Cognitive Views of Learning
What Would You Do?

Teachers’ Casebook

The students in your senior history classes seem to equate understanding with memorizing. They prepare for each unit test by memorizing the exact words of the textbook. Even the best students seem to think that flash cards are the only learning strategy possible. In fact, when you try to get them to think about history by reading some original sources, debating issues in class, or examining art and music from the time period you are studying, they rebel. “Will this be on the test?” “Why are we looking at these pictures—will we have to know who painted them and when?” “What’s this got to do with history?” Even the students who participate in the debates seem to use words and phrases straight from the textbook without knowing what they are saying.

Critical Thinking

- What are these students’ beliefs and expectations, and how do these affect their learning?
- Why do you think they insist on using the rote memory approach?
- How would you use what the students already know to help them learn in better, more meaningful ways?
- How will these issues affect the grade levels you will teach?

Collaboration

With 2 or 3 other people in your class, talk about teachers you’ve had who helped you develop deep knowledge about a topic. How did they guide your thinking to move past memorizing to a more complete understanding?

We turn from behavioral theories of learning to the cognitive perspective in this chapter. This means a shift from “viewing the learners and their behaviors as products of incoming environmental stimuli” to seeing the learners as “sources of plans, intentions, goals, ideas, memories, and emotions actively used to attend to, select, and construct meaning from stimuli and knowledge from experience” (Wittrock, 1982, pp. 1–2). We will begin with a discussion of the general cognitive approach to learning and memory and the importance of knowledge in learning. To understand memory, we will consider a widely accepted cognitive model, information processing, which suggests that information is manipulated in different storage systems. Next, we will explore metacognition, a field of study that may provide insights into individual and developmental differences in learning. Then, we turn to ideas about how teachers can help their students become more knowledgeable. By the time you have completed this chapter, you should be able to answer these questions:

- What is the role of knowledge in learning?
- What is the human information processing model of memory?
- How do perception, attention, schemas, and scripts influence learning and remembering?
- What are declarative, procedural, and conditional knowledge?
- Why do students forget what they have learned?
- What is the role of metacognition in learning and remembering?
- What are the stages in the development of cognitive skills?
Elements of the Cognitive Perspective

The cognitive perspective is both the oldest and one of the youngest members of the psychological community. It is old because discussions of the nature of knowledge, the value of reason, and the contents of the mind date back at least to the ancient Greek philosophers (Hemshaw, 1987). From the late 1800s until several decades ago, however, cognitive studies fell from favor and behavioralism thrived. Then, research during World War II on the development of complex human skills, the computer revolution, and breakthroughs in understanding language development all stimulated a resurgence in cognitive research. Evidence accumulated indicating that people plan their responses, use strategies to help themselves remember, and organize the material they are learning in their own unique ways (Miller, Galanter, & Pribram, 1960; Shuell, 1986). Educational psychologists became interested in how people think, learn concepts, and solve problems (e.g., Ausubel, 1965; Bruner, Goodnow, & Austin, 1956).

Interest in concept learning and problem solving soon gave way, however, to interest in how knowledge is represented in the mind and particularly how it is remembered. Remembering and forgetting became major topics for investigation in cognitive psychology in the 1970s and 1980s, and the information-processing model of memory dominated research.

Today, there is renewed interest in learning, thinking, and problem solving. The cognitive view of learning can be described as a generally agreed-upon philosophical orientation. This means that cognitive theorists share basic notions about learning and memory. Most importantly, cognitive psychologists assume that mental processes exist, that they can be studied scientifically, and that humans are active participants in their own acts of cognition (Ashcraft, 2006).

Comparing Cognitive and Behavioral Views

The cognitive and behavioral views differ in their assumptions about what is learned. According to the cognitive view, knowledge is learned, and changes in knowledge make changes in behavior possible. In the behavioral view, the new behaviors themselves are learned (Shuell, 1986). Both behavioral and cognitive theorists believe reinforcement is important in learning, but for different reasons. The strict behaviorist maintains that reinforcement strengthens responses; cognitive theorists see reinforcement as a source of information that provides feedback about what is likely to happen if behaviors are repeated or changed.

The cognitive view sees learning as extending and transforming the understanding we already have, not simply writing associations on the blank slates of our brains (Greene,

Cognitive view of learning. A general approach that views learning as an active mental process of acquiring, remembering, and using knowledge.

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Collins, & Resnick, 1996). Instead of being passively influenced by environmental events, people actively choose, practice, pay attention, ignore, reflect, and make many other decisions as they pursue goals. Older cognitive views emphasized the acquisition of knowledge, but newer approaches stress its construction (Anderson, Reder, & Simon, 1996; Greeno, Collins, & Resnick, 1996; Mayer, 1996).

The methods of cognitive and behavioral researchers also differ. Much of the work on behavioral learning principles has been with animals in controlled laboratory settings. The goal is to identify a few general laws of learning that apply to all higher organisms—including humans, regardless of age, intelligence, or other individual differences. Cognitive psychologists, on the other hand, study a wide range of learning situations. Because of their focus on individual and developmental differences in cognition, they have not been as concerned with general laws of learning. This is one of the reasons that there is no single cognitive model or theory of learning that is representative of the entire field.

The Importance of Knowledge in Learning

STOP | THINK | WRITE  Quickly, list 10 terms that pertain to educational psychology. Now list 10 terms that relate to ceramic engineering.

Unless you are studying ceramic engineering, it probably took you longer to list 10 terms from that field than from educational psychology. Some of you may still be asking, “What is ceramic engineering anyway?” Your answers depend on your knowledge of ceramic engineering. (Hint: Think fiber optics, ceramic teeth and bones, ceramic semi-conductors for computers, heat-shielding tiles for space shuttles.)

Knowledge and knowing are the outcomes of learning. When we learn the history of cognitive psychology, the products of ceramic engineering, or the rules of tennis, we know something new. However, knowing is more than the end product of previous learning; it also guides new learning. The cognitive approach suggests that one of the most important elements in the learning process is what the individual brings to new learning situations. What we already know is the foundation and frame for constructing all future learning. Knowledge determines to a great extent what we will pay attention to, perceive, learn, remember, and forget (Alexander, 1996; Bransford, Brown, & Cocking, 2000).

An Example Study. A study by Recht and Leslie (1988) shows the importance of knowledge in understanding and remembering new information. These psychologists identified junior-high-school students who were either very good or very poor readers. They tested the students on their knowledge of baseball and found that knowledge of baseball was not related to reading ability. So the researchers were able to identify four groups of students: good readers/high baseball knowledge, good readers/low baseball knowledge, poor readers/high baseball knowledge, and poor readers/low baseball knowledge. Then, students in all four groups read a passage describing a baseball game and were tested in a number of ways to see if they understood and remembered what they had read.

The results demonstrated the power of knowledge. Poor readers who knew baseball remembered more than good readers with little baseball knowledge and almost as much as good readers who knew baseball. Poor readers who knew little about baseball remembered the least of what they had read. Thus, a good basis of knowledge can be more important than good reading skills in understanding and remembering—but extensive knowledge plus good reading skills are even better.

General and Specific Knowledge. Knowledge in the cognitive perspective includes both subject-specific understandings (math, history, soccer, etc.) and general cognitive abilities, such as planning, solving problems, and comprehending language (Greeno, Collins, & Resnick, 1996). So, there are different kinds of knowledge. Some is domain-specific knowledge that pertains to a particular task or subject. For example, knowing that the shortstop plays between second and third base is specific to the domain of baseball. Some knowledge, on the other hand, is general—it applies to many different situations. For example, general knowledge about how to read or write or use a computer is
useful both in and out of school. Of course, there is no absolute line between general and domain-specific knowledge. When you were first learning to read, you may have studied specific facts about the sounds of letters. At that time, knowledge about letter sounds was specific to the domain of reading. But now you can use both knowledge about sounds and the ability to read in more general ways (Alexander, 1992; Schunk, 2004).

What we know exists in our memory. To know something is to remember it over time and be able to find it when you need it. Psychologists have studied memory extensively. Let's see what they have learned.

The Information Processing Model of Memory

There are a number of theories of memory, but the most common are the information processing explanations (Ashcraft, 2006; Hunt & Ellis, 1999; Sternberg, 1999). We will use this well-researched framework for examining learning and memory.

Early information processing views of memory used the computer as a model. Like the computer, the human mind takes in information, performs operations on it to change its form and content, stores the information, retrieves it when needed, and generates responses to it. Thus, processing involves gathering information and organizing it in relation to what you already know, or encoding, holding information, or storage; and getting at the information when needed, or retrieval. The whole system is guided by control processes that determine how and when information will flow through the system.

For most cognitive psychologists, the computer model is only a metaphor for human mental activity. But other cognitive scientists, particularly those studying artificial intelligence, try to design and program computers to “think” and solve problems like human beings (Anderson, 2005; Schunk, 2000). Some theorists suggest that the operation of the brain resembles a large number of very slow computers, all operating in parallel (at the same time), with each computer dedicated to a different, specific task (Ashcraft, 2006).

Figure 7.1 is a schematic representation of a typical information processing model of memory, derived from the ideas of several theorists (Atkinson & Shiffrin, 1968; R. Cagné, 1985; Neisser, 1976). In order to understand this model, let’s examine each element.

Sensory Memory

Stimuli from the environment (sights, sounds, smells, etc.) constantly bombard our body’s mechanisms for seeing, hearing, tasting, smelling, and feeling. Sensory memory is the initial processing that transforms these incoming stimuli into information so we can make sense of them. Even though sights and sounds may last only fractions of a second, the transformations (information) that represent these sensations are briefly held in the sensory register or sensory information store so that this initial processing can take place (Driscoll, 2005; Sperling, 1960).

Capacity, Duration, and Contents of Sensory Memory. The capacity of sensory memory is very large, and can take in more information than we can possibly handle at once. But this vast amount of sensory information is fragile in duration. It lasts between one and three seconds.

STOP | THINK | WRITE. Wave a pencil (or your finger) back and forth before your eyes while you stare straight ahead. What exactly do you see? Pinch your arm and let go. What do you feel just after you let go?

You just experienced this brief holding of sensory information in your own sensory register. You could see a trace of the pencil after the actual stimulus has been removed and feel the pinch after you let go. The sensory register held information about the stimuli very briefly after the actual stimulus had left (Lindsay & Norman, 1977).
The information content of sensory memory resembles the sensations from the original stimulus. Visual sensations are coded briefly by the sensory register as images, almost like photographs. Auditory sensations are coded as sound patterns, similar to echoes. It may be that the other senses also have their own codes. Thus, for a second or so, a wealth of data from sensory experience remains intact. In these moments, we have a chance to select and organize information for further processing. Perception and attention are critical at this stage.

**Perception.** The process of detecting a stimulus and assigning meaning to it is called perception. This meaning is constructed based on both physical representations from the world and our existing knowledge. For example, consider these marks: 13. If asked what the letter is, you would say "I." If asked what the number is, you would say "13." The actual marks remain the same; their meaning changes in keeping with your expectation to recognize a letter or a number. To a child without appropriate knowledge to perceive either a letter or a number, the marks would probably be meaningless (F. Smith, 1975).

Some of our present-day understanding of perception is based on studies conducted in Germany early in this century (and later in the United States) by psychologists called Gestalt theorists. Gestalt, which means "pattern" or "configuration" in German, refers to people's tendency to organize sensory information into patterns or relationships. Instead of perceiving bits and pieces of unrelated information, we usually perceive organized, meaningful wholes. Figure 7.2 on page 252 presents a few Gestalt principles.

The Gestalt principles are reasonable explanations of certain aspects of perception, but they do not provide the whole story. There are other kinds of explanations in information processing theory for how we recognize patterns and give meaning to sensory events. The first is called feature analysis, or bottom-up processing because the stimulus must be analyzed into features or components and assembled into a meaningful pattern.
**Examples of Gestalt Principles**

**a. Figure-ground**
What do you see? Faces or a vase? Make one figure—the other ground.

**b. Proximity**
You see these lines as 3 groups because of the proximity of the lines.

**c. Similarity**
You see these lines as an alternating pattern because of the similarity in height of lines.

**d. Closure**
You perceive a circle instead of dotted curved lines.


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**Connect and Extend to PRAXIS II**

Attention has an important place in instructional activities. What steps can a teacher take to gain and maintain student attention during instruction?

**Memory and Recall (I, A1)**

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**Connect and Extend to the Research**

Over 20 years ago, Flavell (1985) described four aspects of attention in developing children:

1. **Controlled:** Develop longer attention spans and ability to focus on important details, ignoring minor ones.
2. **Tailored to task:** Older children focus attention on most difficult material being learned (Berk, 2002).
3. **Directive:** They develop a feel for cues (teacher’s voice, gestures) telling them when/how to direct their attention.
4. **Self-monitoring:** They learn to decide if they are using the right strategy, and to change if it’s not working.

