychological processes essential to developing higher forms of thinking are conscious awareness and volitional (self-directed) control of one's cognitive activities. These foundational functions begin to emerge at school age, but are imperfect at that time.

PRINCIPLES OF INSTRUCTION

Vygotsky described the transformation of simple perception, involuntary attention, and simple memory into categorical perception, conceptual thinking, logical memory, and self-organized attention. Although he did not state explicit principles of instruction, he identified several requirements for instruction.

Basic Assumptions

Both the individual’s culture and the relationship of education to development play important roles in cognitive development. They provide the foundation for inferring basic assumptions about instruction.

Role of the Culture

According to Vygotsky, the culture does more than simply provide the setting for the individual’s cognitive development. The culture provides cultural symbols (psychological tools) and the child learns to think with these forms of reasoning.

The Cross-Cultural Study. Vygotsky and Luria researched their view of historical-cultural differences in thinking in the early 1930s in isolated parts of the Soviet Union. Luria (1976) led the study in the villages and mountain pasture lands of Uzbekistan and Kirghizia. Of the five groups that participated in the research, two groups were illiterate: Islamic women who had to remain within the ichkari (women’s quarters) and peasants in the remote villages. The other three groups had varying amounts of literacy. They were women who attended short-term courses in teaching kindergarten, collective farm workers who had completed some short courses, and female students in a teachers’ school who had completed two to three years of study (p. 15).

The tasks, which were accompanied by in-depth interviews, involved perceptual and memory strategies, classification, and reasoning tasks. One task, for example, required naming and classifying 27 colors in skeins of wool. The collective farm workers and students usually arranged all the colors in seven or eight groups, using categorical names (e.g., red, blue). In contrast, some of the ichkari women maintained that the task could not be done. Others arranged the skeins of yarn into different series of colors according to increasing brightness. One series, for example, included pale pink, pale yellow, and pale blue. Attempts by the
实验者获得一个只包含一种主要颜色的色群导致任务失败（Luria, 1976, p. 30）。

其他任务，如需要一般化和抽象的，结果相似。例如，之前提到的，是一个农民不会从锤子-锯-木头-斧头的组中移除“木头”物体。研究得出结论，比较物体根据逻辑属性并一般化到已知的逻辑类别不是普遍的操作（Luria, 1971, p. 269）。

The Relationship between Education and Development

Vygotsky (1982-1984/1997h) 指出，阿尔弗雷德·比内（Alfred Binet）（他开发了现在被称为斯坦福-比内测试的智力测试）专注于理解儿童的自然发展，而不是儿童的学校经验与教育的影响。相比之下，维果茨基认为自然发展与教育是“一个统一的合金”（p. 88）。他支持这种观点的论据是“教育不仅影响某些发展过程，而且重新构建了行为的所有功能，以最必要的方式”（p. 88）。"Instruction is not limited to trailing after development or moving stride for stride along with it. It can move ahead of development, pushing it further and eliciting new formations"（Vygotsky, 1934/1987a, p. 198）。


其次，学术课程对于学习者的认知发展是必要的。也就是说，“abstract thinking develops in all [the learner's] lessons”（Vygotsky, 1934/1987a, p. 208）。如阅读和数学等学科涉及需要意识和有意识控制的活动。学习掌握并有意识地控制算术和乘法等数学概念和思考促进更高水平思维的发展。

然而，Vygotsky (1934/1987a) 警告说，不存在一对一的关系。也就是说，算术教学的第。第一、第二、第三和第四部分的算术教学可能无足轻重，因为发展算术思维，但第五部分可能决定性”（Vygotsky, 1934/1987a, p. 207）。在这一点上，孩子已经学到了一个普遍的原则。

总结，两个基本假设可能从维果茨基的理论推断出。第一个是，文化已经建立了借助语言和其他文化符号的思考方式，它们是该文化中儿童发展的方式。第二个是，教育是认知发展的前提并引领认知发展。
The Components of Instruction

Important components of instruction are (1) determining the appropriate level of instruction, (2) implementing the genetic law of cognitive development, and (3) developing students' verbal thinking.

Determining the Appropriate Level of Instruction

Instruction can lead development when any form of higher thinking is beginning to mature (Vygotsky, 1930–1931/1998g, p. 204). Specifically, “instruction impells (sic) or wakens a whole series of functions that are in a stage of maturation lying in the zone of proximal development [ZPD]” (Vygotsky, 1934/1987b, p. 212). Determining the appropriate level of instruction for cognitive development requires determining the mental processes that are about to emerge.

Assessment. Vygotsky (1930–1931/1998g) suggested that school psychologists should implement any of four strategies to determine the higher mental processes that are “immature, but maturing” (p. 202). They are (a) demonstrate solving the problem and observe whether the child can imitate the demonstration, (b) begin solving the problem and ask the child to complete the solution, (c) ask the child to cooperate with another more advanced child in solving the problem, or (d) explain the process of solving the problem to the child, ask leading questions, analyze the problem for the child, and so on (p. 202). These strategies can determine for the child “precisely the mental maturation that must be realized in the proximal and subsequent periods of his stage of development” (p. 203). Vygotsky referred to determining the actual level of development, which is the problems that the child can solve independently, and determining the higher cognitive functions that are emerging (the zone of proximal development) as comprising normative age-level diagnostics (p. 204). In Vygotsky's (1930–1931/1998g) hypothetical example, the ZPD for one child may advance his mental age forward 4 years, from 8 to 12. However, the mental age of another child may only reach the age-level performance of 9 years (p. 202).

Implications for the Classroom. Although Vygotsky described assessment of the child's ZPD as part of clinical diagnosis, the practical significance of assessing a child's ZPD is related to teaching (Vygotsky, 1930–1931/1998g). The teacher can implement one or more of the four strategies to determine a child's readiness for developing particular cognitive processes. For example, a child's difficulty in the cooperative assessment may be that he or she lacks psychological awareness of the task requirements. The young child who attempts to count but assigns numbers to his or her fingers haphazardly is unaware of the psychological correspondence between a particular number and a certain quantity (Gredler & Shields, 2008, p. 85).

Other Examples of the ZPD. The ZPD is not always manifested in social interaction. For example, the school-age child operates in the zone of proximal development as he or she solves problems at home by recreating the previous classroom
collaboration with the teacher. Another example is a 6-year-old who, growing up in a home with many books, newspapers, and magazines where the parents are avid readers, imitates them and learns to read without explicit instruction (Valsiner, 1988, p. 148).

**Implementing the Law of Genetic Development**

Vygotsky maintained that interactions between the adult (the "ideal form" of behavior) and the child are the first stage in the child's development of word meaning, concepts, the use of speech for thinking, and the higher mental functions. For example, the teacher may model how he or she determines one or two of the similarities and differences between triangles, parallelograms, squares, and rectangles (e.g., four sides for parallelograms, squares, and rectangles) by talking aloud as he or she thinks. The teacher then asks the students to identify other similarities and differences, providing feedback and providing explanations when needed.

Also, in implementing lessons, failing to consider the concrete and graphic nature of pupils' memory would be foolish (Vygotsky, 1982–1984/1997e, p. 224). However, Vygotsky cautioned that "it would also be folly to cultivate this type of memory. This would keep the child at a lower step of development. It also reflects the teacher's failure to see that the concrete type of memory is only a transitional step to a higher type, that concrete memory must be overcome in the process of teaching" (p. 224).

In addition, social interaction is only the first step. The learner's subsequent activities are also essential. The student must imitate, invent, and practice with respect to him- or herself the same forms of behavior that others formerly practiced with respect to him (Vygotsky, 1960/1997s, p. 88).

**Developing Students' Verbal Thinking**

A major premise in Vygotsky's theory is that the signs and symbols used for communication in a culture are also the original mechanisms for developing children's thinking. When the child enters school, word meaning and speech are two mechanisms that can facilitate the development of verbal thinking. First, the inner aspect of the word (meaning) is key to freeing the child from perception and sensation (Vygotsky, 1934/1987d). "The word does not relate to a single object, but to an entire group or class of objects" (p. 47); therefore, it is a generalization—a verbal act of thought (p. 47).

From Vygotsky's perspective, a goal of instruction should be developing word meanings. However, if the expectation is that the student is to internalize existing knowledge, thought processes are not required to grow, change, and develop. Teaching subjects that involve symbol systems, such as writing and mathematics, will not bring about the development of complex mental functions if the goal is the transmission of knowledge (Elsasser & John-Steiner, 1977, p. 363).

Also, "thinking depends on speech, on the means of thinking, and on the child's socio-cultural experience" (Vygotsky, 1934/1987c, p. 120). The structure of speech mastered by the child becomes the basic structure of the child's thinking
In the classroom, this relationship has implications for children with poor vocabularies and those whose primary language is a dialect of English (non-standard English) or a language other than English.

At school age, the child’s internal speech is a weak, unstable form that is not yet fully functional (Vygotsky, 1930–1931/1998c, p. 70). Therefore, “in order to think, the school child must think aloud” (p. 70). When a child who has solved a problem on his own obtains an absurd answer, the teacher asks him to solve it aloud. Also important is to teach students to be conscious of their own operations, following each step, and to control the course of their thinking (p. 71).

In summary, appropriate instruction for the child should address the problems that he or she can solve with assistance. These problems in the assessment indicate the cognitive processes that are in the period of maturation, referred to as the zone of proximal development. Also important in the classroom is the law of genetic development in which the teacher or other knowledgeable adult works with the student in cognitive tasks. The student then must imitate, invent, and practice the forms of behavior that were the focus of the student–teacher interaction. Finally, teachers also should work with children to assist them in learning word meanings and in learning to use speech as a tool of thinking.

### Designing Instruction to Develop Higher Cognitive Functions

The higher cognitive functions identified by Vygotsky are self-organized attention, categorical perception, conceptual thinking (verbal and mathematical), and logical memory. Instructional topics important in facilitating the development of these processes are teaching writing, the pivotal role of subject-matter concepts, and the role of the teacher.

#### Teaching Writing

Writing is one of the most important subjects in the child’s early school years because it requires deliberateness and analysis. Learning to write assists the student to develop the foundational cognitive functions of conscious awareness and control of one’s thinking processes (Vygotsky, 1934/1987a p. 211). For example, the preschool child can use the correct case and verb form in oral speech, but is unaware that such forms exist (p. 206). However, the school child becomes aware of different verb forms and tenses in writing and can choose the correct form.

Two aspects of the difficulty in learning to write also explain its contribution to developing thinking (Vygotsky, 1934/1987a). First, writing does not reproduce oral speech but is a unique speech function (p. 202). It requires a high degree of abstraction that “uses representations of words [printed symbols] rather than the words themselves” (p. 202). In other words, “written speech is the algebra of speech” (p. 203).

Second, in choosing words and phrases, unlike most oral speech, the process is intentional and must reflect expected syntactic sequence. Third, writing is a conversation with a sheet of paper rather than with another individual. Therefore, the child must conceptualize the receiver of the message. Finally, the motivations for oral speech are present prior to conversing with another, for example.
However, the motivations for writing are less accessible to the child when he or she begins to learn to write. In written speech, the writer must create the situation (Vygotsky, 1934/1987a, p. 203).

Some writing curricula in the early grades address the motivational aspects of the process by providing several types of resources. Included are uninterrupted reading and writing time; access to books, picture books, and magazines; opportunities for other students to serve as an audience of early drafts; and publication of the children’s favorite pieces (see Harste, Short, & Burke, 1988).

An example of the relationship to thinking is the teaching of composition to older Brazilian women in the College of the Bahamas (Fiore & Elsasser, 1982). Teaching began with the use of “generative themes,” which are themes drawn from the students’ daily lives. These themes were important because they allowed the students to explore the larger cultural and historical implications of personal experience. One generative theme, for example, was marriage. The students gradually moved from personal anecdotes toward more sophisticated forms of expressions, such as cause and effect, definition, and comparison and contrast. The increasing sophistication of the women’s writing was accompanied by a more analytical approach to the issues.

**The Pivotal Role of Subject-Matter Concepts**

During the last years of his life, Vygotsky began to emphasize the importance of concepts as a form of verbal thinking (Valsiner & van der Veer, 2000, p. 375), and to describe their pivotal role in developing the higher mental functions.

**Stages of Concept Formation.** The Vygotskian experiments on concept formation indicated four developmental stages that parallel the stages in developing memory and attention. The basic level of proficiency in terms of concepts is the identification of examples that represent a particular concept, such as identifying all the squares in a group of geometrical figures. However, very young children formed “unordered heaps” of objects based on subjective connections (stage one; Vygotsky, 1934/1987b, 1931/1994b). Then preschool children grouped objects together on the basis of concrete observable characteristics, but the selected connections were not consistent (stage two). For example, a child might first select a green circle, then add a green triangle (matching color), and then a parallelogram (two sloping sides), and so on.

Stages three and four of concept formation have implications for developing higher mental functions. In stage three, the child can, for example, accurately select all the triangles from a group of geometric figures. A model example (a triangle) and the concept label, the word, served as signs for the selection of objects that share the visual characteristics defining the concept. Vygotsky (1934/1987b, 1931/1994b, 1930–1931/1998c) referred to this level as the formation of pseudoconcepts because (a) the accurate selection of examples reflects their concept membership, but (b) the child has not yet abstracted and synthesized the concept attributes as a means of making logical judgments about reality. Recognizing concrete examples of a concept does not mean that the individual has developed a category of thinking that he or she can apply in other situations. Like the third stage of sign use, the child’s thinking is bound to external concrete stimuli.
Stage four, the culminating stage in concept formation, does not develop prior to adolescence. Stage four is true conceptual thinking; that is, the individual is “thinking in concepts,” which is “a new intellectual mechanism” (Vygotsky, 1930–1931/1998c, p. 40). In other words, a “true” concept is one that has a place in a network with connections to and relationships with other concepts. These connections mean that “thinking in concepts leads to discovery of the deep connections that lie at the base of reality, to recognizing patterns that control reality, to order the perceived world with the help of the network of logical relations cast upon it” (p. 48). Therefore, “we could define logical thinking as a concept in action” (p. 57).

**The Problem with Everyday Concepts.** The child’s everyday concepts, such as flower, cat, and brother, are those learned through daily activities that involve contact with actual objects and things. The child typically uses them without conscious awareness of their meaning because his or her attention is directed toward the particular object that the concept represents.

Everyday concepts are not organized formally in a relational network. However, the weakness of everyday concepts is the lack of abstraction (Vygotsky, 1934/1987a, p. 169). An example is the child’s concept of brother, which is “saturated with the child’s own rich personal experience” (p. 178).

**The Nature of Subject-Matter Concepts.** Unlike everyday concepts, subject-matter concepts in a domain can be represented in terms of other concepts, and they form an interrelated system. Mastery of subject-matter concepts means that the student can define them easily, implement them in various logical operations, and identify the relationships among them (Vygotsky, 1934/1987a, p. 218). Also, because subject-matter concepts form an interrelated system, thinking in concepts cannot be separated from the content of thinking (Vygotsky, 1930–1931/1998c, pp. 34–39). Mastery of a complex system such as algebra does not mean simply filling the forms of thinking present in a 3-year-old with new content. Instead, new content requires new forms of thinking (p. 35). “Cognition, in the true sense of that word, science, art, various spheres of cultural life may be adequately assimilated only in concepts” (p. 42).

One implication for instruction is that attempting a direct communication of concepts from the teacher’s head to that of a child is a practice that is “educationally fruitless” (Vygotsky, 1935/1994a, p. 356). All that is accomplished is simply a “meaningless acquisition of words” and “mere verbalization” that, in reality, hides a vacuum (p. 356).

**The Relationship to Higher Mental Functions.** Children who are unable to select examples of a concept lack psychological awareness of both the nature of concepts and their own thinking. Instruction that focuses on the relationships within and across concept categories assists the student to become aware of and gain some control over his or her thinking. In other words, “conscious awareness enters through the gate opened up by the scientific [subject-matter] concept” (Vygotsky, 1934/1987a, p. 191).
Vygotsky (1930–1931/1998b) maintained that the development of the higher mental functions is not completed prior to adolescence. Also, they stem from a single center, which is the formation of “true” concepts (p. 121). Through the development of true concepts, memory and attention “transition from the system of perception to the system of thinking” (p. 108). The emergence of categorical perception, for example, means to think of visual images in terms of concepts and to synthesize the concrete and general (p. 122). The image of an object is complex in that it reflects the connections and relationships with other concept examples and other concepts. Internal mastery of cognitive behavior through conceptual thinking is the highest level of sign use (p. 104). For this reason, Vygotsky (1934/1987a, p. 167) referred to the process of the development of subject-matter concepts as containing “the key to the whole history of the child’s mental development.”

**The Role of the Teacher**

Two terms often used in current discussions of Vygotsky’s work for the classroom require clarification. They are the term **collaboration** and the use of scaffolding. Also, most educational discussions of the classroom do not include an essential component in instruction, the importance of the adult—the “ideal form” of behavior.

**The Meaning of Collaboration.** Current classroom recommendations advocate the use of large- and small-group discussions, often citing Vygotsky as the source. O’Connor (1996) noted that this collaborative or joint reasoning is viewed as the genesis of a child’s individual intermental function (p. 495).

However, from Vygotsky’s perspective, the term **collaboration** in the school setting refers to collaboration between teacher and student. Specifically, “the teacher, working with the school child on a given question, explains, informs, inquires, corrects, and forces the child himself to explain; [and] when the child solves a problem, although the teacher is not present, he or she must make independent use of the earlier collaboration” (Vygotsky, 1934/1987a, p. 216). Furthermore, “the process of teaching itself is always done in the form of the child’s cooperation with adults and represents a partial case of the interaction of the ideal and the present form” (Vygotsky, 1930–1931/1998g, p. 204). Learning in the classroom requires teacher modeling, explaining, and asking the student for explanations because these verbalizations by the teacher are the basis for the student’s self-questioning and explaining of concepts when studying (Vygotsky, 1934/1987a).

Vygotsky (1930–1931/1998g) did propose a role for task sharing in the assessment of the child’s emerging mental functions. However, the child’s partner was a more advanced child. Also, the purpose was to determine the child’s level of functioning. The implication is that the partner, given the context of the assessment, has a higher IQ.

**The Importance of the “Ideal Form.”** The ideal or final form of cognitive behavior is the behavior of the adult. It serves as a model for what the child should
achieve in a particular developmental period as well as what the child should attain at the end of his or her development (Vygotsky, 1935/1994d, p. 348). The child’s behavior is the rudimentary or present form and it is guided by the ideal form. This relationship is particularly important for the development of the young child’s speech and his or her conception of number. If children are only able to interact with each other, even the mathematically gifted children will undergo an extremely limited and very narrow development (p. 351). Also, as stated above, interaction between the ideal, the teacher, and the present form, the student, is essential in the classroom.

**The Role of Scaffolding.** Some current recommendations also state that, as a part of instruction, the teacher should initially control task elements that are beyond the learner’s capability. According to this suggestion, scaffolding in instruction allows the student to concentrate on the elements that he or she can complete. However, a critical component of instruction in the ZPD is “the child’s persistent imitation that develops the emerging psychological functions” (Valsiner & van der Veer, 1993, p. 50). The problem is that this essential aspect of instruction “is not captured in the scaffolding metaphor” (p. 50).

Vygotsky did propose a role for scaffolding in the assessment of a child’s capabilities in determining the ZPD. The purpose is to determine the tasks that the child can partially complete, or complete with extensive guidance, because it serves as an indicator of higher mental processes that are emerging.

**Summary**

Instruction in writing is one of the most important subjects in the early school years because it requires deliberate actions and analysis. Included are the use of print symbols, observing correct syntax, conceptualizing the receiver of the message, and developing the motivation to write.

In addition to writing, the later stages of concept formation are essential to developing conscious awareness and control of one’s thinking. Young children formed unorganized collections of objects and the connections established between objects by preschool children were haphazard. However, in stage three of concept formation, school-age children accurately selected concept examples on the basis of visual characteristics. This stage, forming pseudoconcepts, precedes the stage of true conceptual thinking, which is based on establishing networks of concepts. True conceptual thinking involves the logical use of concepts. This level of thinking develops through learning concepts in different subject areas and is not completed prior to adolescence.

In addition, the teacher works with the individual student on a particular problem, explaining, inquiring, correcting, and requiring explanations from the child. The teacher is the “ideal form” of behavior, which is both a model and a guide in the child’s development. Finally, scaffolding a task by controlling the elements that are beyond the learner’s capability is not congruent with Vygotsky’s view of instruction. Task sharing, in his writings, occurs during the assessment of a child’s emerging capabilities, not in the subsequent instruction.
EDUCATIONAL APPLICATIONS

Vygotsky’s cultural-historical theory has received considerable attention in the United States in recent years. Two programs to teach reading to poor readers reflect Vygotsky’s concepts of teacher-student collaboration, teacher modeling and imitation, and the abstraction of meaning from symbols. One is Reading Recovery, designed by Marie Clay (1985) for first-grade children who have not mastered the reading process in regular classrooms (the lowest 10%). The shared collaboration between teacher and child helps children monitor and integrate information from many sources (semantic, syntactic, visual, and phonological cues), and develop meaning from reading (Clay & Cazden, 1990). The other is reciprocal teaching, developed by Palinscar and Brown to teach comprehension strategies to older children with reading problems. Children learn the subjective judgments essential in monitoring whether they have understood the text (Brown, 1994, p. 6).

Vygotsky’s principles have at least two other important implications. First, the meaning of signs and symbols used in the culture cannot be left to chance. Second, the theory also speaks to society in general as cultures attempt to understand the implications of a media-based society. Historically, thinking and new discoveries produced by civilizations increased as their symbol systems became more advanced. The implications of Vygotsky’s theory, however, are profound for a civilization in which the major symbol system is one that makes use of co-occurring stimuli (images) and thus requires of the individual only elementary mental functions. Thinking, in other words, can regress in society as well as show progress from one generation to another.

Classroom Issues

The theory establishes the sociocultural setting in which the child learns from adults (the “ideal form” of cognitive behavior) as the genesis for cognitive development and learning. Therefore, learner characteristics, cognitive processes, and the context for learning are all viewed from that perspective.

Learner Characteristics

Individual differences and readiness are two issues that Vygotsky addressed in his theory.

Individual Differences. One of the incomplete concepts in Vygotsky’s theory is that of individual differences. However, he noted that differences in the quality of memory are not the major differences between individuals (Vygotsky, 1930/1977b). Instead, the power of attention and the force of one’s drives are the critical differences. In other words, the ways that the individual makes use of his or her own capacities, that is, their role in the personality, is the important factor in determining individual differences.

Readiness. The zone of proximal development, in which cognitive functions are beginning to emerge, represents readiness. Because readiness refers to potential development, it cannot be determined by a standardized test.
**Motivation.** One of Vygotsky’s major interests that remained incomplete at his death was the issue of affect. He believed that primitive emotions developed in the same general cycle as mental processes. They become moral, ethical feelings in the way that elementary mental functions are transformed into higher mental processes (Vygotsky, 1930/1977b). Also, he believed that subjective feelings regulated behavior, but the mechanisms of this regulation remain to be developed.

**Cognitive Processes and Instruction**
Transfer of learning, developing “how-to-learn” skills, and teaching problem solving are addressed by the theory in terms of the social interactions between the learner and an adult, the “ideal form” of behavior.

**Transfer of Learning.** All higher mental functions first appear as interactions between a knowledgeable member of society and the child. “Transfer,” then, in Vygotsky’s view, is the qualitative shift between interindividual actions and the internalization of these actions as complex intellectual functions. This lengthy process consists of three major stages. They are (a) the use of the symbol system as communication, (b) use of the symbol system to guide developing mental processes, and (c) the development of internal cues and signs to monitor and regulate one’s remembering and thinking.

**Developing “How-to-Learn” Skills.** This issue is not addressed in the terminology familiar to American psychologists. However, Vygotsky does describe the highest level of symbol use—that of creating internal cues to monitor and regulate one’s behavior. This activity involves the control of logical memory and thinking through symbol use. It is one aspect of learning how to learn.

**Teaching Problem Solving.** Like the learning of signs and symbols, learning to solve problems occurs in a social context. The teacher models the appropriate behaviors and then provides guidance as the learner works through the task.

**Implications for Assessment**
Three concepts in Vygotsky’s cultural-historical theory have implications for assessment. One is the qualitative difference in thinking between the stage of naive psychology and external regulation. Specifically, mastering a cognitive task through auxiliary stimuli depends on an awareness of the psychological requirements of the task. In terms of assessment, this means that classroom instruction should assess students’ understandings frequently when new situations and new material are being presented.

Second is the difference between pseudoconcepts and true conceptual thinking. For example, a problem in teaching science is the issue of conceptual understanding. Structured interviews of students in grades one through ten indicated that students described substances in everyday terms and often used scientific terminology incorrectly (Liu & Lesniak, 2006, p. 328). In other words, many students use the language as a veneer, without a change in thinking. The implication for classroom instruction is assessments that focus on conceptual thinking.
Third is the ZPD. Vygotsky’s description of the strategies to determine mental functions that are maturing reflects his effort to focus assessment on the potential for subsequent development instead of attempting to rely on test-based outcomes (Valsiner & van der Veer, 1993, p. 43). The implication for current educational practice is clear. That is, statewide achievement tests administered near the end of the school year in many states are not informing instruction. Although the assessments may identify what the student has not yet accomplished, they do not identify which of those capabilities are within the student’s potential for development.

The ZPD does not refer to specific classroom tasks, drill sheets on terms, specific homework problems, or mothers assisting young children to solve puzzles (van der Veer & Valsiner, 1991). Instead, a ZPD is “the domain of transitions that are accessible by the child” (Vygotsky, 1934/1987a, p. 211). Therefore, implementing the concept of the ZPD in classroom assessment requires identifying the mental processes that represent cognitive development. An example is concept formation, an important aspect of the higher mental functions. This capability requires the processes of attention, association, and the cooperation of judgment and representation (Vygotsky, 1934/1987b, p. 131). A prerequisite to developing true conceptual thinking is the pseudoconcept. A child, for example, may be able to select all the triangles in a group of geometric figures. If the child can name at least one defining characteristic of the concept, abstracting the other defining characteristics is the process that is on the verge of emerging (Gredler & Shields, 2008, p. 87).

**The Social Context for Learning**

Two aspects of the social setting determine the nature and extent of the child’s cognitive development. One is the historical developments inherited by the child as a member of a particular culture. That is, the culture may rely on a primitive counting system, as in Papua New Guinea, or it may rely extensively on complex symbol systems, such as algebra, calculus, and probability systems. The nature of the symbol system inherited by the child sets broad parameters on the higher cognitive functions the child can develop.

The second crucial element is the nature of the child’s social interactions with knowledgeable members of the society. Only through these interactions does the child acquire both meaning and ways to utilize symbols to facilitate thinking. The implication is that the culture that teaches its children symbols as only communication is omitting the most important function of artificial signs, that of developing and mastering one’s thought processes.

**A Comparison with Piaget’s Perspective**

Vygotsky and Piaget focused their work on cognitive development—the development of thinking. Their approach to this task shares four major characteristics. They are (a) the establishment of a theoretical framework for the study of psychological processes, (b) the identification of different psychological structures constructed during development, (c) the analysis of the psychological processes required to attain the highest levels of cognitive development, and
(d) the assertion that cognitive development does not proceed through small incremental changes. Instead, it undergoes qualitative transformations.

However, they addressed different aspects of cognitive development. Piaget focused on logical thinking that culminates in capabilities to solve multifactor situations in terms of cause–effect components. Vygotsky, in contrast, focused on the development of attention, perception, and memory, for which mastering symbol systems (signs) and conceptual thinking are essential.

Piaget and Vygotsky held different views of the relationship of the infant and the young child to his or her social surroundings. This difference contributed to their different views of the roles of egocentric speech and imaginary play in cognitive development. Piaget described the infant and the very young child as closed within itself, accepting objects and people around him as part of himself (the state referred to as solipsism; Vygotsky, 1930–1931/1998f). Egocentric speech, so named by Piaget, is an expression of egocentric thought, which is the inability to see the viewpoints of others. Gradually, egocentric thought disappears as the child becomes socialized into adult ways of thinking, and egocentric speech also disappears. Also, imaginary play, which occurs in the age period from 3 to 7, provides a temporary escape from a strange outside world and consists of situations that are under the child's intellectual control.

In contrast, Vygotsky (1934/1987f; 1982–1984/1998a) described the infant and young child as a social being and involved with the social circle around her. The child is not an isolated being who gradually becomes socialized. Instead, the child's thinking begins as social interactions with adults. Then his or her thinking is transformed from social interchanges into individual thinking. Imaginary play is important in this process because the child assigns new meanings to objects and he or she begins to act in a cognitive rather than a visual domain.

Egocentric speech, which accompanies the child's practical activity, gradually takes on a planning function. At about age seven, when egocentric speech ends, it does not disappear, but becomes internal speech. It is the mechanism that determines the structure of the child's inner speech.

Both Piaget and Vygotsky assigned a major role in cognitive development to courses in the curriculum. However, consistent with a focus on logical thinking, Piaget maintained that disagreement among students as they engage in real experimentation would lead to a rethinking of inaccurate views. Vygotsky, who focused on intellectual processes that require self-organization and mastery of language and other cultural symbols for thinking, identified interactions with the "ideal form" of behavior—the adult—as essential for cognitive development. Vygotsky also identified an essential role in cognitive development for subject-matter concepts.

**Relationships to Other Perspectives**

Vygotsky discussed the importance of developing the cognitive processes of abstraction and generalization through learning concepts some 40 years prior to their discussion in Gagné’s conditions of learning and the instructional design literature. Furthermore, given the current interest in self-organized learning, is Vygotsky’s identification of (a) the importance of self-organized attention, (b) the
role of signs and symbols in directing and managing one’s learning, and (c) the identification of two key foundational processes in self-regulated learning. They are the learner’s conscious awareness of the cognitive process to be developed and voluntary control (mastery) of one’s actions. He also introduced the role of the “ideal form” and the importance of imitation prior to the introduction of modeling in American psychology. Finally, his focus on signification, the development of meaning, identifies Vygotsky as an early constructivist.

