18MPS15E-EDUCATIONAL PSYCHOLOGY

UNIT-4 COMPLEX COGNITIVE PROCESSES

WHAT ARE CONCEPTS?

Concepts group: They objects, events, and characteristics on the basis of common properties. Concepts help us to simplify, summarize, and organize information (Quinn, 2009, 2011).

Concepts also aid the process of remembering, making it more effi cient (Racine, 2011). When students group objects to form a concept, they can remember the concept, then retrieve the concept's characteristics. Th us, when you assign math homework, you probably won't have to go through the details of what math is or what homework is. Students will have embedded in their memory a number of appropriate associations. In ways such as this, concepts not only help to jog memory but also make communication more efficient. If you say, "It's time for art," students know what you mean. You don't have to go into a lengthy explanation of what art is. Th us, concepts help students to simplify and summarize information, as well as improve the efficiency of their memory, communication, and use of time. Students form concepts through direct experiences with objects and events in their world. For example, in constructing a sophisticated concept of "cartoons," children might initially experience TV cartoon shows, then read comic strips, and eventually look at some political caricatures. Students also form concepts through experience with symbols (things that stand for, or represent, something else). For example, words are symbols. So are math formulas, graphs, and pictures. Some concepts are relatively simple, clear, and concrete, whereas others are more complex, fuzzy, and abstract. Th e former are easier to agree on. For example, most people can agree on the meaning of "baby." But we have a harder time agreeing on what is meant by "young" or "old." We agree on whether something is an apple more readily than on whether something is a fruit. Some concepts are especially complex, fuzzy, and abstract, like the concepts involved in theories of economic collapse or string theory in physics.

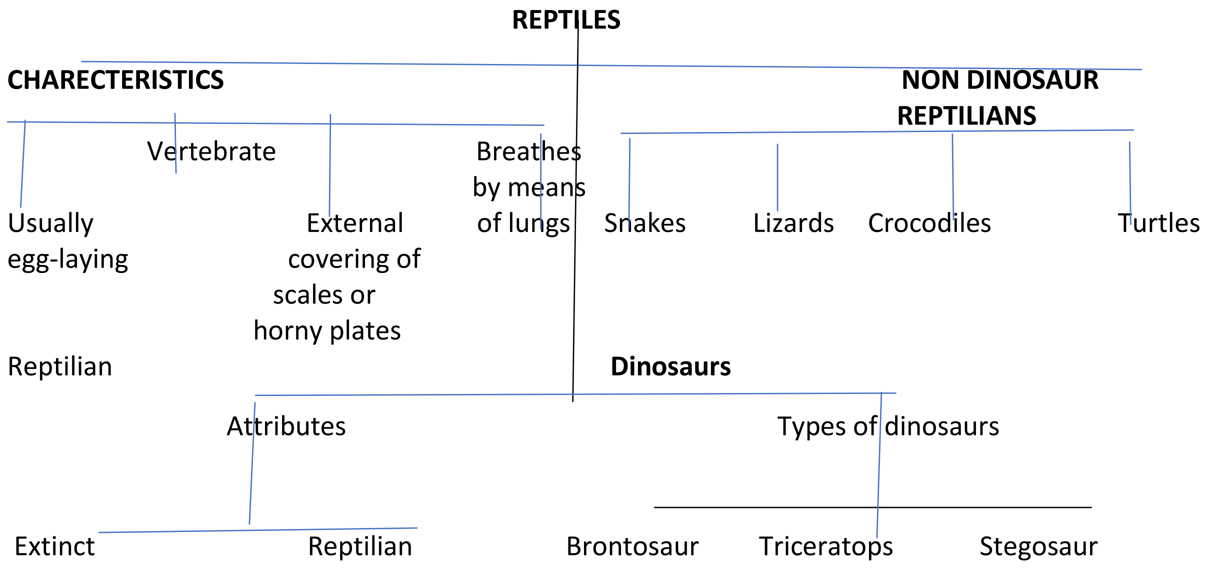
PROMOTING CONCEPT FORMATION

Teachers can guide students to recognize and form eff ective concepts in a number of ways. Th e process begins with becoming aware of the features of a given concept. Learning About the Features of Concepts An important aspect of concept formation is learning the key features, attributes, or characteristics of the concept (Madole, Oakes, & Rakison, 2010; Racine, 2011). Th ese are the defi ning elements of a concept, the dimensions that make it diff erent from another concept. For example, in our earlier example of the concept of "book," the key features include sheets of paper, being bound together along one edge, and being full of printed words and pictures in some meaningful order. Other characteristics such as size, color, and length are not key features that defi ne the concept of "book." Consider also these critical features of the concept of "dinosaur": extinct and reptilian. In the case of the concept of "dinosaur," the feature "extinct" is important.