**Prototype** A best example or best representative of a category.

**Top-down processing** Perceiving based on the context and the patterns you expect to occur in that situation.

**Attention** Focus on a stimulus.

**Automaticity** The ability to perform thoroughly learned tasks without much mental effort.

“from the bottom up.” For example, a capital letter A consists of two relatively straight lines joined at a 45-degree angle and a horizontal line through the middle. Whenever we see these features, or anything close enough, including A, A, A, A, A, and A, we recognize an A (Anderson, 2005). This explains how we are able to read words written in other people’s handwriting. We also have a prototype (a best example or classic case) of an A stored in memory to use along with features to help us detect the letter A (Driscoll, 2005).

If all perception relied only on feature analysis and prototypes, learning would be very slow. Luckily, humans are capable of another type of perception based on knowledge and expectation often called **top-down processing**. To recognize patterns rapidly, in addition to noting features, we use what we already know about the situation—what we know about words or pictures or the way the world generally operates. For example, you would not have seen the marks above as the letter A if you had no knowledge of the Roman alphabet. So, what you know also affects what you are able to perceive. The role of knowledge in perception is represented by the arrows pointing left in Figure 7.1 from long-term memory (stored knowledge) to working memory and then to sensory memory.

**The Role of Attention.** If every variation in color, movement, sound, smell, temperature, and so on ended up in working memory, life would be impossible. But attention is selective. By paying attention to selected stimuli and ignoring others, we limit the possibilities that we will perceive and process. What we pay attention to is guided to a certain extent by what we already know and what we need to know, so attention is involved and influenced by all three memory processes in Figure 7.1. Attention is also affected by what else is happening at the time, by the complexity of the task, and by your ability to control or focus your attention (Driscoll, 2005). Some students with attention-deficit disorder have great difficulty focusing attention or ignoring competing stimuli.

But attention takes effort and is a limited resource. I imagine you have to work a bit to pay attention to these words about attention! We can pay attention to only one cognitively demanding task at time (Anderson, 2005). For example, when I was learning to drive, I couldn’t listen to the radio and drive at the same time. After some practice, I could listen, but I had to turn the radio off when traffic was heavy. After years of practice, I can plan a class, listen to the radio, and carry on a conversation as I drive. This is possible because many processes that initially require attention and concentration become automatic with practice. Actually, automaticity probably is a matter of degree; we are not completely automatic, but rather more or less automatic in our performances depending on how much practice we have had and the situation. For example, even experienced drivers might become very attentive and focused during a blinding blizzard (Anderson, 2005).
Attention and Teaching. The first step in learning is paying attention. Students cannot process information that they do not recognize or perceive (LaBert, Forster, & Ruthruff, 2004). Many factors in the classroom influence student attention. Eye-catching or startling displays or actions can draw attention at the beginning of a lesson. A teacher might begin a science lesson on air pressure by blowing up a balloon until it pops. Bright colors, underlining, highlighting of written or spoken words, calling students by name, surprise events, intriguing questions, variety in tasks and teaching methods, and changes in voice level, lighting, or pacing can all be used to gain attention. And students have to maintain attention—they have to stay focused on the important features of the learning situation. The Guidelines offer additional ideas for capturing and maintaining students’ attention.

Working Memory

The information in sensory memory is available for further processing as soon as it is noticed and transformed into patterns of images or sounds (or perhaps other types of sensory codes). Working memory is the “workbench” of the memory system, the interface where new information is held temporarily and combined with knowledge from long-term memory, to solve problems or comprehend a lecture, for example. Working memory “contains”

Guidelines: Gaining and Maintaining Attention

Use signals.

EXAMPLES:

1. Develop a signal that tells students to stop what they are doing and focus on you. Some teachers move to a particular spot in the room, flick the lights, tap the table, or play a chord on the class piano. Mix visual and auditory signals.
2. Avoid distracting behaviors, such as tapping a pencil while talking, that interfere with both signals and attention to learning.
3. Give short, clear directions before, not during, transitions.
4. Be playful with younger children: Use a dramatic voice, sensational hat, or clapping game (Miller, 2005).

Reach out rather than call out (Miller, 2005).

EXAMPLES:

1. Walk to the child, look into his or her eyes.
2. Speak in a firm but nonthreatening voice.
3. Use child’s name.

Make sure the purpose of the lesson or assignment is clear to students.

EXAMPLES:

1. Write the goals or objectives on the board and discuss them with students before starting. Ask students to summarize or restate the goals.
2. Explain the reasons for learning, and ask students for examples of how they will apply their understanding of the material.

3. Tie the new material to previous lessons—show an outline or map of how the new topic fits with previous and upcoming material.

Incorporate variety, curiosity, and surprise.

EXAMPLES:

1. Arouse curiosity with questions such as “What would happen if?”
2. Create shock by staging an unexpected event such as a loud argument just before a lesson on communication.
3. Alter the physical environment by changing the arrangement of the room or moving to a different setting.
4. Shift sensory channels by giving a lesson that requires students to touch, smell, or taste.
5. Use movements, gestures, and voice inflection—walk around the room, point, and speak softly and then more emphatically. (My husband has been known to jump up on his desk to make an important point in his college classes!)

Ask questions and provide frames for answering.

EXAMPLES:

1. Ask students why the material is important, how they intend to study, and what strategies they will use.
2. Give students self-checking or self-editing guides that focus on common mistakes or have them work in pairs to improve each other’s work—sometimes it is difficult to pay attention to your own errors.

For more ideas about gaining student attention, see http://www.inspiringteachers.com/tips/management/attention.html
what you are thinking about at the moment. For this reason, some psychologists consider the working memory to be synonymous with "consciousness" (Sweller, van Merriënboer, & Paas, 1998). Unlike sensory memory or long-term memory, working memory capacity is very limited—something many of your professors seem to forget as they race through a lecture while you work to hold and process the information.

You may have heard the term short-term memory. This was an earlier name for the brief memory component of the information processing system. Short-term memory is not exactly the same as working memory. Working memory includes both temporary storage and active processing—the workbench of memory—where active mental effort is applied to both new and old information. But short-term memory usually means just storage, the immediate memory for new information that can be held about 15 to 20 seconds (Baddeley, 2001). Early experiments suggested that the capacity of short-term memory was only about 5 to 9 separate new items at once (Miller, 1956). Later, we will see that this limitation can be overcome using strategies such as chunking or grouping, but the 5 to 9 limit generally holds true in everyday life. It is quite common to remember a new phone number after looking it up, as you walk across the room to make the call. But what if you have two phone calls to make in succession? Two new phone numbers (14 digits) probably cannot be stored simultaneously.

A current view of working memory is that it is composed of at least three elements: the central executive that controls attention and other mental resources (the "worker" of working memory), the phonological loop that holds verbal and acoustical (sound) information, and the visuospatial sketchpad for visual and spatial information (Gathercole, Pickering, Ambridge, & Wearing, 2004).

STOP | THINK | WRITE  Solve this problem from Ashcraft (2006, p. 190) and pay attention to how you go about the process:

\[
\begin{align*}
(4 + 5) \times 2 \\
3 + (12/4)
\end{align*}
\]

The Central Executive. As you solved the problem above, the central executive of your working memory focused your attention on the facts that you needed (what is 4 + 5? 9 \times 2?), retrieved rules for which operations to do first, and recollected how to divide. The central executive supervises attention, makes plans, retrieves, and integrates information. Language comprehension, reasoning, rehearsing information to transfer to long-term memory—all these activities and more are handled by the central executive, as you can see in Figure 7.3. Two systems help out and support the central executive—the phonological loop and the visuospatial sketchpad.

The Phonological Loop. The phonological loop is a system for rehearsing words and sounds for short-term memory. It is the place you put the "18" (4 + 5 = 9 \times 2 = 18) from the top line of the problem above while you calculated the 3 + (12/4) on the bottom of the problem. Baddeley (1986, 2001) suggests that we can hold as much in the phonological loop as we can rehearse (say to ourselves) in 1.5 to 2 seconds. The 7-digit telephone number fits this limitation. But what if you tried to hold these 7 words in mind: 

disentangle appropriation gossamer anti-intellectual preventative foreclosure documentation

(Gray, 2002)? Besides being a mouthful, these words take longer than 2 seconds to rehearse and are more difficult to hold in working memory than 7 single digits or 7 short words.

Remember—put in your working memory—that we are discussing temporarily holding new information. In daily life we certainly can hold more than 5 to 9 bits or 1.5 seconds of information at once. While you are dialing that 7-digit phone number you just looked up, you are bound to have other things "on your mind"—in your memory—such as how to use a telephone, whom you are calling, and why. You don’t have to pay attention to these things; they are not new knowledge. Some of the processes, such as dialing the phone, have become automatic. However, because of the working memory's limitations, if you were in a foreign country and were attempting to use an unfamiliar telephone.
system, you might very well have trouble remembering the phone number because your central executive was trying to figure out the phone system at the same time. Even a few bits of new information can be too much to remember if the new information is very complex or unfamiliar or if you have to integrate several elements to make sense of a situation (Sweller, van Merrienboer, & Paas, 1998).

**The Visuospatial Sketchpad.** Now try this problem from Gray (2002).

**STOP. THINK. WRITE:** If you rotate a $p$ 180 degrees, do you get a $b$ or a $d$?

Most people answer the question above by creating a visual image of a “p” and rotating it. The visuospatial sketchpad is the place where you manipulated the image (after your central executive retrieved the meaning of “180 degrees,” of course). Working in the visuospatial sketchpad has some of the same aspects as actually looking at a picture or object. If you have to solve the “p” problem and also pay attention to an image on a screen, you will be slowed down just like you would be if you had to look back and forth between two different objects. But if you had to solve the “p” problem while repeating digits, there is little slow down. You can use your phonological loop and your visuospatial sketchpad at the same time, but each is quickly filled and easily overburdened. In fact, each kind of task—verbal and visual—appears to happen in different areas of the brain. As we will see later, there are some individual differences in the capacities of these systems, too (Ashcraft, 2006; Gray, 2002).

**Duration and Contents of Working Memory.** It is clear that the duration of information in the working memory system is short, about 5 to 20 seconds, unless you keep rehearsing.
the information or process it some other way. It may seem to you that a memory system with a 20-second time limit is not very useful, but, without this system, you would have already forgotten what you read in the first part of this sentence before you came to these last few words. This would clearly make understanding sentences difficult.

The contents of information in working memory may be in the form of sounds and images that resemble the representations in sensory memory, or the information may be structured more abstractly, based on meaning.

**Retaining Information in Working Memory.** Because information in working memory is fragile and easily lost, it must be kept activated to be retained. Activation is high as long as you are focusing on information, but activation decays or fades quickly when attention shifts away. Holding information in working memory is like keeping a series of plates spinning on top of poles in a circus act. The performer gets one plate spinning, moves to the next plate, and the next, but has to return to the first plate before it slows down too much and falls off its pole. If we don’t keep the information “spinning” in working memory—keep it activated—it will “fall off” (Anderson, 2005, 1995). When activation fades, forgetting follows, as shown in Figure 7.4. To keep information activated in working memory for longer than 20 seconds, most people keep rehearsing the information mentally.

There are two types of rehearsal (Craik & Lockhart, 1972). **Maintenance rehearsal** involves repeating the information in your mind. As long as you repeat the information, it can be maintained in working memory indefinitely. Maintenance rehearsal is useful for retaining something you plan to use and then forget, such as a phone number or a location on a map.

**Elaborative rehearsal** involves connecting the information you are trying to remember with something you already know, with knowledge from long-term memory. For example, if you meet someone at a party whose name is the same as your brother’s, you don’t have to repeat the name to keep it in memory; you just have to make the association. This kind of rehearsal not only retains information in working memory but also helps move information to long-term memory. Rehearsal is a process the central executive controls to manage the flow of information through the information processing system.

The limited capacity of working memory can also be somewhat circumvented by the process of **chunking.** Because the number of bits of information, not the size of each bit, is a limitation for working memory, you can retain more information if you can group individual bits of information. For example, if you have to remember the six digits 3, 5, 4, 8, 7, and 0, it is easier to put them together into three chunks of two digits each (35, 48, 70).

**FIGURE 7.4**

<table>
<thead>
<tr>
<th>Maintenance rehearsal</th>
<th>Keeping information in working memory by repeating it to yourself.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elaborative rehearsal</td>
<td>Keeping information in working memory by associating it with something else you already know.</td>
</tr>
<tr>
<td>Chunking</td>
<td>Grouping individual bits of data into meaningful larger units.</td>
</tr>
</tbody>
</table>
70) or two chunks of three digits each (354, 870). With these changes, there are only two or three bits of information rather than six to hold at one time. chunking helps you remember a telephone number or a social security number (Driscoll, 2005).

**Forgetting.** Information may be lost from working memory through interference or decay (see Figure 7.4). Interference is fairly straightforward: Processing new information interferes or gets confused with old information. As new thoughts accumulate, old information is lost from working memory. Information is also lost by time decay. If you don’t continue to pay attention to information, the activation level decays (weakens) and finally drops so low that the information cannot be reactivated—it disappears altogether.