**Developing a Classroom Strategy**

Implementing Vygotsky’s theory in the classroom changes the roles of both teacher and students. Ideally, one teacher would be working with one or two students; at most, the group should be limited to five or six. The steps for planning instruction inferred from Vygotsky’s broad outline are as follows.

**Elementary grades:**

**Step 1:** Determine the appropriate instructional level for each child in terms of cognitive processes (not items of content).

1.1 Which tasks/problems reflect important cognitive processes?
1.2 Which of the problems can the child solve with teacher assistance?

**Step 2:** Identify situations that can develop the children’s verbal thinking.

2.1 What are the key word meanings to be learned?
2.2 In what ways can the learner demonstrate that key words are generalizations?

**All grades:**

**Step 3:** Structure the learning task as a collaborative teacher–student activity.

3.1 What aspects of the task are to be modeled by the teacher?
3.2 What self-regulatory skills are to be modeled by the teacher?
3.3 In what ways is the student to use signs and symbols to regulate his or her own behavior?
3.4 What teacher suggestions and feedback to students are needed to assist learning?

**Step 4:** Structure the learning of subject-matter concepts.

4.1 Review the concepts in textbooks or other adopted classroom materials and classify them as “need to know” or “nice to know.”
4.2 For the “need to know” concepts, identify the interconnections and relationships among them.
4.3 Develop instruction, building on the concept connections and relationships.

**Step 5:** Implement instruction and evaluate the results.

5.1 Did instruction gradually add other concepts as the students acquired mastery?
5.2 Were the students able to function independently at the conclusion of instruction?
5.3 Do the students’ skills generalize to other settings and situations?
Classroom Example

Palinscar and Brown (1984) developed the method referred to as reciprocal teaching. It is an example of the transition from the teacher and child working on a cognitive skill to control by the child alone. It also illustrates priming–prompting–reinforcement and fading the prompts progression of operant conditioning.

The following lessons are taken from day one and day four of the teaching. The teacher was working with a student who met minimal decoding standards but failed on comprehension.

Day 1: The teacher and student have read one paragraph silently together, and the teacher has modeled the self-review questions one would ask to check comprehension. The second paragraph, also read silently, mentions several poisonous snakes called pit vipers. The paragraph explains the reason for the name and describes some characteristics of one pit viper known as the water moccasin, or “cottonmouth.”

Teacher: This paragraph talks about several different kinds of poisonous snakes called pit vipers. What would be a good question to ask about pit vipers that begins with the word why?
Student: (no response)
Teacher: How about “Why are the snakes called pit vipers”? How about “Why are the snakes called pit vipers”? How about “Why are the snakes called pit vipers”? Who do they, uh, put vipers in a pit?
Teacher: Try it again. “Why are the snakes called . . .”? Why are the snakes called pit vipers?
Student: Why are the snakes called pit vipers?
Teacher: Good for you. Now what would be a good question to ask about the water moccasin?
Student: The name?
Teacher: What about the name?
Student: Why is it called a moccasin?
Teacher: That’s close; try again. What about the name “cottonmouth”? Why is it called a cottonmouth?
Teacher: Good. But we need to know which snake is called a cottonmouth.
Student: How about, “Why is the moccasin called a cottonmouth”? Why is it called a cottonmouth?
Teacher: Good. Now let’s answer the questions to be sure we understand the paragraph. (Teacher and student review the questions and the answers in the same manner.)

Day 4: The brief paragraph is about a spinner’s mate and his characteristics.

Student: (no question)
Teacher: What is this paragraph about?
Student: Spinner’s mate. How do spinner’s mate . . .
Teacher: Good. Keep going.
Student: How do spinner’s mate is smaller than . . . how am I going to say that?
Teacher: Take your time. You want to ask about spinner’s mate and what he does, using the word how.
Student: How do they spend most of their time sitting?
Teacher: That’s almost it. Sitting is the answer to the question. Can you ask the question without using sitting?
Student: How do they spend most of their time?
Teacher: Good, but we should name spinner’s mate in the question. “How does a spinner’s . . .” Now you finish it.
Student: How does a spinner’s mate spend most of his time?
Teacher: Good job.

Review of the Theory

Vygotsky emphasized the complex mental functions of categorical perception, logical memory, conceptual thinking, and self-regulated attention. The potential for development of these capabilities is determined by the cultural-historical heritage of the child’s culture and the child’s social experience.

The key to the development of complex mental functions is mastering the signs and symbols of the culture as the means to master one’s thinking. The creation and use of arbitrary signs changes the psychological nature of processes such as perception, memory, and attention into more complex forms.

Basic principles in cognitive development identified by Vygotsky include the two branches of cultural cognitive development, the laws of sign use, and the general law of genetic development. Essential in the development of higher mental functions are interactions with knowledgeable adults to develop both the meanings of cultural symbols and the ways of thinking of the culture. Also important in this process are the imitation and invention by the learner in applying actions modeled during adult–student interactions (see Table 9.7).

The major disadvantage of the theory is that Vygotsky was unable to complete his ideas before his death. Thus, educators are left with a broad outline but with few details on implementation.

Major contributions of the theory include the role of cultural signs and symbols in learning and development, recognition of the psychological contributions of the stages of sign use in developing thinking, and the importance of social interaction with the “ideal form” of behavior during learning.
TABLE 9.7
Summary of Vygotsky’s Cultural-Historical Theory

<table>
<thead>
<tr>
<th>Basic Elements</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumptions</td>
<td>(1) Human cognition cannot be explained by animal behavior.</td>
</tr>
<tr>
<td></td>
<td>(2) Humans are rational and gradually gain control of their thinking.</td>
</tr>
<tr>
<td></td>
<td>(3) Cognitive development can be described by dialectical synthesis.</td>
</tr>
<tr>
<td></td>
<td>(4) The psychological tools developed by humans change their thinking.</td>
</tr>
<tr>
<td></td>
<td>(5) Cognitive processes should be studied in ways that reveal their dynamic and changing nature.</td>
</tr>
<tr>
<td>Cognitive development</td>
<td>The development of complex mental functions that make use of both given stimuli and created stimuli</td>
</tr>
<tr>
<td>Components of development</td>
<td>The internalization of actions that first appear on an interpsychological plane; the mastery of the signs and symbols of the culture and learning to use them to master one’s own behavior</td>
</tr>
<tr>
<td>Outcomes of cognitive development</td>
<td>Complex mental functions, including self-organized attention, categorical perception, conceptual thinking, and logical memory</td>
</tr>
<tr>
<td>Designing instruction for complex skills</td>
<td>Developing conscious awareness of and mastery of one’s thinking through teaching concepts, and the use of writing for thinking</td>
</tr>
</tbody>
</table>

Analysis of the Theory

Disadvantages                             | The incompleteness of the system and the lack of specific guidelines for implementation |
Contributions                              | Recognition of the psychological contribution of created stimuli in cognitive development; the importance of social interaction and the social nature of learning |

CHAPTER QUESTIONS

Understanding Concepts

1. Children whose homes lack magazines and other reading material and where reading is not a regular activity for the parents are typically viewed as disadvantaged. How would Vygotsky explain the children’s disadvantage?  
2. Why would Vygotsky not advocate the use of mechanized devices such as computers to provide remedial instruction?  
3. Vygotsky described the preschool period, ages 3–7, as the years when imaginary play and egocentric speech are essential to cognitive development. What are their roles
and what is the likely impact of heavy television watching during these years?


5. What are the key differences between developing verbal thinking as Vygotsky described it in stage three of sign use and selecting mnemonics (such as “rose” to remember the term roseola) to remember phrases and terms?

Applying Concepts to Instructional Settings

1. Schoenfeld (1985) and others express concern that individuals approach mathematical problems as mechanical exercises and seem to possess little awareness of what they are doing (see discussion in Chapter 7). How would Vygotsky explain the problem, and what should instruction include to correct the problem?

2. A 9-week unit on matter in middle-school earth science lists 61 terms in the glossary for that unit. That is almost seven new concepts to be introduced each week. According to Vygotsky’s perspective, what are some problems with this situation?

3. Select one or two major concepts in a subject area in the school curriculum. Describe the components of an instructional plan for the concepts that incorporates the requirements for student performance identified by Vygotsky. (The student can define the concepts, implement them in various logical operations, and identify the interconnections and relationships; Vygotsky, 1934/1987a, p. 218).

4. In the above situation, how would you ensure that the children or older students developed a conscious awareness of their own thinking?

5. Vygotsky (1935/1994d) expressed concern about children going to nursery school becoming at risk for delayed speech development because the children’s “own conversations cannot serve as a source of any significant development for them” (p. 350). Assume that you are the director of a nursery school for children ages 3–5. Given Vygotsky’s other statements about that age period, describe the staffing and activities that must be present to address Vygotsky’s concerns.

REFERENCES


Vygotsky, L. S. (1997c). Conclusion; further research; development of personality and world view in the child. In R. W. Rieber (Ed.),


PART IV

Social-Context Theories

The theories and models discussed in this section address the role of various aspects of the social setting on learning and motivation. The primary mechanism in Bandura's social-cognitive theory is that individuals are learning cognitive and affective behaviors from observing the behaviors of others and the social consequences of those actions. The acquisition of skilled or accomplished performance, however, depends also on the learner's belief that he or she can execute various capabilities, referred to as self-efficacy. The acquisition of complex behaviors, however, depends on the development of the learner's self-regulatory system.

In contrast, the expectancy–value model, the goal orientation model, and attribution theory address particular characteristics of the individual and the setting for learning that influence motivation. The expectancy–value model emphasizes students' expectations of success, the value they place on success, and the beliefs that support motivations. Goal orientation models focus on students' intentions that determine the ways they approach and engage in learning activities. Attribution theory addresses individuals' perceived causes of achievement-related outcomes and the links to subsequent behavior.
CHAPTER 10

Albert Bandura's Social-Cognitive Theory

A major function of thought is to enable people to predict events and to develop ways to control those [events] that affect their lives. (Bandura, 1995, p. 6)

Social-cognitive theory began with Albert Bandura's clinical work with patients with snake phobia. A key component in effective therapy was the observation of former patients handling snakes. The patients in treatment abstracted the information that others who were like them (experienced the phobia) handled snakes with no ill effects, and the patients made use of that information in reflecting on their own behavior. Also, the observation of former patients handling snakes was a more effective therapy technique than persuasion and observations of others who had not experienced snake phobia.

Early work identified the role of behavioral models in the learning of both prosocial and antisocial behaviors (Bandura, 1969, 1971a; Bandura & Walters, 1963; Walters & Parke, 1964), and the role of models in the modification of behavior (Bandura, 1965, 1971a). The theory then identified several social and cognitive factors that influence learning. Included are the capabilities of using symbols and engaging in intentional and purposive actions. Also included in the theory are the influences of the media on the values, attitudes, and behavior styles of observers (Bandura, 1986). "Whether it be thought patterns, values, attitudes, or styles of behavior, life increasingly models the media" (p. 20).

Since the 1980s, the concepts of perceived self-efficacy and self-regulated learning have become a major focus of the theory. Self-efficacy refers to personal beliefs about one's capabilities to be successful in tasks with novel or ambiguous elements and includes teacher efficacy (Bandura, 1977a, 1997). In education, self-regulated learning refers to (a) students' proactive efforts to mobilize emotional, cognitive, and environmental resources during learning and (b) self-observation, judgment, and reaction to one's progress (Bandura, 1986; Schunk & Zimmerman, 1998; Zimmerman, 2001). The concepts of self-efficacy and the self-regulation of behavior also are being incorporated into programs for the self-management of healthy lifestyles as well as chronic diseases (Bandura, 2004a, 2005; Maes & Karoly, 2005).
CHAPTER 10  Albert Bandura’s Social-Cognitive Theory

PRINCIPLES OF LEARNING

Albert Bandura’s social-cognitive theory seeks to explain learning in the naturalistic setting. Unlike the laboratory setting, the social milieu provides numerous opportunities for individuals to acquire complex skills and abilities through the observation of modeled behaviors and the behavioral consequences.

Basic Assumptions

The assumptions of social-cognitive theory address the nature of the learning process and the outcomes of learning.

The Nature of the Learning Process

The definition of observational learning in social-cognitive theory is based on identified weaknesses in prior views of imitative learning.

Other Views of Imitative Learning.

In general, behaviorists treat imitative learning as an association between a particular type of stimulus and a response. The learner mimics or imitates a modeled behavior, is reinforced for the response that matches the model, and later repeats the behavior. One problem with this description is that it does not account for the acquisition of novel responses. In the natural setting, observers do more than mimic an observed behavior. They often imitate a variety of behaviors and abstract a set of behaviors from the actions of several models. For example, children’s exposure to multiple models who demonstrated diverse aggressive behaviors led to novel responses by the children that were new combinations of observed elements (Bandura, Ross, & Ross, 1963).

Other perspectives maintained that a particular relationship between the child and the adult was responsible for the child’s patterning of the adult’s thoughts and actions. The mechanisms proposed to account for the imitative behavior were the child’s identification with the same-sex parent, nurturance, fear, and others. However, these mechanisms are insufficient to explain much of the child’s imitative behavior (Bandura, 1969). For example, the learning of sex-role behaviors is facilitated by a variety of events. Included are the pink or blue treatment of the nursery, parental selection of particular clothing and toys, and parental reinforcement for gender-appropriate activities (p. 215).

Early studies of observational learning also indicated that a nurturant relationship is not a prerequisite for imitation. Furthermore, fear of an aggressor is not a sufficient condition for the imitation of aggressive behaviors. Instead, the attractiveness of imitating an aggressor is that dominance through physical and verbal force leads to possession of material resources and control over others.

In addition to prosocial behaviors, theories have proposed a variety of mechanisms to account for antisocial behavior. One belief is that frustration activates a frustration drive that then produces aggression. However, the term frustration is not a unidimensional state. Instead, it includes a variety of aversive conditions
such as physical assault, insult, deprivation, harassment, goal blocking, and defeat (Bandura, 1979, p. 329).

Moreover, the aversive stimulation from these conditions leads to a variety of responses. Included are withdrawal and resignation, achievement, self-anesthetization with drugs and alcohol, and aggression. Furthermore, millions of people live in a state of deprivation. Yet comparatively few of those deprived engage in civil disturbances. The important question for social scientists, therefore, is not why aggression occurs in such conditions but why a majority of the ghetto population is resigned to dismal living conditions in the midst of affluence (Bandura, 1979, p. 333).

Assumptions about Learning. As described in the prior paragraphs, prior theories excluded two important considerations in their explanations. They are that the learner can (a) abstract a range of information from observing the behavior of others, and (b) make decisions about the behaviors to adopt and enact. A basic assumption of social-cognitive theory is that this observation and decision-making process is a key mechanism in the acquisition of both prosocial and antisocial behaviors (see Table 10.1). Specifically, “a functional consciousness involves purposeful accessing and deliberative processing of information for selecting, constructing, and evaluating courses of action” (Bandura, 2001, p. 3).

In addition, other views of learning assumed a unidimensional relationship between the individual and the environment. That is, either the environment or the individual is a controlling factor in learning. Bandura maintained that this simple relationship did not account for the development of complex behaviors. Instead, a variety of internal personal factors mediate most environmental influences on behavior. For example, the selection of events to be observed and the ways in which the observer perceives and judges events intervene between environmental influences and behavior. Therefore, Bandura (1978) included the three factors first proposed by Kurt Lewin, a German psychologist, in his explanation of learning. They are behavior (B), the environment (E), and the internal events that influence perception and actions (P). In Bandura’s view, a three-way interlocking relationship, referred to as reciprocal determinism, unites these three factors. The use of the term determinism, however, does not imply a fatalistic view in which the individual is at the mercy of preestablished causes. Rather, the term is used to mean that events produce effects rather than a prior set of causal external factors (Bandura, 1978, 1986). For example, after assertiveness training, an individual’s behavior activates new environmental reactions (Bandura, 1977b).

**TABLE 10.1**
Assumptions of Social-Cognitive Learning Theory

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>1.</td>
<td>The learner can (a) abstract information from observing others, and (b) make decisions about the behaviors to enact. 2. A three-way interlocking relationship between behavior (B), the environment (E), and internal, personal events (P) explains learning. 3. Learning is the acquisition of symbolic representations in the form of verbal or visual codes.</td>
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</table>
These reactions, in turn, generate self-confidence in the individual, which then mediates future behavior.

**The Outcomes of Learning**

Other theories typically equate learning and performance or accept performance as an indicator that learning has in fact occurred. In contrast, Bandura noted that individuals acquire internal codes of behavior that may or may not be performed later. Support for this view is the situations in which performance by observers did not occur, but the observers were able to describe the behaviors. In addition, observers subsequently enacted the behaviors following inducements (Bandura, 1965, 1971a).

Therefore, social-cognitive theory views learning and performance as two separate events. Learning is defined as the acquisition of symbolic representations in the form of verbal or visual codes that serve as guidelines for future behavior. An example is a child who sees an older boy in a fight with the class bully. Admiration from classmates may lead the observer to conclude that fighting in certain circumstances is both acceptable and rewarding. The younger child acquires both a set of behaviors and a tendency to enact the behaviors at a later point in time.

The memory codes of observed behaviors are known as **representational systems** (Bandura, 1971b, 1986). The two types of systems are visual (imaginal) and verbal-conceptual. Both types of symbolic codes include a great deal of information in an easily stored form (Bandura, 1977b, p. 26). The visual system consists of abstractions of the distinctive features of events (activities, places, and objects) instead of merely mental copies (Bandura, 1986). Examples are tennis, Paris, France, and the Washington monument.

Other events are coded in verbal form. Details of a particular procedure, such as checking the oil level in one's car, may be remembered more easily through conversion to a verbal code of the steps. Language symbols are the most used verbal codes in everyday life. However, the system also includes numbers, musical notations, Morse code, and others (Bandura, 1971b).

In summary, three assumptions support social-cognitive theory. First, the learning process requires both the cognitive processing and decision-making skills of the learner. Second, learning is a three-way interlocking relationship that consists of the environment, personal factors, and behavior. Third, learning results in the acquisition of verbal and visual codes of behavior that may or may not be performed later.

**The Components of Learning**

In the naturalistic setting, individuals learn new behaviors through the observation of models and through the effects of their own actions. The components of learning are (a) the behavioral model, (b) the consequences of the modeled behavior, (c) the learner's internal processes, and (d) the learner's perceived self-efficacy.

**The Behavioral Model**

Key issues in the role of the behavioral model are the types and their effects, modeling in the mass media and computer environments, model characteristics, and the characteristics of observers.
Types of Models and the Potential Effects. Defined functionally, a model consists of an organized stimulus array such that an observer can extract and act on the main information. The two principal types are live and symbolic models. Live models include family members, friends, work associates, and others with whom the individual has direct contact. Symbolic models, in contrast, are pictorial representations of behavior. Included are television and film that portray environments and situations beyond those with which the child, adolescent, or adult has direct contact.

The primary function of the modeled behavior is to transmit information to the observer. This function may occur in any one of three different ways (see Table 10.2). One is that the modeled behavior serves as a social prompt to initiate similar behavior in others. For example, a guest at an elaborate dinner party may observe the hostess in order to select the piece of silver appropriate for each course.

On the darker side, sensational crimes also serve as cues for copycat acts that erupt after the publicized event. For example, after the first airplane hijacking to Cuba in 1961, subsequent hijackings eventually involved 71 different countries over the next 14 years (Bandura, 1979, p. 325). A more recent concern about the extensive media coverage of school shootings is that repetitions of video reports of the incidents accompanied by national attention are powerful cues to individuals who may feel disenfranchised by society.

The second effect of modeling is to strengthen or weaken the learner’s existing restraints against the performance of particular behaviors. Individuals’ restraints typically are strengthened if the model receives punishment or other aversive consequences for the behavior. However, long-term exposure to reprehensible acts can influence the behavior of some observers.

The weakening of the learner’s restraints toward the performance of particular behaviors can occur in two ways. One is the lack of punishment for reprehensible behavior (discussed in detail later in this chapter). The other is the modeling of defensible violence, which adds legitimacy to the use of violence as a solution to a problem (Bandura, 1973, p. 33). Verbal and physical abuse by authority figures to restrain rioters is an example. Repeated exposure to such models results in a weakening of the individual’s restraints on the use of aggressive solutions.

The third influence of modeling is to demonstrate new patterns of behavior. Models are particularly important in the socialization of both children and

<table>
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<tr>
<th>TABLE 10.2</th>
<th>The Effects of Models</th>
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<tbody>
<tr>
<td><strong>Effects</strong></td>
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</tr>
<tr>
<td>1. Serve as cues for the imitative behavior of others</td>
<td>Copycat crimes</td>
</tr>
<tr>
<td>2. (a) Strengthen or (b) weaken restraints against performing particular behaviors</td>
<td>Student cheating on a test is (a) punished or (b) not punished</td>
</tr>
<tr>
<td>3. Demonstrate new patterns of behavior</td>
<td>Televised cooking shows</td>
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</tbody>
</table>
adults. Language, mores, and familial customs as well as educational, social, and political practices are modeled in countless situations.

**Models in the Mass Media and Computer Environments.** In contemporary American society, the greatest range of exposure to models is through the mass media. Symbolic models have supplanted the role of direct experience in learning about different aspects of the world (Bandura, 1982a, 1986). For example, the individual's only knowledge of an operating room, a criminal courtroom, a jail, and other settings may be from the mass media.

Reports in the late 1980s indicated that children engaged in more television viewing than in any other activity except sleeping (Berk, 1989; Carpenter, Huston, & Spear, 1989; Huston, Watkins, & Kunkel, 1989). A decade later, the Kaiser Family Foundation (1999) reported that, overall, children between the ages of 2 and 18 spend an average of nearly $5\frac{1}{2}$ hours per day watching television, surfing the Web, engaging in video games, or using some other media form. Another report stated that a typical adult spends at least 3 hours a day watching television (Robinson & Godbey, 1997).

At least two issues have emerged concerning these activities. One is the portrayals of violence. Considering only television, by the end of elementary school, the average child will have seen more than 8,000 murders and more than 100,000 other violent acts (Huston et al., 1992). However, in real life, only 0.2% of crimes are murders, whereas about 50% of the crimes in so-called reality-based TV are murders (Oliver, 1994, in Bushman & Anderson, 2001). The “facts of life” presented in the media are the hidden curriculum that no one teaches but that everyone learns (Gerbner, 1974; Gerbner & Gross, 1976).

Three decades of reports from national organizations (e.g., American Psychological Association) and institutions (e.g., Centers for Disease Control) and other studies concur that “the extensive viewing of violence increases the acceptance of aggressive attitudes” and contributes to overt aggressive behavior (Zillman & Weaver, 1999, p. 145). The comprehension of a violent television program is related to the viewer's tendency to identify with aggressive characters that are portrayed (Rule & Ferguson, 1986). Nevertheless, exposure to media violence does contribute to emotional desensitization to the consequences of the aggression against the victim and can arouse the observer’s aggressive inclinations. That is, exposure to aggression increases tolerance for aggression (Friedrick-Cofer & Huston, 1986; Rule & Ferguson, 1983; Wilcox & Kunkel, 1999).

The second issue that has attracted attention is the sexualization of girls and teenagers through television, music videos, movies, magazines, video games, the Internet, and advertising (Zurbriggen et al., 2007). The APA Task Force report (Zurbriggen et al., 2007) defines sexualization as basing a person's value only on his or her sexual appeal (excluding other characteristics), sexually objectifying a person, or inappropriately imposing sexuality on a person. Self-objectification occurs when girls internalize the media portrayals and begin to treat themselves as objects that are to be looked at and judged for their appearance (p. 2).

The media portrays sexy images as a kind of girl power, but girls may be unaware that this kind of power does not contribute to a successful, happy
adulthood (Lamb & Brown, 2006). Negative impacts of these images include (a) a disruption in the capability to concentrate and focus attention on mental tasks, (b) an undermining of the comfort with one's body, and (c) lower self-esteem and symptoms of depression in adolescent girls and women. The report suggests raising public awareness of the problem as well as the effects on boys, women, and men in addition to girls (Zurbriggen et al., 2007).

Factors That Influence Responsiveness to Models. An important factor in the learning process is the degree to which the learner attends to the model. Some models, such as regular associates and peers, are more effective than others in attracting the learner's attention. For young children, peers, older children, and adults play an important role in the socialization process.

Three situational characteristics influence responsiveness to models (Bandura, 1986, p. 207). One is the particular attributes or characteristics of the model. Important model characteristics are relevance and credibility for the observers. Models who have an impact on observers may be prestigious, appear to deserve trust, portray consensus in a group, offer believable standards to guide observers' aspirations, or provide realistic reference figures for observer comparison (Rosenthal & Bandura, 1978, p. 636). In the classroom, observing success on school tasks achieved by those who are similar in age and competence should enhance the likelihood of observational learning (Schunk, 1987).

The second factor that influences responsiveness to a model is uncertainty about a particular course of action. In such situations, the observer is likely to attend to the behavior of a prestigious model. Cues such as general appearance, speech, style, age, and signs of expertise are interpreted as indicators of past successes (Bandura, 1986, p. 208). However, these characteristics exert the greatest influence when the consequences of the modeled action are unknown (Bandura, 1986).

The third factor is the degree of intrinsic reinforcement already present in the situation. Watching television is an example. Engaging in the activity itself is reinforcing for the observer (Bandura, 1971c).

Relevant Observer Characteristics. In addition to situational characteristics, the nature of the observer also affects responsiveness to modeling influences (Bandura, 1986). Some research indicates that those who lack self-confidence and have low self-esteem are especially prone to adopt the behavior of successful models. Such characteristics may in part explain the tendencies of teenagers to emulate the dress and hairstyles of rock stars, for example.

However, when instruction explicitly uses modeling to develop competencies, those who are more talented and venturesome are likely to derive the greatest benefit from observing proficient models (Bandura, 1986, p. 208). In other words, individuals with clear goals select models that are examples of valued skills. These observers differ greatly from insecure observers who turn to others because they lack confidence in their own abilities (p. 208).

Summary. Observed behaviors are an essential component of learning in the naturalistic setting. The primary function of the modeled behavior is to transmit
information to the observer in any of three different ways. They are (a) to serve as a cue for similar behavior in others, (b) to strengthen or weaken the learner’s existing restraints against the performance of particular behaviors, and (c) demonstrate new patterns of behavior.

Live models are family members, teachers, friends, work associates, and others in the immediate social setting. Symbolic models are pictorial examples of behavior, of which the largest group is the mass media. However, mass media often present fictional views of the world. In addition, the media portray disproportional amounts of violence and also contribute to the sexualization of young girls.

Situational characteristics that influence observer reactions to models are (a) the attributes of the model, (b) the extent of uncertainty about a particular course of action, and (c) the degree of reinforcement present in the situation. Observer characteristics also influence observer responsiveness to models. Some research indicates that observers who lack self-confidence are likely to adopt the behaviors of successful models. However, when teachers use modeling to develop particular competencies, the talented and adventurous observers are most likely to derive the greatest benefit from the modeling.

The Consequences of Behavior
Social-cognitive theory identifies three types of consequences that influence behavior. One type, vicarious consequences, are associated with the observed behaviors of others. A model receives reinforcement or punishment for a particular behavior, and the consequence to the model generates emotional reactions in the observer. For example, the teacher acknowledges a child who shares her crayons with others at the table, and a child who observed the situation experiences positive feelings.

The second type, direct consequences, are the immediate outcomes generated by the observer’s subsequent imitative behavior. Teacher acknowledgment for the child who observed the crayon-sharing and shared her pencils with another is an example. The third type consists of the observer’s self-administered consequences for his or her imitative behavior.

Vicarious Reinforcement. For vicarious reinforcement to occur, (a) the behavior of a model must produce reinforcement for a particular behavior, and (b) positive emotional reactions must be aroused in the observer. Television commercials rely on this type of situation. For example, a well-known actress eats a particular low-calorie food and demonstrates her weight loss. A handsome actor dressed in a tuxedo demonstrates the features of a luxury car and then joins other expensively dressed people entering a large house for a party. In these situations, the vicarious reinforcement for a particular group of viewers is the positive feelings associated with being slim or acquiring social status.

Similarly, players at slot machines, for example, see and hear the other players win (Kazdin, 1989, p. 197). The loud noises and flashing lights announce the winners to others. Also, advertisements of contests often include pictures of happy previous winners that may elicit positive emotional reactions in certain readers.
In addition to emotional reactions, vicarious reinforcement also conveys information about which behaviors are appropriate in which settings. A third effect occurs when the model’s behavior is repeatedly reinforced. When outcomes are viewed as personally attainable, seeing others reinforced for successful behaviors arouses expectations of similar results in observers. The observer anticipates the same reinforcement consequences for enactment of the same or similar behaviors. In other words, continued reinforcement of the model’s behavior predicts success for the observer. Such behaviors are described as having acquired functional value (Bandura, 1971b). (See Table 10.3 for a summary of the three effects.)

In one semester-long observational study of a third-grade classroom (Goetz, 1976), the children indicated that finishing on time, getting the right answers, and mastering the subject were important. These behaviors earned time for fun activities and had acquired functional value for the children.

**Vicarious Punishment.** Like vicarious reinforcement, punishment administered to a model tends to convey three primary effects. First, the outcome conveys information about behaviors that are likely to be punished and are therefore inappropriate. Second, a restraining influence on imitative aggressive actions is also likely to occur (inhibitory effect).

Finally, because the behavior transmitted to the observers was not successful, the model’s status is likely to be devalued. However, if the model enacts a behavior highly prized by a peer group, such as challenging unfair treatment, punishment may enhance the model’s status.\(^1\) Usually, however, the model’s status is devalued.