Defining Concepts and Providing Examples An important aspect of teaching concepts is to clearly defi ne them and give carefully chosen examples. Th e rule-example strategy is an eff ective way to do this (Tennyson & Cocchiarella, 1986). Th e strategy consists of four steps: 1. Defi ne the concept. In addition to identifying the concept's key features or characteristics, link it to a superordinate concept, which is a larger class into which it fits. Th us, in specifying the key features of the concept of " dinosaur, " you might want to mention the larger class into which it fi ts: "reptiles." 2. Clarify terms in the definition. Make sure that the key features or characteristics are well understood. Th us, in describing the key features of the concept of " dinosaur, " it is important for students to know what a reptile is—usually an egg-laying vertebrate with an external covering of scales or horny plates that breathes by means of lungs. 3. Give examples to illustrate the key features or characteristics. With regard to dinosaurs, one might give examples and descriptions of different types of dinosaurs, such as a triceratops, an apatosaur, and a stegosaur. Th e concept can be further clarified by giving examples of other reptiles that are not dinosaurs, such as snakes, lizards, crocodiles, and turtles. Indeed, giving nonexamples of a concept as well as examples is oft en a good strategy for teaching concept formation. More examples are required when you teach complex concepts and when you work with less sophisticated learners. 4. Provide additional examples. Ask students to categorize concepts, explain their categorization, or have them generate their own examples of the concept. Give examples of other dinosaurs, such as Tyrannosaurus, Ornitholestes, and Dimetrodon, or ask students to fi nd more examples themselves. Also ask them to think up other nonexamples of dinosaurs, such as dogs, cats, and whales. Do some children develop an intense, passionate interest in a particular category of objects or activities? A recent study of 11-month-old to 6-year-old children confi rmed that they do (DeLoache, Simcock, & Macari, 2007). A striking fi nding was the large gender diff erence in categories, with an extremely intense interest in particular categories for boys as compared with girls. Categorization of boys' intense interests focused on vehicles, trains, machines, dinosaurs, and balls; girls' intense interests were more likely to involve dress-ups and books/reading but were not as extreme as boys' most intense interests were.