Actually, forgetting is very useful. Without forgetting, people would quickly overload their working memories and learning would cease. Also, it would be a problem if you remembered permanently every sentence you ever read, every sound you ever heard, every picture you ever saw. . . . you get the idea. Finding a particular bit of information in all that sea of knowledge would be impossible. It is helpful to have a system that provides temporary storage and that “weeds out” some information from everything you experience.

We turn next to long-term memory. Because this is such an important topic for teachers, we will spend quite a bit of time on it.

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**Long-Term Memory: The Goal of Teaching**

Working memory holds the information that is currently activated, such as a telephone number you have just found and are about to dial. Long-term memory holds the information that is well learned, such as all the other telephone numbers you know.

**Capacity, Duration, and Contents of Long-Term Memory**

There are a number of differences between working and long-term memory, as you can see in Table 7.1. Information enters working memory very quickly. To move information into long-term storage requires more time and a bit of effort. Whereas the capacity of working memory is limited, the capacity of long-term memory appears to be, for all practical purposes, unlimited. In addition, once information is securely stored in long-term memory, it can remain there permanently. Our access to information in working memory is immediate because we are thinking about the information at that very moment. But access to information in long-term memory requires time and effort. Recently, some psychologists have suggested that there are not two separate memory stores (working and long-term). Rather, working memory is the part of long-term memory that works on

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**TABLE 7.1**

<table>
<thead>
<tr>
<th>Type of Memory</th>
<th>Input</th>
<th>Capacity</th>
<th>Duration</th>
<th>Contents</th>
<th>Retrieval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working</td>
<td>Very fast</td>
<td>Limited</td>
<td>Very brief: 5–20 sec.</td>
<td>Words, images, ideas, sentences</td>
<td>Immediate</td>
</tr>
<tr>
<td>Long-Term</td>
<td>Relatively slow</td>
<td>Practically unlimited</td>
<td>Practically unlimited</td>
<td>Propositional networks, schemata, productions, episodes, perhaps images</td>
<td>Depends on representation and organization</td>
</tr>
</tbody>
</table>

(processes) currently activated information—so working memory is more about processing than storage (Wilson, 2001). Another take on the information processing model is the notion of long-term working memory (Kintsch, 1998). **Long-term working memory** holds the retrieval structures and strategies that pull from long-term memory the information needed at the moment. As you develop knowledge and expertise in an area, you create efficient long-term working memory structures for solving problems in that area. So long-term working memory involves a set of domain-specific access tools that improve as you gain expertise in that domain.

**Contents of Long-Term-Memory: Declarative, Procedural, and Conditional Knowledge.** What we know is stored in long-term memory. Earlier, we talked about general and specific knowledge. Another way to categorize knowledge is as declarative, procedural, or conditional (Paris & Cunningham, 1996; Paris, Lipson, & Wigston, 1983). **Declarative knowledge** is knowledge that can be declared, through words and symbol systems of all kinds—Braille, sign language, dance or musical notation, mathematical symbols, and so on (Farnham-Diggory, 1994). Declarative knowledge is "knowing that" something is the case. The history students in the opening "What Would You Do?" situation were focusing exclusively on declarative knowledge about history. The range of declarative knowledge is tremendous. You can know very specific facts (the atomic weight of gold is 196.967), or generalities (leaves of some trees change color in autumn), or personal preferences (I don't like lima beans), or rules (to divide fractions, invert the divisor and multiply). Small units of declarative knowledge can be organized into larger units; for example, principles of reinforcement and punishment can be organized in your thinking into a theory of behavioral learning (Gagné, Yekovich, & Yekovich, 1993).

**Procedural knowledge** is "knowing how" to do something such as divide fractions or clean a carburetor—it is knowledge in action. Procedural knowledge must be demonstrated. Notice that repeating the rule "to divide fractions, invert the divisor and multiply" shows declarative knowledge—the student can state the rule. But to show **procedural knowledge**, the student must act. When faced with a fraction to divide, the student must divide correctly. Students demonstrate procedural knowledge when they translate a passage into Spanish, correctly categorize a geometric shape, or craft a coherent paragraph.

**Conditional knowledge** is "knowing when and why" to apply your declarative and procedural knowledge. Given the many kinds of math problems, it takes conditional knowledge to know when to apply one procedure and when to apply another to solve each problem. It takes conditional knowledge to know when to read every word in a text and when to skim. For many students, conditional knowledge is a stumbling block. They have the facts and can do the procedures, but they don't seem to understand how to apply what they know at the appropriate time.

Table 7.2 illustrates how declarative, procedural, and conditional knowledge can be either general or domain-specific.

**TABLE 7.2**

<table>
<thead>
<tr>
<th>Kinds of Knowledge</th>
<th>General Knowledge</th>
<th>Domain-Specific Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declarative</td>
<td>Hours the library is open</td>
<td>The definition of &quot;hypotenuse&quot;</td>
</tr>
<tr>
<td></td>
<td>Rules of grammar</td>
<td>The lines of the poem &quot;The Raven&quot;</td>
</tr>
<tr>
<td>Procedural</td>
<td>How to use your word processor</td>
<td>How to solve an oxidation-reduction equation</td>
</tr>
<tr>
<td></td>
<td>How to drive</td>
<td>How to throw a pot on a potter's wheel</td>
</tr>
<tr>
<td>Conditional</td>
<td>When to give up and try another approach</td>
<td>When to use the formula for calculating volume</td>
</tr>
<tr>
<td></td>
<td>When to skim and when to read carefully</td>
<td>When to rush the net in tennis</td>
</tr>
</tbody>
</table>

Chapter 7: Cognitive Views of Learning
Contents of Long-Term Memory: Words and Images. Allan Paivio (1971, 1986; Clark & Paivio, 1991) suggests that information is stored in long-term memory as either visual images or verbal units, or both. Psychologists who agree with this point of view believe that information coded both visually and verbally is easiest to learn (Mayer & Sims, 1994). This may be one reason why explaining an idea with words and representing it visually in a figure, as we do in textbooks, has proved helpful to students. For example, Richard Mayer and his colleagues (Mayer, 1998a, 2001; Mautone & Mayer, 2001) have found that illustrations like the one in Figure 7.5 on page 278 are helpful in improving students’ understanding of science concepts. Paivio’s ideas have support, but critics contend that many images are actually stored as verbal codes and then translated into visual information when an image is needed (Driscoll, 2003).

Most cognitive psychologists distinguish two categories of long-term memory, explicit and implicit, with subdivisions under each category, as shown in Figure 7.5. Explicit memory is knowledge from long-term memory that can be recalled and consciously considered. We are aware of these memories—we know we have remembered them. Implicit memory, on the other hand, is knowledge that we are not conscious of recalling, but that influences behavior or thought without our awareness. These different kinds of memory are associated with different parts of the brain (Ashcraft, 2006).

Explicit Memories: Semantic and Episodic

In Figure 7.5, you will see that explicit memories can be either semantic or episodic. Semantic memory, very important in schools, is memory for meaning, including words, facts, theories, and concepts—declarative knowledge. These memories are not tied to particular experiences and are stored as propositions, images, and schemas.

Propositions and Propositional Networks. A proposition is the smallest unit of knowledge that can be judged true or false. The statement, “Ida borrowed the antique tablecloth” has two propositions:

1. Ida borrowed the tablecloth.
2. The tablecloth is an antique.

FIGURE 7.5

Explicit memory (conscious) | Implicit memory (unconscious)
---|---
Episodic memory (your own experiences) | Classical conditioning (e.g., conditioned emotional responses)
Semantic memory (facts, general knowledge) | Procedural memory (motor skills, habits, tacit rules)


Long-term memory: memories that involve deliberate or conscious recall.

Implicit memory: Knowledge that we are not conscious of recalling, but influences behavior or thought without our awareness.

Semantic memory: Memory for meaning.
Propositions that share information, such as the two above that share information about the tablecloth (Ida borrowed the tablecloth and the tablecloth is an antique), are linked in what cognitive psychologists call propositional networks. It is the meaning, not the exact words or word order, that is stored in the network. The same propositional network would apply to the sentence: “The antique tablecloth was borrowed by Ida.” The meaning is the same, and it is this meaning that is stored in memory as a set of relationships.

It is possible that most information is stored and represented in propositional networks. When we want to recall a bit of information, we can translate its meaning (as represented in the propositional network) into familiar phrases and sentences, or mental pictures. Also, because propositions are networked, recall of one bit of information can trigger or activate recall of another. We are not aware of these networks, for they are not part of our conscious memory (Anderson, 1995a). In much the same way, we are not aware of underlying grammatical structure when we form a sentence in our own language; we don’t have to diagram a sentence in order to say it.

Images. Images are representations based on the structure or appearance of the information (Anderson, 1995a). As we form images (like you did in the “p” problem), we try to remember or recreate the physical attributes and spatial structure of information. For example, when asked how many windowpanes are in their living room, most people call up an image of the windows “in their mind’s eye” and count the panes—the more panes, the longer it takes to respond. If the information were represented only in a proposition such as “my living room has seven window panes,” then everyone would take about the same time to answer, whether the number was 1 or 24 (Mendel, 1971). However, as we saw earlier, researchers don’t agree on exactly how images are stored in memory. Some psychologists believe that images are stored as pictures; others believe we store propositions in long-term memory and convert to pictures in working memory when necessary.

There probably are features of each process involved—some memory for images and some verbal or propositional descriptions of the image. Seeing images “in your mind’s eye” is not exactly the same as seeing the actual image. It is more difficult to perform complicated transformations on mental images than on real images (Driscoll, 2001; Mullin & Poley, 1997). For example, if you had a plastic “p,” you could very quickly rotate it. Rotating mentally takes more time for most people. Nevertheless, images are useful in making many practical decisions such as how a sofa might look in your living room or how to line up a golf shot. Images may also be helpful in abstract reasoning. Physicists, such as Faraday and Einstein, report creating images to reason about complex new problems. Einstein claimed that he was visualizing chasing a beam of light and catching up to it when the concept of relativity came to him (Kosslyn & Koenig, 1992).

Schemas. Propositions and single images are fine for representing single ideas and relationships, but often our knowledge about a topic combines images and propositions. To explain this kind of complex knowledge, psychologists developed the idea of a schema (Gagné, Yekovich, & Yekovich, 1993). Schemas (sometimes called schemata) are abstract knowledge structures that organize vast amounts of information. A schema (the singular form) is a pattern or guide for representing an event, concept, or skill. For example, Figure 7.6 is a partial representation of a schema for knowledge about “reinforcement.”

The schema tells you what features are typical of a category, what to expect about an object or situation. The pattern has “slots” that are filled with specific information as we apply the schema in a particular situation. And schemas are personal. For example, my schema of reinforcement is less richly developed than Skinner’s schema must have been. You encountered a very similar concept of scheme in the discussion of Piaget’s theory of cognitive development in Chapter 2.

When you hear the sentence, “Ida borrowed the antique tablecloth,” you know even more about it than the two propositions because you have schemas about borrowing, tablecloths, antiques, and maybe even Ida herself. You know without being told, for example, that the lender does not have the tablecloth now, because it is in Ida’s possession, and that Ida has an obligation to return the tablecloth to the lender (Gentner, 1975).
None of this information is explicitly stated, but it is part of our schema for the meaning of "borrow." Other schemas allow you to infer that the cloth is not plastic (if it is a real antique) and that Ida has probably invited guests for a meal. If you actually knew Ida, your schema about her may even allow you to predict how promptly the cloth will be returned and in what condition.

Another type of schema, a story grammar (sometimes called a schema for text or story structure) helps students to understand and remember stories (Gagné, Yekovich, & Yekovich, 1993; Rummelhart & Ortony, 1977). A story grammar could be something like this: murder discovered, search for clues, murderer's fatal mistake identified, trap set to trick suspect into confessing, murderer takes bait... mystery solved! In other words, a story grammar is a typical general structure that could fit many specific stories. To comprehend a story, we select a schema that seems appropriate. Then, we use this framework to decide which details are important, what information to seek, and what to remember. It is as though the schema is a theory about what should occur in the story. The schema guides us in "interrogating" the text, pointing to the specific information we expect to find so that the story makes sense. If we activate our "murder mystery schema," we may be alert for clues or a murderer's fatal mistake. Without an appropriate schema, trying to understand a story, textbook, or classroom lesson is a very slow, difficult process, something like finding your way through a new town without a map. A schema representing the typical sequence of events in an everyday situation is called a script or an event schema. Children as young as age 3 have basic scripts for the familiar events in their lives (Nelson, 1986).

**WHAT WOULD YOU SAY?**

During your interview, the supervisor for the primary grades asks you, "What is your script for a typical day? Tell me how a good day should go in terms of what you would plan and how much time you would give to each segment of your day."