Other outcomes may occur as the result of the presence or absence of punishment. One outcome is that of altering the observer’s valuation of reinforcing agents (Bandura, 1977b, p. 51). The misuse of power generates resentment in observers and undermines the legitimacy of the agent’s power. The observation of inequitable punishment may release angry observers from self-censure of their own behavior. The result is increased transgression rather than compliance. An example

<table>
<thead>
<tr>
<th>TABLE 10.3</th>
<th>Primary Effects of Vicarious Consequences</th>
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<tbody>
<tr>
<td><strong>Vicarious Reinforcement</strong></td>
<td><strong>Vicarious Punishment</strong></td>
</tr>
<tr>
<td>Conveys information about which behaviors are appropriate in which settings</td>
<td>Conveys information about which behaviors are inappropriate in which settings</td>
</tr>
<tr>
<td>Arousal of the emotional responses of pleasure and satisfaction in the observer</td>
<td>Tends to exert a restraining influence on imitation of modeled behavior (inhibitory effect)</td>
</tr>
<tr>
<td>After repeated reinforcements, incentive-motivational effects are generated; behavior acquires functional value</td>
<td>Tends to devalue the model's status since a functional behavior was not transmitted</td>
</tr>
</tbody>
</table>

\(^1\)Personal communication
is that of excessive police reactions to crimes committed in certain urban neighborhoods or by members of particular subgroups in society. Outbreaks of vandalism and riots by other members of the subgroup often follow. (See Figure 10.1.)

**The Absence of Punishment.** The anticipation of punishment usually restrains the imitation of forbidden actions. However, when individuals are not punished for transgressions, the information conveyed to observers is that of implicit acceptance. An example is a classroom in which the teacher is careless about monitoring examinations and cheating occurs. If the cheating goes unpunished, others are more inclined to cheat on the next test. The behavior has acquired functional value through the omission of punishment.

Similarly, when aggressive actions go unpunished or when people respond approvingly or indifferently, aggression is viewed as both acceptable and expected in similar circumstances (Bandura, 1973, p. 129). Aggression acquires functional value for the observer.

The lack of punishment for forbidden actions has important implications for the classroom. In one group of junior high classrooms, for example, some of the new teachers ignored students' initial disruptive actions and continued to teach or to wait until the situation was out of hand before trying to get order (Moskowitz-Hayman, 1976, p. 288). By the end of the school year, in one class, students were throwing chairs, pencils, and books; walking around the room; slapping each other; and humming, singing, and talking out loud. The importance of addressing disruptive actions early and consistently is supported by a number of classroom studies (see Doyle, 1986; Good & Brophy, 1987).

However, the absence of adverse consequences to the model fulfills a useful purpose in situations such as the treatment of phobic patients. Patients with snake phobia, for example, experienced reduced fear and anxiety after observing models handle snakes without incurring adverse consequences.

The influence of vicarious consequences, however, is relative rather than absolute (Bandura, 1971c). The extent of the influence varies with the observer's valuation of the type of outcome and the type of behavior (Bandura, 1977b, p. 119). In addition, observed consequences are of minimal influence if observers believe that the model's contingencies do not apply to them. For example, the physical aggression of a soldier is unlikely to enhance imitative aggression in the average

![FIGURE 10.1](image)

Some effects of consequences for reprehensible conduct
citizen (Bandura, 1971b). Moreover, both vicarious and direct reinforcement are operating together in most situations. Therefore, the separate effects of either type are difficult to determine.

**Direct and Self-Reinforcement.** Direct reinforcement in social-cognitive theory is the positive reinforcement identified in operant conditioning. That is, an individual’s behavior produces a change in the environment such that the behavior is likely to be enacted again in similar circumstances. In social-cognitive theory, direct reinforcement refers to the outcomes of the observer’s imitative behavior. It is essential if the imitative behavior is to continue.

Self-reinforcement, in contrast, is independent of the consequences delivered by society. In addition, it must be consciously cultivated by the individual. Young children respond to immediate physical consequences (food and physical contact) and other material rewards. Then, symbolic consequences, including social reactions of approval and disapproval, followed by social contracting arrangements, become reinforcing or punishing. Finally, individuals become capable of establishing self-evaluative and self-produced consequences (Bandura, 1978, p. 103).

Self-reinforcement involves three subsidiary elements. They are (a) a self-prescribed standard of behavior, (b) reinforcing events under the control of the individual, and (c) the individual as his or her own reinforcing agent. In general, individuals establish performance standards for themselves and tend to respond to their behavior in self-rewarding ways if their performance matches or exceeds the standard. Similarly, they respond in self-criticizing ways if their performance fails to meet the standard. Thus, although humans—like rats and chimpanzees—respond to reinforcement, the human capacity for thought and self-direction sets the species apart. Unlike human beings, “rats and chimpanzees are disinclined to pat themselves on the back for commendable performances, or to berate themselves for getting lost in the cul-de-sacs” (Bandura, 1971b, p. 249).

**Interactions with External Consequences.** An important characteristic of self-imposed consequences is that they often operate together with external consequences (Bandura, 1974). These two sources of reinforcement either conflict with or complement each other. When external rewards are outweighed by self-condemnation, they are relatively ineffective. An example is the student who seeks to earn an A grade in every course. Earning a B in a particular course in which others earn Cs and Ds does not meet the individual’s standards. Earning the highest grade in that class is small consolation.

A second type of conflict that can occur is that of external punishment delivered by the environment for behaviors that the individual values higher (and therefore believes are worthy of reward). Nonconformists, dissenters, and, at the extreme, martyrs are in this category. For the latter group, their sense of self-worth is so strongly linked to particular beliefs that they suffer pain and even death rather than relinquish their values.

**Summary.** Like operant conditioning, the consequences of behavior are essential to learning in social-cognitive theory. However, unlike operant conditioning,
the theory incorporates vicarious and self-administered consequences in addition to the direct consequences produced in the environment. Vicarious consequences are those immediate outcomes produced by modeled behavior that generate emotional reactions in the observer. Self-administered consequences are produced by the individual for his or her behavior that meets or fails to meet the person’s self-prescribed standard.

Vicarious consequences also convey information about which behaviors are appropriate or inappropriate. Modeled behavior viewed as personally attainable by the observer and that receives repeated reinforcements has acquired functional value for the observer. However, vicarious punishment conveys information that the modeled behaviors are inappropriate, exerts an inhibitory effect on imitative behavior, and devalues the status of the model. In contrast, the absence of punishment implies implicit acceptance of the modeled behaviors.

Although important, the influence of vicarious consequences on observers is relative rather than absolute. The extent of influence varies with the observer’s valuation of the outcome and the behavior and the importance of the model. Finally, self-administered consequences operate in situations in which individuals have established personal standards of performance. They then respond in self-censuring ways if behavior fails to meet the standard and in self-reinforcing ways if the behavior matches or exceeds the standard. External rewards are relatively ineffective when outweighed by self-censure. Also, external punishment delivered for behaviors that the individual values highly has little effect.

The Learner’s Internal Processes

Cognitive processes play a central role in learning. The learner’s ability to code and store transitory experiences in symbolic form and to represent future consequences in thought are essential to the acquisition and modification of human behavior.

The cognitive processing of events and potential consequences guide the learner’s behavior. For example, homeowners do not wait until their houses are burning down to buy insurance. Instead, knowledge of the potential loss that can be the consequence of no insurance is the stimulus that prompts individuals to invest in homeowner’s protection (Bandura, 1971b).

Four component processes are responsible for learning and performance. They are attention, retention, motor production, and motivational processes (Bandura, 1971a, 1977b). The relationships between the behavioral model, the learner’s cognitive processes, and learning and performance are illustrated in Figure 10.2.

Attentional Processes. New behaviors cannot be acquired unless the observer attends to and accurately perceives them (Bandura, 1977b). However, several factors can influence attention. Included are the characteristics of the model, characteristics and functional value of the behavior, and observer characteristics.

Characteristics of the behaviors include complexity and relevance. For example, long verbal sequences are too complex for young children to process. However, they are able to process visually presented models that are accompanied by a high degree of verbal repetition. The animal characters and dialogue in
Sesame Street are an example. Relevance, in general, refers to the importance of the behavior to the observer. Learning to drive a car, for example, is relevant for a teenager but not for a 2-year-old child.

Among the observer characteristics that influence attention are perceptual set, observational skills, arousal level, past performance, and sensory capacities (Bandura, 1977b, p. 23). The learner’s arousal level and perceptual set influence the selection of activities to be observed, whereas observational skills influence the accuracy of processing.

Learning from models also depends on the observer’s skill in monitoring and interpreting ongoing events. Preschool children, for example, typically believe that an instant replay on television is a new example of the same event (Rice, Huston, & Wright, 1986). Also, Huston et al. (1989, p. 426) found that preschool children typically do not differentiate between program content and commercials. Thus, developmental differences in abstracting information from symbolic models influence the interpretation of events.

Retention Processes. These processes are responsible for the symbolic coding of the behavior and storage of the visual or verbal codes in memory. These processes are important because the learner cannot benefit from the observed behaviors in the absence of the model unless they are coded and retained for later use (Bandura, 1977b).

An important retention process is rehearsal. Both mental rehearsal, in which individuals imagine themselves enacting the behavior, and motor rehearsal (overt action) serve as important memory aids. Mental rehearsal requires that the learner
internally represent the absent events. These representations can then guide the motor rehearsal.

Retention processes are, of course, influenced by the learner's development. The ability to represent behaviors in the form of labels and to generate verbal and visual cues enhances retention.

Motor Reproduction and Motivational Processes. After the observer has acquired a symbolic code, performance of the acquired behaviors depends on the learner's motor reproduction and motivational processes. Motor reproduction includes the selection and organization of responses at the cognitive level, followed by their execution (Bandura, 1977b). Like the processes of retention, the developmental level of the individual influences motor reproduction.

The three processes that function in social-cognitive theory as motivators are direct (external) reinforcement, vicarious reinforcement, and self-reinforcement. During the modeling of behavior, reinforcement to the model that can precipitate vicarious reinforcement in the observer is important in motivating the learner to attend to and code the observed behavior.

The Role of Self-Efficacy

The construct labeled self-efficacy refers to beliefs about one's capabilities, and these beliefs motivate learners in particular ways. Important issues in self-efficacy are the essential characteristics, the sources of efficacy beliefs, and the effects on psychological processes.

Definition. Perceived self-efficacy refers to a belief in one's capabilities to organize and execute the actions necessary to produce particular attainments (Bandura, 1997, p. 3). Such judgments typically apply to situations that may include novel, unpredictable, or often stressful elements (Bandura, 1986; Bandura & Schunk, 1981). Perceived self-efficacy plays a pivotal role in people's lives (Bandura, 2001, p. 10). Efficacy beliefs are instrumental in the activities and situations that people choose, and these beliefs can affect the direction of personal development (p. 10).

Self-efficacy differs from self-concept in that self-concept is a general assessment. It is a global construct that includes several self-reactions (such as one's perceptions of popularity) (see Bong & Clark, 1999, for a discussion of the differences). Self-efficacy, in contrast, is a content-related judgment and, in the academic sphere, it refers to the belief that one can perform particular academic tasks successfully (Zimmerman, 1995, p. 218).

Efficacy expectations should not be confused with response–outcome expectations. A response–outcome expectancy is the belief that a particular behavior will lead to certain outcomes. However, an efficacy expectation is the belief in one's capability to execute the required behavior successfully (Bandura, 1977b, p. 193). For example, the anticipated social recognition, applause, trophies, and self-satisfaction for the highest broad jump are outcome expectations. The belief that one can successfully high jump 6 feet is an efficacy judgment (Bandura, 1986, p. 391).
Perceived self-efficacy involves self-appraisal; it is not a fixed act, and it involves more than simply knowing what to do (Bandura, 1982b). Included in the self-appraisal are both personal and situational factors. For example, students who are capable of mastering a situation often make judgments that indicate they consider themselves to be inadequate (Zimmerman, 1986). University students often find their career options limited because they fear taking courses that involve quantitative methods (Henderson, 1986).

Faulty self-appraisal can, on occasion, lead to high self-efficacy that may be inaccurate. For example, in mathematics, children sometimes rely on “buggy algorithms.” They are the systematic but inaccurate strategies that children often use in solving arithmetic problems. Knowledge of such strategies and being able to apply them well (they sometimes lead to correct answers) lead to a false sense of self-efficacy (Schunk, 1995, p. 214).

Sources of Efficacy Beliefs. Four types of influence contribute to individuals’ beliefs about their personal efficacy (Bandura, 1986, 1995). They are mastery experiences, vicarious experiences, social persuasion, and physiological and emotional states. As indicated in Table 10.4, they range in influence from mastery experiences to physiological and emotional states. Success in actual situations tends to raise the judgment of efficacy, whereas repeated failures lower the judgment. For the individual who has a strong sense of efficacy, occasional failure will affect judgment very little. In contrast, failure is influential for individuals who are unsure of their abilities.

Mastery experiences designed to enhance students’ self-efficacy should not consist of easy successes. Individuals who experience only easy successes are easily discouraged by failure because they tend to expect quick results (Bandura, 1995). Also, developing a sense of efficacy through mastery experiences must involve acquiring the cognitive and behavioral capabilities for executing appropriate courses of action (p. 3). Then, after individuals are convinced that they have the capabilities required to succeed, they are able to persevere in the face of setbacks.

<table>
<thead>
<tr>
<th>Source</th>
<th>Influence</th>
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<tbody>
<tr>
<td>Mastery experiences</td>
<td>The most authentic evidence of the individual’s capabilities to master the resources required for success</td>
</tr>
<tr>
<td>Vicarious experiences</td>
<td>Particularly influential in the absence of direct experience in a situation</td>
</tr>
<tr>
<td>Verbal persuasion</td>
<td>Can help counter an individual’s mild self-doubts</td>
</tr>
<tr>
<td>Physiological and emotional states</td>
<td>Can provide information about efficacy</td>
</tr>
</tbody>
</table>

Note: Compiled from Bandura (1986, 1995)
Observing the success of others whom the observer considers similar to him or her (vicarious experience) also contributes to self-efficacy. Vicarious experiences are particularly influential when people have had little or no direct experience in a situation. Models also may demonstrate effective strategies for managing environmental demands and positive attitudes (Bandura, 1995, p. 4).

Verbal persuasion, the third source of efficacy beliefs, can help counter an individual's mild self-doubts. Persuasion can assist individuals to avoid a focus on their personal deficiencies and to measure success in terms of improvement rather than outperforming others. However, in the absence of other influences, persuasion cannot develop high beliefs of personal efficacy. Physiological and emotional states, such as stress reactions and tension, also provide information about efficacy. Individuals tend to interpret negative physiological reactions, such as tension, as indicators of vulnerability to poor performance (Bandura, 1995, p. 4). Therefore, one way to alter personal efficacy is to reduce these tendencies. In addition, individuals should learn to interpret the first signs of tension as an indicator that more focused effort is needed. Those with high self-efficacy tend to perceive heightened tension as a signal to energize their efforts.

**Effects on Psychological Processes.** Self-efficacy beliefs influence human functioning indirectly through four major processes. They are cognitive, motivational, affective, and selection processes (Bandura, 1995). Those with high self-efficacy construct success scenarios, whereas individuals with low self-efficacy do not. In specific, demanding situations, high self-efficacy contributes to continued analytical thinking, whereas low self-efficacy is accompanied by erratic strategies and thought processes (Wood & Bandura, 1989).

Efficacy beliefs enhance or limit motivation by influencing the types of goals that individuals set for themselves, the extent of effort they expend, and their persistence in the face of difficulties. A low sense of efficacy contributes to a slackening of effort and the tendency to give up easily.

Affective processes that are influenced by personal efficacy include anxiety, frustration, and depression (Bandura, 1993, 1995). A sense of efficacy assists in controlling disturbing thoughts and supports coping behaviors in difficult situations. For smokers, for example, research indicates that perceived self-efficacy in resisting smoking in stressful situations is related to relapses and the reinstatement of self-control after a relapse. Those with low self-efficacy relapse completely (Bandura, 1982b, p. 131). In other words, high self-efficacy contributes to the creation of a positive psychological environment that enables people to manage difficult situations.

Finally, efficacy beliefs influence the types of activities and environments that individuals choose (Bandura, 1995). Specifically, people avoid activities and environments that they believe are beyond their coping capabilities (p. 10). In contrast, individuals with a strong sense of efficacy approach difficult tasks as challenges to be mastered. Such an outlook, in turn, fosters personal accomplishment (Bandura, 1986).

Table 10.5 summarizes the task-related and long-term effects of high and low self-efficacy. As indicated, those with low self-efficacy focus attention on their
### TABLE 10.5
Effects of Perceived High and Low Efficacy

<table>
<thead>
<tr>
<th></th>
<th>High Self-Efficacy</th>
<th>Low Self-Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task-related behavior</strong></td>
<td>1. Effort is strengthened in the face of difficulties.</td>
<td>1. Efforts slacken.</td>
</tr>
<tr>
<td></td>
<td>2. Already-acquired skills are intensified and strengthened in the face of difficulties.</td>
<td>2. Task may be given up altogether in the face of difficulties.</td>
</tr>
<tr>
<td></td>
<td>3. Effort and attention are focused on the demands of the situation.</td>
<td>3. Attention is focused on personal deficiencies and difficulties; these problems are magnified.</td>
</tr>
<tr>
<td><strong>Long-term effects</strong></td>
<td>4. Aids self-development through precipitating involvement in a variety of activities and experiences.</td>
<td>4. Hinders development by facilitating the avoidance of enriching environments and activities.</td>
</tr>
<tr>
<td></td>
<td>5. Individual experiences little stress in taxing situations.</td>
<td>5. Individual suffers anxiety and stress in a variety of performance situations.</td>
</tr>
<tr>
<td></td>
<td>6. Typically leads to lack of effort rather than lack of ability as the cause for failure.</td>
<td>6. Undermines the effective use of one's skills by directing attention to personal shortcomings.</td>
</tr>
<tr>
<td></td>
<td>7. Leads to goals that are challenging, that sustain interest and involvement.</td>
<td>7. Leads to lowered aspirations as a mechanism for avoiding stress.</td>
</tr>
</tbody>
</table>


deficiencies, set lower aspirations, and avoid the particular enriching environments that can enhance their competencies. Also of interest is that self-efficacy beliefs contribute to predictions of mathematics performance (Pajares, 1996; Pajares & Graham, 1999) and writing achievement (Pajares, Miller, & Johnson, 1997; Zimmerman & Bandura, 1994), and differentiate between high and low achievers in high school (Zimmerman & Martinez-Pons, 1986).

**Summary.** Perceived self-efficacy is the learner's belief in his or her capabilities to successfully manage situations that may include novel or unpredictable elements. Perceived self-efficacy involves self-appraisal and is not a fixed act. Students with similar academic abilities may differ in their sense of efficacy for particular subjects.

The four types of influence that contribute to efficacy beliefs are mastery experiences, vicarious experiences, social persuasion, and physiological and emotional states. They range from a strong influence on efficacy for mastery experiences to a relatively weak influence for physiological and emotional states.
Efficacy beliefs affect human functioning indirectly by influencing cognitive, motivational, affective, and selection processes. Those with high self-efficacy construct success scenarios, set challenging goals, persist in the face of difficulties, and control disturbing thoughts. Also, choices of activities, tasks, and even career are influenced by self-efficacy. Individuals avoid situations that they believe are beyond their coping abilities.

The Nature of Complex Learning

Unlike other theories, social-cognitive theory does not describe the forms of thinking and/or behavior that represent complex learning. Instead, the theory describes the factors essential to the attainment of superior performance in any domain or discipline. According to Bandura (1986), the essential factor in achieving complex capabilities is the individual's self-regulatory system. Important topics are the components of the system and the ways in which the self-regulatory system develops.

The Self-Regulatory System

Self-regulated academic learning emerged as a major topic in the mid-1980s to address the issue of the ways that “students become masters of their own learning processes” (Zimmerman, 2000, p. 1). Discussed in this section are the definition, subprocesses, and influences on the system.

Definition. Self-regulated learning refers to “self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals” (Zimmerman, 2000, p. 14). Self-regulation, because it is dependent on the individual's beliefs and motives, is not a singular trait, mental ability, or stage of competence (p. 14). It is “the self-directive process through which learners transform their mental abilities into task-related academic skills” (Zimmerman, 2000, p. 1). In other words, self-regulated learners view learning as a proactive enterprise. They set goals for themselves, are accurate self-monitors, and are resourceful in selecting learning strategies (Zimmerman, 1998).

In addition, self-regulation is highly context-dependent; it is not a general trait (Schunk, 2001, p. 125). Although the processes, such as goal-setting, apply to different settings, the learner must be able to adapt the processes to different areas, and also maintain a sense of self-efficacy (p. 125).

Subprocesses. The three key subprocesses in the self-regulatory system are self-observation, self-judgment, and self-reaction (Bandura, 1986; Schunk, 2000, p. 130). Self-observation requires deliberate attention to one's behavior. For example, a student who observes that he or she accomplishes less when studying with a friend may decide to spend more time studying alone (p. 131).

Self-observation can be aided by recording key aspects of learning-related behavior. One course designed to help college students required that the students keep an activity log with 30-minute intervals for 1 week. Students often
expressed surprise at the data, which indicated the amount of procrastination and nonproductive time (Zimmerman, Greenberg, & Weinstein, 1994).

Self-judgment refers to comparisons of one's present performance with preestablished goals (Schunk, 1995, 2001). Goals may be long term, such as doing well in mathematics or more immediate, such as completing a certain reading assignment with understanding. Finally, self-reactions in the form of determining that one has made progress toward meeting his or her goals or the lack of progress can influence motivation. People who believe that their performance can improve typically work longer and harder (Schunk, 2001, p. 133). Also, individuals often make consequences such as work breaks contingent on progress toward or attainment of their goals. An anecdote about Ernest Hemingway is that the author recorded his daily production of words (self-observation) on a mounted chart. If the amount was less than originally planned (self-judgment), Hemingway curtailed his time spent fishing (self-reaction; Graham & Harris, 1994, p. 206).

Goal setting and self-evaluation are critical for superior accomplishments in any area and particularly in the development of innovations. Self-generated standards and reinforcements sustain developments that often are resisted initially by society. In the absence of public recognition, self-reinforcement for meeting one's own standards maintains the creative efforts of the artist or innovator. Highly stringent standards, however, lead to self-created distress (Bandura, 1986). For example, the violinist in the second chair likely began as a prodigy with every expectation of dazzling the world. At 45 and balding, he is the most disappointed man on Earth (p. 357).

**Influences on Self-Regulation.** Self-efficacy is an important influence in self-regulation because it affects both the level of selected goals and one's responses to failure to meet those goals, such as persistence and effort. A major environmental influence on self-regulatory processes is achievement. Individuals receive information about achievement outcomes, determine whether they meet their goals, and alter their behavior accordingly. If the achievement does not meet the preset goal, the individual may alter his or her strategies, increase effort, or lower the goals.

**Development of the Self-Regulatory System**
As stated previously in this chapter, Bandura (1977a, 1978, 1986) proposed a three-way interaction between personal factors, behavior, and the environment. This three-way interaction contributes to the development of the self-regulatory system.

**Interactions in the Triad.** A variety of models—teachers, parents, work associates, peers, and others—function as sources of information for standard setting and self-management of behavior. However, people do not passively incorporate everything they hear or see (Bandura, 1986). Instead, personal factors influence the development of generic standards from the behaviors of models in a variety of settings. In early childhood, for example, the approvals and punishments handed out by children to each other and to dolls or stuffed animals indicate the standards acquired by the children through modeling and direct experience (p. 372).
The individual’s self-regulated behavior also influences the environment. In turn, environmental influences contribute to the development of self-monitoring and evaluative skills. They also provide support for the maintenance of internal standards (Bandura, 1986). (See Figure 10.3.) Self-regulation is cyclical because feedback on prior performance provides information for current adjustments in one’s efforts (Zimmerman, 2001, p. 4).

Included in external reinforcements are rewards for excellence and negative sanctions for individuals who provide themselves with undeserved self-reward (Bandura, 1977b, 1978; Bandura, Mahoney, & Dirks, 1976). Examples include scholarships and other awards for outstanding academic achievements. Prizes, public acclaim, and monetary rewards reinforce winners of arduous sports events (e.g., the Indianapolis 500, the Wimbledon tennis tournament, and the Olympic Games). Negative sanctions also include public dishonor for cheating performances, such as that of Rosie Ruiz, the marathon runner who faked a victory.

The behavioral standards used by the individual and the delivery of self-reinforcement depend on the relationship between the particular task and the individual’s expertise. A mathematician, for example, would not consider that solving elementary arithmetic problems is deserving of self-reward. On the other hand, a humanities scholar would not devalue his or her poor performance on a test of engineering skills (Bandura, 1971b). Particularly important are the self-reinforcements for engaging in difficult tasks or aversive activities, such as completing homework or speaking up in social situations. Arranged

![Figure 10.3](image-url)

**FIGURE 10.3**
Reciprocal determinism in the development of self-regulatory systems
self-reward bridges the gap between initiation of the new behavior and the environmental contingencies that will be activated by competent performance.

The relationships between the environment, internal events, and behaviors are often complex and subtle. Certain personal attributes, such as gender or race, often activate differential social treatment. The individual's self-conception, in turn, is influenced by the treatment such that biases are either altered or maintained. Also, the relative influence exerted by each of the factors will vary across individuals and situations. For example, behavior and the intrinsic feedback in the form of enjoyment is a major influence for people who play the piano for relaxation (Bandura, 1986, p. 21). However, in other situations, cognitive factors are dominant, such as efforts to learn a new skill.

**The Disengagement of Self-Evaluative Capabilities.** The three-way interaction between personal factors, environmental factors, and behavior, given different sets of circumstances, also can lead to the disengagement of self-evaluative capabilities. The result is the development and maintenance of reprehensible conduct and inhumane activities (Bandura, 1977a, 1979, 1986, 1999, 2004b). Prior theories have proposed different internal "watchdogs" that are responsible for moral behavior, such as a conscience, a superego, or an internalized moral code. Such theories, however, encounter difficulties when they attempt to explain inhumane conduct by otherwise humane moral persons (Bandura, 1982a, p. 351).

In the social-cognitive analysis, such acts are performed through processes that disengage the behavior from a self-evaluative reaction. Among the dissociative practices that are responsible for this disengagement are moral justification (the end justifies the means), displacement of responsibility (I was only following orders), dehumanization of the victim (use of terms such as "gooks" and "wetbacks"), and euphemistic labeling. The role of euphemisms is to "sanitize" reprehensible or pernicious behavior by using benign expressions. Euphemisms also are used in everyday affairs to disguise negative situations or behavior. Examples include "fourth-quarter equity retreat" (decline in stock dividends; Evans, 1989, p. 43), corporate "downsizing" (firing employees), and mercenaries "fulfilling a contract" (killing others).

The practices of dehumanizing victims, blaming victims to justify persecution, and other practices do not quickly transform a law-abiding citizen into an aggressor (Bandura, 1982a). Rather, the process is gradual, beginning with acts that do not generate excessive self-censure. Discomfort and self-reproach then gradually diminish through repeated performance until brutal acts are committed with little distress (Bandura, 1982a, p. 354).

The importance of these analyses is twofold. First, the self-system is a critical factor in the development of accomplished skills and capabilities in any field of endeavor. Second, neither the development of self-evaluative reactions nor their disengagement is an automatic process. Rather, a series of particular types of reciprocal interactions between the individual and the environment is required.

**Other Developments.** Since the development of social-cognitive theory, others have proposed both additional processes involved in self-regulated learning and expanded models of self-regulation. An example is the learner's volitional processes that keep learning on track, particularly when there are more interesting things to
do (Corno, 2001). Strategies may be covert (e.g., tuning out classroom noise) and overt (e.g., controlling the task and/or the setting). In other words, volitional strategies include the management of time and other resources as well as prioritizing goals.

An expanded model of self-regulated learning describes two different student priorities in the classroom (Boekaerts & Corno, 2005). One is to achieve growth, which involves deepening one’s knowledge or enhancing cognitive and social skills. A second priority is to maintain emotional well-being, such as trying to look smart or to avoid harm (pp. 202–203). According to this model, the growth process is top-down and guided by the learner’s goals. In contrast, self-regulation may respond to cues in the environment and is bottom-up. For example, boredom, feeling coerced, or insecure may raise well-being goals, such as seeking entertainment (following boredom), self-determination (initiated by feeling coerced), or safety goals (precipitated by feelings of insecurity) (p. 204).

Summary. The self-regulatory system consists of informational cognitive structures of goals, outcomes, and behavior, and cognitive processes that perceive, evaluate, and regulate behavior. The self-system includes standards for one’s behavior, self-observation, self-judgment, and self-reaction. The goal of self-regulated learning is to regulate sources of personal, behavioral, and social-environmental sources of influence. Individuals set goals for themselves, pay deliberate attention to their behavior (self-observation), and compare their performance with preset goals (self-judgment). Depending on the comparison, they may reward themselves and set higher goals, exert further effort to meet the goals, or lower the goals.

Achieving accomplished performance in any field requires goal setting and self-evaluation. Familiar examples are concert pianists and other artists. Self-generated standards and reinforcements are particularly important in the development of innovations that often are initially resisted by society. Self-efficacy is important because it influences the individual’s choice of activities, effort and persistence, and tolerance of failure.

The development of the self-regulatory system depends on the reciprocal three-way interaction between the environment, personal influences, and behavior. Individuals abstract information from the behavior of others, and personal factors influence the development of generic standards from those behaviors. The individual’s behavior influences both the environment and one’s personal reactions. The consequences in the environment, in turn, influence both personal perceptions and subsequent behavior. In some situations, the three-way interaction can lead to the disengagement of self-evaluative capabilities and the development of reprehensible conduct that is sanctioned by some in the environment.

**PRINCIPLES OF INSTRUCTION**

A theory of instruction has yet to be derived from social-cognitive theory. However, the principles of the theory have major implications for the classroom. The theory has been implemented successfully in the acquisition of both motor and cognitive skills. Early applications to cognitive skills included linguistic rules,
concept formation, and problem solving (see Rosenthal & Zimmerman, 1973, 1976, 1978). In recent years, modeling has been used to teach learning strategies. Examples include finding the main idea in paragraphs, setting up word problems, and monitoring one’s own learning. Recall the references to teacher modeling in Chapters 6 and 7.