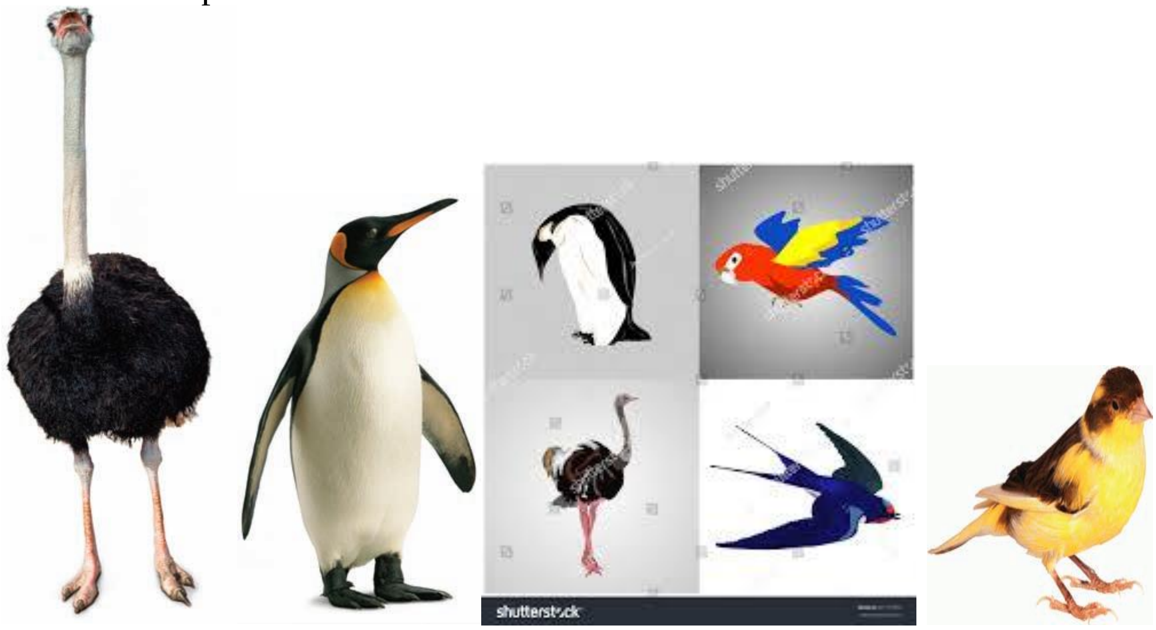
Hierarchical Categorization and Concept Maps Categorization is important because once a concept is categorized it can take on characteristics and features from being a member of a category (Chi & Brem, 2009). For example, students can infer that a triceratops is a reptile even if they have never been told that fact as long as they know that dinosaurs are reptiles and a triceratops is a dinosaur. Knowing that a triceratops is a type of dinosaur lets students infer that a triceratops assumes the characteristics of dinosaurs (that they are reptiles). A concept map is a visual presentation of a concept's connections and hierarchical organization. Getting students to create a map of a concept's features or characteristics can help them to learn the concept (Amadieu & others, 2009). Th e concept map also might embed the concept in a superordinate category and include examples and nonexamples of the concept (Ritchart, Turner, and Hadar, 2009). Th e visual aspects of the concept map relate to our Chapter 8 discussion of the use of imagery in memory. You might create a concept map with students' help, or let them try to develop it individually or in small groups. Teachers can access a number of concept mapping software programs to use in the classroom. Inspiration and Kidinspiration are good ones.

Figure shows an example of a concept map for the concept of "reptile."



EXAMPLE OF A CONCEPT MAP FOR THE CONCEPT OF "REPTILE"

Hypothesis Testing: Students benefit from the practice of hypothesis testing in order to determine what a concept is and is not. Hypotheses are specific assumptions and predictions that can be tested to determine their accuracy. One way to develop a hypothesis is to come up with a rule about why some objects fall within a concept and others do not. Here is an example of how you can give your students practice in developing such hypotheses:. Th insolently select the concept of one of those geometric forms (such as "circle" or "green circle") and ask your students to develop hypotheses about the concept you have selected. They can zero in on your concept by asking you questions related to the geometric forms and eliminating nonexamples. You might also let the students take turns selecting a concept and answering questions from the other students. Work with your students on developing the most efficient strategies for identifying the correct concept.



The concept of birds includes many different types of birds. *Which of these birds is likely to be viewed as the most typical bird?*

Problem solving involves finding an appropriate way to attain a goal. Consider these tasks that require students to engage in problem solving: creating a project for a science fair, writing a paper for an English class, getting a community to be more environmentally responsive, and giving a talk on the factors that cause people to be prejudiced. Although they seem quite different, each involves a similar series of steps.

STEPS IN PROBLEM SOLVING

Efforts have been made to specify the steps that individuals go through in effectively solving problems. Following are four such steps (Bransford & Stein, 1993):

Step 1. Find and Frame Problems

Before you can solve a problem, you must recognize that it exists (Mayer, 2008). In the past, most problem-solving exercises in school involved well-defi ned problems that lent themselves to specifi c, systematic operations that produced a well-defi ned solution. Today educators increasingly recognize the need to teach students the real-world skill of identifying problems instead of just off ering clear-cut problems to be solved (Chen, 2010; Laxman, 2010).

Consider a student whose broad goal is to create a science-fair project. What branch of science would it be best for her to present— biology, physics, computer science, psychology? Aft er making this decision, she'll have to narrow the problem further: which domain within psychology should she choose—perception, memory, thinking, personality? Within the domain of memory, she might pose this question: How reliable are people's memories of traumatic events they have experienced? Th us, it may take considerable exploration and refinement for the student to narrow the problem down to a point of generating specific solutions. Exploring such alternatives is an important part of problem solving.

Step 2. Develop Good Problem-Solving Strategies

Once students fi nd a problem and clearly defi ne it, they need to develop strategies for solving it (Quiamzade, Mugny, & Darnon, 2009; Yu, She, & Lee, 2010). Among the eff ective strategies are setting subgoals and using algorithms, heuristics, and means-end analysis.