Storing knowledge of the world in schemas and scripts has both advantages and disadvantages. A schema can be applied in many contexts, depending on what part of the

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**Connect and Extend to Your Teaching/Portfolio**

How can schemas about differences among individuals, groups, and social contexts determine how new information about people and situations is interpreted?
schema is relevant. You can use what you know about reinforcement, for example, to take a test in educational psychology, to analyze why a student continues to be sent to the principal’s office, or to design an incentive program for your employees. Having a well-developed schema about Ida lets you recognize her (even as her appearance changes), remember many of her characteristics, and make predictions about her behavior. But it also allows you to be wrong. You may have incorporated incorrect or biased information into your schema of Ida. For example, if Ida is a member of an ethnic group different from yours and if you believe that group is dishonest, you may assume that Ida will keep the tablecloth. In this way, racial and ethnic stereotypes can function as schemas for misunderstanding individuals and for racial discrimination (Sherman & Bessenoff, 1999).

The second kind of explicit memory is episodic. We turn to that now.

**Episodic Memory.** Memory for information tied to a particular place and time, especially information about the events or episodes of your own life, is called episodic memory. **Episodic memory** is about events we have experienced, so we often can explain when the event happened. In contrast, we usually can’t describe when we acquired a semantic memory. For example, you may have a difficult time remembering when you developed semantic memories for the meaning of the word “injustice,” but you can easily remember a time that you felt unjustly treated. Episodic memory also keeps track of the order of things, so it is a good place to store jokes, gossip, or plots from films.

Memories for dramatic or emotional moments in your life are called flashbulb memories. These memories are vivid and complete, as if your brain demanded that you “record this moment.” Under stress, more glucose energy goes to fuel brain activity, while stress-induced hormones signal the brain that something important is happening (Myers, 2005). So when we have strong emotional reactions, memories are stronger and more lasting. Many people have vivid memories of very positive or very negative events in school, winning a prize or being humiliated, for example. You probably know just where you were and what you were doing on 9/11. People over 50 have vivid memories of the day John Kennedy was assassinated. My whole school had walked to the main street of our suburb of Ft. Worth, Texas, to applaud as his motorcade drove by en route to the airport for the flight to Dallas. By the time I got back to geometry class, we heard the announcement that he had been shot in Dallas. My friend who had been at breakfast with him that very day was devastated.

**Implicit Memories**

Look back at Figure 7.5 on page 259. You see that there are three kinds of implicit or out-of-awareness memories: classical conditioning, procedural memory, and priming effects. In classical conditioning, as we saw in Chapter 6, some out-of-awareness memories may cause you to feel anxious as you take a test or make your heart rate increase when you hear a dentist’s drill.

The second type of implicit memory is **procedural memory** for skills, habits, and how to do things—in other words, memory for procedural knowledge. It may take a while to learn a procedure—such as how to ski, serve a tennis ball, or factor an equation, but once learned, this knowledge tends to be remembered for a long time. Procedural memories are represented as condition-action rules, sometimes called productions. **Productions** specify what to do under certain conditions: If A occurs, then do B. A production might be something like, “If you want to snow ski faster, lean back slightly,” or “If your goal is to increase student attention and a student has been paying attention a bit longer than usual, then praise the student.” People can’t necessarily state all their condition-action rules, and don’t even know that they are following these rules, but they act on them nevertheless. The more practiced the procedure, the more automatic the action and the more implicit the memory (Anderson, 1995a).

**STOP|THINK|WRITE** Fill in these blanks: ME _ _ _

The final type of implicit memory involves **priming**, or activating information that already is in long-term memory through some out-of-awareness process. You might have
seen an example of priming in the fill-in-the-blank question above. If you wrote MEMORY instead of MENTOR or MEMBER, or MFTEOR or other ME words, then priming may have played a role because the word “memory” has occurred many times in this chapter. Priming may be the fundamental process for retrieval as associations are activated and spread through the memory system (Ashcraft, 2005).

Storing and Retrieving Information in Long-Term Memory

Just what is done to “save” information permanently—to create explicit and implicit memories? How can we make the most effective use of our practically unlimited capacity to learn and remember? The way you learn information in the first place—the way you process it in working memory at the outset—strongly affects its recall later. One important requirement is that you integrate new information with knowledge already stored in long-term memory as you construct an understanding. Here, elaboration, organization, and context play a role.

Elaboration is adding meaning to new information by connecting with already existing knowledge. In other words, we apply our schemas and draw on already existing knowledge to construct an understanding. Frequently, we change our existing knowledge in the process. We often elaborate automatically. For example, a paragraph about an historic figure in ancient Rome tends to activate our existing knowledge about that period; we use the old knowledge to understand the new.

Material that is elaborated when first learned will be easier to recall later. First, as we saw earlier, elaboration is a form of rehearsal. It keeps the information activated in working memory long enough to have a chance for the new information to be linked with knowledge in long-term memory. Second, elaboration builds extra links to existing knowledge. The more one bit of information or knowledge is associated with other bits, the more routes there are to follow to get to the original bit. To put it another way, you have several “handles” or priming/retrieval cues to “pick up” or recognize the information you might be seeking (Schunk, 2004).

The more students elaborate new ideas, the more they “make them their own,” the deeper their understanding and the better their memory for the knowledge will be. We help students to elaborate when we ask them to translate information into their own words, create examples, explain to a peer, draw or act out the relationships, or apply the information to solve new problems. Of course, if students elaborate new information by developing misguided explanations, these misconceptions will be remembered too.

Organization is a second element of processing that improves learning. Material that is well organized is easier to learn and to remember than bits and pieces of information, especially if the information is complex or extensive. Placing a concept in a structure will help you learn and remember both general definitions and specific examples. The structure serves as a guide back to the information when you need it. For example, Table 7.1 gives an organized view of the capacity, duration, contents, and retrieval of information from working and long-term memory; Table 7.2 organizes information about types of knowledge; and Figure 7.6 organizes my knowledge about reinforcement.

Context is a third element of processing that influences learning. Aspects of physical and emotional context—places, rooms, moods, who is with us—are learned along with other information. Later, if you try to remember the information, it will be easier if the current context is similar to the original one. Context is a kind of priming that activates the information. This has been demonstrated in the laboratory. Students who learned material in one type of room performed better on tests taken in a similar room than they did on comparable tests taken in a very different-looking room (Smith, Glenberg, & Bjork, 1978). So, studying for a test under “test-like” conditions may result in improved performance. Of course, you can’t always go back to the same place or a similar one in order to recall something. But if you can picture the setting, the time of day, and your companions, you may eventually reach the information you seek.

Levels of Processing Theory. Craik and Lockhart (1972) first proposed their levels of processing theory as an alternative to short-/long-term memory models, but levels of
processing theory is particularly related to the notion of elaboration described earlier. Craik and Lockhart suggested that what determines how long information is remembered is how extensively the information is analyzed and connected with other information. The more completely information is processed, the better are our chances of remembering it. For example, according to the levels of processing theory, if I ask you to sort pictures of dogs based on the color of their coats, you might not remember many of the pictures later. But if I ask you to rate each dog on how likely it is to chase you as you jog, you probably would remember more of the pictures. To rate the dogs, you must pay attention to details in the pictures, relate features of the dogs to characteristics associated with danger, and so on. This rating procedure requires "deeper" processing and more focus on the meaning of the features in the photos.

Retrieving Information from Long-Term Memory. When we need to use information from long-term memory, we search for it. Sometimes, the search is conscious, as when you see a friend approaching and search for her name. At other times, locating and using information from long-term memory is automatic, as when you dial a telephone or solve a math problem without having to search for each step, or the word "memory" pops to mind when you see ME _. _ _. Think of long-term memory as a huge shelf full of tools (skills, procedures) and supplies (knowledge, schemas) ready to be brought to the workbench of working memory to accomplish a task. The shelf (long-term memory) stores an incredible amount, but it may be hard to find what you are looking for quickly. The workbench (working memory) is small, but anything on it is immediately available. Because it is small, however, supplies (bits of information) sometimes are lost when the workbench overflows or when one bit of information covers (interferes with) another (L. C. Gagné, 1985).

Spreading Activation. The size of the network in long-term memory is huge, but only small parts from it are activated at any one time. Only the information we are currently thinking about is in working memory. Information is retrieved in this network through spreading activation. When a particular proposition or image is active—when we are thinking about it—other closely associated knowledge can be primed or triggered as well, and activation can spread through the network (Anderson, 2005; Gagné, Yekovich, & Yekovich, 1993). Thus, as I focus on the propositions, "I'd like to go for a drive to see the fall leaves," related ideas such as, "I should rake leaves," and "The car needs an oil change," come to mind. As activation spreads from the "car trip" to the "oil change," the original thought, or active memory, disappears from working memory because of the limited space. Thus, retrieval from long-term memory occurs partly through the spreading of activation from one bit of knowledge to related ideas in the network. We often use this spreading in reverse to retrace our steps in a conversation, as in, "Before we got onto the topic of where to get the oil changed, what were we talking about? Oh yes, seeing the leaves." The learning and retrieving processes of long-term memory are diagrammed in Figure 7.7.

Reconstruction. In long-term memory, the information is still available, even when it is not activated, even when you are not thinking about it at the moment. If spreading activation does not "find" the information we seek, then we might still come up with an answer through reconstruction, a cognitive tool or problem-solving process that makes use of logic, cues, and other knowledge to construct a reasonable answer by filling in any missing parts (Koriat, Goldsmith, & Pansky, 2000). Sometimes reconstructed recollections are incorrect. For example, in 1932, L. C. Bartlett conducted a series of famous studies on remembering stories. He read a complex, unfamiliar Native American tale to students at England's Cambridge University and, after various lengths of time, asked the students to recall the story. Stories the students recalled were generally shorter than the original and were translated into the concepts and language of the Cambridge student culture. The story told of a seal hunt, for instance, but many students remembered (reconstructed) a "fishing trip," an activity closer to their experiences and more consistent with their schemas.
One area where reconstructed memory can play a major role is eyewitness testimony. Elizabeth Loftus and her colleagues have conducted a number of studies showing that misleading questions or other information during questioning can affect memory. For example, in a classic study, Loftus and Palmer (1974) showed subjects slides of a car wreck. Later, the experimenters asked some subjects, “How fast were the cars going when they hit each other?” while other subjects who saw the same slides were asked, “How fast were the cars going when they smashed into each other?” The difference in verbs was enough to bias the subjects’ memories—the “hit” subjects estimated the cars were traveling an average of 34 miles per hour, but the “smashed” subjects estimated almost 41 miles per hour. And one week later, 32% of the “smashed” subjects remembered seeing broken glass at the scene of the wreck, while only 14% of the “hit” subjects remembered glass. (There was no broken glass visible in any of the slides.)

**Forgetting and Long-Term Memory.** Information in working memory that is lost before it has a chance to integrate into the network of long-term memory truly disappears. No amount of effort or searching will bring it back. But information stored in long-term memory may be available, given the right cues. Some people believe that nothing is ever lost from long-term memory; however, research casts doubt on this assertion (Schwarz, Wasserstein, & Robbins, 2002).

**WHAT WOULD YOU SAY?**

As part of your interview, the principal says, “We have to cover so much material to get our students ready for the state assessments. What would you do to help your students remember what they have learned in your classes?”

Information appears to be lost from long-term memory through time decay and interference. For example, memory for Spanish–English vocabulary decreases for about 3 years after a person’s last course in Spanish, then stays level for about 25 years, then drops again for the next 25 years. One explanation for this decline is that neural connections, like muscles, grow weak without use. After 25 years, it may be that the memories are still somewhere in the brain, but they are too weak to be reactivated (Anderson, 2005, 1995). And some neurons simply die. Finally, newer memories may interfere with or obscure older memories, and older memories may interfere with memory for new material.
Even with decay and interference, long-term memory is remarkable. In a review of almost 100 studies of memory for knowledge taught in school, George Scerb and John Ellis (1994) concluded, "contrary to popular belief, students retain much of the knowledge taught in the classroom" (p. 279). It appears that teaching strategies that encourage student engagement and lead to higher levels of initial learning (such as frequent reviews and tests, elaborated feedback, high standards, mastery learning, and active involvement in learning projects) are associated with longer retention. The Guidelines give applications of information processing for teaching.

### Guidelines: Using Information Processing Ideas in the Classroom

**Make sure you have the students’ attention.**

**EXAMPLES:**

1. Develop a signal that tells students to stop what they are doing and focus on you. Make sure students respond to the signal—don’t let them ignore it. Practice using the signal.
2. Move around the room, use gestures, and avoid speaking in a monotone.
3. Begin a lesson by asking a question that stimulates interest in the topic.
4. Regain the attention of individual students by walking closer to them, using their names, or asking them a question.

**Help students separate essential from nonessential details and focus on the most important information.**

**EXAMPLES:**

1. Summarize instructional objectives to indicate what students should be learning. Relate the material you are presenting to the objectives as you teach: “Now I’m going to explain exactly how you can find the information you need to meet Objective One on the board—determining the tone of the story.”
2. When you make an important point, pause, repeat, ask a student to paraphrase, note the information on the board in colored chalk, or tell students to highlight the point in their notes or readings.