Basic Assumptions

The three major assumptions that support the principles of social-cognitive theory also are applicable to classroom instruction. They are (a) the learner’s cognitive processes and decision making are important factors in learning; (b) the three-way interaction between the environment, personal factors, and behavior is responsible for learning; and (c) the outcomes of learning are visual and verbal codes of behavior.

The Components of Instruction

In social-cognitive theory, the essential components of learning are a behavioral model, reinforcement to the model, and the learner’s cognitive processing of the modeled behaviors. The components of instruction, therefore, are (a) identifying appropriate models in the classroom, (b) establishing the functional value of behaviors, and (c) guiding the learner’s internal processing, which includes facilitating the learner’s sense of self-efficacy.

Identifying Appropriate Models

In the classroom, both teachers and students can serve as live models for a variety of academic and social behaviors. For adolescents, the influence of peer models often is emphasized. However, the teacher is responsible for the classroom and is important as a model of responsibility, integrity, sincerity, and concern for both the individual and the collective welfare of the students (Brophy & Putnam, 1979, p. 196). At any level of education, the teacher or faculty member should model emotional maturity, rationality, “common sense,” and consistent follow-through on commitments (Brophy & Putnam, 1979).

Community members, such as firefighters, police, doctors, nurses, and other models who are interesting to young children, can be invited to spend some time in the classroom. To be maximally effective, however, a planned program of community involvement is needed. Visits or talks that appear to fill up time or give everyone a break on Friday will be ineffective. They also may convey the message that being a responsible adult is not important and does not contribute to self-worth.

Symbolic models also are effective influences in the development of prosocial behaviors. Research on Sesame Street and Mister Rogers’ Neighborhood, for example, indicated that the modeled prosocial behaviors enhance children’s cooperativeness and friendliness (see Leifer, 1976).

The selection of a live or symbolic model often depends on practical considerations. For cognitive and motor skills, the advantages of the live model are (a) the physical demonstration of the behavior in front of the students and (b) the opportunities for student questions. The chemistry class in which the use of laboratory equipment often is demonstrated by the teacher is an example.

Another example is the method referred to as reciprocal teaching, discussed in Chapter 9. The method teaches four strategies to enhance students' comprehension of text (Palinscar & Brown, 1984). Initially, the teacher models these strategies. Then, as students become more proficient, they become peer models for other students.

The major advantage of symbolic modeling is that the models may be viewed more than once by students. In one study, for example, a videotape was used to teach toothbrushing skills to children in Head Start classrooms (Murray & Epstein, 1981). In a project supervised by this author, videotapes of classroom teachers with their classes were made available to undergraduates about to undertake their own student teaching. The undergraduates returned to the tapes several times, reporting that they found something informative and interesting on each viewing.

In addition to the selection of the model, another important consideration is the selection of the behaviors to be modeled. They should be interesting to the observer and portrayed at a level of complexity to be understood by the learner. Also significant are the type and status of the model. Some research indicated that children are more likely to remember the actions of a friendly, powerful person than those of a cold, neutral person (Baldwin, 1973).

Nurturance of the model, however, must be implemented with care in powerful models. Because the young child seeks feedback from nurturant authority figures, expressive features can detract the child’s attention away from modeled behaviors. This potential problem can be counteracted by the use of verbal directives focused on the relevant behavior as well as the display of minimal expressive reactions during modeling.

**Establishing the Functional Value of the Behavior**

According to social-cognitive theory, individuals pay attention to events in the environment that predict reinforcement (Bandura, 1977b, p. 85). They tend to ignore events that do not include reinforcement predictions. Therefore, Bandura (1977b) recommended that instruction should attempt to establish an expectancy for positive outcomes. Such an expectancy increases task attention.

Events that predict reinforcement have acquired functional value for the student and will be attended to. In the classroom, establishing the usefulness of new learning for the students is important. First-grade children, for example, frequently view the purpose of assignments as content coverage rather than content mastery (Anderson, 1981).

Also, in teaching learning strategies, students must learn when to use them and why they are used (the metacognitive knowledge described in Chapter 7). For example, skimming is a strategy for previewing the information in a text passage. (It is dysfunctional if used merely to skip difficult words or sentences.) For
a student to sense the need to use skimming and to spend effort in executing it, skimming must have utility (Paris, Lipscom, & Wilson, 1985, p. 304). Otherwise, it will be used only to comply with a teacher’s request.

Establishing the functional value of social behaviors is also important in the classroom. Reinforcement to peer models for working quietly, proceeding in an orderly manner to recess, and so on can influence the adoption of those behaviors by classmates.

Two cautions, however, must be observed in the use of reinforcement. First, vicarious reinforcement differs from implicit reinforcement. Exemplary behavior that is praised in one individual and disregarded in others may to the teacher imply reinforcement to all the students who behaved well. To the slighted individuals, the direct consequences of their behavior (i.e., no reinforcement) may be perceived as punishment.

The second caution is that reinforcement, like beauty, is in the eye of the beholder. The same compliment, when given to two different individuals, can have different effects. Similarly, the omission of expected punishment conveys the impression of permissiveness. Behavioral restraints are reduced, and the formerly forbidden behaviors are performed with greater freedom (Bandura, 1971a). Therefore, clearly stated rules in the classroom must be maintained when transgressions occur.

Guiding the Learner’s Internal Processes

The recommended instructional activities vary somewhat, depending on the type of skill to be learned. Different emphases are required for cognitive and motor skills. However, for both types of skills, instruction should provide opportunities (a) to code the observed behavior into visual images or word symbols and (b) to mentally rehearse the modeled behaviors. Unless imitative performances are symbolized in memory codes and then stabilized through rehearsal, neither the memory codes nor the behaviors can be retrieved later (Bandura & Jeffrey, 1973). Also important is facilitating the learners’ sense of personal efficacy.

Motor Skills. Successful performance of complex motor skills such as golf, skiing, and tennis depends on the individual’s internal monitoring of kinesthetic feedback. A recommended strategy consists of (a) the presentation of a videotaped model, (b) the opportunity to develop a conceptual representation, and finally, (c) practice with concurrent visual feedback via a monitor (Carroll & Bandura, 1982). The strategy can be successful in teaching a new motor skill that is outside the learner’s visual field, such as executing the backstroke.

Of primary importance is that mental rehearsal by the learner should precede physical execution of the skill (Jeffrey, 1976). Mental rehearsal fulfills an organizational function for the subsequent performance. Also, too early an emphasis on motor performance can jeopardize retention at a time when memory codes are unstable.

Delayed self-observation following modeling is also very useful for social and communication skills. Students in speech and debate, for example, can acquire essential information about needed changes in posture, voice level, gestures, and presentation and response styles.
**Conceptual Behavior.** Initial studies indicated that children can infer judgmental rules from models when instructed to find consistencies across presented situations (Rosenthal & Zimmerman, 1978; Zimmerman & Rosenthal, 1974). However, in the classroom, the use of modeling alone appears to be less effective than when combined with some form of verbal instruction (Schunk, 1986). Verbalization during modeling should be carefully selected, however, so that it conveys important information. In addition, overt responding by the learner should not be required. Organizing and producing verbal responses appears to interfere with the observation of the behavioral sequence (Zimmerman & Rosenthal, 1974).

**Facilitating Learner Efficacy.** Important for impulsive children is to exercise self-control when faced with new or ambiguous tasks. A plan developed by Meichenbaum and Goodman (1971) to teach impulsive children to manage their own behavior uses modeling combined with verbalized self-instruction. The method has been used for the self-regulatory training of underachieving children (see Fox & Kendall, 1983; Loper & Murphy, 1985).

An adult first models self-talk in three aspects of monitoring one’s own learning. They are (a) problem definition (“What is it that I have to do?”), (b) self-instructions that focus on the task (“Now stop and repeat the instruction”), and (c) self-reinforcement and self-evaluation (“Good, I’m doing fine”; “That’s OK, I can take my time until I get it right”) (Meichenbaum & Goodman, 1971).

After observing the model, the students undertake four practice phases. The phases are (a) imitation of the model with guidance, (b) performance of the task while verbalizing aloud, (c) practice while whispering, and (d) practice using silent speech.

Student self-efficacy in the classroom also may be enhanced by observing the success of peers who are perceived to be similar in competence. Children with difficulties in subtraction who observed both the teacher and a peer model scored higher on self-efficacy, persistence, and achievement than those who observed only the teacher or no model (Schunk & Hanson, 1985).

**The Role of Teacher Efficacy.** Teacher efficacy refers to the extent that the teacher believes he or she has the capabilities to effect student performance (McLaughlin & Marsh, 1978, p. 84). Specifically, it is a “teacher judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated” (Tschannen-Moran & Woolfolk Hoy, 2001, p. 783). Several studies reported that teacher efficacy is related to student gains and that teachers in effective schools have a strong sense of efficacy (see Guskey, 1987, and Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998, for a discussion).

One model of teacher efficacy maintains that it consists of two joint simultaneous decisions. One is analyzing the teaching task, which included the various factors that contribute to the difficulty of the task weighed against available resources to facilitate learning; the other is the teacher’s self-perceptions of his or her personal teaching competence (Tschannen-Moran et al., 1998, p. 228).
In other words, like student efficacy, teacher efficacy refers to a particular context, such as teaching probability to middle school students.

Efficacy influences a variety of teachers’ actions. Included are the goals they set, their level of aspiration, and effort invested in teaching. Teachers with a strong sense of efficacy are more open to new ideas, are more willing to experiment with different methods that may help their students, and exhibit greater enthusiasm for teaching (Allinder, 1994; Ashton & Webb, 1986; Tschannen-Moran & Woolfolk Hoy, 2001, pp. 783, 784). They also are nonauthoritarian, persist with struggling students, providing them with the help they need to be successful, and praise students for their accomplishments (Gibson & Dembo, 1994). In addition, they support the development of students’ academic self-direction (Woolfolk & Hoy, 1990).

In contrast, teachers with a low sense of instructional efficacy tend to use a custodial orientation that relies primarily on external inducements and negative sanctions to promote academic work. Such teachers also spend more time in nonacademic activities and quickly give up on students if they do not get results (Gibson & Dembo, 1984; Woolfolk & Hoy, 1990). They also tend to identify low ability as the reason some students cannot be taught (Bandura, 2000, p. 4).

Teacher efficacy, however, does not function in isolation. Bandura (2000) noted that self-efficacy plays a key role in cognitive development and accomplishment through three pathways. They are (a) “students’ beliefs in their efficacy to regulate their learning activities and master academic subjects, (b) teachers’ beliefs in their personal efficacy to motivate and promote learning in their students; and (c) the faculty’s collective sense of efficacy that their schools can accomplish significant academic progress” (p. 4). Collective teacher efficacy is the perception of teachers that the school faculty will have a positive effect on student achievement (Goddard, Hoy, & Woolfolk Hoy, 2000, p. 486). However, it is not simply a summation of individual perceptions of themselves. Instead, collective teacher efficacy refers to “individual perceptions of the capabilities of the entire faculty in a school organization” (Henson, 2002, p. 142). It is an example of the collective efficacy concept described by Bandura (1997), which consists of the shared perceptions of group members about “the performance capability of a social system as a whole” (p. 469). Early research suggests that goal consensus among faculty is an indicator of collective teacher agency. However, people’s shared beliefs in their collective capability to produce desired outcomes is the key component of collective agency (Bandura, 2000, p. 4).

**Designing Instruction for Complex Skills**

Social-cognitive theory addresses the learning of complex skills in three ways. One is to model and teach effective strategies for success in complex tasks. Examples in reading include analyzing word parts and using context to determine word meaning. The second application is that of modeling strategies for directing and monitoring one’s own learning. For example, talking through unobservable processes as part of modeling learning strategies is essential. Recall the example in Chapter 7 in which the teacher verbalized her uncertainty in understanding a paragraph and noted she would reread it and summarize it in her own words.
Making unobservable processes explicit is particularly important for low-achieving students. Unlike other students, low achievers do not develop these skills spontaneously (Brophy, 1988; Corno, 1986). Even if motivated to learn, low-achieving students tend to depend on rote memorization and other inefficient learning skills. Also, special needs students may exhibit low motivation, high anxiety, or dysfunctional behavior resulting from a poor home environment (Boekaerts & Corno, 2005).

The third application of social-cognitive theory in developing complex skills includes two general approaches. They are to (a) promote new self-regulatory skills and strategies, and (b) encourage and support self-regulation when it emerges in the classroom (Boekaerts & Corno, 2005).

Developing students' self-regulatory skills requires attention to students' personal characteristics, their present behavior, and ways that aspects of the environment interact with the other two components of the triad.

An example of a supportive environment for self-regulation in reading and writing in first grade gave the children choices, provided opportunities to control challenges, provided support, and gave feedback that was nonthreatening (Perry, Vande Kamp, Mercer, & Nordby, 2002, p. 9). In the area of writing, research indicates that teachers should (a) make writing an enjoyable and interesting activity, (b) provide opportunities for students to initiate and direct their own efforts, (c) use writing tasks that require self-regulation (narrating a personal experience is not one), and (d) model self-regulation, providing strategy assistance to students as they write (Graham & Harris, 1994, p. 223).

**EDUCATIONAL APPLICATIONS**

Social-cognitive theory has two major implications for education. First, modeling is a primary source of information for learners. The theory identifies situations in which children acquire information from the models in the mass media as well as from family models and others. Second is the importance of a sense of personal efficacy and self-regulatory skills in becoming a successful learner.

**Classroom Issues**

Social-cognitive theory addresses some of the issues of concern in the classroom setting. It also addresses some learner characteristics and aspects of the social setting for learning.

**Learner Characteristics**

Individual differences, readiness, and motivation for learning are the student characteristics that interact with instruction. Both individual differences and readiness are discussed in social-cognitive theory in terms of their relationship to learning through observation.

**Individual Differences.** Learners differ in their ability to abstract, code, remember, and enact the behaviors that they see. They also differ in their receptivity to
models. Behaviors watched intently by nature lovers, for example, will be considered
dull and boring by others. Receptivity to a particular model varies along the dimen­
sions of (a) the valuation of the behavior for the observer and (b) the degree of sim­
ilarity between the observed model/context of the behavior and the observer’s status
and situation.

In the classroom, after the early school years, students also will differ on
the functional value of the learning outcomes established by the school or the
teacher. Some students will enthusiastically engage in learning activities, many will
be more or less passively compliant, and others who perceive no social value in
the outcomes may engage in antisocial behavior.

**Readiness.** The developmental level of the learner and receptivity to particu­
lar models are the two major factors that determine the individual’s capability for
observational learning. The learner’s perceptual set and the degree of anticipated
reinforcement influence the decision to attend to or to ignore the model. The
ability to abstract the important features of the modeled behaviors and to recall
them later without error also influences the extent and accuracy of the learning.
Young children, for example, cannot process complex sequences of behaviors.
Instead, they require short explicit visual sequences with repetition.

**Motivation.** Although some activities are initiated for direct reinforcemen­
te (e.g., activities prompted by thirst, hunger, pain, etc.), the primary source of moti­
vation is cognitively based (Bandura, 1977b, p. 161). Two types of cognitive motiv­
vators are included. One is the cognitive representation of future consequences
for particular behaviors. “Past experiences create expectations that certain actions
will bring valued benefits, that others will have no appreciable effects, and that still
others will avert future trouble” (Bandura, 1977b, p. 18).

The second type of cognitive motivator may be referred to as self-motivation
because it involves the standard setting and self-evaluative mechanisms of the
learner. This type of motivation develops as part of the individual’s self-regulatory
system, discussed earlier.

**Cognitive Processes and Instruction**
Transfer of learning, developing the individual’s learning-how-to-learn skills, and
teaching problem solving are cognitive issues of importance to education. Of the
three, social-cognitive theory discusses the first issue.

**Transfer of Learning.** The concept of transfer has been researched in the social-
cognitive context in two ways. One is the investigation of different treatments
for patients with phobia. Self-directed mastery experiences were found to be
more effective in providing transfer to generalized threat situations than partic­i­
participant modeling alone (Bandura, 1976; Bandura, Adams, & Beyer, 1977).

**Implications for Assessment**
Social-cognitive theory introduces two concepts that refer to personal character­
istics of the learner and that are influential in learning. They are self-regulation and
self-efficacy. As these concepts gained prominence in both classroom research and interventions for the classroom, researchers have developed and discussed methods of assessment.

Self-regulation in learning may be assessed in any of several ways (Boekaerts & Corno, 2005). Included are self-report surveys, think-aloud protocols, unstructured interviews, structured interviews, student diaries, and observations of classroom dialogue. Issues with self-report surveys are the same for self-efficacy and are discussed in subsequent paragraphs. Think-aloud protocols require that the student talk aloud about the steps he or she is taking during problem solving or some other academic task. Two problems associated with protocols are that (a) this requirement is difficult for some students and (b) the speech can actually alter the cognitive process itself. Keeping diaries, in which the student records his or her activity every 30 minutes, can be useful for students who tend to believe that they study more than they actually do. However, analyzing diaries is not practical for the classroom teacher.

For the teacher, logical assessments are some form of interview, which provides qualitative data, and/or observations. Unstructured interviews permit students to describe the ways that they manage their learning, whereas structured interviews consist of specific questions (Boekaerts & Corno, 2005, p. 210). Examples are What are your study goals in “X” subject? How do you organize your study activities?, and What do you do when you experience difficulties?

Researchers who implement classroom observations identify in advance the categories of self-regulation to be observed (e.g., orientation to the task, resource management, and/or checking progress) and whether time periods or events are the focus (Boekaerts & Corno, 2005, p. 209). Teachers can note instances of self-regulation in individual and group work, which may be addressed further in brief teacher-student conferences.

Researchers frequently assess self-efficacy, and also self-regulation, through self-report surveys. Items related to self-efficacy often begin with the phrase, “How confident are you that you can . . . ” followed by various activities, such as succeed in mathematics, solve problems that you have not seen before, and so on. Items related to self-regulation typically ask questions such as “How well do you . . . ” organize your class work, plan what you are going to do before beginning a class project, and so on. Respondents choose from a range of possible responses from “very well” to “not well at all.” Some surveys use declarative statements and the answer choices range from “very true of me” to “not true of me.”

Particular problems with surveys of self-efficacy and self-regulation are that (a) data on self-efficacy, described as a dynamic construct, is in the form of cross-sectional snapshots (Henson, 2002, p. 142); (b) data on self-regulation, a continuing process, is captured at one point in time (Nenninger, 2005); (c) research on self-regulatory skills indicates a varying number of scale factors, depending on the instruments (Gredler & Garavalia, 2000b; Gredler & Schwartz, 1997; Pintrich & DeGroot, 1990); and (d) some self-efficacy assessments tend to focus on basic competencies rather than beliefs about mastering situations with novel or ambiguous elements. Also, students tend to overestimate their self-regulatory skills (Boekaerts & Corno, 2005; Pajares, 1996). In one study of 225 entering freshmen,
provisionally admitted students (with insufficient SAT scores or high school grades) did not differ in their beliefs about their self-regulatory capabilities from fully admitted (qualified) freshmen (Gredler & Garavalia, 2000a).

A more basic issue with self-report instruments on self-efficacy, self-regulation, and other cognitive, perceptual, and affective processes is that respondents are likely to interpret survey items in different ways (Karabenick et al., 2007). An example is the item “My math teacher helps us to apply math in our lives” (p. 144). Some children failed to process both the intended classroom activity and the connection to the real world. One learner, for example, interpreted the item as referring to long-range effects of paying attention or not paying attention to the teacher (p. 145). To address this problem in survey development, Karabenick et al. (2007) recommend cognitive pretesting, an interview technique that probes respondents’ meaning associated with individual survey items (Willis, 2005). The interview consists of three questions: What is the question trying to find out from you? Which answer would you select as the right answer for you? and Can you explain why you chose that answer? (Karabenick et al., 2007, p. 143). Children’s answers to these questions can provide information for improving the clarity of self-report items.

In summary, researchers have developed several approaches to assessing self-regulation and self-efficacy. For the classroom teacher, assessing self-regulation through observations in which the teacher keeps anecdotal notes and teacher–student conferences are the most practical. Self-report surveys, which are frequently used in research, require careful attention to development to ensure that the items are addressing the intent of the survey.

The Social Context for Learning

Social-cognitive theory addresses the issue of learning in the naturalistic setting. Thus it describes specifically the mechanisms by which individuals learn from each other as they go about their daily lives. The observation of a variety of models (family members, regular associates, films, television) and the reinforcements delivered to peers and others are all important influences on learning. In particular, social-cognitive theory reminds the educational system that learning in a media-oriented society extends beyond the classroom in subtle and pervasive ways.

Relationships to Other Perspectives

Bandura’s social-cognitive theory describes learning in the naturalistic setting. Observing peers and others (models), learners abstract behaviors relevant for them and later execute these actions. Bandura’s concept of modeling plus reinforcement to the model is a key feature of Gagné’s attitudinal domain. Furthermore, cognitive theorists recommend teacher modeling and verbalization of learning and metacognitive strategies. Although the theory refers to the learners’ attentional and retention processes, these processes are not prescribed in detail (unlike Gagné’s internal conditions or the phases of information processing).

Like operant conditioning, social-cognitive theory incorporates both direct and self-reinforcement. A key difference is the inclusion of vicarious reinforcement, the physiological effects of observing reinforcement accorded the model.
The self-regulatory system, essential for complex learning, includes the metacognitive skills of monitoring and evaluation. However, descriptions of the self-regulatory system also include goal setting, learner values and interests, perceptions of the learning environment, and learner self-efficacy.

In the classroom setting, social-cognitive theory assumes that instruction is teacher managed and directed and the individual student is the locus of learning. Thus, it differs from social constructivist perspectives in which a community of learners is primary.

**Developing a Classroom Strategy**

The design of instruction for observational learning includes a careful analysis of the behaviors to be modeled and the processing requirements for learning.

**Step 1:** Analyze the behaviors to be modeled.

1.1 What is the nature of the behavior? Is it primarily conceptual, motor, or affective, or is it a learning strategy (such as rereading difficult paragraphs and making notes)?

1.2 What are the sequential steps in the behavior?

1.3 What are the critical points in the sequence, such as the steps that may be difficult to observe and those for which alternative incorrect actions are likely?

**Step 2:** Establish the functional value of the behavior and select the behavioral model.

2.1 Does the behavior or strategy carry a “success prediction,” such as learning to operate equipment essential for a job promotion?

2.2 If the behavior is a weak success predictor, which potential model is most likely to predict success? Examples include peers, the teacher, and status models that appeal to the target group.

2.3 Should the model be live or symbolic? Consider cost, the need to repeat the experience for more than one group, and the opportunity for portraying the functional value of the behavior.

2.4 What reinforcement(s) is the model to receive for the behavior?

**Step 3:** Develop the instructional sequence.

3.1 For motor skills, what are the “do this” but “not this” verbal codes to be used?

3.2 Which steps in the sequence are to be presented slowly? What are the verbal codes that supplement but do not supplant these steps?

3.3 For a learning strategy, what unobservable processes and self-talk are to be modeled?

**Step 4:** Implement the instruction to guide the learner’s cognitive and motor reproduction processes.

**Motor Skills:**

4.1 Present the model.
4.2 Provide students the opportunity for symbolic rehearsal.
4.3 Provide student practice with visual feedback.

Conceptual Behavior:
4.1 Present the model with supporting verbalization.
4.2 If a concept or a rule, provide students with opportunities to summarize the modeled behaviors.
4.3 If the learning is a problem-solving or strategy application, provide opportunities for participant modeling.
4.4 Provide opportunities to generalize to other situations.
4.5 Assist the students in analyzing their applications and setting goals.

Classroom Example

The behaviors modeled in the following example are note-taking skills. The identified population is middle school students (ages 10–14, grades 6–8).

The teacher first models the strategy of note taking from written text. Important in this exercise is that the teacher model the process in which a particular recall cue is chosen over another. The teacher should “talk aloud” the cues that come to mind and the reasons for rejection of poor cues. After the teacher’s demonstration, the students suggest the notes to be taken in the next two exercises. This activity provides for corrective feedback early in the learning. The students then complete a note-taking exercise on their own. This activity provides the symbolic coding and mental rehearsal necessary for conceptual behavior.

The follow-up exercise that demonstrates note taking from audiotaped material should be initiated only after the students have applied their skills for written materials in a variety of situations. Taking notes from an ongoing oral presentation is a difficult skill to learn. It is dependent on good listening skills and practice in the use of temporary auditory memory. In teaching this skill, exercises in listening and recall of oral material may be required prior to the note-taking exercise.

The teacher explains the importance of note taking in helping the students to remember material that they have heard or read. Also, good note-taking strategies should help them remember important information for tests.

Before beginning the actual classroom exercise, the teacher and students determine an initial goal for the skills to be learned. For example, they may decide that the goal should be to develop good recall cues for three important points in a short reading passage.

The teacher then distributes a four-paragraph reading selection and asks the students to read the first paragraph silently while the teacher reads it aloud.

A transparency that illustrates the note-taking format is placed on the overhead projector. It is divided into two columns, headed “recall cues” and “notes.”

The teacher talks through the first paragraph in terms of its important points. Then under the “notes” column, two summary sentences for the paragraph and

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2 Example designed by Sharon Cohn, University of South Carolina
3 Suggested by W. Paulk, How to Study in College (New York: Houghton Mifflin, 1962)
associated cues in the “recall cues” column are entered. The teacher verbalizes the ways in which these sentences and the recall words will help students to remember the paragraph.

The teacher then carries out the same procedure with the other two paragraphs. After reading each one aloud, the teacher talks through several alternatives for notes, selects one or two, and enters them in the appropriate column with associated cues. The importance of the exercise is that the students observe the ways in which the teacher analyzes the paragraph and selects summary sentences.

The students and the teacher then work through two or three exercises together, with the students suggesting the study notes. This activity is followed by independent note taking by the students on short passages that they have selected from other sources.

The teacher reviews the notes developed independently by the students on short passages they have selected and gives each student feedback on progress toward the initial goal. Suggested changes are made to students who are having difficulty with the assignment.

**Reading Passage for Note-Taking Exercise**

A land grant of 10 million acres was given to George Calvert, a prominent nobleman from England known as Lord Baltimore. The land given by the king, Charles I, was located near Chesapeake Bay, and this gift enabled George Calvert to exert tremendous power. He was capable of establishing manors that resembled those of the feudal era, and of treating the inhabitants as serfs. He also functioned as a prosecutor and a judge of inhabitants charged with law breaking. George Calvert was called a proprietor, or an owner of landholdings, and his colony was known as a proprietary colony.

Prior to the king’s seal being affixed to the charter describing the land grant, George Calvert died, and his son served as the first proprietor. The colony was known as Maryland, named after the wife of Charles I, Queen Henrietta Maria. Since the Calvert family was Catholic, they intended to establish a Catholic colony in Maryland.

In 1634 the first settlers arrived and established the town of St. Mary’s. The settlers could obtain food and other provisions from the adjacent and prosperous colony of Virginia. They did not have to wait for ships from England. They did not waste time looking for gold; instead, they immediately began to grow tobacco.

**Note-Taking Exercise II**

In this exercise, the teacher has previously recorded a script on audiotape. The speech is recorded with short pauses, much as one might give a talk to a group. In the modeling, the teacher plays each paragraph of the recorded tape and demonstrates how to take notes while the tape is playing. She writes recall cues and sentence fragments on the transparency during the brief pauses in the tape. The tape is stopped at the end of each paragraph, and the teacher completes the sentence fragments.

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After the demonstration, the students and the teacher complete several short paragraphs together. This exercise is usually quite difficult for students because it involves listening and jotting down notes at the same time. Therefore, only very short paragraphs should be used until the students' skills are acquired; this may require several exercises over a period of time.

**Taped Paragraph**

In the 17th century a cluster of religious reformers resided in England. These reformers were critical of the Church of England. However, they did not want to separate from the church. They wished to reform and to purify the church from the inside. These reformers were called Puritans.

**Review of the Theory**

Albert Bandura's social-cognitive theory began with his analyses of prior approaches to the learning of imitative behavior. Prior theories proposed a variety of mechanisms to account for the adoption of prosocial and antisocial behaviors. Included were reinforcement for imitation, nurturance, power, envy, and frustration.

In contrast, Bandura proposed a single paradigm to account for the acquisition of both prosocial and antisocial behaviors. The components are (a) the modeled behaviors, (b) the consequences of the model, and (c) the learner's cognitive processes (Table 10.6). The consequences received by the model that contribute to the observer's learning the behavior include vicarious reinforcement, and the absence of anticipated punishment. These consequences signal behaviors that have functional value and therefore may be useful to the observer. Later successful performance by the observer depends in part on the learner's cognitive processes (attention, retention, motor reproduction, and motivation).

Learning, according to Bandura, is represented by a three-way interaction among the environment, the individual's internal events, and the individual's behavior (reciprocal determinism). Also included in the theory is the development of the self-regulatory system, a necessary component in the development of outstanding performance in any area. Included in the system are a sense of personal efficacy, goal setting, self-evaluation, and self-directed rewards or punishments.

**Disadvantages**

Bandura identifies the importance of the learner's self-direction and sense of efficacy in interacting with the environment. However, in the limited classroom setting, developing the learner's self-regulatory system and sense of efficacy is a difficult task.

**Contributions to Educational Practice**

Important contributions are the effects of environments and behaviors modeled in the electronic media and the detailed descriptions of the role of models, reinforcement, and punishment in the classroom setting. That is, punishment or lack

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5Paraphrased from J. A. Garraty et al., *American History* (New York: Harcourt, 1982)
TABLE 10.6
Summary of Bandura's Social-Cognitive Theory

<table>
<thead>
<tr>
<th>Basic Elements</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumptions</td>
<td>Learning is a three-way interaction between the environment, personal factors, and behavior that also involves the learner's cognitive processes</td>
</tr>
<tr>
<td>Components of learning</td>
<td>Modeled behaviors, consequences to the model, and the learner's cognitive processes</td>
</tr>
<tr>
<td>Learning outcomes</td>
<td>Verbal and visual codes that may or may not later be performed</td>
</tr>
<tr>
<td>Designing instruction for complex skills</td>
<td>In addition to component skills, develop the learner's sense of efficacy and self-regulation</td>
</tr>
<tr>
<td>Major issues in designing instruction</td>
<td>Provide for mental rehearsal prior to practice; avoid omission of reinforcement and punishment when needed; avoid excessive use of punishment</td>
</tr>
</tbody>
</table>

Analysis of the Theory

| Disadvantages | Difficult to implement the requirements for self-efficacy and self-regulation along with other classroom priorities |
| Contributions | Description of the variety of attitudes and behaviors acquired from the mass media |
|              | Provides a detailed description of the mechanisms of reinforcement and punishment in the group setting |
|              | Identifies the importance of self-efficacy in learning |

of it delivered to others as well as vicarious reinforcement are both operating in the classroom setting. Another contribution is the identification of the role of personal efficacy in learning.