Sub-goaling involves setting intermediate goals that put students in a better position to reach the fi nal goal or solution. Students might do poorly in solving problems because they don't generate subproblems or subgoals. Let's return to the science-fair project on the reliability of people's memory for traumatic events they have experienced. What might be some sub goaling strategies? One might be locating the right books and research journals on memory; another might be interviewing people who have experienced traumas in which basic facts have been recorded. At the same time as the student is working on this sub goaling strategy, she likely will benefit from establishing further subgoals in terms of what she needs to accomplish along the way to her final goal of a finished science project. If the science project is due in three months, she might set the following subgoals: finishing the fi rst draft of the project two weeks before the project is due; having the research completed a month before the project is due; being halfway through the research two months before the project is due; having three trauma interviews completed two weeks from today; and starting library research tomorrow. Notice that in establishing the subgoals, we worked backward in time. Th is is often a good strategy. Students first create a subgoal closest to the final goal and then work backward to the subgoal closest to the beginning of the problem-solving effort.

Fixation It is easy to fall into the trap of becoming fixated on a particular strategy for solving a problem. **Fixation** involves using a prior strategy and failing to look at a problem from a fresh, new perspective. *Functional fixedness* is a type of fixation in which an individual fails to solve a problem because he views the elements involved solely in terms of their usual functions. A student who uses a shoe to hammer a nail has overcome functional fixedness to solve a problem.

A **mental set** is a type of fi xation in which an individual tries to solve a problem in a particular way that has worked in the past. I (your author) had a mental set about using a typewriter rather than a computer to write my books. I felt comfortable with a typewriter and had never lost any sections I had written. It took a long time for me to break out of this mental set. Once I did, I found that books are much easier to write using a computer. You might have a similar mental set against using the new computer and video technology available for classroom use. A good strategy is to keep an open mind about such changes and monitor whether your mental set is keeping you from trying out new technologies that can make the classroom more exciting and more productive.

An important complex cognitive goal is for students to be able to apply what they learn in one situation to new situations (Banich & Caccamise, 2010; Stahl, 2010). An important goal of schooling is that students learn things that they can apply outside the classroom. Schools are not functioning eff ectively if students do well on tests in language arts but can't write a competent letter as part of a job application. Schools also are not effectively educating students if the students do well on math tests in the classroom but can't solve arithmetic problems on a job.

METACOGNITION

In Chapter 8 we discussed a number of executive control processes, including attention, rehearsal, organization, imagery, and elaboration. These executive control processes are sometimes called *metacognitive* skills, because they can be intentionally used to regulate cognition.

Metacognitive Knowledge and Regulation

Emily Fox and Michelle Riconscente define metacognition simply as "knowledge or awareness of self as knower" (2008, p. 373). Metacognition literally means cognition about cognition—or thinking about thinking—something William James wrote about over 100 years ago (although he did not give it that name). In the Bruner quote earlier, metacognition is involved in the "reflection, brooding about what it is that you know"—thinking about your own thinking. Metacognition is higher-order knowledge about your own thinking as well as your ability to use this knowledge to manage your own cognitive processes such as comprehension and problem solving (Bruning et al., 2011).

There are many metacognitive processes and skills, including judging if you have the right knowledge to solve a problem, deciding where to focus attention, determining if you understood what you just read, devising a plan, using strategies such as mnemonics, revising the plan as you proceed, determining if you have studied enough to pass a test, evaluating a problem solution, deciding to get help, and generally orchestrating your cognitive powers to reach a goal (Castel et al., 2011; Meadows, 2006; Schneider, 2004). In second-language learning, you have to focus on the important elements of the new language, ignore distracting information,and suppress what you know in the first language that interferes or confuses learning the second language (Engel de Abreu & Gathercole, 2012).

Metacognition involves all 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) *self-regulatory knowledge* to ensure the completion of the task—*knowing the conditions,* when and why, to apply the procedures and strategies (Bruning et al., 2011). Metacognition is the strategic application of this declarative, procedural, and self-regulatory knowledge to accomplish goals and solve problems (Schunk, 2012). Metacognition also includes knowledge about the value of applying cognitive strategies in learning (Pressley & Harris, 2006).