**Help students make connections between new information and what they already know.**

**EXAMPLES:**

1. Review prerequisites to help students bring to mind the information they will need to understand new material: “Who can tell us the definition of a quadrilateral? Now, what is a rhombus? Is a square a quadrilateral? Is a square a rhombus? What did we say yesterday about how you can tell? Today we are going to look at some other quadrilaterals.”
2. Use an outline or diagram to show how new information fits with the framework you have been developing. For example, “Now that you know the duties of the FBI, where would you expect to find it in this diagram of the branches of the U.S. government?”
3. Give an assignment that specifically calls for the use of new information along with information already learned.

**Provide for repetition and review of information.**

**EXAMPLES:**

1. Begin the class with a quick review of the homework assignment.
2. Give frequent, short tests.
3. Build practice and repetition into games, or have students work with partners to quiz each other.

**Present material in a clear, organized way.**

**EXAMPLES:**

1. Make the purpose of the lesson very clear.
2. Give students a brief outline to follow. Put the same outline on an overhead transparency so you can keep yourself on track. When students ask questions or make comments, relate these to the appropriate section of the outline.
3. Use summaries in the middle and at the end of the lesson.

**Focus on meaning, not memorization.**

**EXAMPLES:**

1. In teaching new words, help students associate the new word to a related word they already understand: “Enmity is from the same root as enemy.”
2. In teaching about remainders, have students group 12 objects into sets of 2, 3, 4, 5, 6, and ask them to count the “leftovers” in each case.

For more information on information processing, see: [http://chiron.valdosta.edu/whititt/coll/egpyan/infoproc.html](http://chiron.valdosta.edu/whititt/coll/egpyan/infoproc.html)
One question that intrigues many cognitive psychologists is why some people learn and remember more than others. For those who hold an information processing view, part of the answer lies in the concept of metacognition.

**Metacognition**

The executive control processes shown in Figure 7.1 guide the flow of information through the information processing system. We have already discussed a number of control processes, including attention, maintenance rehearsal, elaborative rehearsal, organization, and elaboration. These executive control processes are sometimes called metacognitive skills, because they can be intentionally used to regulate cognition.

**Metacognitive Knowledge and Regulation**

Donald Meichenbaum and his colleagues described metacognition as people's "awareness of their own cognitive machinery and how the machinery works" (Meichenbaum, Bialik, Gruson, & Cameron, 1985, p. 5). Metacognition literally means cognition about cognition—or knowledge about knowing and learning. This metacognitive knowledge is higher-order cognition used to monitor and regulate cognitive processes such as reasoning, comprehension, problem solving, learning, and so on (Metcalf & Shimamura, 1994). Because people differ in their metacognitive knowledge and skills, they differ in how well and how quickly they learn (Brown, Bransford, Ferrara, & Campione, 1983; Morris, 1990).

Metacognition involves the three kinds of knowledge we discussed earlier: (1) declarative knowledge about yourself as a learner, the factors that influence your learning and memory, and the skills, strategies, and resources needed to perform a task—knowing what to do; (2) procedural knowledge or knowing how to use the strategies; and (3) conditional knowledge to ensure the completion of the task—knowing when and why to apply the procedures and strategies (Bruning, Schraw, Norby, & Ronning, 2004). Metacognition is the strategic application of this declarative, procedural, and conditional knowledge to accomplish goals and solve problems (Schunk, 2004).

Metacognitive knowledge is used to regulate thinking and learning (Brown, 1987; Nelson, 1996). There are three essential skills that allow us to do this: planning, monitoring, and evaluating. Planning involves deciding how much time to give to a task, which strategies to use, how to start, what resources to gather, what order to follow, what to skim and what to give intense attention to, and so on. Monitoring is the real-time awareness of "how I'm doing." Monitoring entails asking, "Is this making sense? Am I trying to

Metacognition involves choosing the best way to approach a learning task. Students with good metacognitive skills set goals, organize their activities, select among various approaches to learning, and change strategies if needed.

**Connect and Extend to PRAXIS II**

**Metacognition (L.A1)**

Often the difference between two students—one a successful learner, and the other a struggling learner—is the effective use of metacognitive processes. Identify strategies that teachers can use to enhance the role of metacognition in instruction.

Executive control processes

Processes such as selective attention, rehearsal, elaboration, and organization that influence encoding, storage, and retrieval of information in memory.

Metacognition Knowledge about our own thinking processes.
go too fast? Have I studied enough?" Evaluating involves making judgments about the processes and outcomes of thinking and learning. "Should I change strategies? Get help? Give up for now? Is this paper (painting, model, poem, plan, etc.) finished?"

Of course, we don’t have to be metacognitive all the time. Some actions become routine. Metacognition is most useful when tasks are challenging, but not too difficult. Then planning, monitoring, and evaluating can be helpful. And even when we are planning, monitoring, and evaluating, these processes are not necessarily conscious, especially in adults. We may use them automatically without being aware of our efforts (Perel, 2000). Experts in a field plan, monitor, and evaluate as second nature; they have difficulty describing their metacognitive knowledge and skills (Barsh & Chartrand, 1999; Reder, 1996).

Reaching Every Student: Metacognitive Strategies for Students with Learning Disabilities

For students with learning disabilities, executive control processes (that is, metacognitive strategies) such as planning, organizing, monitoring progress, and making adaptations are especially important, but often underdeveloped (Kirk, Gallagher, Anastasiow, & Coleman, 2006). It makes sense to teach these strategies directly. Some approaches make use of mnemonics to remember the steps. For example, teachers can help older students use a writing strategy called DEFENDS (Deshler, Ellis, & Lentz, 1996):

- Decide on audience, goals, and position.
- Estimate main ideas and details.
- Figure best order of main ideas and details.
- Express your position in the opening.
- Note each main idea and supporting points.
- Drive home the message in the last sentence.
- Search for errors and correct.

Of course, you have to do more than just tell students about the strategy—you have to teach it. Michael Pressley and his colleagues (1995) developed the Cognitive Strategies Model as a guide for teaching students to improve their metacognitive strategies. Table 7.3 describes the steps in teaching these strategies.

**TABLE 7.3**

<table>
<thead>
<tr>
<th>Teaching Strategies for Improving Students' Metacognitive Knowledge and Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>These eight guidelines, taken from Pressley and Woloshyn (1995), should help your in teaching and metacognitive strategy</td>
</tr>
<tr>
<td>• Teach a few strategies at a time, intensively and extensively as part of the ongoing curriculum.</td>
</tr>
<tr>
<td>• Model and explain new strategies.</td>
</tr>
<tr>
<td>• If parts of the strategy were not understood, model again and re-explain strategies in ways that are sensitive to those confusing or misunderstood aspects of strategy use.</td>
</tr>
<tr>
<td>• Explain to students where and when to use the strategy.</td>
</tr>
<tr>
<td>• Provide plenty of practice, using strategies for as many appropriate tasks as possible.</td>
</tr>
<tr>
<td>• Encourage students to monitor how they are doing when they are using strategies.</td>
</tr>
<tr>
<td>• Increase students’ motivation to use strategies by heightening their awareness that they are acquiring valuable skills—skills that are at the heart of competent functioning.</td>
</tr>
<tr>
<td>• Emphasize reflective processing rather than speedy processing; do all possible to eliminate high anxiety in students; encourage students to shield themselves from distractions so they can attend to academic tasks.</td>
</tr>
</tbody>
</table>

Now that we have examined the information processing explanation of how knowledge is represented and remembered, let's turn to the really important question: How can teachers support the development of knowledge?

**Becoming Knowledgeable: Some Basic Principles**

Understanding a concept such as “reinforcement” involves declarative knowledge about characteristics and images as well as procedural knowledge about how to apply rules to categorize specific consequences. We will discuss the development of declarative and procedural knowledge separately, but keep in mind that real learning is a combination and integration of these elements.

**Development of Declarative Knowledge**

Within the information processing perspective, to learn declarative knowledge is really to integrate new ideas with existing knowledge and construct an understanding. As you have seen, people learn best when they have a good base of knowledge in the area they are studying. With many well-elaborated schemas and script to guide them, new material makes more sense, and there are many possible spots in the long-term memory network for connecting new information with old. But students don’t always have a good base of knowledge. In the early phases of learning, students of any age must grope around the landscape a bit, searching for landmarks and direction. Even experts in an area must use some learning strategies when they encounter unfamiliar material or new problems (Alexander, 1996, 1997; Garner, 1990; Perkins & Salomon, 1989; Shuell, 1990).

What are some possible strategies? Perhaps the best single method for helping students learn is to make each lesson as meaningful as possible.

**Making It Meaningful.** Meaningful lessons are presented in vocabulary that makes sense to the students. New terms are clarified through ties with more familiar words and ideas. Meaningful lessons are well organized, with clear connections between the different elements of the lesson. Finally, meaningful lessons make natural use of old information to help students understand new information through examples or analogies.

The importance of meaningful lessons is emphasized below in an example presented by Smith (1975).

**STOP | THINK | WRITE** Look at the three lines below. Begin by covering all but the first line. Look at it for a second, close the book, and write down all the letters you remember. Then repeat this procedure with the second and third lines.

1. KBVODUWGRJMSQTXNOGMCRTSO
2. READ JUMP WHEAT POOR BUT SEEK
3. KNIGHTS RODE HORSES INTO WAR

Each line has the same number of letters, but the chances are great that you remembered all the letters in the third line, a good number of letters in the second line, and very few in the first line. The first line makes no sense. There is no way to organize it in a brief glance. Working memory is simply not able to hold and process all that information quickly. The second line is more meaningful. You do not have to see each letter because your long-term memory brings prior knowledge of spelling rules and vocabulary to the task. The third line is the most meaningful. Just a glance and you can probably remember all of it because you bring to this task prior knowledge not only of spelling and vocabulary but also of rules about syntax and probably some historical information about knights (they didn’t ride in tanks). This sentence is meaningful because you have existing schemas for assimilating it. It is relatively easy to associate the words and meaning with other information already in long-term memory (Sweller, van Merriënboer, & Paas, 1998).
The challenge for teachers is to make lessons less like learning the first line and more like learning the third line. Although this may seem obvious, think about the times when you have read a sentence in a text or heard an explanation from a professor that might just as well have been KBVODUWG.PJMSQXNOGMCTRSO. But remember, attempts to change the ways that students are used to learning—moving from memorizing to meaningful activities as in the opening “What Would You Do?” situation—are not always greeted with student enthusiasm. Students may be concerned about their grades; at least when memorization gains an A, they know what is expected. Meaningful learning can be riskier and more challenging. In Chapters 8, 9, 11, and 13 we will examine a variety of ways in which teachers can support meaningful learning and understanding. For now, see how one teacher made learning meaningful for her new students in Stories of Learning/Tributes to Teaching.

Visual Images and Illustrations. Is a picture worth 1000 words in teaching? Richard Mayer (1999a, 2001) has studied this question for several years and found that the right combination of pictures and words can make a significant difference in students’ learning. Mayer’s cognitive theory of multimedia learning includes three ideas:

Dual Coding: Visual and verbal materials are processed in different systems (Clark & Paivio, 1991).

Limited Capacity: Working memory for verbal and visual material is severely limited (Baddeley, 2001).

Generative Learning: Meaningful learning happens when students focus on relevant information and generate or build connections (Mayer, 1999a).

The problem: How to build complex understandings that integrate information from visual (pictures, diagrams, graphs, films) and verbal (text, lecture) sources, given the limitations of working memory. The answer: Make sure the information is available at the same time or in focused small bites. Mayer and Gallini (1990) provide an example. They used three kinds of texts to explain how a bicycle pump works. One text used only words,

SUSAN lived in what seemed to be a normal upper middle-class home, but her abusive father caused problems for the entire family. It was difficult for her to devote attention to school work. Susan thought she was just dumb, but she enjoyed art and dance and had the strong support of many family members. When her mother divorced and moved the family to another state, Susan encountered some wonderful teachers who captured her imagination and capitalized on her talents. Susan went on to earn a PhD in early childhood education and counseling—using her experiences as a resilient child to help others. She describes her senior English teacher.

The most exciting thing about my move was starting over academically. I was placed in a superior English class that year and I was also in pretty good classes across the board. I’ll never forget the first time I heard my English teacher, Mr. Borders, teach. I was sitting in class, and, for the first time in my life, I was able to really listen, pay attention, and focus on what the teacher was saying. It was an overwhelming experience and a wonderful feeling. I felt like the top of my head was off and everything that had previously clouded my brain and life was being lifted. I could use my brain like it was supposed to be used. There was a sense of quiet where I was free to think and process information without worrying about what was happening at home or how my mom was doing.

I began getting excited about learning. In fact, I liked learning because Mr. Borders, my “Superior English” teacher, made it exciting. He also introduced me to project work. I was able to make a Shakespearean character for one of my projects. I loved doing this project. I remember the great detail I took to make this character look authentic. I also saw myself excelling academically even though I thought I wasn’t supposed to be smart. I was also drawing my cousin’s lab pictures for her college biology class. Of course, art was one of my gifts and it didn’t take brains to do this, I thought, but, nevertheless, I felt proud. So, I began to surprise my mom as well as myself.

the second had pictures that just showed the parts of the brake system and the steps, and the third (this one improved student learning and recall) showed both the “on” and the “off” states of the pumps with labels for each step, as in Figure 7.8.