CHAPTER QUESTIONS

Understanding Concepts

1. In Chapter 2, one technique for unconditioning children's fears used other children's acceptance of the feared object. According to social-cognitive theory, why was this technique successful?
2. Which types of reinforcement or punishment are likely to be operating in the following situations?

(a) Three classmates are allowed to go to the library early because they completed their assignments early.
(b) A student who is studying for a difficult final exam promises herself a day at the beach if she does well on the test.
(c) Kazdin (1989) indicated that when brief time-outs (removal from the group or class) are administered to disruptive
students, the number of similar incidents in the classroom tends to decrease.

3. Describe a television commercial in which an action or belief demonstrated by a model earns positive consequences for the model.

4. What are some similarities and differences between self-efficacy and self-concept?

5. What is the relationship between metacognition and self-regulation?

Applying Concepts to Instructional Settings

1. A few students in a classroom are struggling with the concept of negative numbers. How would a teacher with high efficacy address this problem? How would his or her actions differ from those of a teacher with low efficacy?

2. Several students in a classroom have worked quietly on their homework during the last 15 minutes of class. The teacher compliments one of the students in the group for appropriate behavior. What has the teacher done wrong?

REFERENCES


CHAPTER 11

Cognitive Models and a Theory of Academic Motivation

Motivational psychologists and educators... are interested in... how [children's] thinking affects their actions—their important choices in school, their engagement with academic tasks, their ability to persist effectively in the face of setbacks. (Dweck, 2002, pp. 80-81)

Students' thoughts and feelings about schooling and school tasks are a major focus in current research and theory about learning. An example, discussed in Chapter 10, is self-efficacy. Students with high self-efficacy increase their effort on difficult tasks, persist when they encounter obstacles, and tend to set challenging goals for themselves. The focus on self-efficacy and other student beliefs and values differs from early views that proposed instincts and will as accounting for motivation.

An example of the role of student beliefs is John W. Atkinson's (1958, 1964) model of achievement motivation. The model identified the individual's disposition to either strive for success or avoid failure as key motivating factors. If the student's motive for success is high, then he or she is likely to engage in achievement tasks. However, if the disposition to avoid failure is high, the student will avoid achievement tasks as much as possible, often procrastinating or handicapping him or herself in other ways (Covington, 1992). Atkinson's model also identifies two other important aspects of the student's belief system that influence achievement motivation. They are expectancy for success and the incentive value of success, identified as pride in accomplishment.

A different approach to motivation is the view that understanding the causes of past events influences an individual's future actions. This approach began with the work of Fritz Heider (1958) who focused on the causes of events developed by "the man in the street" (p. 79). For example, suppose that one's foot is stepped on during a subway ride. The possible sets of conditions responsible for this and other outcomes of human action are factors within the person and factors in the
environment. The first question is, What are the perceived causes (e.g., standing too near the door, an aggressive act, etc.)? Second, What information influenced the identification of a cause (e.g., the belief that one is clumsy, a clenched fist)? Third, What are the consequences of the selected cause (attribution)? In other words, attribution theorists focus on the ways that people answer the question, Why?

A subsequent development, referred to as locus of control (Rotter, 1966), specified that the perceived causes of behavior lie on a continuum between the two extremes of internal and external locus of control. Individuals who believe that reinforcements (positive consequences) are the result of hard work and planning also believe that they control their own destiny. They are, therefore, inner-directed and take responsibility for events in their lives. Arriving late to class is likely to be acknowledged as the result of leaving home too late to find a parking place, rather than some vague external condition.

In contrast, individuals who are outer-directed perceive no relationship between their behavior and reinforcements. Instead, luck, fate, or powerful others are in control. Therefore, the student may believe that a D on a test is the result of lack of ability (internal locus) or the result of teacher bias (external locus). A variation of this conceptual framework is described in the origin/pawn analysis by deCharms (1968). Origins initiate behavior intended to produce a change in the environment. Pawns, in contrast, perceive that they are pushed around by the environment.

Since the development of these initial models of motivation, society has become more complex and the importance of schooling has also increased. Careers typically require more than a high school diploma, and access to higher education often depends on meeting particular requirements. Therefore, research on motivation has moved beyond the laboratory to the classroom and incorporates various factors related to real-world settings. Currently, the major approaches to conceptualizing achievement-related motivation include the expectancy–value model, goal-orientation models, and attribution theory.

**PRINCIPLES OF MOTIVATION**

Prior chapters in this text discuss theories of learning or cognitive development. They describe either the factors necessary for the achievement of particular skills and capabilities or the conditions essential to cognitive growth in thinking. Motivational models and theories, in contrast, focus on factors that influence students’ engagement in achievement-related activities.

**Basic Assumptions**

The major approaches to the analysis of motivation share three major assumptions. First, an individual’s motivation is the result of interactions between environmental factors and the child’s particular characteristics (Wigfield & Eccles, 2002b). (See Table 11.1.) Among them are social norms, the performance records of others (Weiner, 1974a), the affective reactions of teachers to students’ successes
TABLE 11.1  
Assumptions Shared by Motivational Models and Attribution Theory

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Model or Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. An individual's motivation develops from a complex interaction of</td>
<td>Expectancy–value model</td>
</tr>
<tr>
<td>environmental factors and factors within the child.</td>
<td>Goal orientation models</td>
</tr>
<tr>
<td></td>
<td>Attribution theory</td>
</tr>
<tr>
<td>2. The learner is an active processor of information.</td>
<td>Same as above</td>
</tr>
<tr>
<td>3. A learner's motives, needs, or goals are explicit information.</td>
<td>Same as above</td>
</tr>
</tbody>
</table>

and failures (Weiner, Graham, Taylor, & Meyer, 1983), types of classroom goal structures (Ames, 1992b), students’ prior achievement history (Weiner, 1985b; Wigfield & Eccles, 2002a), and their beliefs about the nature of ability (Dweck, 2002).

Second, the learner is an active processor of information. At the highest level, self-assessment of one’s capabilities and the interpretation of information from the environment are involved in achievement-related motivation.

Third, and related to the prior assumption, is that a student’s motives, needs, or goals are explicit knowledge. This means that the student can reflect on these beliefs and communicate them to others (Murphy & Alexander, 2000, p. 38). This assumption is important because many studies of motivation rely on student self-reports in the form of surveys. However, Wigfield (1994) noted that the questionnaire format only indirectly assesses children’s beliefs. The reason is that the respondents to the survey can only address the constructs as defined by the researcher rather than generating their own definitions (p. 61).

In addition to the general assumptions, each particular view of motivation also includes assumptions specifically relevant to that perspective. For example, goal orientation models focus on the motivational role of students’ achievement-related goals. An assumption of one view of goal orientation is that the orientation of classroom goals influences students’ personal goal orientations (Ames, 1992b). That is, when the classroom orientation is mastery and classroom activities focus on developing student mastery of skills and capabilities, then students tend to subscribe to a mastery goal for themselves.

Components of the Motivational Process

Three approaches to the study of motivation in achievement-related settings are (a) the expectancy–value model, (b) goal orientation models, and (c) attribution theory.

The Expectancy–Value Model

The current expectancy–value model is an expansion of Atkinson’s (1958) model, which defined expectancy and value as motivational constructs. Unlike Atkinson’s model, the current version views expectancy and value as cognitive rather
than totally motivational (Wigfield & Eccles, 1992, pp. 278–279). They are also direct influences on achievement-related behaviors. For example, one form of value is attainment value. It refers to the importance of doing well in a particular domain or course. For example, algebra may be required for college admission and, therefore, has high attainment value.

The basic premise of the model is that students’ expectations of success and the value they place on success are important determinants of their motivation to engage in achievement-related behaviors (Wigfield & Eccles, 2002a, p. 91). In this model, however, “task” is typically measured at the domain level. That is, task refers to a subject area or a particular course, such as mathematics, biology, or social studies. Task does not refer to a specific activity (Wigfield & Eccles, 2000, p. 72; 2002a, p. 94).

The model identifies five achievement-related behaviors that are influenced by motivational processes. They are choice, persistence, extent of effort, cognitive engagement, and actual performance. That is, motivational beliefs may influence students’ choosing to enroll in biology, their persistence when faced with difficulties, the expenditures of considerable effort, and/or their final grade.

The two key motivational beliefs, task value and expectancy of success, are most directly determined by other achievement-related beliefs. (See Figure 11.1.) These related beliefs are summarized as the child’s affective memories and the goals and general self-schemata of the child.

**Task (Domain) Value and Expectancy Value.** Task value is an important component in the model because competence is an insufficient explanation of choosing to enroll in a subject or course. A student may be competent in an area, but
choose not to engage in it because it is not of sufficient value to the student (Wigfield & Eccles, 2002a, p. 94).

Task value in the model includes four components. They are attainment value, intrinsic value, utility value, and cost (Eccles et al., 1983; Wigfield & Eccles, 1992). Attainment value refers to the importance of doing well in a particular domain or course, and intrinsic value refers to the enjoyment for the student of doing well or the students' subjective interest (see Table 11.2). In assessing motivation beliefs in mathematics, the child indicates (a) the importance of being good in math on a range from not at all important to very important, and (b) the importance of being good in math compared to other activities.

Intrinsic value is assessed by asking the child how much he or she likes doing math and the extent to which working on math assignments ranges from boring to very interesting (Wigfield & Eccles, 2000, p. 70). In this assessment, level of interest is documented as an index of enjoyment.

Utility value refers to the usefulness of the course or domain for the child. One assessment of utility states that some things in school can help in learning to do things better out of class. The example is that learning about plants might help to grow a garden (p. 7). Then the student identifies the usefulness of the material he or she is learning in math. Thus, student responses may vary according to the topic currently under study.

Cost refers to the extent that choosing to engage in an activity, such as schoolwork, limits the opportunity to participate in other activities (p. 70). However, data collection on aspects of the model has primarily focused on the other three subtypes of value (importance, intrinsic value, and usefulness).

In the model, expectancy value refers to children's beliefs about the extent to which they will do well. Children are asked how well they expect to do in math this year and how well they will be able to learn something new in math (p. 70). Expectancy value, in other words, is, in part, an estimation by the child of his or her capacity of succeeding in the subject area or course. It is a prediction and, therefore, is future oriented.

**TABLE 11.2**
Components of Task Value in the Expectancy–Value Model

<table>
<thead>
<tr>
<th>Component</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attainment value</td>
<td>The importance of doing well in a particular domain or course</td>
</tr>
<tr>
<td>Intrinsic value</td>
<td>The enjoyment for the student of doing well or the student's subjective interest</td>
</tr>
<tr>
<td>Utility value</td>
<td>The usefulness of the course or domain for the child</td>
</tr>
<tr>
<td>Cost</td>
<td>The extent that choosing to engage in an activity, such as schoolwork, limits the opportunity to participate in other activities</td>
</tr>
</tbody>
</table>

Note: Compiled from Wigfield & Eccles, 2000
Direct Determinants of Task (Domain) Value and Expectancy. The two sets of beliefs that directly determine task value and expectancy are the student's affective memories and his or her goals and general self-schemata (Wigfield & Eccles, 2002a). Affective memories are activated by anticipation of engaging in the domain or course and involve the positive or negative emotions associated with prior similar experiences (Pintrich & Schunk, 2002, p. 62). For example, a student's motivation for enrolling in an advanced math class such as calculus is related to his or her affective reactions to prior math courses such as algebra.

The other set of supporting motivational beliefs, goals and self-schema, consists of the student's long- and short-term goals, perceptions of his or her "ideal self," perceptions of task (domain) difficulty, and the student's beliefs about his or her competence or ability. Ideal self refers to the kind of person the student seeks to become and is related to the student's perception of personal identity. For example, a student may view herself as someone who helps others. Her short-term goals may include volunteering at the local hospital during the summer break, and her long-term goal may be to become a social worker (Pintrich & Schunk, 2002, p. 62).

The model defines ability beliefs as the student's perceptions of his or her current competence in a particular area (Wigfield & Eccles, 2000). They differ from success expectancies, which focus on the future, whereas ability beliefs focus on the present (p. 70). Items that assess ability beliefs include How good in math are you? and Compared to the other students in your class, where do you put yourself? (p. 70). In other words, students' affective memories of similar prior experiences, their goals, personal identity, perceptions of ability, and perceptions of the difficulty of the subject directly determine their expectancies for success and the value of the course or subject for them.

Factors Contributing to Motivational Beliefs. The factors that contribute to students' motivational beliefs are the social world in which the student functions; his or her perceptions of the social experiences, environment, and prior achievement-related factors; and the student's aptitudes. Important elements in the child's social world, according to the model, include gender role stereotypes, cultural stereotypes of subject matter, and previous achievement-related experiences (Wigfield & Eccles, 2002a). For example, a cultural stereotype in the child's world may be that people who are Hispanic cannot be engineers because they are not good at math. Important perceptions that contribute to motivational beliefs are the student's perceptions of stereotypes and his or her interpretations of previous achievement-related experiences.

Summary. The current expectancy-value model expands Atkinson's (1958) model, but differs from it in two ways. The current model focuses on social-psychological reasons for students' choices, and tasks in the model refer to domains or courses of study. The two key motivational beliefs are task value (attainment, intrinsic, and utility values and cost) and expectancy value, the extent to which the child believes he or she will do well. These beliefs directly influence choice, persistence, extent of effort, and actual performance.
Task value and expectancy are directly determined by the child’s affective memories and the goals and self-schemata of the child. Affective memories consist of the positive or negative emotional reactions associated with prior similar experiences. Goals may be both short and long term, and self-schemata includes perceptions of the “ideal self,” perceptions of task (domain) difficulty, and beliefs about one’s ability. Contributing to these beliefs are the child’s social world, his or her perceptions of it and prior social experiences, and aptitudes.

**Goal Orientation Models**

In contrast to expectancy-value models, goal orientation models address students’ rationales for engagement in academic tasks (Anderman, Austin, & Johnson, 2002; Pintrich & Schunk, 2002). For example, a student’s goal in biology class may be to get an “A,” but this statement does not indicate the purpose for enrolling in the course. Goal orientation models, however, pursue whether the purpose was to learn new concepts, demonstrate one’s competence to others, or some other intent.

Formally stated, goal orientation refers to “a set of behavioral intentions that determine how students approach and engage in learning activities” (Meece, Blumenfeld, & Hoyle, 1988, p. 514). The original descriptions of students’ goal structures contrasted two general categories that reflect different purposes for engaging in achievement tasks. The designations, which are similar in their definitions, are (a) learning and performance goals (Dweck, 1986; Elliott & Dweck, 1988); (b) mastery and performance goals (Ames, 1992b; Ames & Archer, 1988); and (c) task- and ego-involved orientation (Jagacinski, 1992; Jagacinski & Nicholls, 1987; Nicholls, 1984, 1989).

Since the development of these models, some have suggested additional refinements in performance goals (Elliot, 1997, 1999). However, questions about measurement items and the implications of performance goals for classroom practice have emerged (Brophy, 2005; Kaplan & Middleton, 2002). Discussed in this section are learning-related goal orientations, performance-goal orientations, problems with performance goals, and failure or work-avoidance goals.

**Learning-Related Goal Orientations.** The three types of learning or effort orientations are summarized in Table 11.3. These orientations reflect a focus on mastering tasks, enhancing one’s learning, and becoming more than superficially involved in achievement-related tasks.

The definition of success for students with learning-related goal orientations is that they master new tasks, make progress in learning new skills, or feel pleased when they have engaged in challenging tasks. A core belief associated with the mastery orientation is that effort and outcomes covary, and this belief maintains achievement-oriented behavior over time. Dweck (1989) also found that children with a learning goal orientation view intelligence as a dynamic, growing set of abilities. That is, intelligence is not a fixed entity.

**Performance Goal Orientations.** The original conceptualizations of goal orientations identified performance and ego-involved goal orientations as
counterproductive for learning. As illustrated in Table 11.4, performance goals involve a focus on demonstrating superior performance. Learners achieve this objective by either outperforming others or doing well with little effort. This type of goal focuses on one’s ability, and self-worth is based on perceptions of one’s ability to perform. Social comparison information (how well others are doing or how much effort they are expending) is the standard for self-judgments about ability. Dweck (1989) also noted that children with performance goal orientations tend to view intelligence as a fixed trait, an “entity” view of intelligence.

The original conceptualizations of goal structure, according to Elliot (1997, 1999; Elliot & Church, 1997), are insufficient to explain the data on achievement-related behaviors and achievement outcomes. Therefore, he proposed a distinction between performance-approach (striving to demonstrate one’s ability relative to others in the class) and performance-avoidance orientations. Performance

TABLE 11.4
Performance Goal Orientations

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ego-involved orientation (Jagacinski, 1992; Jagacinski &amp; Nicholls, 1987; Nicholls, 1984, 1989)</td>
<td>Feeling successful when one knows more than others</td>
</tr>
<tr>
<td>(a) Performance-approach component</td>
<td>Attainment of favorable judgments of competence</td>
</tr>
<tr>
<td>(b) Performance-avoidance component</td>
<td>Avoiding unfavorable judgments of competence</td>
</tr>
</tbody>
</table>
avoidance involves fearing being thought stupid, avoidance of asking the teacher a “dumb” question, and often worrying about doing badly in school (p. 180).

Some studies with college students (e.g., Harackiewicz, Barron, Tauer, & Elliot, 2002) have found that both mastery and performance-approach goals are linked to components of academic success. Other studies have linked performance-approach goals to such variables as task value (e.g., Bong, 2001) effort expenditure (e.g., Elliot, McGregor, & Gable, 1999), and performance (e.g., Lopez, 1999). Such findings have led to calls to revise goal theory to include performance-approach and performance-avoidance orientations (e.g., Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002).

However, Kaplan and Middleton (2002) disagree. They note that the desirability of mastery goals, performance goals, or various combinations of them is dependent on the purposes expressed in the achievement setting (p. 648). In other words, one should question the nature of the educational setting where mastering and understanding the material does not contribute to higher grades (p. 648).

Problems with Performance Goals. A general problem with performance goals is that this orientation leads to primarily superficial engagement in achievement-related tasks. A performance-avoidance orientation is further maladaptive in that even superficial engagement in learning activities is minimal.

A second problem is the view that students might pursue multiple goals simultaneously (mastery and performance goals). Goal coordination is difficult, particularly for struggling students in elementary and middle school, because a commitment to a mastery goal requires that they work harder than their classmates (Brophy, 2005, p. 169).

There are also measurement problems in the research on student goal orientations. For example, the instructions in experiments that induced different goal orientations did not differentiate clearly between mastery and performance goals (Brophy, 2005, p. 170). In addition, the questionnaires used in correlational studies in classrooms consist of explicit statements. Respondents indicate the extent to which each statement reflects their beliefs. However, respondents do not have the opportunity to state their goals. Studies that have asked students to state their goals have found vague references to learning goals, but no mention of performance (p. 171).

In addition to the concerns identified by Brophy (2005), a study that sought to identify differences in the use of handicapping strategies by students with different goal orientations (Midgely & Urdan, 2001) found a moderately strong correlation (.59) between performance-approach and performance-avoidance goals. In other words, the assessment items used to document students’ beliefs in performance-approach or performance-avoidance goals did not clearly differentiate between these two orientations.

Other Goal Orientations. Two other goal orientations measured by researchers are work avoidance and failure avoidance. Work avoidance seems to represent the absence of an achievement goal, and the endorsement of just “getting through” task requirements (Archer, 1994; Elliot, 1999, p. 184). Briefly, examples are feeling
successful when all the work is easy and not having any tough tests (Thorkildsen & Nicholls, 1998).

Failure avoidance involves avoiding looking stupid in one’s classes through self-protecting strategies, such as not responding to teacher questions (Middleton & Midgley, 1997). Brophy (1999) suggested that students who attribute failure to uncontrollable causes seek to defend against perceptions of incompetence or to hide their incompetence from others (p. 76).

**Summary.** Goal orientation models address students’ reasons for engagement in academic tasks. Original conceptualizations of goal orientation defined dichotomous contrasts (e.g., learning-oriented vs. performance-oriented). Students with learning or effort orientations seek to master new tasks, make progress in learning new skills, or feel pleased when they have engaged in challenging tasks. One researcher also found that students with a mastery orientation viewed intelligence as a dynamic, growing set of abilities.

In contrast, students with performance or ego-involved orientations focus on demonstrating superior performance. This purpose is accomplished by either outperforming others or doing well with little effort. Social comparison information is the standard for self-judgments about ability. These students also tend to view intelligence as a fixed entity.

Some have suggested that the performance goal orientation should be considered as two separate emphases: performance approach and performance avoidance orientations. However, given the problems with performance goals, one researcher suggested they should be replaced with validation goals that refer to certifying one’s ability. Two other goal orientations measured by researchers are work avoidance and failure avoidance.

**Attribution Theory**

The expectancy–value model and the goal orientation models describe particular anticipations, values, or rationales for approaching and engaging in achievement-related tasks. Furthermore, goal orientation models identify positive and negative learning strategies associated with different goal orientations.

In contrast, attribution theory addresses individuals’ thoughts, emotions, and expectancies following an achievement-related outcome (Weiner, 1980b). Researchers also have applied the theory to the role of attributions in help-giving behavior (Weiner, 1979, 1980a, 1980c, 1982, 1983, 1995), in explaining children’s reactions to unusual characteristics or behavior (Juventen, 1991, 1992), and in analyzing children’s reactions to negative events precipitated by other children (Graham & Hudley, 1992; Graham, Hudley, & Williams, 1992; Hudley & Graham, 1993).

In achievement-related situations, the theory rests on three assumptions. They are (a) the search for understanding is a prime motivator of action, (b) attributions for achievement-related outcomes are complex sources of information, and (c) future behavior is determined, in part, by the perceived causes of prior outcomes.

Attribution theory describes (a) the processes involved in determining the causes of success and failure outcomes (attributions), and (b) the resulting emotions
and expectancies that influence subsequent behavior. For example, the learner may attribute failure on a math exam to lack of ability, which generates negative emotions. Also, because lack of ability is an internal, stable attribution (it is unlikely to change), the student expects failure in math in the future.

The basic building blocks of formulating a cause or attribution for success or failure in achievement are (a) the typical attributions and their properties (dimensions), (b) emotional reactions, and (c) information sources for selecting attributions.

**Attributions and Their Properties.** Multiple causes of outcomes in the achievement domain may be identified (Weiner, 1985b). Failure, for example, may be attributed to lack of effort, the absence of ability, poor strategies, bad luck, teacher bias, the hindrance of peers, and so on. However, the typical attributions for success and failure outcomes are ability, effort, task difficulty, and luck (Weiner, 1972). Sometimes other attributions are cited, such as mood, illness, or help from others. However, the most dominant attributions for success and failure, according to Weiner (1985a), are ability and effort. That is, success is attributed to high ability and/or hard work, and failure is attributed to lack of ability and/or lack of effort.

The causal meaning of attributions is determined largely by their underlying bipolar properties. They are stability, locus of causality, and controllability. The key questions are as follows: Is a particular attribution stable or unstable, internal or external, and under the individual’s control or controlled by other individuals or events? For example, ability is internal, stable, and is not controlled by the individual. Success in mathematics that is attributed to ability, a stable cause, will be expected again.

Also, the student who attributes a low test grade to low ability is likely to expect future failure and to believe that he or she has no behavioral response that can alter subsequent events (Weiner, 1979). Therefore, the learner will expend little or no effort on achievement-related tasks. In contrast, failure attributed to lack of effort, which is internal but unstable, is not expected in the future. The learner can increase his or her effort and prevent failure (Eswara, 1972; Rosenbaum, 1972; Weiner, Neurenberg, & Goldstein, 1976). Also, lack of effort is punished more than lack of ability (Rest, Neirenberg, Weiner, & Heckhausen, 1973; Weiner & Kukla, 1970; Weiner & Peter, 1973).

In addition, as indicated in Table 11.5, the properties of attributions generate particular emotions. For example, the locus of causality is linked primarily to the individual’s self-esteem. Causes attributed to the self either enhance feelings of self-worth (positive achievement outcome) or contribute to a negative self-image (negative achievement outcome). The affective relationship for stability is the intensification of emotions generated by other properties.

**The Role of Emotional Reactions.** Emotions are important in the attributional perspective because they are motivators of subsequent behavior. “Attributions tell us what to feel, and feelings tell us what to do” (Weiner, 1983, p. 69). An individual who has experienced apathy, resignation, and feelings of incompetence will
TABLE 11.5
Properties of Major Achievement-Related Attributions

<table>
<thead>
<tr>
<th>Attribution</th>
<th>Dimension</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability</td>
<td>Internal</td>
<td>Generates feelings of competence or incompetence and feelings of pride or shame</td>
</tr>
<tr>
<td></td>
<td>Stable</td>
<td>Same outcome expected again; emotions of pride and shame magnified; for failure, resignation and apathy magnified</td>
</tr>
<tr>
<td></td>
<td>Uncontrollable</td>
<td>For failure, magnifies feelings of resignation and apathy</td>
</tr>
<tr>
<td>Effort</td>
<td>Internal</td>
<td>Generates feelings of pride for success</td>
</tr>
<tr>
<td></td>
<td>Unstable</td>
<td>Does not decrease success expectancy</td>
</tr>
<tr>
<td></td>
<td>Controllable</td>
<td>Magnifies feelings of pride or guilt</td>
</tr>
<tr>
<td>Luck</td>
<td>External</td>
<td>Self-image not altered</td>
</tr>
<tr>
<td></td>
<td>Unstable</td>
<td>No decrease in success expectancy</td>
</tr>
<tr>
<td></td>
<td>Uncontrollable</td>
<td>Generates surprise for both success and failure</td>
</tr>
<tr>
<td>Others</td>
<td>External</td>
<td>Self-image not altered</td>
</tr>
<tr>
<td></td>
<td>Unstable</td>
<td>No decrease in success expectancy</td>
</tr>
<tr>
<td></td>
<td>Uncontrollable</td>
<td>Generates gratitude for help and anger for hindrance</td>
</tr>
<tr>
<td>Task difficulty</td>
<td>External</td>
<td>No enhancement of self-esteem for success outcome</td>
</tr>
<tr>
<td></td>
<td>Stable</td>
<td>Same outcome expected again</td>
</tr>
<tr>
<td></td>
<td>Uncontrollable</td>
<td>Depression and frustration for failure outcomes</td>
</tr>
</tbody>
</table>

cease trying in achievement-related situations. On the other hand, one who feels gratitude and relief is motivated to express thankfulness. The individual who experiences feelings of competence, however, will approach achievement-related situations with confidence.

Following a positive outcome, the individual may experience feelings of pride and self-worth, confidence, or gratitude. The individual’s identification of a personal characteristic as an attribution for a positive outcome generates feelings of pride and self-worth because the cause is internal (see Table 11.6). Kant described the locus of causality–pride linkage when he noted that everyone at a
TABLE 11.6  
Emotions Generated by the Properties of Attributions

<table>
<thead>
<tr>
<th>Outcome/Dimensions Linkage</th>
<th>Emotional Reactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>Internal cause</td>
<td>Feelings of pride and self-esteem</td>
</tr>
<tr>
<td>Controllable cause</td>
<td>Feelings of confidence</td>
</tr>
<tr>
<td>Stable cause</td>
<td>Maximizes feelings of pride, self-worth, and confidence (for internal causes)</td>
</tr>
<tr>
<td>Uncontrollable/external cause</td>
<td>Feelings of gratitude</td>
</tr>
<tr>
<td><strong>Negative outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>Internal cause</td>
<td>Feelings of embarrassment, guilt, and shame</td>
</tr>
<tr>
<td>Controllable cause</td>
<td>Feelings of guilt</td>
</tr>
<tr>
<td>Stable cause</td>
<td>Maximizes emotions of shame, apathy, and resignation associated with internal, controllable causes</td>
</tr>
<tr>
<td>Uncontrollable/external cause</td>
<td>Feelings of anger</td>
</tr>
</tbody>
</table>

meal may enjoy the good food, but only the cook could experience pride (Weiner, 1985a, p. 561). In contrast, success ascribed to external causes, such as luck or help from others, does not influence self-esteem or future task engagement (Weiner, 1982). An example is receiving an A from a teacher who awards only good grades (external cause); pride is not experienced for the success. Instead, success attributed to external causes typically generates feelings of gratitude.

Success attributed to internal causes influences one’s self-image. Similarly, failure attributed to internal causes contributes to negative self-image. Some studies (Brown & Weiner, 1984; Covington & Omelich, 1984; Jagacinski & Nicholls, 1984) have reported that shame-related affects (disgrace, embarrassment, humiliation, and/or shame) are associated with low ability, and guilt-related reactions are associated with lack of effort. The occurrence of shame, a more negative emotion than guilt, may be related to the stability and uncontrollability of ability (aptitude). In contrast, lack of effort, which is controllable, may tend to generate guilt but not the stronger emotion, shame. Graham and Weiner (1996) noted that “guilt tends to promote goal-directed activity, whereas shame gives rise to task withdrawal and is a motivational inhibitor” (p. 72).

Also important is that shame-related emotions often are followed by withdrawal and inhibition of motivation. In contrast, guilt-related emotions often lead to reproach behavior and retribution (Hoffman, 1982; Weiner, 1985a). Thus, failure attributed to stable and uncontrollable factors generates strong negative emotions and exerts a debilitating influence on future achievement-related behavior as well.