Metacognition regulates thinking and learning (A. Brown, 1987; T. O. Nelson, 1996). There are three essential skills: *planning, monitoring,* and *evaluating. Planning* involves deciding how much time to give to a task, which strategies to use, how to start, which 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 is asking, "Is this making sense? Am I trying to 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?" The notion of *reflection* in teaching— thinking back on what happened in class and why, and thinking forward to what you might do next time—is really about metacognition in teaching (Sawyer, 2006). Of course, we don't have to be metacognitive all the time. Some actions become routine or habits. Metacognition is most useful when tasks are challenging, but not too difficult. 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 (Perner, 2000). Experts in a particular field plan, monitor, and evaluate as second nature; they have difficulty describing their metacognitive knowledge and skills (Pressley & Harris, 2006; Reder, 1996).

Individual Differences in Metacognition

People differ in how well and how easily they use metacognitive strategies. Some differences in meta cognitive 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, 2009b). 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 or if they have studied enough to remember a set of items. Metacognitive abilities begin to develop around ages 5 to 7 and improve throughout school (Flavell, Green, & Flavell, 1995; Woolfolk & Perry, 2015). But as we will see many times in this book, knowing and doing are not the same. Students may know that it is better to study on a regular basis but still cram in the hopes of defying "just once" that long-established principle. Not all differences in metacognitive abilities have to do with age or maturation (Lockl & Schneider, 2007; Vidal-Abarca, Mañá, & Gil, 2010). Some individual differences in metacognitive abilities are probably caused by differences in biology or learning experiences. Many students diagnosed as having learning disabilities have problems monitoring their attention (Hallahan, Kauffman, & Pullen, 2012), particularly with long tasks. Working to improve metacognitive skills can be especially important for students who often have trouble in school (Schunk, 2012; H. L. Swanson, 1990).

Lessons for Teachers: Developing Metacognition

Like any knowledge or skill, metacognitive knowledge and skills can be learned and improved.
METACOGNITIVE DEVELOPMENT FOR YOUNGER STUDENTS. In his second-grade classroom in Queens, New York, Daric Desautel (2009) worked with mostly Latino/a and Asian students. As part of teaching literacy, Desautel decided to focus on student metacognitive knowledge and skills such as setting goals, planning, evaluating achievements, and self-reflection to help students develop the habit of "looking in" at their own thinking. He also included self reflections to help students evaluate their writing and gain insight into themselves as readers and writers. For example, one self-reflection included a checklist asking:

- Did you pick a topic that you know all about?
- Did you write a special beginning that makes the reader want more?
- Did you organize your thoughts and make a Table of Contents?
- Did you pick the right kind of paper and illustrate your book clearly?
- Did you re-read your work to check for SOUND, SENSE, ORDER, and GOOFS?

Desautel was successful in helping all his students, not just the most verbal and advanced, develop metacognitive knowledge. One student noted in his reflection, "I worked hard and did my best to make this book. I like nonfiction books better than stories. Next time, I would write about a different sport" (p. 2011).

In her work with first- and second-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).

Many of the cooperating teachers I work with use a strategy called KWL to guide reading and inquiry in general. This general frame can be used with most grade levels. The steps are:

K What do I already know about this subject?

W What do I want to know?
L At the end of the reading or inquiry, what have I learned?
The KWL frame encourages students to "look within" and identify what they bring to each learning situation, where they want to go, and what they actually achieved—a very metacognitive approach to learning. Marilyn Friend and William Bursuck (2002, pp. 362–363) describe how one teacher used modeling and discussion to teach the KWL strategy. After reviewing the steps, the teacher models an example and a nonexample of using KWL to learn about "crayons."
Teacher: What do we do now that we have a passage assigned to read? First, I brainstorm, which means I try to think of anything I already know about the topic and write it down.
The teacher writes on the board or overhead known qualities of crayons, such as "made of wax," "come in many colors," "can be sharpened," and "several different brands."
Teacher: I then take this information I already know and put it into categories, like "what crayons are made of" and "crayon colors." Next, I write down any questions I would like to have answered during my reading, such as "Who invented crayons? When were they invented? How are crayons made? Where are they made?" At this point, I'm ready to read, so I read the passage on crayons. Now I must write down what I learned from this passage. I must include any information that answers the questions I wrote down before I read and any additional information. For example, I learned that colored crayons were first made in the United States in 1903 by Edwin Binney and E. Harold Smith. I also learned that the Crayola Company owns the company that made the original magic markers. Last, I must organize this information into a map so I can see the different main points and any supporting points.
At this point, the teacher draws a map on the chalkboard or overhead.
Teacher: Let's talk about the steps I used and what I did before and after I read the passage.
A class discussion follows.
Teacher: Now I'm going to read the passage again, and I want you to evaluate my textbook reading skills based on the KWL Plus strategy we've learned The teacher then proceeds to demonstrate the strategy *incorrectly.*