The moral of the story? Give students multiple ways to understand—pictures and explanations. But don’t overload working memory—“package” the visual and verbal information together in bite-size (or memory-size) pieces.

Another memory strategy that often makes use of images is mnemonics.

Mnemonics. Mnemonics are systematic procedures for improving memory (Atkinson et al., 1999; Levin, 1994; Rummel, Levin, & Woodward, 2003). When information has little inherent meaning, mnemonic strategies build in meaning by connecting what is to be learned with established words or images.

The loci method derives its name from the plural of the Latin word locus, meaning “place.” To use loci, you must first imagine a very familiar place, such as your own house or apartment, and pick out particular locations. Every time you have a list to remember, the same locations serve as “pegs” to “hang” memories. Simply place each item from your list in one of these locations. For instance, let’s say you want to remember to buy milk, bread, butter, and cereal at the store. Imagine a giant bottle of milk blocking the entry hall, a loaf of bread sleeping on the living room couch, a stick of butter melting all over the dining room table, and cereal covering the kitchen floor. When you want to remember the items, all you have to do is take an imaginary walk through your house. Other peg-type mnemonics use a standard list of words (one is bun, two is shoe) as pegs. Then, the items to be remembered are linked to the pegs through images or stories. The rhyming primes the list of pegs.

If you need to remember information for long periods of time, an acronym may be the answer. An acronym is a form of abbreviation—a word formed from the first letter of each word in a phrase, for example, HOMES to remember the Great Lakes (Huron, Ontario, Michigan, Erie, Superior). Another method forms phrases or sentences out of

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Medical students often use mnemonics to remember the vast amounts of information they encounter in their studies. Be familiar with the major mnemonic methods and the kinds of information that they are most suitable for. Attention (I, A1)

Connect and Extend to Your Teaching/Portfolio

Use the section on mnemonics to generate ideas for helping your students learn key vocabulary in science or social studies subjects and include these ideas in your Teaching Resources file.

Mnemonics Techniques for remembering; also, the art of memory.

Loci method Technique of associating items with specific places.

Peg-type mnemonics Systems of associating items with cue words.

Acronym Technique for remembering names, phrases, or steps by using the first letter of each word to form a new, memorable word.
the first letter of each word or item in a list, for example, Every Good Boy Does Fine to remember the lines on the G clef—F, G, B, D, F. Because the words must make sense as a sentence, this approach also has some characteristics of chain mnemonics, methods that connect the first item to be memorized with the second, the second item with the third, and so on. In one type of chain method, each item on a list is linked to the next through some visual association or story. Another chain method approach is to incorporate all the items to be memorized into a jingle such as “I before e except after c.”

The mnemonic system that has been most extensively researched in teaching is the keyword method. Joel Levin and his colleagues use a mnemonic (the 3 Rs) to teach the keyword mnemonic method:

- **Recode** the to-be-learned vocabulary item as a more familiar, concrete keyword — this is the keyword.
- **Relate** the keyword close to the vocabulary item's definition through a sentence.
- **Retrieval** the desired definition.

For example, to remember that the English word carlin means old woman, you might recode carlin as the more familiar keyword ear. Then, make up a sentence such as The old woman was driving a car. When you are asked for the meaning of the word carlin, you think of the keyword ear, which triggers the sentence about the car and the old woman, the meaning (Jones, Levin, & Beitzel, 2000).

The keyword method has been used extensively in foreign language learning. For example, the Spanish word carta (meaning “letter”) sounds like the English word “cart.” Cart becomes the keyword: You imagine a shopping cart filled with letters on its way to the post office, or you make up a sentence such as “The cart full of letters tipped over” (Pressey, Levin, & Delaney, 1982). A similar approach has been used to help students connect artists with particular aspects of their paintings. For example, students are told to imagine that the heavy dark lines of paintings by Rouault are made with a ruler (Rouault) dipped in black paint (Carnery & Levin, 2000). Figure 7.9 is an example of using mnemonic pictures as aids in learning complicated science concepts (Carnery & Levin, 2002).

The keyword method does not work well if it is difficult to identify a keyword for a particular item. Many words and ideas that students need to remember are quite a challenge to associate with keywords (Hall, 1991; Pressley, 1991). Also, vocabulary learned with keywords can be easily forgotten if students are given keywords and images instead of being asked to supply words and images that are relevant to them. When the teacher provides the memory links, these associations may not fit the students' existing knowledge and may be forgotten or confused later, as a result, remembering suffers (Wang & Thomas, 1995; Wang, Thomas, & Quellet, 1992). Younger students have some difficulty forming
their own images. For them, memory aids that rely on auditory cues—rhymes such as "Thirty days hath September" seem to work better (Willoughby, Porter, Belsito, & Yerkesley, 1999).

Many teachers use a mnemonic system to quickly learn their students’ names. Until we have some knowledge to guide learning, it may help to use some mnemonic approaches to build vocabulary and facts. Not all educators agree, however, as you will see in the Point/Counterpoint.

Rote Memorization. Very few things need to be learned by rote. The greatest challenge teachers face is to help students think and understand, not just memorize. Unfortunately,

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**Point/Counterpoint**

**What’s Wrong with Memorizing?**

For years, students have relied on memorization to learn vocabulary, procedures, steps, names, and facts. Is this a bad idea?

**POINT** Rote memorization creates inert knowledge.

Years ago William James (1912) described the limitations of rote learning by telling a story about what can happen when students memorize but do not understand:

A friend of mine, visiting a school, was asked to examine a young class in geography. Glancing at the book, she said: "Suppose you should dig a hole in the ground, hundreds of feet deep, how should you find it at the bottom—warmer or colder than on top?" None of the class replying, the teacher said: 'I'm sure they know, but I think you don't ask the question quite rightly. Let me try.' So, taking the book, she asked: "In what condition is the interior of the globe?" And received the immediate answer from half the class at once. "The interior of the globe is in a condition of igneous fusion." (p. 150)

The students had memorized the answer, but they had no idea what it meant. Perhaps they didn't understand the meaning of "interior," "globe," or "igneous fusion." At any rate, the knowledge was useless to them only when they were answering test questions, and only then when the questions were phrased exactly as they had been memorized. Students often resort to memorizing the exact words of definitions when they have no hope for actually understanding the terms when teachers count off for definitions that are not exact.

Howard Gardner has been a vocal critic of rote memorization and a champion of teaching for understanding. In an interview in Phi Delta Kappan (Siegel & Shaughnessy, 1994), Gardner says:

My biggest concern about American education is that even our better students in our better schools are just going through the motions of education. In The Unschooled Mind, I review ample evidence that suggests an absence of understanding—the inability of students to take knowledge, skills, and other apparent attainments and apply them successfully in new situations. In the absence of such flexibility and adaptability, the education that the students receive is worth little. (pp. 563-564)

**COUNTERPOINT** Rote memorization can be effective.

Memorization may not be such a bad way to learn new information that has little inherent meaning, such as foreign language vocabulary. Alvin Wang, Margaret Thomas, and Judith Ouellette (1992) compared learning Tagalog (the national language of the Philippines) using either rote memorization or the keyword approach. The keyword method is a way of creating connections and meaning for associating new words with existing words and images. In their study, even though the keyword method led to faster and better learning initially, long-term forgetting was greater for students who had used the keyword method than for students who had learned by rote memorization.

There are times when students must memorize and we do them a disservice if we don’t teach them how. Every discipline has its own terms, names, facts, and rules. As adults, we want to work with physicians who have memorized the correct names for the bones and organs of the body or the drugs needed to combat particular infections. Of course, they can look up some information or research certain conditions, but they have to know where to start. We want to work with accountants who give us accurate information about the new tax codes, information they probably had to memorize because it changes from year to year in ways that are not necessarily rational or meaningful. We want to deal with computer salespeople who have memorized their stock and know exactly which printers will work with our computer. Just because something was learned through memorization does not mean it is inert knowledge. The real question, as Gardner points out above, is whether you can use the information flexibly and effectively to solve new problems.

**WHAT DO YOU THINK?**

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many students, including those in the scenario opening this chapter, see rote memorizing and learning as the same thing (Iran-Nejad, 1990).

However, on rare occasions we have to memorize something word-for-word, such as lines in a song, poem, or play. How would you do it? If you have tried to memorize a list of items that are all similar to one another, you may have found that you tended to remember items at the beginning and at the end of the list, but forgot those in the middle. This is called the serial-position effect. Part learning, breaking the list into smaller segments, can help prevent this effect, because breaking a list into several shorter lists means there will be fewer middle items to forget.

Another strategy for memorizing a long selection or list is the use of distributed practice. A student who studies Hamlet's soliloquy intermittently throughout the weekend will probably do much better than a student who tries to memorize the entire speech on Sunday night. Studying for an extended period is called massed practice. Massed practice leads to fatigue and lagging motivation. Distributed practice gives time for deeper processing and the chance to move information into long-term memory (Mumford, Costanza, Baughman, Threlfall, & Fleishman, 1994). What is forgotten after one session can be relearned in the next with distributed practice.

**Becoming an Expert: Development of Procedural and Conditional Knowledge**

Experts in a particular field have a wealth of domain-specific knowledge, that is, knowledge that applies specifically to their area or domain. This includes declarative knowledge (facts and verbal information), procedural knowledge (how to perform various cognitive activities), and conditional knowledge (knowing when and why to apply what they know). In addition, it appears that experts have developed their long-term working memories in the domain and can quickly access relevant knowledge and strategies for solving problems in that domain.

Another characteristic distinguishes experts from novices. Much of the expert’s declarative knowledge has become “proceduralized,” that is, incorporated into routines they can apply automatically without much demand on working memory. Explicit memories have become implicit and the expert is no longer aware of them. Skills that are applied without conscious thought are called automated basic skills. An example is shifting gears in a standard transmission car. At first you had to think about every

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**Rote memorization**  Remembering information by repetition without necessarily understanding the meaning of the information.

**Serial-position effect**  The tendency to remember the beginning and the end but not the middle of a list.

**Part learning**  Breaking a list of rote learning items into shorter lists.

**Distributed practice**  Practice in brief periods with rest intervals.

**Massed practice**  Practice for a single extended period.

**Automated basic skills**  Skills that are applied without conscious thought.

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Driving a car employs both automated basic skills and domain-specific strategies.
step, but as you became more expert (if you did), the procedure became automatic. But not all procedures can be automatic, even for experts in a particular domain. For example, no matter how expert you are in driving, you still have to consciously watch the traffic around you. This kind of conscious procedure is called a domain-specific strategy. Automated basic skills and domain-specific strategies are learned in different ways (Gagné, Yekovich, & Yekovich, 1993).

**WHAT WOULD YOU SAY?**

As part of your interview, the department chair asks, "What are the basic skills for your students—the foundations of their more advanced learning—and how would you teach them?"

**Automated Basic Skills.** Most psychologists identify three stages in the development of an automated skill: cognitive, associative, and autonomous (Anderson, 1995b; Fitts & Posner, 1967). At the cognitive stage, when we are first learning, we rely on declarative knowledge and general problem-solving strategies to accomplish our goal. For example, to learn to assemble a bookshelf, we might try to follow steps in the instruction manual, putting a shelf beside each step as we complete it to keep track of progress. At this stage, we have to "think about" every step and perhaps refer back to the pictures of parts to see what a "4-inch metal bolt with lock nut" looks like. The load on working memory is heavy. There can be quite a bit of trial-and-error learning at this stage when, for example, the bolt we chose doesn't fit.

At the associative stage, individual steps of a procedure are combined or "chunked" into larger units. We reach for the right bolt and put it into the right hole. One step smoothly cues the next. With practice, the associative stage moves to the autonomous stage, where the whole procedure can be accomplished without much attention. So if you assemble enough bookshelves, you can have a lively conversation as you do, paying little attention to the assembly task. This movement from the cognitive to the associative to the autonomous stage holds for the development of basic cognitive skills in any area, but science, medicine, chess, and mathematics have been most heavily researched.

What can teachers do to help their students pass through these three stages and become more expert learners? In general, it appears that two factors are critical: prerequisite knowledge and practice with feedback. First, if students don't have the essential prior knowledge (schemas, skills, etc.), the load on working memory will be too great. In order to compose a poem in a foreign language, for example, you must know some of the vocabulary and grammar of that language, and you must have some understanding of poetry forms. To learn the vocabulary, grammar, and forms you also try to compose the poem would be too much.

Second, practice with feedback allows you to form associations, recognize cues automatically, and combine small steps into larger condition-action rules or productions. Even from the earliest stage, some of this practice should include a simplified version of the whole process in a real context. Practice in real contexts helps students learn not only how to do a skill but also why and when (Collins, Brown, & Newman, 1989; Gagné, Yekovich, & Yekovich, 1993). Of course, as every athletic coach knows, if a particular step, component, or process is causing trouble, that element might be practiced alone until it is more automatic, and then put back into the whole sequence, to lower the demands on working memory (Anderson, Reder, & Simon, 1996).