Sources of Information for Attributions. As indicated in Table 11.7, the individual makes use of several sources of information in the search for a causal attribution. A primary determinant is the learner’s prior success history. A consistent
TABLE 11.7  
Sources of Information for Attributions

<table>
<thead>
<tr>
<th>Source</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner's prior success history</td>
<td>The primary determinant for the selection of ability or lack of it as an attribution</td>
</tr>
<tr>
<td>Social norms and the performance of others</td>
<td>Failing a task that others achieved may lead to an attribution of lack of ability</td>
</tr>
<tr>
<td>Learner's causal schema</td>
<td>(a) Ability or effort may account for success</td>
</tr>
<tr>
<td></td>
<td>(b) Ability and effort are essential for success</td>
</tr>
<tr>
<td>Individual characteristics</td>
<td>Example: Self-concept; elementary school children who have a high self-concept credit skill and ability for success</td>
</tr>
<tr>
<td>Developmental level</td>
<td>Children in kindergarten and first grade hold high perceptions of their ability and expectations of success.</td>
</tr>
</tbody>
</table>

Note: Compiled from Weiner (1974a, 1977)

A record of prior achievements leads to attributions of ability for success, whereas a moderate success record is likely to generate effort as a cause of success. In contrast, success for an individual with a consistently poor achievement record is likely to be attributed to luck, and failure will be attributed to lack of ability.

Social norms and the performance records of others also provide information. Succeeding at a task failed by others likely leads to the perception that one is able (Weiner, 1974a). Similarly, failing a task that others accomplished successfully may lead to an attribution of lack of ability.

The individual's causal schema and individual characteristics also influence attributions. A sufficient causal schema is the belief that either ability or effort may account for success (Weiner, 1974a). In contrast, a necessary causal schema is the belief that ability and effort are essential for success, and is often the selected explanation for successes to both ability and hard work (Dai, Moon, & Feldhusen, 1998). An important individual characteristic that is related to the causal attributions made by children is self-concept. Elementary school students who are high in self-concept credit skill and ability for success. They also engage in more self-reward following success than low self-concept children (Ames, 1978; Ames, Ames, & Felker, 1977).

Developmental level also influences attribution selection. Most children in kindergarten and first grade hold high perceptions of their ability and high expectancies of success. They also are more likely to attribute success and failure to luck than are older children (Wigfield & Harold, 1992, p. 102).

The Attributional Process. The attributional process begins with an achievement-related outcome. The learner first appraises his or her performance and assigns it a subjective rating on a continuum from success to failure. Then the individual either
identifies a cause for the outcome or reflectively begins to look for the probable cause. A search occurs most often for unexpected outcomes, such as failure when the learner expected success.

The identification of the outcome as success or failure generates emotional reactions of satisfaction, or perhaps happiness, for success and frustration or upset for a failure outcome (see Figure 11.2). For example, in athletic competitions, one tends to experience happiness for a victory whether the win resulted from additional training, a poor competitor, or luck (Weiner, 1985a).

The learner then identifies a causal attribution for the success or failure. Sources of information for this decision include the learner’s prior success history, social norms and the performance of others, the learner’s causal schema, and individual characteristics. The properties or dimensions of the selected attribution generate particular emotions and may influence the learner’s expectancy for future outcomes.

An example of the attributional process is the Little League baseball player who performs poorly during a game. The boy has played poorly in the past, and the other children are playing well. The boy also has tried to improve by practicing
many hours. On the basis of history, social comparison, and expenditures of effort, the boy is likely to conclude that he has failed because he is not good at baseball (lack of ability) (Weiner, 1985b, p. 566).

In summary, the basic building blocks of the attributional model are the individual’s attributions for success and failure outcomes and the dimension of those attributions. The typical attributions are ability, effort, task difficulty, and luck. Others are mood, illness, fatigue, and help from others. Information that contributes to the identification of a particular attribution includes specific information cues, the individual’s causal schema, and individual predispositions.

The causal meaning of attributions is determined largely by their underlying bipolar properties, which are stability, locus of causality, and controllability. The stability property influences future goal expectancy, and each property also generates particular emotions. The locus of causality is linked primarily to the individual’s self-esteem. Causes attributed to the self either enhance feelings of self-worth (positive achievement outcome) or contribute to a negative self-image (negative achievement outcome). The affective relationship for stability is the intensification of emotions generated by other properties.

**Summary**

Three analyses of motivational processes in achievement-related settings are the expectancy–value model, goal-orientation models, and attribution theory. Basic assumptions shared by these analyses are (a) an individual’s motivation develops from a complex interaction of environmental factors and factors within the child, (b) the student is an active processor of information, and (c) a student’s motives, goals, or attributions are explicit knowledge that can be communicated to others.

Each of the three analyses describes a different constellation of factors that account for the achievement-related behaviors of persistence, choice of tasks, cognitive engagement, and performance. The expectancy–value model identifies the value of the task and the expectancy of success as key motivational processes. The term *task* in the model refers to domain or course, such as mathematics or social studies. Direct determinants of these processes are the student’s affective memories and self-schemata and goals. Contributing to these factors are the student’s social world, his or her interpretation of that world, prior achievement-related experiences, and aptitude.

In contrast, goal orientation models address students’ reasons for engagement in academic tasks. The two general orientations are learning, effort, or mastery-oriented and performance or ego-oriented. Students with a mastery or learning orientation seek to develop new skills and increase their competence. They also tend to hold an incremental view of intelligence.

Currently, the performance-goal orientation includes two subcategories, performance approach and performance avoidance. The performance-approach orientation is accompanied by efforts to demonstrate superior performance by outperforming others or doing well with little effort. Performance avoidance, in contrast, is accompanied by avoiding unfavorable judgments of competence. Students with performance-goal orientations tend to hold an entity view of intelligence.
The third motivational analysis, attribution theory, addresses an individual’s determination of an outcome as success or failure and the likely causes for the outcome (attributions). Sources of information in identifying attributions are the individual’s success history, social norms, the performance records of others, the learner’s causal schema, individual characteristics, and developmental level. Typical attributions for success and failure outcomes are ability, effort, task difficulty, and luck. However, the properties or dimensions of the attribution are the key factors that generate emotional reactions and expectancy for the future. These dimensions are stability, locus of causality, and controllability by the student. For example, success attributed to help from others, which is unstable, external, and uncontrollable, may generate gratitude but not pride. Therefore, help from others does not influence self-esteem or future task engagement.

Of particular importance are the attributions of ability and effort. A negative outcome attributed to lack of ability generates feelings of shame, which may be followed by withdrawal. Also, because lack of ability is stable, internal, and not controlled by the individual, the same negative outcome is expected in the future.

The Cumulative Effects of Different Experiences on Motivational Beliefs

Two different motivational patterns that occur in the educational setting require intervention. One is the changes in children’s motivations as they progress through school. The other is the extremely maladaptive patterns referred to as “learned helplessness.”

Changes Throughout Schooling. Children’s motivational beliefs are not static; evidence indicates that they develop and change over time (Anderman et al., 2002, p. 203). Children’s competence beliefs and expectancies for success for different tasks typically decline across the elementary school years into middle school (Wigfield & Eccles, 2002). These declines, especially in mathematics, often continue into high school. Also, middle school students rate the importance and utility of school subjects, as well as their interest, lower than young children do (Eccles & Midgley, 1989; Wigfield, 1994; Wigfield & Eccles, 1992).

Identification of likely attributions for achievement outcomes also changes throughout childhood. The subtle cues that indicate ability inferences often are not differentiated clearly by young children. Also, they typically do not differentiate between ability and effort. That is, young children tend to believe that success is related to working hard.

By the age of 11 or 12, children have begun to make normative evaluations of their ability. By that age, children use concepts such as effort, ability, task difficulty, and luck in an adult-like way, even if they cannot explain their reasons (Thorkildsen & Nicholls, 1998). Their ratings are more consistent with their report cards, their confidence is likely to decline under failure, and success expectancies decrease (Dweck, 1989; Nicholls, 1978; Ruble & Rhales, 1981). For example, if students attribute poor performance in math to ability, which is stable, they are
likely to devalue math to protect their overall self-worth (Pintrich & Schunk, 2002; Steele, 1988; Wigfield & Eccles, 1992).

One rationale for the changes in motivation is that children become more proficient at understanding and interpreting the feedback they receive, and some self-assessments become more negative. Also, the nature of the school environment changes. Evaluation becomes more important and the likelihood of competition among the children increases (Wigfield & Eccles, 2002a, p. 97). In addition, the classroom tasks become more abstract as opposed to the more concrete tasks in elementary school (Dweck, 1989). Furthermore, in the early school years, more than half of the feedback addresses adherence to classroom procedures and conduct and not academic performance (Pintrich & Blumenfeld, 1985).

In addition to the decline in children’s competency beliefs and expectancies for success, research indicates a decline in the endorsement of mastery goals by adolescents and an increase in the endorsement of performance goals (Anderman & Anderman, 1999; Anderman et al., 2002, p. 209). Several studies indicate that the student’s increased endorsement of performance goals, which is often accompanied by self-handicapping strategies such as procrastination, is related to the implementation of performance goals at the classroom level (Ames & Archer, 1988; Anderman & Anderman, 1999; Anderman & Midgley, 1997; Midgley, Anderman, & Hicks, 1995; Urdan, Midgley, & Anderman, 1998).

As already stated, one rationale for the changes in children’s motivations is the interaction between their information-processing skills and some alterations in the school setting. However, another rationale places a greater responsibility on the school setting. First, the instructional methods of middle-school teachers differ from those of elementary school teachers (e.g., Anderman & Maehr, 1994; Eccles & Midgley, 1989), relationships between teachers and students often are poor, opportunities are lacking for students to be involved in decision making, and grading practices are strict (Anderman et al., 2002; Eccles et al., 1993). That is, some middle schools function as “mini high schools” with a focus on grades and performance (Anderman et al., 2002, p. 211). In other words, students are developing strong needs for autonomy and control that conflict with the organization of the school.

**“Learned Helplessness” Versus a Mastery Orientation.** Individuals low in self-concept who have experienced few successes are likely (a) to attribute failure to lack of ability and (b) to see no relationship between their success and their own actions. The belief that outcomes are independent of one’s actions was researched originally as the construct known as “learned helplessness” (Seligman, 1975). In the initial experimental studies, dogs subjected to inescapable electric shock learned that no response, such as tail wagging, barking, or jumping, influenced the shocks. Then when placed in a situation in which knocking down a barrier terminated the shock, the animals first ran around frantically for a few seconds and then lay down, passively submitting to the shock. In other words, after the experience of uncontrollable trauma, the animals lost the motivation to respond, and depression and anxiety resulted. Furthermore, even if a response was successful, the animal had difficulty in learning that the response was effective (Seligman, 1975, p. 22).
A major characteristic of helplessness in humans is whether individuals believe that outcomes are more or less likely to happen only to themselves or to relevant others as well. For example, a student may spend long hours studying, enroll in remedial courses, and still fail. The person eventually arrives at the conclusion that he or she is incompetent. In this case, important outcomes are available to others (they pass), but the student does not possess the behaviors to acquire them. The cause of the event is internal; this phenomenon is referred to as personal helplessness (Abramson, Garber, & Seligman, 1980, p. 11). The problem with personal helplessness, as in attributions for a single failure outcome, is that the internal nature of the attribution generates low self-esteem.

Research indicates that children of equal ability often react to failure in very different ways (Diener & Dweck, 1978; Dweck, 1975). Learned-helpless children attribute failure to stable factors, such as lack of ability. They also react to failure with solution-irrelevant statements, stereotypic responses, and derogatory comments. Examples include “I am stupid” and “I never did have a good memory” (Diener & Dweck, 1978). In addition, a marked and rapid decline typically occurs in the sophistication and appropriateness of the children’s problem-solving strategies. In one study, by the fourth problem in a discrimination-testing situation, over two-thirds of the children made ineffectual responses.

In contrast, mastery-oriented children tend to acknowledge their errors but do not regard them as failures (Dweck & Licht, 1980, p. 199). They attribute the mistakes to unstable factors, such as bad luck, lack of effort, and unfairness of the experimenter. They also engage in self-instructional statements such as “I should slow down and try to figure this out” (Diener & Dweck, 1978, p. 459). Mastery-oriented children also maintain mature strategies in the face of failure. The unflagging optimism of these children, however, is perhaps the most striking difference between them and the learned-helpless group (Dweck & Licht, 1980, p. 201).

The two groups also differ in their reactions to success. In one study, learned-helpless children were less likely to attribute success to ability, and they underestimated their number of successes. They also tended to state that other children outperformed them, and they predicted poor future performance for themselves (Diener & Dweck, 1980). Mastery-oriented children, however, attributed performance to ability, correctly estimated their number of successes, thought they were doing better than other children, and expected continued success.

The underlying problem for “helpless” children is that they do not view themselves as instrumental in the determination of outcomes. They are therefore likely to consider adverse circumstances as insurmountable. Thus, the important factor is not the occurrence of aversive events but, rather, the perceived relationship between the individual’s behavior and the event (Dweck, 1975, p. 75).

Classroom conditions can place children at risk for developing learned helplessness. When normative performance evaluations prevail in the classroom, low-confidence children react with ineffective strategies and attributions of lack of ability. However, when tasks are presented in terms of learning, such as to sharpen one’s mind, maladaptive responses tend to decrease (Elliott & Dweck, 1988).
Summary. The two motivational patterns that require intervention are the changes in children’s motivational beliefs during the middle school years and the maladaptive pattern referred to as “learned helplessness.” The declines in children’s motivational beliefs, especially in mathematics, often continue into high school, and middle-school students often rate school subjects lower on utility and importance.

One rationale for motivational decline is that by the age of 11 or 12, children differentiate between ability and effort. That is, they become more proficient at interpreting classroom feedback. Also, the school environment changes in the middle-school years. Competition often increases, classroom tasks become more abstract, and evaluation becomes more important.

The concept of learned helplessness refers to individuals with low self-concept who have experienced few successes. They are likely to see no relationship between any success they have and their own actions. Learned-helpless children also attribute failure to stable factors, such as lack of ability. They differ from mastery-oriented children, who do not give up in the face of failure and who try various strategies.

PRINCIPLES OF INSTRUCTION

In the formal educational setting, children soon learn that doing well in school is an implicit goal, but an important one. Throughout the school years, in both formal and informal situations, students are faced with a continuing succession of achievement-related situations. These situations, and the inferences that students make about them, are important in the development of students’ motivational beliefs. Unlike learning and cognitive-development theories, motivational models and theories have not developed explicit principles of instruction. However, they have identified characteristics of classroom instruction that influence students’ motivations.

Basic Assumptions

The shared assumptions of the expectancy–value model, goal orientation models, and attribution theory also apply to classroom instruction. They are (a) academic motivation develops, in part, from a complex interaction of classroom factors and factors within the student, (b) the student is an active processor and interpreter of the classroom setting, and (c) students can reflect on and report their perceptions to others. A fourth assumption is that motivation is subject-specific; that is, students’ values and goals may differ for mathematics, biology, history, literature, and other courses.

Classroom Influences on Student Motivation

The classroom setting is one in which hundreds of interactions occur between teachers and students. These interactions are sources of information for both teacher and student beliefs about students’ abilities and students’ motivational
beliefs. Discussed in this section are classroom goal structures, teacher reactions to student performance, and implementing a learning goal orientation.

**Classroom Goal Structures**

Research on mastery and performance goal orientations by Ames (1992b; Ames & Archer, 1988) indicated that classroom goal orientations influence students' goal orientations. The activities and emphases in the classroom may be categorized as mastery- or performance-oriented. Mastery-oriented classrooms emphasize effort, improvement, and challenge. Teachers encourage student persistence and effort, view errors as opportunities for learning, express positive emotion and enthusiasm for learning, and hold students accountable by asking them to explain their learning (Turner & Patrick, 2004). However, Ames (1990) cautioned teachers against urging learners to try harder because this practice is counterproductive in two ways: Young children believe that they always work hard and other students are discouraged by directives that indicate their success depends on maximum effort. Instead, the teacher should organize his or her classroom to maximize students' involvement in academic tasks. In other words, the teachers establish an environment in which students can experience improvement and feelings of mastery.

In contrast, teachers who focus on ability perceptions, make evaluations public, and show only the best students' work are performance-oriented. Examples include announcements of the highest and lowest scores; posted charts of students' projects, scores, and progress; and public displays of selected projects and achievements (Ames, 1992b, p. 264). Frequent use of written assignments that are graded, the display of only A or mostly correct papers, and the use of both positive and negative feedback in a public context also reflect a performance orientation in the classroom (Stipek & Daniels, 1988). Such practices provide many opportunities for students to question their ability and to judge themselves inadequate (Ames, 1984, 1992a; Mac Iver, 1987; Stipek, 1981).

Other studies also support the linkage between classroom practices and students' goal orientations (e.g., Anderman & Young, 1994; Meece, 1991; Meece et al., 1988). One study of 570 students in grades 3–6 from 12 schools found that performance-oriented classroom goals were associated with a decline in students' valuations of mathematics and reading (Anderman et al., 2001). Also, students' performance-avoidance goals were predictors of students' self-handicapping strategies (Middleton & Midgley, 1997; Midgley & Urdan, 2001). Included in handicapping strategies are putting off studying until the last minute and avoiding seeking help in the classroom.

One difficulty in implementing a learning-goal orientation in middle and junior high schools is the shift in grading practices from elementary school. The focus in elementary school classrooms is on task mastery, improvement, and intellectual development. However, teachers, students, and observers perceive middle and junior high schools to be performance-focused with the emphasis on competition and social comparison (Anderman & Midgley, 1997; Covington, 1999; Wigfield, Eccles, & Pintrich, 1996). Grading practices tend to be stricter at those levels, and grades often are determined relative to the performance of others.
Covington (1999; Covington & Teel, 1996) refers to this structure as the "ability game." In such a competitive, zero-sum situation, an inadequate supply of rewards (good grades) is available to only a few students. When one player "wins" (receives a high grade), then other students must lose (receive lower grades). Classrooms in which only a few high grades are available tend to foster the perception that self-worth is related to success (Covington, 1999) and contributes to student goal orientations of performance-approach, performance-avoidance, and failure-avoidance. Anderman and Maehr (1994) maintain that the motivational problems of adolescents are largely the result of a performance-goal orientation in the classroom.

Teacher Reactions to Student Performance
Teacher reactions to student success or failure in the classroom, for formal or informal assessments, can influence students' attributions for the assessment outcome. Specifically, the teacher evaluates the performance as success or failure, makes an attribution for the outcome, and communicates the outcome to the student. Both the verbal feedback and the teacher's nonverbal reactions (e.g., facial expression, hesitation) send messages to the student. The basis for this conclusion is the research on reactions to success and failure. In one series of studies, research participants responded to hypothetical situations as the "teacher." In the success conditions, they rewarded high effort more than ability, and, for failure, punished lack of effort more than lack of ability.

In other studies, both children and adults, when presented failure situations and "teacher" reactions of anger, inferred lack of effort as the cause. For teacher reactions of pity, they inferred the cause of failure to be lack of ability (Graham & Weiner, 1983; Weiner, Graham, Stern, & Lawson, 1982). In other words, sympathy expressed to certain students following failure is one of the cues for low-ability inferences by others (Graham, 1984, 1988, 1990). More important, the sympathy may (a) prevent the teacher from providing challenging tasks to the student and/or (b) lead to too much teacher help, thereby removing student responsibility for learning (Weiner, 1980d, p. 10). Unsolicited aid may lead the student to conclude that the teacher perceives his or her ability to be low. Such behaviors also may lead to devaluation of the subject by the student by contributing to negative affective memories and may contribute to a work-avoidance goal orientation.

Other teacher behaviors may contribute to negative motivational beliefs of students. Teachers who expect certain students to perform poorly will treat them differently, thereby reducing their opportunities to learn and contributing to poor achievement. Good (1980) listed 11 ways that students designated as low achievers are rated differently in some classrooms. Included are seating low achievers farther from the teacher and/or in a group, asking for less work and effort from them and paying less attention to them. Less attention includes less eye contact, fewer opportunities to respond to teacher questions, less time to answer questions, and less detailed feedback on errors (p. 88). In one study, fifth-grade students were asked to evaluate teacher expectations for a hypothetical smart student (G) and a low-ability student (E). The children indicated that the teacher would not expect the low-ability student to remain task involved (Thorkildsen & Nicholls, 1998).
Good (1980) suggested that teachers should be proactive by building classroom structures in which the needs of low achievers can be met without ignoring the needs of other students. Also important is to avoid feedback to students that sends negative messages. Rohrkemper and Brophy (1983) found that the teacher’s affective reaction typically influences his or her subsequent actions, which also convey messages about ability. Pintrich and Blumenfeld (1985) found that teacher feedback about work was a better predictor for children’s ability and effort perceptions of themselves than other interactions with teachers or peers.

**Implementing a Learning Goal Orientation**

Characteristics of learning-oriented classrooms include flexible instructional groups, variations in assignments according to students’ skill levels, discouragement of normative comparison, frequent group projects, encouragement of peer assistance, and substantive comments on student work (Stipek & Daniels, 1988). Also, one study indicated that implementing grading policies based on specific, clearly defined criteria was effective in discouraging negative achievement goals in at-risk middle school students (Teel, DeBruin-Parecki, & Covington, 1998). Furthermore, initial discussions of classroom goal orientations identified procedural and cognitive priorities that are important in learning-oriented classrooms (Ames, 1992b). Examples are permitting students to participate in decision making and designing tasks that provide reasonable challenges to students (see Figure 11.3).

Another mechanism that can contribute to a positive learning environment is some form of cooperative learning. Examples include small-group teaching; the Jigsaw method; Teams, Games, and Tournaments (TGT); and Student Teams and Achievement Divisions (STAD). In small-group teaching, students typically select subtopics within a general area and then organize themselves in groups of two to six to prepare for presentation to the total class. In the Jigsaw method, groups of students who are working on the same portion of the material help each other learn and prepare the material for presentation to their original group (Aronson, Stephan, Sikes, Blaney, & Snapp, 1978). Teams, Games, and Tournaments and Student Teams and Achievement Divisions are group study approaches that each conclude with a formal method of evaluating student learning on a weekly basis. Use of the Jigsaw method with one class in a science museum resulted in several minutes at the designated exhibits rather than the typical time spent by students of less than 1 minute (Hidi, Weiss, Berndorff, & Nolan, 1998).

Perhaps most important, recent research indicates that the motivational statements of teachers, their respect and support for students, and their expressions of the nature of learning also are important in implementing a mastery or learning goal orientation (Patrick, Anderman, Ryan, Edelin, & Midgley, 2001). Practices observed in two fifth-grade mastery-oriented classrooms are summarized in the following paragraphs.

**Student Participation.** In one classroom, the teacher engaged the students in generating the rules for the class. When discussing math problems, both teachers called on all students in the class, not only the ones who volunteered. Also, because
the emphasis was on the strategies used by students in working through problems, students were encouraged to share their approaches.

**Autonomy.** Teachers allowed considerable freedom in the classroom for students to talk with others, go to the pencil sharpener, and so on, provided they were not distracted from learning and did not distract others (Patrick et al., 2001, p. 46). They also were permitted to decide whether they worked individually or with others, and the order in which to complete tasks during seatwork.

However, providing autonomy does not mean simply providing trivial choices. That approach is unlikely to develop motivation for engaging in academic tasks over time (Stefanou, Perencevich, DiCintio, & Turner, 2004). Also

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**FIGURE 11.3**

Classroom structure and instructional strategies essential for mastery goal orientation

important is cognitive autonomy, which refers to teacher support of the students’ thinking as they work through tasks or problems. The classroom example at the end of Chapter 6, in which the children construct various ways to solve simple addition problems, illustrates the development of cognitive autonomy. Another example is a math exercise in which students worked on completing three charts (on the blackboard) that required converting (a) decimals to percentages, (b) fractions to percentages, and (c) percentages to fractions. The teacher probed the students’ thinking by asking how they dealt with switching back and forth between decimals and percents. She also asked what it meant to move the decimal point two places, and so on (p. 104). In other words, developing students’ cognitive autonomy involves their growing independence in addressing different academic tasks.

**Recognition and Support.** Teachers recognized student efforts in learning with “warm praise that was also task-related, clear, contingent and credible,” and was not limited to only a few students (Stefanou et al., 2004, p. 47). For example, when one student was reading aloud, he struggled with one word and finally read it correctly. The teacher commended him for not giving up and referred to him as a good reader (p. 47). Also, when several students raised their hands to answer a question, the teacher commented on what a bright class they were, with so many hands raised.

The teachers also voiced positive expectations for the students. They stated often that the students could do the work, even if they were having difficulties (Stefanou et al., 2004, p. 47). In addition, feedback focused consistently on the particular academic activity and provided specific suggestions for improvement. Students also were encouraged to help each other.

**The Nature of Learning.** Both mastery-oriented teachers in the study emphasized that learning is a process. One teacher said that seeing, hearing, and doing were ways of learning and the class would do all three. Both teachers also stressed the importance of understanding and improvement, which were more important than getting the right answer (Stefanou et al., 2004, p. 45). They also viewed mistakes as indicators that a shift in strategy was needed.

The importance of teacher structuring of the social environment for learning in these ways is indicated by a survey of 233 seventh and eighth graders from three ethnically diverse schools. Results indicated that teacher caring and support, opportunities to interact with classmates about academic work, and teacher encouragement of mutual respect led to more adaptive patterns of learning and engagement in learning (Ryan & Patrick, 2001).

**Summary**

The shared assumptions of the expectancy–value model, goal orientation models, and attribution theory also apply in the classroom. A fourth assumption is that motivation is subject-specific.

Two classroom influences on the development of students’ motivational beliefs are the nature of classroom goal structures and teacher reactions to students who differ in ability. Mastery-oriented classrooms facilitate the development of positive
student motivations because such classrooms emphasize effort, improvement, and challenge, and establish an environment in which students can experience improvement and mastery. In contrast, a focus on perceptions of ability, public evaluation, and showcasing only the best students' work are performance-oriented.

Also, teacher feedback, both verbal and nonverbal, sends messages to students about the teacher's attributions for a failure outcome. That is, teacher reactions of anger typically are interpreted as lack of effort as the cause for failure. Expressions of pity and unsolicited help are interpreted as sympathy, which indicates lack of ability. Other teacher behaviors that send messages of low ability are seating low achievers farther from the teacher, less eye contact, and fewer opportunities to respond to teacher questions.

Implementing a learning or mastery goal orientation includes flexible instructional groups, variations in assignments due to skill levels, encouragement of peer assistance, and substantive comments on student work. Observed characteristics of two mastery-oriented classrooms included student participation in generating class rules, considerable student autonomy, recognition and support of students' efforts, and a view of learning as a process that focuses on understanding and improvement.

Developing Programs for Motivational Change

One type of maladaptive motivational pattern is the decline in positive motivation beliefs in some children during the middle-school years. Included are competence beliefs and success expectancies, the importance and utility of school subjects, decline in the endorsement of mastery goals, and a change in attributions for failure from effort-related to ability-related (Anderman & Anderman, 1999; Anderman et al., 2002; Eccles & Midgley, 1989; Wigfield & Eccles, 1992, 2002a). Analysis of school-related items of the latest available survey of Health Behavior in School-Aged Children, administered by the World Health Organization, indicated serious problems for U.S. middle schools. For the sample of 32,793 youth in North America, parts of Europe, and Israel, U.S. middle school students were 2 standard deviations below the mean on the school climate items (Juvonen, 2007, p. 199). That is, U.S. students did not consider their school a pleasant place where they feel they belong. Also, U.S. middle-school students ranked 6th out of 12 countries in ranking teacher support, and 10th out of 12 on “perceptions of peers as accepting, kind, and helpful” (p. 199).

One approach, discussed at the end of this chapter, emphasizes fostering reading engagement, which includes both cognitive and motivational variables (Guthrie, McRae, & Klauda, 2007). Another intervention, Project HiPlaces, focuses on personalizing the school environment through establishing small learning environments within schools (some organizational changes are referred to as schools-within-schools). The focus of the project is to engage students more deeply in learning through building on connections to the teacher and to peers who are actively committed to learning (Fehner, Seitsinger, Brand, Burns, & Bolton, 2007). The essential characteristics include implementing deep, integrated standards-based instruction, maintaining an emphasis on numeracy and literacy, staffing
schools with teachers who are experts in teaching their students and empowering them to make decisions about students’ experiences, fostering health and safety, connecting the school with the community (p. 213), and ensuring effective team structures. Common planning periods and sufficient time for planning are key characteristics of effective teams.

A related issue for motivation is the relationship between disruptive behavior and classroom goals (Kaplan, Gheen, & Midgley, 2002; Kaplan & Maehr, 1999; Roeser, Midgley, & Urdan, 1996). Disruptive behavior is likely to be high in classrooms in which students perceive that the classroom values demonstration of ability and performing better than others (Kaplan et al., 2002, p. 203). In contrast, classrooms perceived to value learning and understanding are likely to be low in disruptive behavior.

The second type of maladaptive motivation beliefs is referred to as “learned helplessness.” These students attribute failure to lack of ability and see no relationship between their actions and outcomes. Attribution training programs implemented with “learned helpless” students and students with learning difficulties have three goals. They are to (a) redirect student focus to the task instead of their fear of failure, (b) encourage students to retrace their actions in problem-solving situations to determine alternate strategies, and (c) assist students to attribute failures to inadequate effort rather than lack of intelligence (Robertson, 2000, p. 112).

A review of 20 attribution training interventions by Robertson (2000) led to five recommendations for implementation (see Table 11.8). First, ensure that the child does have the capability to succeed at the particular task before introducing attributions for effort. Otherwise, if the child works hard but does not succeed, the child’s self-view of low ability is reinforced (p. 131).