Teacher: The passage is about crayons. Well, how much can there really be to know about crayons besides there are hundreds of colors and they always seem to break in the middle? Crayons are for little kids, and I'm in junior high so I don't need to know that much about them. I'll just skim the passage and go ahead and answer the question. Okay, how well did I use the strategy steps?
The class discusses the teacher's inappropriate use of the strategy. Notice how the teacher provides both an *example* and a *nonexample*—good teaching.
METACOGNITIVE DEVELOPMENT FOR SECONDARY AND COLLEGE STUDENTS (LIKE YOU). For older students, teachers can incorporate metacognitive questions into their lessons, lectures, and assignments. For example, David Jonassen (2011, p. 165) suggests that instructional designers incorporate these questions into hypermedia learning environments to help students be more self-reflective:
What are my intellectual strengths and weaknesses?
How can I motivate myself to learn when I need to?
How good am I at judging how well I understand something?
How can I focus on the meaning and significance of new information?
How can I set specific goals before I begin a task?
What questions should I ask about the material before I begin?
How well have I accomplished my goals once I'm finished?
Have I learned as much as I could have once I finish a task?
Have I considered all options after I solve a problem?
Metacognition includes knowledge about using many strategies in learning—our next topic.

LEARNING STRATEGIES

Most teachers will tell you that they want their students to "learn how to learn." Years of research indicate that using good learning strategies helps students learn and that these strategies can be taught (Hamman, Berthelot, Saia, & Crowley, 2000; Pressley & Harris, 2006). But were you taught "how to learn"? Powerful and sophisticated learning strategies and study skills are seldom taught directly until high school or even college, so most students have little practice with them. In contrast, early on, students usually discover repetition and rote learning on their own, so they have extensive practice with these strategies. And, unfortunately, some teachers think that memorizing is learning

(Beghetto, 2008; Woolfolk Hoy & Murphy, 2001). This may explain why many students cling to flash cards and memorizing—they don't know what else to do (Willoughby, Porter, Belsito, & Yearsley, 1999).

As you saw in Chapter 8, the way something is learned in the first place greatly influences how readily we remember the information and how appropriately we can apply the knowledge later. First, students must be *cognitively engaged* in order to learn; they have to *focus attention* on the relevant or important aspects of the material. Second, they have to *invest effort,* make connections, elabo rate, translate, invent, organize, and reorganize to think and *process deeply*—the greater the practice and processing, the stronger the learning. Finally, students must *regulate and monitor* their own learning—keep track of what is making sense and notice when a new approach is needed; they must be *metacognitive.* The emphasis today is on helping students develop effective learning strategies that focus attention and effort, process information deeply, and monitor understanding.

Being Strategic About Learning

Learning strategies are a special kind of procedural knowledge—*knowing how* to do something. There are thousands of strategies. Some are general and taught in school, such as summarizing or outlining. Others are specific to a subject, such as using a mnemonic to remember the order of the planets: "My Very Educated Mother Just Served Us Nachos" for Mercury, Venus, Earth, Mars,

Jupiter, Saturn, Uranus, and Neptune. Other strategies may be unique, invented by an individual to learn Chinese characters, for example. Learning strategies can be cognitive (summarizing, identify ing the main idea), metacognitive (monitoring comprehension—do I understand?), or behavioral (using an Internet dictionary, setting a timer to work until time's up) (Cantrell, Almasi, Carter, Rintamaa, & Madden, 2010). All are ways of accomplishing a learning task that are intention ally applied when usual methods have not worked and strategic effort is needed (K. R. Harris, Alexander, & Graham, 2008). Over time, as you become more expert at using the strategies, you need less intentional effort. Ultimately you may become more automatic in applying the strategies; in other words, the strategies will become your usual way of accomplishing that kind of task, until they don't work and you need new strategies.