**Domain-Specific Strategies.** As we saw earlier, some procedural knowledge, such as monitoring the traffic while you drive, is not automatic because conditions are constantly changing. Once you decide to change lanes, the maneuver may be fairly automatic, but the decision to change lanes was conscious, based on the traffic conditions around you. Domain-specific strategies are consciously applied skills that organize thoughts and actions to reach a goal. To support this kind of learning, teachers need to provide opportunities for practice in many different situations—for example, practice reading with newspapers, package labels, magazines, books, letters, operating manuals, and so on. In the next chapter's discussion of problem-solving and study strategies, we will examine...
other ways to help students develop domain-specific strategies. For now, let's turn to a consideration of diversity and convergence in cognitive learning.

### Diversity and Convergences in Cognitive Learning

Many of the concepts and processes discussed in this chapter—the importance of knowledge in learning; the sensory, working, and long-term memory; metacognition—apply to all students. But there are developmental and individual differences in what students know and how their memory processes are used.

### Diversity: Individual Differences and Working Memory

As you might expect, there are both developmental and individual differences in working memory. Let's examine a few. First, try this:

**STOP | THINK | WRITE**  
Read the following sentences and words in caps out loud once:

- **For many years my family and friends have been working on the farm.** SPOT
- **Because the room was stuffy, Bob went outside for some fresh air.** TRAIL
- **We were fifty miles out to sea before we lost sight of the land.** BAND

Now cover the sentences and answer these questions (be honest):

- Name the words that were in all caps. Who was in the stuffy room? Who worked on the farm?

You have just taken a few items from a test of working memory span (Engle, 2001). The test required you to both process and store—process the meaning of the sentences and store the words (Ashcraft, 2006). How did you do?

**Developmental Differences.** Research indicates that young children have very limited working memories, but their memory span improves with age. Recent research shows that the three components of working memory—the central executive, phonological loop, and visuospatial sketch pad—all increase in capacity from ages 4 through adolescence (Gathercole, Pickering, Ambridge, & Wearing, 2004). It is not clear whether these differences are the result of changes in memory capacity or improvements in strategy use. Case (1998) suggests that the total amount of “space” available for processing information is the same at each age, but young children must use quite a bit of this space to remember how to execute basic operations, such as reaching for a toy, finding the right word for an object, or counting. Using a new operation takes up a large portion of the child’s working memory. Once an operation is mastered, however, there is more working memory available for short-term storage of new information. For very young children, biology may play a role, too. As the brain and neurological system of the child matures, processing may become more efficient so that more working-memory space is available (Bransford, Brown, & Cocking, 2000).

As children grow older, they develop more effective strategies for remembering information. At about age 3, children begin to understand that “remembering” means recalling something from the past. Before age 4, children think remembering means what they see or know now and forgetting means not knowing (Petren, 2000). Most children spontaneously discover rehearsal around age 5 or 6. Siegler (1998) describes a 9-year-old boy who witnessed a robbery, then mentally repeated the license number of the getaway car until he could give the number to the police. Younger children can be taught to rehearse, and will use the strategy effectively as long as they are reminded, but they will not apply the strategy spontaneously. Children are 10 to 11 years old before they have adult-like working memories.

According to Case (1998), young children often use reasonable, but incorrect strategies to solve problems because of their limited memories. They try to simplify the task by
ignoring important information or skipping steps to reach a correct solution. This puts less strain on memory. For example, when comparing quantities, young children may consider only the height of the water in a glass, not the diameter of the glass, because this approach demands less of their memory. According to Case, this explains young children's inability to solve the classic Piagetian conservation problem. (See Figure 2.2 on page 33.)

There are several developmental differences in how students use organization, elaboration, and knowledge to process information in working memory. Around age 6, most children discover the value of using organizational strategies and by 9 or 10, they use these strategies spontaneously. So, given the following words to learn:

couch, orange, rat, lamp, pear, sheep, banana, rug, pineapple, horse, table, dog

an older child or an adult might organize the words into three short lists of furniture, fruit, and animals. Younger children can be taught to use organization to improve memory, but they probably won't apply the strategy unless they are reminded. Children also become more able to use elaboration as they mature, but this strategy is developed late in childhood. Creating images or stories to remember ideas is more likely for older elementary school students and adolescents (Stegler, 1998).

**Individual Differences.** Besides developmental differences, there are other individual variations in working memory, and these differences have implications for learning. For example, the correlation between scores on a test of working memory span (like the one you just took in the Stop/Think/Write exercise) and the verbal portion of the Scholastic Assessment Test (SAT) are about .59. But there is no correlation between the SAT and simple short-term memory span (repeating digits). Working-memory span is also related to scores on intelligence tests. If a task requires controlled attention or higher-level thinking, then working-memory span probably is a factor in performing that task (Ashcraft, 2006; Hambrick, Kane, & Engle, 2005; Ackerman, Beier, & Boyle, 2005; Unsworth & Engle, 2005).
Some people seem to have more efficient working memories than others (Cariglia-Bull & Pressley, 1990; DiVesta & Di Cintio, 1997; Jarden, 1995), and differences in working memory may be associated with giftedness in math and verbal areas. For example, subjects in one research study were asked to remember lists of numbers, the locations of marks on a page, letters, and words (Dark & Benbow, 1991). Subjects who excelled in mathematics remembered numbers and locations significantly better than subjects talented in verbal areas. The verbally talented subjects, on the other hand, had better memories for words. Based on these results, Dark and Benbow believe that basic differences in information processing abilities play a role in the development of mathematical and verbal talent.

**Diversity: Individual Differences and Long-Term Memory**

The major individual difference that affects long-term memory is knowledge. When students have more domain-specific declarative and procedural knowledge, they are better at learning and remembering material in that domain (Alexander, 1997). Think about what it is like to read a very technical textbook in an area you know little about. Every line is difficult. You have to stop and look up words or turn back to read about concepts you don’t understand. It is hard to remember what you are reading because you are trying to understand and remember at the same time. But with a good basis of knowledge, learning and remembering become easier; the more you know, the easier it is to know more. This is true in part because having knowledge improves strategy use. Another factor is related to developing domain knowledge and remembering it: interest. To develop expert understanding and recall in a domain requires the “continuous interplay of skill (i.e., knowledge) and thrill (i.e., interest)” (Alexander, Kulikowich, & Schulze, 1994, p. 334).

People also differ in their abilities to use images in remembering. There are both developmental and individual differences. Children are more likely than adults to use images. As they mature cognitively, children may replace using images with using verbal propositions. As adults, some people are better than others at using imagery, but most people could improve their imagery abilities with practice (Schunk, 2004).

As we have seen throughout this book, because people grow up in different cultural contexts, they have different funds of knowledge (Moll, 1994; Nieto, 2004). Table 2.4 on page 51 lists possible knowledge areas for the Latino families in Luis Moll’s studies of cultural knowledge. Remember the baseball study earlier in this chapter—attention, learning, and memory are supported when teaching builds on the prior knowledge of students.

**Individual Differences in Metacognition**

Some differences in metacognitive abilities are the result of development. Younger children, for example, may not be aware of the purpose of a lesson—they may think the point is simply to finish. They also may not be good at gauging the difficulty of a task—they may think that reading for fun and reading a science book are the same (Gredler, 2005). As children grow older, they are more able to exercise executive control over strategies. For example, they are more able to determine if they have understood instructions (Markman, 1977, 1979) or if they have studied enough to remember a set of items (Flavell, Friedrichs, & Hoyt, 1970). Metacognitive abilities begin to develop around ages 5 to 7 and improve throughout school (Flavell, Green, & Flavell, 1995; Garner, 1990). In her work with 1st and 2nd graders, Nancy Perry found that asking students two questions helped them become more metacognitive. The questions were “What did you learn about yourself as a reader/writer today?” and “What did you learn that you can do again and again and again?” When teachers asked these questions regularly during class, even young students demonstrated fairly sophisticated levels of metacognitive understanding and action (Perry et al., 2000).

Not all differences in metacognitive abilities have to do with age or maturation. There is great variability even among students of the same developmental level, but these differences do not appear to be related to intellectual abilities. In fact, superior metacognitive skills can compensate for lower levels of ability, so these metacognitive skills can be especially important for students who often have trouble in school (Schunk, 2004; Swanson, 1990).
Some individual differences in metacognitive abilities are probably caused by biological differences or by variations in learning experiences. Students can vary greatly in their ability to attend selectively to information in their environment. In fact, many students diagnosed as having learning disabilities actually have attention disorders (Hallahan & Kauffman, 2006), particularly with long tasks (Pelham, 1981). Other attention and behavior difficulties associated with attention disorders may stem from sociocultural, emotional, developmental, cognitive, or educational sources, as indicated in Table 7.4.

### Convergences: Connecting with Families

The last several sections of this chapter have described many ideas for helping students become knowledgeable—memory strategies, mnemonics, metacognitive skills such as planning or monitoring comprehension, and cognitive skills. Some students have an advantage in school because they learn these strategies and skills at home. One way to capitalize on this diversity is to connect with the family in support of the child’s learning. The *Family and Community Partnerships Guidelines* on the next page give ideas for working with families to give all your students more support and practice developing these skills.

#### Table 7.4

<table>
<thead>
<tr>
<th>Paradigm or Perspective</th>
<th>Key Question</th>
<th>Key Experts</th>
<th>Examples of Potential Assessments</th>
<th>Examples of Potential Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sociocultural</td>
<td>How much of the child’s attention and behavior difficulties result from cultural differences?</td>
<td>Culturally sensitive social worker, psychologist, teacher</td>
<td>Home visits; classroom observations</td>
<td>Provision of culturally sensitive curriculum; celebration of cultural diversity</td>
</tr>
<tr>
<td>Psychoaffective</td>
<td>How much of the child’s attention and behavior difficulties result from emotional trauma, anxiety/depression, or temperamental differences?</td>
<td>Clinical psychologist; psychiatrist; licensed counselor</td>
<td>Assessments for depression, anxiety; temperament assessments</td>
<td>Psychotherapy; family therapy; provision of emotionally supportive classroom environment</td>
</tr>
<tr>
<td>Developmental</td>
<td>How much of the child’s attention and behavior difficulties result from a different pace of development?</td>
<td>Developmental pediatrician; child development specialist</td>
<td>Child development indices; observation in natural settings</td>
<td>Provision of developmentally appropriate curriculum; readjustment of behavioral expectations</td>
</tr>
<tr>
<td>Cognitive</td>
<td>How much of the child’s attention and behavior difficulties result from creative behavior or other positive cognitive differences?</td>
<td>Gifted and talented specialist; cognitive psychologist</td>
<td>Creativity Instruments; cognitive style assessments</td>
<td>Use of expressive arts, creative curriculum, gifted and talented curriculum, and other creative approaches</td>
</tr>
<tr>
<td>Biological</td>
<td>How much of the child’s attention and behavior difficulties result from biological problems or neurobiological differences?</td>
<td>Family physician; medical specialist (e.g., neurologist, psychiatrist)</td>
<td>Medical examination; specialized medical tests</td>
<td>Medications (e.g., Ritalin); treatment for underlying physical problems</td>
</tr>
<tr>
<td>Educational</td>
<td>How much of the child’s attention and behavior difficulties result from learning differences?</td>
<td>Learning specialist; classroom teacher</td>
<td>Learning style inventories; multiple intelligences assessments, authentic assessments, portfolio of the child’s work</td>
<td>Teaching strategies tailored to the child’s individual learning style/multiple intelligences</td>
</tr>
</tbody>
</table>

Source: Adapted from *ADD/ADHD alternatives in the classroom* (p. 54) by T. Armstrong. Copyright © 1999 by the Association for Supervision and Curriculum Development. Reprinted with permission from ASCD. All rights reserved. The Association for Supervision and Curriculum Development is a worldwide community of educators advocating sound policies and sharing best practices to achieve the success of each learner. To learn more, visit ASCD at www.ascd.org.
Family and Community Partnerships

Guidelines: Organizing Learning

Give families specific strategies to help their children practice and remember.

**EXAMPLES**

1. Develop “super learner” homework assignments that include material to be learned and a “parent coaching card” with a description of a simple memory strategy—appropriate for the material—that parents can teach their child.

2. Provide a few comprehension check questions so a family member can review reading assignments and check the child’s understanding.

3. Describe the value of distributed practice and give family members ideas for how and when to work skills practice into home conversations and projects.

Ask family members to share their strategies for organizing and remembering.

**EXAMPLES**

1. Create a family calendar.

2. Encourage planning discussions in which family members help students break large tasks into smaller jobs, identify goals, and find resources.

Discuss the importance of attention in learning.