Second, encourage student attributions to the use of a strategy, instead of ability and/or effort. This focus protects the child’s self-esteem when failure occurs. Third, attribution training in addition to strategy training is not needed unless the child does not understand the causal relationship between strategy use and a successful outcome. Fourth, peer models are more effective than the teacher stating the attribution to effort or lack of effort in solving the problem. Finally,

**TABLE 11.8**
Recommendations for Attribution Training

| 1. | Attributions to ability and effort must be accurate in order to influence motivation. |
| 2. | Encourage success attributions to use of strategies instead of to ability and/or effort. |
| 3. | Combining attribution training with instruction for strategies should be implemented only when the learner does not understand the causal relationships between use of a strategy with success and failure. |
| 4. | Peer models (live or video) are more effective than indirect methods (e.g., the teacher states the attribution) in demonstrating the effects of attribution or strategy use. |
| 5. | Large group attribution training is not recommended. |

*Note: Summarized from Robertson (2000, p. 131)*
attribution training should not be attempted with large groups because public attributions may embarrass some children (Robertson, 2000, p. 131).

Building the high, stable, and resilient expectancies that accompany challenge seeking and persistence also requires attention to other variables. Among them are an environment that supports risk taking and tasks that include challenge, and even failure, within a learning-orientation setting (Dweck, 1989, p. 118).

Planning an attributional change program should include at least three steps. The first step is to develop an analysis of the attributional cues that currently signal failure in the child’s experience. The second step is to identify and implement alternative teacher behaviors that can serve as attributional cues to the student. Examples are legitimate, positive comments for both effort and partial activities completed correctly. The third is to identify group activities that foster beliefs in the importance of developing alternative strategies to reach a goal and that emphasize realistic goal setting.

EDUCATIONAL APPLICATIONS

A major contribution of motivational perspectives to education is the analyses of classroom interactions. In the classroom setting, researchers have applied these frameworks to analyze both student and teacher behaviors and to suggest remedies (Ames, 1992b; Ames & Archer, 1988; Anderman et al., 2002; Covington, 1999; Dweck, 1989; Eccles et al., 1983; Elliot, 1999; Elliott & Dweck, 1988; Jagacinski & Nicholls, 1987; Stipek & Daniels, 1988). On a broader scale, attribution theory has implications for the ways that our culture defines success. Frieze, Francis, and Hanusa (1983) described several analyses of the American definition of success. It is viewed as attainable by the individual who outperforms others in competitive situations. Such a societal value, by its very nature, relegates some people to failure status. In contrast, other cultures define success in terms of group accomplishment and cooperation. At the very least, attribution theory suggests success definitions that emphasize accomplishment through effort and the exercise of learned skills (Frieze et al., 1983).

Classroom Issues

The issues of student characteristics, cognitive processes and instruction, and the social context for learning are viewed from the perspective of motivational perspectives.

Learner Characteristics

The characteristics of major concern to education include individual differences, readiness for learning, and motivation. Motivational perspectives do not directly address individual differences or readiness for learning.

Individual Differences. Motivational models and theories identify various factors, such as achievement history and the learner's social context, that influence
the individual’s motivational beliefs. However, they do not identify particular constellations of these factors that differentiate individuals.

**Readiness for Learning.** Although readiness is yet to be researched by the motivational perspectives, the implications are clear. Low expectancy for success, low task value, the adoption of performance-avoidance, work or failure-avoidance goal orientation, and attributions of lack of ability for failure influence students’ receptivity to instruction.

**Motivation.** Theories of learning typically treat motivation as a concept that is an adjunct to the principles for generating learning in the student. For the most part, these theories focus on some environmental manipulation that may lead to student motivations, such as arousing the student’s attention, examining the role of incentives, or making the material relevant, meaningful, or interesting (Weiner, 1974b).

In contrast, motivational perspectives view certain classroom processes and student characteristics as important sources of motivation. Classroom processes, for example, include supporting a mastery goal orientation, the teacher’s affective reactions to students’ successes and mistakes, support for autonomy, and recognition and support of effort.

**Cognitive Processes and Instruction**
The three cognitive issues of importance to education are transfer of learning, teaching problem solving, and learning how-to-learn skills. Motivational perspectives indicate that self-handicapping and avoidance strategies are likely to be transferred to subsequent achievement tasks as are maladaptive problem-solving approaches. Acquiring how-to-learn skills is most likely to occur in classrooms with a mastery goal orientation in which errors are treated as clues to remedy one’s learning.

**Implications for Assessment**
An aspect of mastery-oriented classrooms rarely discussed in the literature is the assignment of grades for the 6- or 9-week grading period. The issue is that A to F grading, which typically begins in middle school, is at odds with a classroom focus on mastery. Why should a student who is weak in math or reading strive to improve if the likely final grade indicates failure? (Thomas & Oldfather, 1997).

One alternative is some variation of Benjamin Bloom’s (1968) mastery learning model. He based his model on the belief that most students could master the subject matter in public schools if given additional time to learn. Bloom’s model also introduced two types of assessment: formative and summative. The function of formative assessments is to provide feedback to teachers and students about students’ errors and misunderstandings. In other words, unit tests are viewed as a mechanism for feedback. Students who do not achieve mastery on the unit test receive additional instruction and retesting on the missed concepts. The belief is that implementation of formative assessments may prevent some cases of failure. Disadvantages of the model are the additional teaching time required on the missed concepts and the difficulty in addressing more deep-seated problems, such as poor reading skills.
Another assessment alternative is portfolio assessment, which is particularly appropriate in addressing the development of literacy. Briefly, a portfolio is “a purposeful collection of student work that tells the story of the student’s efforts, progress, or achievement in (a) given area(s)” (Arter, 1992, p. 1). Established first are the purpose and instructional goals, such as to show growth over time (purpose), interact with text to construct meaning, communicate effectively through writing, and compose oral or written summaries to support comprehension (instructional goals).

Then guidelines for portfolio items specify the types of student work to be included, such as several drafts of an essay, a reading log, and other writing samples, including some student-selected work (Gillespie, Ford, Gillespie, & Leavell, 1996). Entries in the portfolio change as students become more proficient in particular tasks. Portfolio assessment can contribute to developing student investment in learning, thereby contributing to the student’s view of the value of the course or domain. However, one difficulty in implementing portfolio assessment is reconciling the processes of learning addressed in the portfolio and external accountability systems.

Unlike the expectancy–value and goal orientation models, attribution theory focuses on the learner’s identification of causes for success and failure outcomes. The theory documents the debilitating effects of attributions to lack of ability for failure. This analysis is supported by the research that has identified the warning flags in sixth grade that predict student failure to later graduate from high school (Balfanz, Herzog, & Mac Iver, 2007). Two of the indicators are failing math and/or failing English in sixth grade. (The other two are attending school less than 80% of the time in sixth grade and receiving an out-of-school suspension that year.) The implications for assessment from attribution theory are to deemphasize the dichotomous success–failure distinction of classroom tasks and assessments. In other words, mastery-oriented classrooms and assessments may reduce the need for addressing school failure.

The Social Context for Learning
Goal orientation models and attribution theory address aspects of the classroom that influence students’ motivations. Classrooms with a mastery goal orientation establish a climate that facilitates learning. The classroom supports student development and the use of self-management skills, avoids competition, and provides reasonable challenges. Attribution theory identifies the teacher as an important source of information for students’ beliefs about their capabilities.

Relationships to Other Perspectives
Unlike the learning-process and cognitive-development theories, motivational perspectives identify the learner as a major factor in developing motivation for school learning. Through the interpretation of information in the social setting and past experiences, the learner develops a set of beliefs that encourage or discourage engagement in achievement-related tasks.

Some concepts in attribution theory and social-cognitive theory are complementary. Learners who attribute success to effort or ability and effort also hold positive self-efficacy beliefs and are self-regulated learners.
Developing a Classroom Strategy

The application of motivational perspectives in the classroom implies a need for proactive strategies rather than a reliance on reactive responses to students’ achievement-related activities. It also implies a classroom climate that emphasizes the process of learning rather than competitive achievement. Such a classroom climate minimizes the number of success–failure judgments with their accompanying self-worth assessments and expectancy consequences. Instead, classroom goals emphasize improved learning strategies, class time is structured to minimize interpersonal competition, and feedback to students minimizes ability or lack of ability as an attribution for classroom outcomes. In other words, the classroom is structured to reinforce the belief that learning is acquired through constructive effort. The following strategy is suggested for the development of a positive proactive environment.

Step 1: Restructure classroom objectives in terms of learning processes or strategies.

1.1 Which objectives can be rewritten to emphasize a learning strategy?
1.2 Which classroom tasks currently in use can be varied to provide novelty and diversity and enhance student interest?

Step 2: Identify appropriate evaluation methods.

2.1 Where can formative evaluations or tests be implemented that focus on identifying mistakes to improve learning?
2.2 Does the classroom contain wall charts, progress reports, or grades that can be replaced with rotating displays of all students’ work?
2.3 Are classroom rewards consistently distributed for effort, not ability?
2.4 Are students given a variety of opportunities to demonstrate what they have learned?

Step 3: Identify classroom activities that (1) deemphasize interpersonal competitiveness and (2) facilitate the development of effective task-approach strategies and effort.

3.1 Is the percentage of time devoted to class activities as compared with small-group and individual seatwork activities too high, for example, 80% as compared with 20%?
3.2 What changes can be made in tasks to increase student decision making?
3.3 Which small-group activities may be used to increase the cooperative nature of learning?
3.4 What individual or group games are available that can enhance student effort and/or improve learning strategies?

Step 4: Develop verbal feedback statements that convey appropriate attributional messages.

4.1 Is praise appropriately used (i.e., avoided for success at easy tasks, provided for persistence and appropriate strategies as well as success at difficult tasks)?
4.2 What constructive teacher strategies may be used instead of sympathy for unsuccessful performance? Are external factors, such as luck, avoided as explanations for success and failure?

4.3 What strategies may be used to encourage students to take responsibility for their own learning?

Classroom Example

The following example, Concept-Oriented Reading Instruction (CORI) in reading addresses reading engagement, defined as merging motivational, cognitive, and behavioral characteristics of students (Guthrie et al., 2007).

Goal: To increase students’ reading comprehension in grades 3–5 through increasing their reading engagement (p. 241).

Targeted motivations: (a) reading for enjoyment, (b) perceived autonomy (student likes to make choices in reading), (c) self-efficacy for reading, (d) collaboration (prosocial goals for participation in various activities), and (e) mastery goal pursuit (i.e., student desires to understand text deeply) (p. 241).

Motivational support: Relevance—hands-on activities, linking content to students’ experience, including class activities.

Autonomy support—student input into topics, choice of partners and, when possible, sequence of work.

Support—ensuring that “students perform meaningful classroom tasks proficiently” (p. 243). Includes (a) providing texts for fluency instruction that can be easily repeated, such as poems; (b) providing many opportunities to practice a reading strategy to proficiency; (c) providing a variety of texts on key concepts; (d) selecting easily readable texts early in instruction such that students should be able to read 90% of the words; (e) permitting students to set short-term reading goals, such as number of pages to be read about a topic; and (f) encouraging students to make effort attributions (pp. 242–243).

Collaboration—arranging for productive social interactions in reading with both team and individual accountability (p. 243). Included are pairing students to read aloud and setting up idea circles in which students learn a concept by reading different text sources (p. 243).

Thematic units—multitiered instruction with a “big idea” at the top supported by major concepts, subconcepts, and examples. Includes (a) a content theme (e.g., animal survival), (b) a prominent guiding question, (c) finding concept examples, and (d) writing compare–contrast charts (p. 243).

Importance of thematic units—students become experts on a topic.

Role of reading strategies—inferencing, asking questions while reading, summarizing, and monitoring one’s understanding during reading are the tools of comprehension (p. 244). Strategies are the means for understanding the information and literature on the theme.
Materials: Trade books on three different reading levels: (a) one-third at or above grade-level reading, (b) one-third 1–2 years below grade level, and (c) one-third that are more than 2 years below grade-level reading. Books are allocated to two sets: class sets (one set for each student) and team sets (one set for each five students). Class sets consist of 14 information books, 21 novels, and three poetry books (p. 241).

Hands-on science materials: terrariums, horseshoe crabs, charts, and posters (p. 241).

Three to six websites that are grade-level appropriate and guides for their use (p. 241).

Daily lessons: 10 minutes—oral fluency 3 days per week; science concepts, including hands-on activities twice weekly
10 minutes—mini-lesson on comprehension strategies

Three 15-minute segments—students alternate between small-group guided reading led by the teacher, writing (portfolio entries), and independent reading (students read book club novels).

Total instructional time: 65 minutes.

Student portfolios—entries consist of students’ summarizations of text passages, questions, inferences, reactions to novels used in small-group discussions, and work on composing a brief personal narrative (p. 242).

Review of Perspectives on Motivation

Three perspectives—the expectancy–value model, goal orientation models, and attribution theory—focus on factors that influence students’ engagement in achievement-related activities (see Table 11.5). They maintain that motivation develops from a complex interaction of environmental and internal factors, the individual is an active processor of information, and achievement-related beliefs are explicit information. The expectancy–value model also maintains that students’ expectations of success are key determinants of task (course) choice, persistence, extent of effort, cognitive engagement, and actual performance. Direct influences on these values are the student’s affective memories and goals and self-schemata. Contributing beliefs are the student’s social world and perceptions of it, and prior achievement-related experiences. (See Table 11.9.)

In contrast, goal orientation models address students’ reasons for engaging in academic tasks because they influence students’ cognitive strategies, task selection, and competence perceptions. Major types are mastery or learning-oriented, which lead to positive task strategies; performance-approach; and performance-avoidance orientations. The latter two orientations focus on obtaining favorable judgments of one’s competence and avoiding unfavorable judgments, respectively. Both orientations lead to superficial engagement with the subject matter.

The third perspective, attribution theory, maintains that the search for understanding is a prime motivator of action, attributions are complex sources
of information, and future behavior, in part, is determined by one's attributions for success and failure outcomes. Typical attributions are ability, effort, task difficulty, luck, others, and mood or illness. They differ on the dimensions of locus of causality, stability, and controllability, which can generate different expectancies for future outcomes and different emotions.

In the classroom, many children's expectancies for success, competence beliefs, and beliefs in the effectiveness of effort typically decline as they enter middle school. This decline may lead to self-handicapping and other avoidance strategies. However, classrooms that focus on mastery-oriented goals, provide student choice on tasks, and provide recognition and support for effort can facilitate the valuing of knowledge and learning by students.

**Disadvantages**

Specific classroom procedures are yet to be developed for the implementation of the motivational perspectives in the classroom.

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**TABLE 11.9**

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Motivation develops from a complex interaction of internal and external factors; the individual actively processes information; and achievement-related beliefs are explicit information.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivational processes</td>
<td>Key determiners of achievement-related behaviors are students' (1) success expectancies and task (domain) values, (2) achievement-goal orientations, or (3) attributions for success/failure outcomes.</td>
</tr>
<tr>
<td>Components of motivation</td>
<td>(1) Students' affective memories, goals, and self-schemata, which directly influence expectancies and values; (2) mastery, performance-approach, and performance-avoidance orientations; or (3) major attributions (ability, effort, task difficulty, mood or illness, luck) and the dimensions (locus of causality, stability, and controllability)</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Specific classroom procedures are yet to be developed</td>
</tr>
<tr>
<td>Contributions to classroom practice</td>
<td>Identification of classroom activities that contribute to maladaptive student behaviors and the problems inherent in competitive classrooms Provide a framework for the research and analysis of affective events operating in the classroom</td>
</tr>
</tbody>
</table>
Contributions to Educational Practice
The motivational perspectives have identified a major problem in the American classroom. It is the competitive nature of learning and the effects that such an atmosphere can have on many children. Competitiveness, by its very nature, relegates someone to last place, often in a race that has limited long-term value. These perspectives provide a framework for the research and analysis of many affective events operating in the classroom.

CHAPTER QUESTIONS

Understanding Concepts

1. According to the expectancy–value model, what is the difference between attainment value and intrinsic value?
2. How does the portrayal of goals in the expectancy–value model and the goal orientation model differ?
3. What is the rationale for subdividing performance goals into performance-approach and performance-avoidance goals? What are the measurement issues involved in developing surveys that require students to respond to constructed statements about goals?
4. What is the relationship between attributions for success and Bandura's concept of self-efficacy?
5. How might a learner's theory of intelligence interact with classroom events to influence attributions for achievement outcomes?

Applying Concepts to Instructional Settings

1. A middle-school teacher observes two students struggling with a set of science questions about a chapter the class has briefly discussed. She says to the students not to worry about answering all the questions—just answer the first one or two. What message about ability has this communication sent to the two students?
2. In the above situation, what should the teacher have done instead?
3. Select a curriculum area or course in the secondary school curriculum that you are interested in or plan to teach. What are some steps that you as the teacher can take to enhance the utility value of the course or curriculum area for students?
4. Goal orientation models discuss the importance of a learning or mastery goal orientation and describes activities and actions the teacher should take to foster a mastery orientation in students. How might this approach in the classroom reduce the success-failure distinction that is a key concept in attribution theory?
5. A classroom teacher typically provides feedback to students following unit tests in statements such as, “You got a great score on this test,” “You didn’t do so well on this test; maybe you should study harder next time,” and so on. Suggest statements that the teacher should use instead.

REFERENCES


PART IV Social-Context Theories


Guthrie, J. T., McRae, A., & Klauda, S. L. (2007). Contributions of concept-oriented reading instruction to knowledge about interven-
CHAPTER 11  Cognitive Models and a Theory of Academic Motivation


Weiner, B. (1972). *Theories of motivation from mechanism to cognition*. Chicago: Markham.


EPILOGUE

Competing perspectives progress and degenerate, or coexist indefinitely, depending on their capability to generate new hypotheses that lead to empirical discoveries. (Lakatos, 1970)

We have concluded our exploration of the world of learning through various changes in societies and ways of thinking and return to where we began with a more complete understanding of this multifaceted phenomenon. The human race has progressed from the first instance of appropriating an artificial sign to change one's memory to the present-day understanding of the essential characteristics of expert problem solvers, requirements for critical thinking, and other factors associated with cognitive operations. In addition, the relationship between knowledge and society has changed from the early centuries of civilization, in which knowledge was a privilege of the few, to the current open access to vast domains of knowledge. Paradoxically, at least in the United States, this unfettered access to knowledge is accompanied by a barrage of electronic images, entertainment, and communications, as well as instant information and misinformation via the Internet.

First discussed are the unique contributions of each theory to our understanding of learning and instruction. Often, insights developed in these theories apply beyond the situations in which they originated. Then, current challenges to the development of learning are discussed, followed by two emerging issues.

UNIQUE CONTRIBUTIONS OF THE VARIOUS THEORIES

Each theory of learning, cognitive development, or motivation has made important contributions to our understanding of learning. Discussed in this section are the insights of each of the four major groups of theories: the early learning theories, the learning-process theories, theories of cognitive development, and social-context theories.
The Early Learning Theories

The early learning theories—classical conditioning, Thorndike’s connectionism, and Gestalt psychology—charted new, unexplored territory in developing information about learning. In these efforts, they designed experimental models for research and introduced basic constructs that could be studied systematically in the laboratory or the school setting. Moreover, connectionism and Gestalt psychology were appropriate for the learning needs of society in the early 20th century. The focus was basic skills in mathematics, reading, and writing, with advanced courses for the 5% who were expected to pursue a college education. Thorndike’s connectionism addressed the learning of specific items of information and Gestalt psychology identified problem set and functional fixedness, difficulties that can occur in learning problem-solving strategies.

Thorndike’s connectionism, classical conditioning, and a basic assumption of Gestalt psychology also are found in current learning situations. College students who cram for final examinations are typically focusing on stimulus-response fragments that are facts or definitions—examples of connectionism. A very different situation, learned helplessness, is, in part, an example of classical conditioning. Just as dogs in the laboratory developed severe anxiety when powerful stimuli (such as electric shock) overwhelmed their typical reactions, children whose efforts meet with continued failure are conditioned to discontinue trying.

The lesser problem, low self-efficacy, reflects a key Gestalt assumption about perception. Specifically, the behavioral environment, one’s perceptions, rather than the geographical environment, the way things are, is important in understanding individual learning problems. Students who have the capabilities to succeed in a cognitively demanding course but who believe that they cannot are examples of the Gestalt assumption that perception trumps reality.

The Learning-Process Theories

Skinner’s operant conditioning, Gagné’s conditions of learning, and information-processing theory represent the essential activities and processes in the learning of voluntary or self-directed responses from the behaviorist perspective, the needs of instruction, or the cognitive perspective. Table E.1 summarizes their contributions.

Skinner’s translations of inner states into observable behaviors, and his identification of the critical component in behavioral change—the dynamic of responses producing reinforcement—apply to a variety of learning situations. For education, another key concept is to avoid placing students in a set of terminal contingencies where they may lack the skills to succeed. A classroom structure in which learners are expected to function as a discourse community can be such a situation for low-ability learners. Students who cannot participate in the construction of meaning through dialogue are unable to be members of the classroom community (Cobb & Bowers, 1999). Also, diverse learners from minority cultures or lower socioeconomic groups may be shut out of environments that appear to be egalitarian because the students lack the knowledge and skills to participate (Delpit, 1988).

Gagné’s conditions of learning contain elements of both the behaviorist and cognitive perspectives. They are the identification of the performance that reflects
<table>
<thead>
<tr>
<th>Theory</th>
<th>Summary of Assumptions</th>
<th>Basic Components</th>
<th>Major Issues in Designing Instruction</th>
<th>Major Contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. F. Skinner's operant conditioning</td>
<td>Learning is behavior; behavioral change, represented by response frequency, is a function of environmental events and conditions.</td>
<td>((S^D))-(Response)-((S^{\text{ext}}))</td>
<td>Transfer of stimulus control, timing of reinforcement, avoidance of punishment</td>
<td>Analysis of states, such as readiness; analysis of aversive classroom practices; individualized learning materials</td>
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<td>Robert Gagné's conditions of learning</td>
<td>Human learning in all its variety is the focus of study. Learning is more than a single process, and these distinct processes cannot be reduced one to the other.</td>
<td>The five varieties of learning, each with its own set of internal and external conditions</td>
<td>Identification of capabilities to be learned; selection of appropriate instructional events; task analysis for cumulative learning</td>
<td>Identification of the psychological processes in cumulative learning; accounts for the diversity of human learning; linked instruction to phases in information processing</td>
</tr>
<tr>
<td>Information-processing theories</td>
<td>Human memory is a complex and active processor and organizer of information that transforms learning into new cognitive structures.</td>
<td>The processes of perception, encoding and storage in long-term memory, metacognitive knowledge and processes, and problem-solving processes</td>
<td>Linking new learning to schema; providing processing aids in comprehension, developing metacognitive skills, and problem solving</td>
<td>Identification of the active processes in the learning of new information, developing learner-directed skills, and development of models of problem solving</td>
</tr>
<tr>
<td>Jean Piaget's cognitive-development theory</td>
<td>Intelligence constructs the cognitive structures that it needs to function. Knowledge is an interactive process between the learner and the environment.</td>
<td>Assimilation and accommodation, regulated by equilibration; physical experience and logical-mathematical experience</td>
<td>Provide rich opportunities for experimentation with physical objects with peer interaction and support from teacher questions</td>
<td>A rich description of the world through the child's eyes; identifies current curriculum problems; operationalizes discovery learning</td>
</tr>
<tr>
<td>Lev Vygotsky's cultural-historical theory of psychological development</td>
<td>The processes of human cognitive development are part of the process of historical development.</td>
<td>The processes of mastering the signs and symbols of the culture; also, learning to use symbols to direct and master one's own behavior</td>
<td>The role of subject matter concepts in developing higher cognitive skills; the creation of zones of proximal development during teaching</td>
<td>Recognition of the psychological contributions of created stimuli in cognitive development; the importance of interaction with adults, the &quot;ideal form&quot; of behavior</td>
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<tr>
<td>Albert Bandura's social-cognitive theory</td>
<td>Learning is a three-way interaction among the environment, personal factors, and behavior.</td>
<td>Modeled behaviors; direct, vicarious, and self-reinforcement; and the learner's cognitive processes</td>
<td>Provide models, reinforcement, and rehearsal; develop efficacy and learner's self-regulation</td>
<td>Description of learning from models in the social-setting and influence of mass media; development of the self-regulatory system</td>
</tr>
<tr>
<td>Cognitive models and theory of academic motivation</td>
<td>Academic motivation arises from a complex interaction of factors in the environment and within the child; the student is an active processor of information; and the student's motives and goals are explicit information</td>
<td>Key motivational factors: expectancy of success, goal orientation, and self-attributions about success and failure outcomes</td>
<td>Implement mastery-oriented classroom goals, student decision making, autonomy, and recognition and support</td>
<td>Identification of the psychological linkages between beliefs and action and the linkages between classroom activities and children's beliefs about themselves</td>
</tr>
</tbody>
</table>
each learned capability (behavior) and the essential internal processing steps required for acquiring each capability (cognition). For learning to be complete, internal processing should conclude with opportunities to apply the new learning in situations different from those introduced initially in instruction. This emphasis on transfer is similar to Skinner’s transfer of stimulus control in which new learning becomes independent of the cues and supports that initiated the behavior.

A unique contribution of the conditions of learning is the identification of the different categories or varieties of learning and the prerequisites to the highest intellectual skill, higher order rule learning or problem solving. The importance of prerequisites is indicated in Brophy’s (2005) recognition that attribution training for learners who are low performers must address the skills that are missing in the student’s repertoire. That is, focusing on changing the student’s attributions from lack of ability to lack of effort is often misguided because the student is trying. In addition, the expansion of Gagne’s learning task analysis into cognitive task analysis indicates the importance for training of identifying key decision points in the activities undertaken by experts.

The first use of an artificial symbol by humans to represent an item of information to be remembered is an early example of metacognition. Currently, information-processing theory has identified other strategies, including comprehension monitoring and planning, monitoring, and evaluating one’s progress in learning. The introduction of cognitive load as an important factor in learning indicates the complexity of learning beyond that of early humans.

**Cognitive-Development Theories**

The focus in the learning theories is the acquisition of some identified achievement in relation to the content in the curriculum. In other words, some form of mastery of course content is the intended outcome. In contrast, the focus of the two cognitive-development theories is proficiency in some form of higher-level thinking. For these theorists, Piaget and Vygotsky, course content serves as a vehicle in developing higher forms of thinking. That is, learning some form of course content is not the ultimate outcome.

Piaget defined the highest level of cognitive development as logical thinking in which individuals reason accurately about cause–effect relationships. He advocated student experimentation on objects and events in the real world to develop this capability. In other words, through experimentation and the weighing of evidence, students can develop an analytical, critical spirit. An example of the application of this perspective is the middle-school earth science curriculum described by O’Neill and Polman (2004) in Chapter 8. The students pose viable research questions based on available information about a topic, collect the data, and are required to analyze the information (rather than appealing to authority). In this way, they develop a logical approach appropriate for problems in mathematics, science, and other disciplines.

For Vygotsky, learning to think conceptually (which involves thinking with networks of concepts in different subject areas) is both an outcome of cognitive development and the set of processes responsible for the development of self-directed attention, categorical perception, and logical memory. Thinking in terms
of concept networks differs from simply identifying the examples of a particular concept in which the individual’s thinking is tied to external stimuli. The higher mental functions develop only with the shift to internal control of internally constructed stimuli.

Vygotsky’s conception of the signs and symbols of a culture and the relationship to thinking also speaks to the issue of the prevalence of electronic media in contemporary daily affairs. The processing of ongoing visual images does not enhance reflection and does not contribute to the development of higher mental functions. The recognition of co-occurring images, from Vygotsky’s perspective, is the definition of signalization. It is an elementary cognitive process in which judgment is based on the recall of similar images, a process that does not contribute to cognitive development.

Social-Context Theories

Since the introduction by Bandura of the importance of models in the social setting, learning contexts have expanded from the home and the classroom to the whole world, which is accessible 24/7 via electronic media. The result is a double-edged sword. On the one hand, new technologies have led to several changes in both schooling and the workplace. Video conferencing has replaced the travel required for face-to-face meetings in business and students can connect with others in different countries. Also, working at home is feasible for some jobs, such as a copy editor for a publishing company. These positions require individuals who are highly skilled, motivated, and self-directed. Personal efficacy and the development of the individual’s self-regulatory system are essential in developing the expertise and self-direction required for such situations.

On the other hand, increased accessibility to entertaining images in the electronic media in recent years poses two problems for education: the increased exposure to a diversity of models, some of which illustrate negative or inappropriate behaviors, and the decreased time in activities that can build language. Brophy (1999) noted the need for models who exemplify enthusiasm for the subject as well as structuring reinforcements for student insights about the subject area. An example is placing high school students in summer internships with university professors in their research laboratories. This practice also can enhance both student expectancy for success in academic activities and the value placed on academic pursuits. The importance of motivational models is supported by the 2007 survey by the World Health Organization. Middle schools in the United States were 2 standard deviations below the mean on school climate items. The challenge for education is to foster deep engagement in learning while addressing established accountability standards.

Current Issues

In recent years, theory and research have begun to address the many complexities inherent in the learning process. However, theory development and research face conceptual, theoretical, and social issues in the efforts to contribute to our
understanding of learning and instruction. They are (a) the gap between development and understanding (conceptual), (b) the gap between the reality of many classrooms, and theory (conceptual and social), (c) the disparity among children entering school (social), (d) the role of technology in learning, and (e) the tension between universalistic and particularistic theories (theoretical).

The Gap Between Theory and Understanding

The rapid popularity of a theory often leads to misconceptions and misapplications. Valsiner (1998) noted that the depth of understanding of a theory is inversely related to its popularity. If the misconceptions are not corrected, the theory often is questioned or discredited on the basis of inaccurate information. An early example in the 1960s was the rush to publish so-called programmed learning materials. On the surface, they resembled Skinner's mode of programming instruction. However, the developers simply left blanks in sentences from textbooks instead of carefully designing the instructional sequence. The problems generated by the poorly designed materials led to criticisms of operant conditioning as a basis for developing individualized instruction.

More recently, the attempted application of the Piagetian stages of cognitive development to the design of curriculum and the stated mandate that Vygotsky advocated group-directed school instruction are examples. The result is curriculum or instruction that fails to meet the potential suggested by the theory.