Skilled learners have a wide range of learning strategies that they can apply fairly automati cally. Using learning strategies and study skills is related to higher grade-point averages (GPAs) in high school and persistence in college (Robbins et al., 2004). Researchers have identified several important principles:

1. Students must be exposed to a number of different strategies, not only general learning strat egies but also very specific strategies for particular subjects, such as the graphic strategies described later in this section.
2. Students should be taught self-regulatory (conditional) knowledge about when, where, and why to use various strategies. Although this may seem obvious, teachers often neglect this step. A strategy is more likely to be maintained and employed if students know when, where, and why to use it.
3. Students may know when and how to use a strategy, but unless they also develop the desire to employ these skills, general learning ability will not improve. Remember, left to their own, many students, adult students included, do not choose the most effective strategies, even if they know how to do the strategy (Son & Simon, 2012). Several learning strategy programs include a motivational training component.
4. Students need to believe that they can learn new strategies, that the effort will pay off, and that they can "get smarter" by applying these strategies.
5. Students need some background knowledge and useful schemas in the area being studied to make sense of learning materials. It will be difficult to find the main idea in a paragraph about *ichthyology,* for example, if you don't know much about fish. So students may need direct instruction in schematic (content) knowledge along with strategy training. Table 9.1 on the next page summarizes several learning strategies.

DECIDING WHAT IS IMPORTANT. You can see from the first entry in Table 9.1 that learning begins with focusing attention—deciding what is important. But distinguishing the main idea from less important information is not always easy. Often students focus on the "seductive details" or the concrete examples, perhaps because these are more interesting (Gardner, Brown, Sanders, & Menke, 1992). You may have had the experience of remembering a joke or an intriguing example from a lecture, but not being clear about the larger point the professor was trying to make. Finding the central idea is especially difficult if you lack prior knowledge in an area and if the amount of new information provided is extensive. Teachers can give students practice using signals in texts such as headings, bold words, outlines, or other indicators to identify key concepts and main ideas

(Lorch, Lorch, Ritchey, McGovern, & Coleman, 2001).
SUMMARIES. Creating summaries can help students learn, but students have to be taught how to summarize (Byrnes, 1996; Palincsar & Brown, 1984). Jeanne Ormrod (2012) summarizes these suggestions for helping students create summaries. Ask students to:

- Find or create a topic sentence for each paragraph or section.
- Identify big ideas that cover several specific points.
- Find some supporting information for each big idea.
- Delete any redundant information or unnecessary details.

Reading Strategies

As we saw earlier, effective learning strategies should help students *focus attention, invest effort* (connect, elaborate, translate, organize, summarize) so they *process information deeply,* and *monitor* their under standing. A number of strategies support these processes in reading. Many strategies use mnemonics to help students remember the steps involved. For example, one strategy that can be used for any grade above later elementary is READS:

R Review headings and subheadings.
E Examine boldface words.
A Ask, "What do I expect to learn?"
D Do it—Read!
S Summarize in your own words. (Friend & Bursuck, 2012)

A strategy that can be used in reading literature is CAPS:

C Who are the characters?
A What is the aim of the story?
P What problem happens?
S How is the problem solved?

These strategies are effective for several reasons. First, following the steps makes students more aware of the organization of a given chapter. How often have you skipped reading headings entirely and thus missed major clues about the way the information was organized? Next, these steps require students to study the chapter in sections instead of trying to learn all the information at once. This makes use of *distributed practice.* Answering questions about the material forces students to process the information more deeply and with greater elaboration.

No matter what strategies you use, students have to be taught how to use them. *Direct teaching, explanation, modeling,* and *practice with feedback* are necessary and are especially important for students with learning challenges and students whose first language is not English. For an example of direct teaching of strategies with explanations, modeling, and practice with feedback, see the KWL discus sion on pages 330–331 of this chapter.

Applying Learning Strategies

One of the most common findings in research on learning strategies is what are known as production deficiencies. Students learn strategies, but do not apply them when they could or should (Pressley & Harris, 2006; Son & Simon, 2012). This is especially a problem for students with learning disabilities. For these students, executive control processes (metacognitive strategies) such as planning, organizing, monitoring progress, and making adaptations often are underdeveloped (Kirk, Gallagher, Anastasiow, & Coleman, 2006). It makes sense to teach these strategies directly. To ensure that students actually use the strategies they learn, several conditions must be met.