**EXAMPLES**

1. Encourage families to create study spaces that are away from distractions.

2. Make sure parents know the purpose of homework assignments.

For a website directed to high-school study skills that might help parents, see [http://www.mtsu.edu/~studskl/hbindex.html](http://www.mtsu.edu/~studskl/hbindex.html)

For help with parent involvement, see [http://www.nnea.org/parents/schoolinvolv.html](http://www.nnea.org/parents/schoolinvolv.html)

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**SUMMARY TABLE**

Elements of the Cognitive Perspective

(pp. 248–250)

Contrast cognitive and behavioral views of learning in terms of what is learned and the role of reinforcement. In the cognitive view, knowledge is learned, and changes in knowledge make changes in behavior possible. In the behavioral view, the new behaviors themselves are learned. Both behavioral and cognitive theorists believe reinforcement is important in learning, but for different reasons. The strict behaviorist maintains that reinforcement strengthens responses; cognitive theorists see reinforcement as a source of feedback about what is likely to happen if behaviors are repeated or changed—as a source of information.

**How does knowledge affect learning?** The cognitive approach suggests that one of the most important elements in the learning process is knowledge the individual brings to the learning situation. What we already know determines to a great extent what we will pay attention to, perceive, learn, remember, and forget.

- **Cognitive view of learning** A general approach that views learning as an active mental process of acquiring, remembering, and using knowledge.

- **Domain-specific knowledge** Information that is useful in a particular situation or that applies mainly to one specific topic.

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General Knowledge: Information that is useful in many different kinds of tasks; information that applies to many situations.

The Information Processing Model of Memory (pp. 250–257)

Give two explanations for perception. The Gestalt principles are valid explanations of certain aspects of perception, but there are two other kinds of explanations in information processing theory for how we recognize patterns and give meaning to sensory events. The first is called feature analysis, or bottom-up processing, because the stimulus must be analyzed into features or components and assembled into a meaningful pattern. The second type of perception, top-down processing, is based on knowledge and expectation. To recognize patterns rapidly, in addition to noting features, we use what we already know about the situation.

**What is working memory?** Working memory is both short-term storage in the phonological loop and visuospatial sketchpad and processing guided by the central executive—it is the workbench of conscious thought. To keep information activated in working memory for longer than 20 seconds, people use maintenance rehearsal (mentally repeating) and elaborative rehearsal (making connections with knowledge from long-term memory). Elaboration rehearsal also helps move new information to long-term memory. The limited capacity
of working memory can also be somewhat circumvented by the control process of chunking.

**Information processing** The human mind’s activity of taking in, storing, and using information.

**Sensory memory** System that holds sensory information very briefly.

**Perception** Interpretation of sensory information.

**Gestalt** German for pattern or whole. Gestalt theorists hold that people organize their perceptions into coherent wholes.

**Bottom-up processing** Perceiving based on noticing separate defining features and assembling them into a recognizable pattern.

**Prototype** A best example or best representative of a category.

**Top-down processing** Perceiving based on the context and the patterns you expect to occur in that situation.

**Attention** Focus on a stimulus.

**Automaticity** The ability to perform thoroughly learned tasks without much mental effort.

**Working memory** The information that you are focusing on at a given moment.

**Short-Term memory** Component of memory system that holds information for about 20 seconds.

**Central executive** The part of working memory that is responsible for monitoring and directing attention and other mental resources.

**Phonological loop** Part of working memory. A memory rehearsal system for verbal and sound information of about 1.5 to 2 seconds.

**Visuospatial sketchpad** Part of working memory. A holding system for visual and spatial information.

**Maintenance rehearsal** Keeping information in working memory by repeating it to yourself.

**Elaborative rehearsal** Keeping information in working memory by associating it with something else you already know.

**Chunking** Grouping individual bits of data into meaningful larger units.

**Decay** The weakening and fading of memories with the passage of time.

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**Long-Term Memory:**

*The Goal of Teaching* (pp. 257–267)

Compare declarative, procedural, and conditional knowledge. Declarative knowledge is knowledge that can be declared, usually in words or other symbols. Declarative knowledge is “knowing that” something is the case. Procedural knowledge is “knowing how” to do something; it must be demonstrated. Conditional knowledge is “knowing when and why” to apply your declarative and procedural knowledge.

**How is information represented in long-term memory, and what role do schemas play?** Memories may be explicit (semantic or episodic) or implicit (procedural, classical conditioning, or priming). In long-term memory, bits of information may be stored and interrelated in terms of propositional networks or images and in schemas that are data structures that allow us to represent large amounts of complex information, make inferences, and understand new information.

**What learning processes improve long-term memory?** The way you learn information in the first place affects its recall later. One important requirement is to integrate new material with knowledge already stored in long-term memory using elaboration, organization, and context. Another view of memory is the levels of processing theory, in which recall of information is determined by how completely it is processed.

**Why do we forget?** Information lost from working memory truly disappears, but information in long-term memory may be available, given the right cues. Information appears to be lost from long-term memory through time decay (neutral connections, like muscles, grow weak without use) and interference (newer memories may obscure older memories, and older memories may interfere with memory for new material).

**Long-term memory** Permanent store of knowledge.

**Long-term working memory** Holds the strategies for pulling information from long-term memory into working memory.

**Declarative knowledge** Verbal information; facts; “knowing that” something is the case.

**Procedural knowledge** Knowledge that is demonstrated when we perform a task; “knowing how.”

**Conditional knowledge** “Knowing when and why” to use declarative and procedural knowledge.

**Explicit memory** Long-term memories that involve deliberate or conscious recall.

**Implicit memory** Knowledge that we are not conscious of recalling, but influences behavior or thought without our awareness.

**Semantic memory** Memory for meaning.

**Propositional network** Set of interconnected concepts and relationships in which long-term knowledge is held.

**Images** Representations based on the physical attributes—the appearance—of information.

**Schemas** (singular, schema) Basic structures for organizing information; concepts.

**Story grammar** Typical structure or organization for a category of stories.

**Script** Schema or expected plan for the sequence of steps in a common event such as buying groceries or ordering pizza.

**Episodic memory** Long-term memory for information tied to a particular time and place, especially memory of the events in a person’s life.

**Flashbulb memories** Clear, vivid memories of emotionally important events in your life.

**Procedural memory** Long-term memory for how to do things.

**Productions** The contents of procedural memory; rules about what actions to take, given certain conditions.

**Priming** Activating a concept in memory or the spread of activation from one concept to another.

**Elaboration** Adding and extending meaning by connecting new information to existing knowledge.
Organization Ordered and logical network of relations.
Context The physical or emotional backdrop associated with an event.
Levels of processing theory Theory that recall of information is based on how deeply it is processed.
Spreading activation Retrieval of pieces of information based on their relatedness to one another. Remembering one bit of information activates (stimulates) recall of associated information.
Retrieval Process of searching for and finding information in long-term memory.
Reconstruction Recreating information by using memories, expectations, logic, and existing knowledge.
Interference The process that occurs when remembering certain information is hampered by the presence of other information.

Metacognition (pp. 267–269)

What are the three metacognitive skills? The three metacognitive skills used to regulate thinking and learning are planning, monitoring, and evaluating. Planning involves deciding how much time to give to a task, which strategies to use, how to start, and so on. Monitoring is the awareness of “how I’m doing.” Evaluating involves making judgments about the processes and outcomes of thinking and learning and acting on those judgments.

How can using better metacognitive strategies improve children’s working and long-term memories? Younger children can be taught to use organization to improve memory, but they probably won’t apply the strategy unless they are reminded. Children also become more able to use elaboration as they mature, but this strategy is developed late in childhood. Creating images or stories to remember ideas is more likely for older elementary school students and adolescents.

Executive control processes Processes such as selective attention, rehearsal, elaboration, and organization that influence encoding, storage, and retrieval of information in memory.
Metacognition Knowledge about our own thinking processes.

Becoming Knowledgeable: Some Basic Principles (pp. 269–276)

Describe three ways to develop declarative knowledge. Declarative knowledge develops as we integrate new information with our existing understanding. The most useful and effective way to learn and remember is to understand and use new information. Making the information to be remembered meaningful is important and often is the greatest challenge for teachers. Mnemonics are memorization aids. They include peg-type approaches such as the loci method, acronyms, chain mnemonics, and the keyword method. A powerful but limiting way to accomplish this is rote memorization, which can best be supported by part learning and distributed practice.

Describe some methods for developing procedural knowledge. Automated basic skills and domain-specific strategies—two types of procedural knowledge—are learned in different ways. There are three stages in the development of an automated skill: cognitive (following steps or directions guided by declarative knowledge), associative (combining individual steps into larger units), and autonomous (where the whole procedure can be accomplished without much attention). Prerequisite knowledge and practice with feedback help students move through these stages. Domain-specific strategies are consciously applied skills of organizing thoughts and actions to reach a goal. To support this kind of learning, teachers need to provide opportunities for practice and application in many different situations.

Mnemonics Techniques for remembering: the art of memory.
Loci method Technique of associating items with specific places.
Peg-type mnemonics Systems of associating items with cue words.
Acronym Technique for remembering by using the first letter of each word to form a new, memorable word.
Chain mnemonics Memory strategies that associate one element in a series with the next element.
Keyword method System of associating new words or concepts with similar-sounding cue words and images.
Rote memorization Remembering information by repetition without necessarily understanding the meaning of the information.
Serial-position effect The tendency to remember the beginning and the end but not the middle of a list.
Part learning Breaking a list of items into shorter lists.
Distributed practice Practice in brief periods with rest intervals.
Massed practice Practice for a single extended period.
Automated basic skills Skills that are applied without conscious thought.
Domain-specific strategies Consciously applied skills to reach goals in a particular subject or problem area.

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  - Lesson Planning
What Would They Do?

Here is how some practicing teachers responded to the teaching situation presented at the beginning of this chapter about history students intent on memorizing:

**Mark Smith** Ninth-Twelfth Grade Teacher, Medford High School, Medford, Massachusetts

The students in this class have always used memorization, and although they have probably been somewhat successful in the past, there comes a point where learners must get into higher-level thinking. Because this is a senior history class and many of these students will be heading off to college, they must be taught different ways of learning and thinking.

A critical piece of learning is being able to debate a topic and do so with a convincing argument. If I were the teacher in this class and the students were so worried about tests and grades, I would add more oral presentations and writing assignments that make the students think about the facts and try to analyze the information. Knowing facts and details in history is not as important as understanding how they affect the present and why the past is important for today and tomorrow.

**Ashley Dodge** Ninth and Tenth Grade Teacher, Los Angeles Unified School District, Los Angeles, California

These students are obviously using strategies that have worked for them in the past (memorization and regurgitation of facts and dates), but they have not developed any critical thinking skills. Many students are very successful with these techniques up to a certain point. They become obsessed with learning only what is necessary to pass the class.

In order to give these students the opportunity to see history as something more than a time line, I would announce to the class that for the next unit, there would be no test. Instead, we would create projects reflective of the era. Perhaps we would produce a play, a fashion show, with period clothing, or a festival. Some students may wish to construct a city at the time being studied, focusing on the differences in the city as it was then compared to now. The students would need to use the information in the text to incorporate their ideas into their projects, but it would not need to be memorized. They would be graded on both the originality and the quality of their work, and the project grade would count as two unit grades.

**Mitchell D. Klett** Twelfth Grade Teacher, A.C. New Middle School, Spring, Texas

Students need to understand that the events of the past have a profound influence on the world today. The adage, "those who don't know history are doomed to repeat it," rings true. As their teacher, I would emphasize cause-and-effect relationships throughout history and compare them with one another. By focusing on the causes of specific events, such as revolutions caused by economic shifts, students can better understand the cyclic nature of these types of revolutions. Events such as the French Revolution and the Russian Revolution could be examined through historical learning, group discussion, role playing. Students could be given the opportunity to explore the nature of revolutions and apply what they have learned to new situations.

**Madya Ayala** High School Teacher of Preparatorio Eugenio Garza Lagüera, Campus Garza Sada, Monterrey, N.L., México

I observe that there are two existing conflicts. First, the students' available cognitive strategies (memorizing) don't fit the assigned task (higher-level thinking). Second, the students can't see connections between current situations and past events. For the first conflict I would use cognitive strategies such as mind mapping, schemas, comparative tables, and other advanced organizers that would enable students to learn the material. For the second, I'd recommend establishing a relationship between past and present realities by focusing students' attention on an important event from the past and asking them to link it to a present-day international, national, local, or even a social problem, perhaps one that is happening in their school.

**Kimberly D. Bridgers** Kindergarten Teacher, Dodson Elementary, Hamilton, Tennessee

Get out of the textbook! Make history relevant by "updating" the issues to hook students before ever talking about dates. I always lay out the situation first before going into what period we're talking about. For example, the American Revolution is essentially about some folks trying hard just to get by when the "big rich man" starts taking what little money they have so that he gets richer. Put into these terms, my inner-city students immediately understand and sympathize with the colonists. Suddenly, they want to know how the colonists stopped the king because it just might help them. Then, we'll do some role playing and reenactments, which they really get into! Once the historical situation has become personal to them, then they're ready to read the text for all of the "juicy details."