The Gap Between the Reality of Many Classrooms and Theory

Three factors are essential in bringing about major changes in social institutions such as schools. They are (a) theoretical principles that identify the specific components of the process of interest, in this case learning; (b) associated activities and strategies required to implement the identified components; and (c) a mechanism for disseminating and installing the specified activities and strategies. Theories related to learning, based on particular assumptions about the process, provide the principles and most of them also address associated essentials for instruction. Lacking, however, is the third factor, the mechanisms for implementation. As Bandura (2004) noted, theorists have identified the principles and the ways they should be implemented in classrooms. However, theory does not profit from its successes because models for implementation are lacking.

Required for successful implementation are accurate information about theoretical principles, adequate training and support while teachers are learning and practicing the strategies, and adequate resources (e.g., materials, instructional and administrative support) to sustain implementation. First, however, there is no clearinghouse for pedagogical developments intended for classroom use. Teachers learn about new developments from a patchwork of sources, which also can promote pedagogic fads. Sources of information for teachers include professional publications, bulletins and newsletters from school districts and state departments of education, and workshops. Second, professional development for teachers occurs in varying degrees and emphases across districts and states.
Third, the accountability requirement has increased the use of published standardized tests. Content coverage and test achievement are related and pervasive priorities. However, items on these tests are not designed to address the outcomes identified in learning theory. Ideally, assessment for accountability should include open-ended items, such as explaining problems in the country at a particular point in history to an English cousin; constructed responses for key definitions; and demonstrating relationships among concepts. However, given that such changes in accountability assessments are unlikely to change in the near future, making a case for changes in instruction is extremely difficult.

The Disparity Among Children Entering School

Differences in children’s prior experiences relevant for school learning is not a new issue in education. Socioeconomic differences, translated as preparation for learning, were the impetus for Head Start. In addition, programs that teach basic concepts about the nature of print and books and the nature of numbers to children (described in prior chapters) respond to the need for particular instruction for some children when they enter school.

Vygotsky highlighted the importance of the child’s language when he or she enters school as the vehicle for learning. The absence of opportunities in the home for young children to engage in dialogues with adults leads to impoverished ways of speaking and, therefore, impoverished ways of thinking (Vygotsky, 1935/1994). Therefore, preschools should provide rich experiences in language use between children and adults who are the ideal form of behavior. This need is supported by Ausubel, Novak, and Hanesian (1968), who noted that disadvantaged children used few parts of speech that are required for thinking. That is, their speech lacked “conjunctons, adjectives, adverbs, and qualifying phrases of clauses” (p. 218).

The Role of Technology in Learning

Bandura’s social-cognitive theory refers to models in the electronic media; however, most theories address the learning of the individual student in interacting with objects in the environment. Yet to be developed are learning principles that address teacher–student interactions, student-to-student communication, and student-to-subject-matter interactions for various uses of computer technology. The structuring of information, the nature of questioning, the nature of informative feedback, and the scheduling of reinforcements are among the many issues to be addressed in relation to technology.

Complicating these issues is the potential of telecommunication exchange projects among classrooms in different cultures to promote simplistic and sanitized views of others (Fabos & Young, 1999). For example, in one project, computer exchanges among students in the United States and New Zealand revealed that the students watched the same television shows and listened to the same music. Such exchanges may indicate the dominance of U.S. entertainment media, but they do not foster in-depth understandings of students’ backgrounds and cultural contexts.
A more profound problem is the dominance of the visual image as both entertainment and a primary form of acquiring information. The pervasiveness of this issue is indicated by the term visual literacy—a skill that involves both understanding images and using them to express oneself. One rationale for relying on visual images in instruction is that children learn to read pictures before learning to read words. However, from Vygotsky's perspective, images are an example of concrete graphic thinking, which is dominated by perception. The issue for education is to move the learner beyond graphic thinking to higher forms of cognition.

The Tension Between Universal and Particularistic Theories

The learning-process theories, Piagetian theory, social-cognitive theory, and academic motivation models and theories are universal perspectives. The goal is to define principles of learning, cognitive development, or motivation that universally apply across settings, contexts, and learners. Whether the learning situation is in the United States or another country, a classroom or the workplace, with children or adults, the same principles apply. They may be implemented in somewhat different ways, but the basic principles do not change.

Vygotsky's theory, in contrast, identifies the signs and symbols of a culture as a major variable in cognitive development. The extent of sophistication of the symbol system of the culture and the ways of thinking used in the culture establish broad limitations on learning. Furthermore, social interaction with capable adults is an essential component of learning. In other words, his theory breaks down the barrier between the individual learner and the context.

Vygotsky provided a new perspective in the form of the role of one's culture in learning. However, theorists and researchers should guard against further development that becomes so particularistic that generalizability is not possible. Bronfenbrenner (1993) noted that both universal and particularistic theories are needed. Universal theories can provide information about the processes, activities, and skills that are to be found across learning settings. Particularistic theories then flesh out the details and fill in the gaps for various applications of the universal theories. In other words, each needs the other, and work should not proceed on one without the other.

EMERGING ISSUES

Two issues are beginning to emerge that are likely to continue in future years. One is that changes in technology are occurring at such a rapid pace that they are changing the basic ways that people communicate and interact with each other. The centuries-old shift from an agricultural/industrial basis of production to an industrial/cybernetic basis is dominated by electronically mediated political economies (Gordon, 1991, p. 99). That is, complex technologies, which most people do not understand, are increasingly regulating their lives (Bandura, 2001). An example is staying in touch with the office through Blackberrys and other devices while on vacation. Although intended to assist individuals to control their lives, the technology
can, paradoxically, control the ways that individuals think and behave (p. 17). The ultimate changes in thinking and behavior are yet to be determined.

The second issue is the tension between microanalytic studies of cognitive functioning and the macroanalytic approach. This emerging tension is manifested in two ways. One is the tendency for the microanalytic approach to treat consciousness as an epiphenomenon—an event on the periphery of cognitive functioning. Consciousness is viewed as an executive subsystem of the processing of information. However, this perspective omits the functional use of the human mind. That is, the mind is “generative, creative, proactive, and reflective, not just reactive” (p. 4).

The other tension between microanalytic and macroanalytic approaches is the emphasis on the biological determinism of human behavior by some microanalysts. Referred to as the biologizing of psychology, the dynamics between psychological and sociological factors are becoming dominated by neurodynamics. Bandura (2001) cautions against this domination, maintaining that psychology is best suited to an understanding of the integrated nature of humans, one that includes psychological, biological, and social factors.

As in the past, the increasingly complex needs of society in the area of learning pose new challenges to theory development. Included are understanding cultural shifts influenced by technological developments and the role of humans in a changing world.

REFERENCES


Abstraction, empirical. The process of constructing internally the physical characteristics of objects.

Abstraction, reflective. The process of reorganizing or coordinating one’s actions on a higher level.

Accommodation. (1) The adjustment of internal cognitive structures to particular characteristics of specific situations; (2) the modification of internal cognitive structures that takes place when thinking is reorganized.

Adaptation, active. The adaptation to the environment undertaken by the human species in which nature is controlled and mastered. The two results of this process are (1) the creation of new natural conditions of existence and (2) altered internal psychological structures.

Adaptation, passive. The adaptation to the environment undertaken by animals in which tasks are mechanically executed according to inherited experience and materials available in the environment.

Advance organizer. An “umbrella” statement that provides a conceptual link between the learner’s existing knowledge and the new learning.

Affect. The general and specific emotions that result from a particular outcome. General emotions include happiness and frustration. Specific emotions include gratitude, pride, incompetence, and guilt.

Antecedent information. The sources of information available to the individual prior to the causal attribution about success or failure. They include success history, the individual’s beliefs about events and associated causes, and individual predispositions, such as need for achievement.

Applied behavioral analysis. The application of Skinner’s experimental analysis of behavior to real-world settings such as classrooms and hospitals (also referred to as contingency management).

Assimilation. The process by which information from the environment is integrated with the subject’s internal structure; not a matter of passive registration of characteristics, however.

Attention. The process of dealing with incoming stimuli; may be automatic, such as attending to usual household sounds, or deliberate, such as attending to unusual noises, a question, a problem, a television program, and so on.

Attitudes. The internal capabilities that govern the individual’s disposition toward or away from events, objects, and individuals.

Attribution. An inference made by an individual about the causes of a particular outcome.

Autonomy. The capability of existing independently; a process or activity carried on without outside control.

Aversive stimuli. Those stimuli from which an individual seeks avoidance or escape.

Axon. The “tail” of a neuron that carries the signals to be transmitted to other neurons.

Behaviorism. The term applied to the study of the relationships among environmental conditions, events, and behavior.

Capabilities. The changes in states of memory that make possible the prediction of many instances of performances by the learner; the outcomes of learning.
Causality dimensions. The characteristics of attributions that lead to different consequences. The three causality dimensions are **locus** (source of the cause), **stability** (temporary or permanent cause), and **control** (internal to the individual or external). Attributions that are internal and stable, for example, strongly influence the individual's feelings of self-worth in contrast to external or unstable causes.

Class inclusion. The ability to deal simultaneously with a general class defined by a general property (e.g., flowers) and with subclasses of the general class that are defined by a restrictive property (e.g., roses). Included are combining classes \( A + A' = B \) and the reverse operation \( B - A' = A \).

Classical (reflex) conditioning. The procedure by which physiological reactions to particular stimuli (e.g., salivation, finger retraction) are trained to respond to new stimuli.

Cognitive behavior. An outward sign of the assimilatory and accommodative capacities of a living organism.

Cognitive strategy. An activity undertaken to facilitate understanding, such as comparing, describing, or summarizing.

Cognitive structures. Internal structures that govern the individual's interactions with the environment; internalized actions.

Cognitive task analysis. An extension of traditional task analysis techniques. The purpose is to develop information about the thought processes, decisions, goals, and knowledge of experts.

Concept learning. The skill of classifying objects or events into categories.

Concrete operations. The first forms of logical thought that begin at age 7 or 8 and continue until age 11 or 12.

Conditional procedure. A set of steps (procedure) that requires decisions about alternative steps at certain points in the sequence.

Conditioned response (CR). A reflex reaction that has been trained to respond to a new stimulus.

Conditioned stimulus (CS). After training, the new stimulus that elicits the reflex reaction.

Connectionism. A synonym for Thorndike's theory of learning, implying that connections are established between stimuli and voluntary behaviors. Also, a view of learning that approximates the neural networks in the brain. Memory is described as consisting of interacting connection nets composed of elements (units) and links referred to as connection weights. Processing occurs in the elements, and knowledge is stored in the connection weights.

Constructivism. Several related perspectives that view knowledge as a human construction. Radical constructivism, derived from Piaget's perspective of learning, views the learner's knowledge as adaptive. The teacher's role is to challenge the child's way of thinking. Social constructivist views, in contrast, view knowledge as a social product.

Contingency-governed behavior. The changing consequences of behavior that bring about behavioral change.

Culture.

  **In operant conditioning** — a set of social practices defined as the contingencies maintained by a group. Such contingencies shape the behavior of each member of the group and also transmit social practices and rituals to new or younger members.

  **In Vygotsky's cultural-historical theory** — the particular social setting in which the child grows up.

  The society (1) transmits the verbal and other codes essential for self-directed thinking and (2) serves, through the interactions between individuals, as the agent of cognitive development.

Cultural development. In Vygotsky's theory, mastering methods of behavior that are based on the use of signs as a means to accomplish a particular psychological operation.

Dendrites. Branching fibers on a neuron that receive signals from other neurons.

Developmental (genetic) epistemology. The study of the growth of logical thinking from infancy to mature thought.

Differential reinforcement. The reinforcement of particular responses to the exclusion of others.

Discriminative stimulus \( (S^D) \). The stimulus that gains control over subject's behavior by its continued presence when responses are reinforced. Examples include red and green traffic lights and verbal stimuli such as "Please pass the salt."

Disequilibrium. A state of nonbalance in the individual's cognitive development that leads to equilibrium.
on a higher level; for example, the child’s recognition that his or her judgments about a situation are in conflict.

**Drive reduction.** The satisfaction of a biological need that strengthens the link between the drive (hunger, thirst, etc.) and the response.

**Dual-code model.** The position that maintains that the information stored in long-term memory may be in either visual or verbal form.

**Egocentric speech.** The child’s speech that is for him or herself and fulfills a cognitive function different from communicative speech. In Vygotsky’s theory, egocentric speech transforms into inner speech at about age seven, but is not complete prior to adolescence.

**Einstellung.** See Problem set.

**Elaboration.** One of the mechanisms by which stimuli are transformed for storage in long-term memory and later retrieval. Included are stimulus substitution, association, and other stimulus modifications (also referred to as secondary or constructive rehearsal).

**Elicited responses.** Responses that are triggered by a particular stimulus. Included are reflexes and conditioned emotional reactions.

**Emitted responses.** Behaviors for which no known correlative stimulus can be identified; operants.

**Encoding.** The process of transforming stimuli so that the information may be stored in long-term memory and retrieved for later use.

**Environment.** The situation in which behavior occurs. It includes both potential environment and actual environment. The potential environment includes the range of possible consequences that can occur following an individual’s response. Actual environment includes all the changes in the situation that occur as a result of the actions of the individual. The learner’s behavior transforms the potential environment into the actual environment.

**Equilibration.** The set of processes that coordinate cognitive development in the individual’s search for “true” equilibrium. Included are alpha, beta, and gamma reactions and reflective abstraction.

**Equilibrium.** A temporary level of understanding to be surpassed by later constructions; for example, concrete operational thought is the equilibrium toward which preoperational thought is striving.

**Events of instruction.** The set of stimuli in the environment that supports the internal processes of learning. Each learning event has a parallel stimulus situation. The set of instructional events comprises the external conditions of learning.

**Expectancy.** The anticipation that some performance will lead to a particular consequence.

**Expectancy value.** The value placed on particular tasks or courses by the learner. Included are the importance of doing well, enjoyment or interest in the task, and the usefulness of the task or course. The cost refers to the extent that engagement in this task or course limits participation in other activities or courses.

**Experimental analysis.** The methodology used to identify the variables of which behavior is a function; accounts for behavior in terms of physical conditions that are both observable and manipulable.

**Experimental-genetic (developmental) method.** The experimental method that permits psychologists to study the causal-dynamic roots of a process. Included are (1) placing subjects in tasks somewhat too difficult for them and introducing other factors into the process, such as auxiliary stimuli or possible disruptions, and (2) comparing the behavior of young children with that of older subjects.

**External conditions of learning.** The set of events deliberately planned to support the phases of learning; also referred to as instructional events.

**Extinction.** The weakening and eventual disappearance of emitted responses through nonreinforcement.

**Formal operational period.** Mature hypothetical reasoning.

**Fossilized behavior.** An action or behavior that has had a very long history in human development and therefore is executed in a mechanized or automatic fashion. The problem for research is that of discovering the internal features of such behaviors and the causal-dynamic roots.

**Functional fixedness.** The inability of the problem solver to perceive elements of a situation in a new relationship or a new way.

**Functional method of double stimulation.** The experimental method that provides both an object stimulus (task or problem) and a neutral stimulus to assist the subject, and that documents the uses of the neutral (auxiliary) stimulus.
**Functional value.** The utility of a particular behavior. The utility of a behavior is established when the observed behavior leads to positive consequences.

**General law of genetic development.** Every function in the child’s cultural development appears first on the social level between people (interpsychological) and then inside the child (intrapsychological).

**Goal orientation.** A student’s purpose or reason for participation in achievement-related tasks.

**Higher psychological (mental) functions.** The psychological processes that are uniquely human. Included are logical memory, voluntary attention, and the activities of generating artificial or self-generated stimuli and mastering and regulating one’s own behavior.

**Implicit reinforcement.** Behavior that is praised in one individual and disregarded in others may be regarded by the teacher as implicit reinforcement. However, it may be perceived by the students as punishment.

**Inhibition.** The reduction in a response caused by the introduction of new stimuli.

**Insight.** A particular reorganization of the perceptual field such that it is seen in a new way.

**Instantaneous matching.** Imitative learning in which the learner copies the behavior immediately after the presentation.

**Instructional events.** See external conditions of learning.

**Instructional systems design.** The development of instruction for specified goals and objectives in which (1) the organized sequential selection of components is made on the basis of information, data, and theoretical principles at every stage and (2) the product is tested in real-world situations both during development and at the end of the development process.

**Instrumental conditioning.** The term applied by Thorndike to his theory to indicate that it addressed the association of voluntary behaviors to new stimuli.

**Intellectual skills.** The organized set of human capabilities that involves the use of symbols in interacting with the environment. Included are discrimination, concepts (concrete and defined), rules, and higher-order rules (problem solving).

**Intelligence.** The individual’s adaptation to the physical and social environment; a growing, developing, changing process that is represented, moment by moment, in the ways that the individual deals with the world.

**Internal conditions of learning.** The learner’s internal states, such as motivation, and the processing steps that facilitate learning.

**Keyword method.** A mnemonic method for learning new vocabulary, particularly foreign languages. The word to be learned is encoded in a visual image that combines its meaning and its pronunciation (or some other distinguishing feature).

**Knowledge.** In Piagetian theory, the constructive interaction between the individual and the object. Knowledge is neither some predefined entity in the environment, nor is it a preformed innate cognitive structure.

- **Explicit knowledge.** In information-processing theory—knowledge that is easily available to consciousness and is the object of thought.
- **Tacit knowledge.** In information-processing theory—knowledge that typically operates below the level of conscious awareness.

**Latency.** The length of time between a stimulus and a response.

**Latent learning.** The acquisition of skills that may or may not be performed.

**Law of contiguity.** The principle that a combination of stimuli accompanied by a movement will tend to be followed by the same movement on its recurrence.

**Law of equivalence.** Any concept may be expressed in any of a variety of ways using other concepts at the same level of generality. For example, “1” may be expressed as “3 – 2,” “4 – 3,” “5 – 4,” “2/2,” “4/4,” and so on.

**Learning.** The process(es) by which humans acquire the range and variety of skills, knowledge, and attitudes that set the species apart from others.

- **In operant conditioning**—a change in the likelihood or probability of a response.
- **In Gagné’s conditions of learning**—the process by which humans acquire unique capabilities.
- **In information-processing theories**—the set of cognitive processes that transforms the individual’s memory from one state to another, resulting in one or more capabilities.

**Learning hierarchy.** An organized set of intellectual skills, from simple to complex, that indicates the set of prerequisites for each capability to be learned.
Learning task analysis. The process by which the true (i.e., essential) prerequisites of an intellectual skill are determined.

Measure of generality. Position of a concept within the total system of concepts in terms of its coordinate, superordinate, and subordinate relationships. It determines both the equivalence of concepts and the intellectual operations possible within a given concept.

Memory, episodic. Personal or autobiographical information characterized by the vividness of the memories.

Memory, long-term. Information in an inactive state that, unless forgotten, may be recalled for future use.

Memory, procedural. Information that enables the individual to respond adaptively to the environment.

Memory, semantic. General information that is part of the common store of knowledge (e.g., historical facts, technical information, addresses, phone numbers, and other bodies of knowledge).

Memory, short-term. Sometimes referred to as working memory; refers to information that is in the active state.

Metacognition. Knowledge about and awareness of one's own thinking and learning and the use of strategies to guide, monitor, and redirect one's thinking and learning.

Method of loci. An associative mechanism for aiding the encoding and storage of stimuli in memory. It involves the construction of bizarre visual images that link the stimuli with familiar, related locations, such as rooms in a house or landmarks on a familiar walk.

Mirror neurons. Particular neuron circuits that fire in response to (1) both observation and execution of grasping actions and feelings of disgust and pleasure when smelling contents of glasses, and (2) seeing an athlete succeed at a difficult task and an individual undergoing a sad event.

Model. Any stimulus organized so that an observer can extract the principal information conveyed by environmental events without first performing overtly.

Modeling. A process in which a demonstrated behavior is the stimulus for learning. The primary function of the model is to transmit information.

Motor skills. The capabilities that govern the individual's execution and performance of particular physical acts.

Naïve psychology. In Vygotsky's theory, a stage in the development of sign use and speech. In sign use, the child is unaware of the role of auxiliary stimuli to manage memory. In speech, the ability to use words is present, but there is a lack of awareness of the internal (symbolic) structure.

Natural history (law) of the sign. The series of transformations that sign-using activity (mastering one's behavior) undergoes. Included are the transitional stages between elementary mental functions and the development of higher mental functions.

Natural or primitive development. The domination in the early months of the child's life of biological principles of development. Included are the development of perception, simple or natural memory, and involuntary attention.

Natural selection. The process whereby certain behaviors are reinforced by survival of the species.

Negation. A form of reversibility; for example, in class inclusion, negation is expressed by \( B - A' = A \). The action negates the combining of classes. Also, the characteristic of an object that must be constructed by the child; for example, the positive characteristic of lengthening a ball of clay is accompanied by increasing thinness (negation). The construction of operational structures depends on the child's development of both affirmations (positive characteristics) and negations.

Negative utility. A variable-ratio schedule of reinforcement in which the ultimate outcome is the long-term detriment of the subject. Compulsive gambling and drug addiction are examples.

Neurotransmitter. A chemical messenger that transports signals across the synapse from one neuron to another.

Operant. Any response that acts or operates on the environment to produce some consequence or change.

Operant conditioning. The process of modifying a subject's behavior through the reinforcement of appropriate responses in the presence of the appropriate stimuli.

Operations. Cognitive structures described by Piaget that govern logical reasoning in the broad sense.

Perceived self-efficacy. The belief that one can perform successfully the behaviors that lead to positive outcomes.
**Personal helplessness.** This state is the perception that outcomes inaccessible to the individual are nonetheless accessible to others.

**Phases of learning.** The nine internal phases of information processing that transform stimulation from the environment into a new capability. The set of events constitutes the internal conditions of learning and is executed in different ways for different capabilities.

**Phi phenomenon.** The projection of two brief illuminations of light such that they are perceived as light in motion.

**Philosophy.** An organized belief system that provides a consistent and unified view of the external world and the inner world of the individual. A philosophy is developed by defining the nature of reality first. Then questions such as “What is truth?” and “What is knowledge?” are answered consistent with the definition.

**Prägnanz.** The Gestalt law that states that a psychological organization of visual stimuli can be only as “good” as prevailing conditions permit.

**Precurrent responses.** Activities often referred to by others as “thinking”; behaviors that make other behaviors more probable (e.g., reviewing a problem).

**Premack principle.** The rule that describes the relative power of certain reinforcers. Specifically, preferred activities may be used to reinforce less preferred activities.

**Preoperational thinking.** Prelogical thought processes that are governed by perceptions. This type of thinking takes place from about the age of 2 to 7 or 8. During these years, the child also develops representational thought and social relations with peers.

**Primitive psychological (mental) functions.** The basic psychological processes that are continuations of the basic processes in animals. Included are perception, simple memory, involuntary attention, and practical tool-using intelligence, such as pulling a string to reach the object at the end of it.

**Problem set.** A view of a problem or situation that immediately predisposes one to a particular conscious act.

**Problem solving.** In general, problem solving involves dealing with new and unfamiliar tasks or situations that present some obstacle, and for which relevant solution methods are not known. In Gagné’s conditions of learning, problem solving is the skill of recalling and applying a set of rules in the proper sequence to solve a problem. Also referred to as higher-order rule learning.

**Procedures.** The organization of discrete motor skills into complex activities; usually requires the learning of related concepts and rules. Examples include administering an injection and dissecting a frog.

**Program.** A series of changing contingencies that shapes behavior until the identified terminal behavior is generated.

**Propositional network theories.** The position that information is stored in long-term memory only in verbal form. This perspective describes networks of verbal information composed of nodes and the pathways that link the nodes.

**Pseudoconcept.** The ability to match concept examples to a model on concrete, observable characteristics. However, the child is unaware of the symbolic nature of the concept as well as interconnections to other concepts.

**Psychological tool.** Any sign or symbol that serves to master one’s thinking.

**Punishment.** The withdrawal of a positive reinforcer or the addition of a negative reinforcer to a behavioral situation.

**Reciprocal determinism.** The mutual influence of the individual and the environment on each other.

**Reciprocity.** The reversibility of an ordered series; for example, if A > B > C, then C < B < A.

**Rehearsal, elaborative.** Also referred to as constructive rehearsal or elaboration; the process of modifying stimuli for storage and later retrieval.

**Rehearsal, primary.** Also referred to as maintenance rehearsal; the process of repletion in order to preserve information in memory.

**Reinforcement.** Any consequence of a response that increases the probability of the behavior’s recurrence.

Negative reinforcement—the withdrawal or termination of a stimulus that strengthens behavior; also known as escape conditioning.

Positive reinforcement—the situation in which an organism’s behavior “produces” a new stimulus that increases the frequency of the behavior.
Vicarious reinforcement—according to Bandura, observation of positive consequences received by the model.
Conditioned or secondary reinforcers—stimuli that acquire reinforcing power through repeated association with primary reinforcers. Examples include rocking and cuddling an infant while feeding it.
Contrived reinforcers—artificial reinforcers that are not normally provided by the environment.
Generalized reinforcers—reinforcers that function in a variety of situations.
Natural reinforcers—nonaversive feedback provided by the environment.

**Representational systems.** The symbolic codes that are stored in the learner's memory. *Visual codes* are vivid images. *Verbal codes* include language symbols, numbers, and musical notation.

**Resistance to extinction.** The tendency of a response to persist after the supporting conditions are withdrawn.

**Reversibility.** An essential characteristic of operational structures; the capability of returning an operation to its starting point. For example, addition is reversed through subtraction.

**Rule-governed behavior.** Verbal stimuli, such as advice, maxims, rules, and laws, that can alter behavior. Unlike reinforcement contingencies, the probability of behavioral change remains undetermined.

**Rule learning.** The skill of recalling and applying a rule to make a prediction, determine an effort, or deduce a consequence.

**Scaffolding.** A term introduced in recent years to describe the process of controlling task elements that are initially beyond the learner's capacity.

**Schedules of reinforcement.** The delivery of reinforcement according to different specifications.

- **Interval schedule**—delivery of reinforcers based on elapsed time; may be fixed (e.g., every 5th second) or variable (e.g., every 5th, 8th, and 12th second).
- **Ratio schedule**—delivery of reinforcers based on emitted responses; may be fixed (every 5th response) or variable (e.g., every 5th, 10th, and 13th response).

**Schema.** A term with no fixed definition that is used to refer to knowledge structures; typically used as a synonym for prior knowledge.

**Scientific concepts.** The domain-specific concepts that are learned in subject areas in formal schooling, according to Vygotsky.

**Scientific empiricism.** The accumulation of facts through carefully designed experiments or "controlled experience."

**Self-efficacy.** The sense that one can execute successfully a behavior required to produce a particular outcome.

**Self-perception.** An individual's ability to respond differently to his or her own behavior.

**Self-reinforcement.** Anticipated and evaluative consequences that are generated by the individual for his or her behavior.

**Sensorimotor thinking.** The action schemes developed by infants to solve problems in their environment. An example is grasping the edge of a blanket and pulling it toward oneself to get the object lying on it (i.e., reaching-grasping-pulling).

**Seriation (serial ordering).** The operational structure by which individuals are able to place objects in a linear sequence from shortest to longest, smallest to largest, and so on. Included is the ordering of both a series $A < B < C$ and its reciprocal $C > B > A$.

**Shaping.** The process of developing complex repertoires of behavior through (1) specifying the terminal skill to be learned and (2) reinforcing successive approximations to the terminal behavior.

**Sign.** A symbol or other stimulus created by humans that serves to master one's thinking.

**Signalization.** The system of connections that is a copy, or the reflection, of the natural ties among all kinds of natural events that indicate the appearance of immediately beneficial or destructive events.

**Signification.** The creation and use of signs, that is, artificial signals.

**Signs.** Artificial or self-generated stimuli that become the immediate causes of higher mental functions.

**Social behavior.** The tendency for an individual to match the behaviors, attitudes, or emotional reactions that are observed in actual or symbolic models.

**Split-attention effect.** The extraneous cognitive load on working memory that results from the requirement to integrate two incomplete sources of information.
Spontaneous concepts. The concepts—such as “dog,” “cat,” “hungry,” and countless others—that are learned naturally in a child's daily interactions with family members and others.

Stimulus generalization. 

In classical conditioning—the tendency of similar stimuli to elicit the same reflex.

In operant conditioning—the tendency of two or more stimuli that share a common feature to acquire control over an operant response (e.g., a child's verbal identification of “p” and “P”).

Stimulus-response (S-R) theories. Behaviorist theories that define learning as an associative link between a particular stimulus and a particular response.

Strategy. A set of actions over and above the processes involved in a task.

Symbolic codes. The representations of information in long-term memory. Theorists disagree as to their forms (i.e., verbal only or visual and verbal [see Propositional network theories and Dual-code model]).

Symbolic model. A visual image of the live model, such as a film or televised presentation.

Synapse. The minute space between neurons across which messages are transmitted from one neuron to another.

Teacher efficacy. The extent to which the teacher believes he or she has the capacity to affect student performance.

Terminal contingency. The complex set of behaviors expected as the outcome of a series of differential reinforcements for related subskills and/or approximations of the complex behavior. Such behaviors have an almost zero probability of occurring naturally in the environment. Instead, behavior must be shaped through a carefully planned sequence of behaviors and reinforcements. Examples include a pigeon bowling and a student writing a term paper.

Transfer of learning. The increased ease of a particular learning task that results from the prior learning of a similar task.

Transitivity. The property that represents the relationships among objects in a series; that is, if A > B > C, then A > C. Similarly, if A = B and B = C, then A = C.

Unconditioned response (UCR). The reflex reaction that naturally occurs following a particular stimulus.

Unconditioned stimulus (UCS). The stimulus that naturally is followed by a particular reflex reaction.

Varieties of learning. The five categories of human learning that (1) are differentiated by at least one unique requirement for learning, (2) result in different classes of performance, and (3) are generalizable across subject areas, grade levels, and learners. The five varieties of learning are verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes.

Verbal information. The variety of skills that includes the acquisition of (1) labels and facts, (2) meaningfully connected selections of prose or poetry, and (3) organized bodies of knowledge.

Zone of proximal development (ZPD). The area of maturing intellectual processes which are emerging and form the domain of transitions (to higher levels of thinking) that are accessible to the child.
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