APPROPRIATE TASKS. First, of course, the learning task must be *appropriate.* Why would students use more complex learning strategies when the task set by the teacher is to "learn and return" the exact words of the text or lecture? With these tasks, teachers reward memorizing, and the best strategies involve distributed practice and perhaps mnemonics (described in Chapter 8). But hopefully, contemporary teachers use few of these kinds of tasks, so if the task is *understanding,* not memorizing, what else is necessary?

VALUING LEARNING. The second condition for using sophisticated strategies is that students must *care* about learning and understanding. They must have goals that can be reached using effective strategies (Zimmerman & Schunk, 2001). I was reminded of this in my educational psychology class one semester when I enthusiastically shared an article about study skills from the newspaper *USA Today.* The gist of the article was that students should continually revise and rewrite their notes from a course, so that by the end, all their understanding could be captured in one or two pages. Of course, the majority of the knowledge at that point would be reorganized and connected well with other knowledge. "See," I told the class, "these ideas are real—not just trapped in texts. They can help you study smarter in college." After a heated discussion, one of the best students said in exasperation, "I'm carrying 18 hours—I don't have time to *learn* this stuff!" She did not believe that her goal—to survive the

18 hours—could be reached by using time-consuming study strategies, and she might have been right.
EFFORT AND EFFICACY. My student also was concerned about effort. The third condition for applying learning strategies is that students must believe the effort and investment required to apply the strategies are reasonable, given the likely return (Winne, 2001). And of course, students must believe they are capable of using the strategies; they must have self-efficacy for using the strategies to learn the material in question (Schunk, 2012). This is related to another condition: Students must have a base of knowledge and/or experience in the area. No learning strategies will help students accomplish tasks that are completely beyond their current understandings.

The *Guidelines: Becoming an Expert Student* on the next page provides a summary of ideas for you and your students.

Reaching Every Student: Learning Strategies for Struggling Students

Reading is key in all learning. Strategy instruction can help many struggling readers. As you have seen, some approaches make use of mnemonics to help students remember the steps. For example, Susan Cantrell and her colleagues identified 862 students in sixth and ninth grade who were at least 2 years behind in reading (Cantrell, Almasi, Carter, Rintamaa, & Madden, 2010). The students were from 23 different schools. Students were randomly assigned to either a Learning Strategies Curriculum (Deshler & Schumaker, 2005) or the traditional curriculum. The Learning Strategies

WHAT IS TRANSFER?

Transfer

occurs when a person applies previous experiences and knowledge to learning or problem solving in a new situation (Mayer, 2008). Th us, if a student learns a concept in math and then uses this concept to solve a problem in science, transfer has occurred. It also has occurred if a student reads and studies about the concept of fairness in school and subsequently treats others more fairly outside the classroom. Some experts argue that the best way to ensure transfer is to "teach for it" (Schwartz, Bransford, & Sears, 2005). Th ey stress that transfer problems virtually are eliminated when teaching occurs in contexts where individuals need to perform. By preparing students so that the problems they are likely to encounter in real life are at worst near transfer problems, the gap between students' present learning level and learning goals is significantly reduced (Bransford & others, 2005). Some other strategies that can improve transfer include giving two or more examples of a concept because one often is not enough; giving students representations or models, such as matrices, that help them structure a problem-solving activity; and encouraging students to generate more information themselves, which increases the likelihood they will remember what needs to be transferred (Sears, 2008). Yet another strategy to increase transfer is to give students well-structured contrasting cases and have them try to invent solutions for them before being given a lecture on the expert solution. Th e idea is that by first inventing a solution, students bring their prior knowledge to bear on the problem and make connections to the features of the problem. When they see the expert solution and how it relates the key features to each other, the students should be able to better understand how it works and thus transfer it better in the future.

TYPES OF TRANSFER

What are some diff erent types of transfer? Transfer can be characterized as (1) near or far and, (2) low-road or high-road (Schunk, 2011).

Near or Far Transfer

In **near transfer** the classroom learning situation is similar to the one in which the initial learning took place. For example, if a geometry teacher instructs students in how to logically prove a concept, and then tests the students on this logic in the same setting in which they learned the concept, near transfer is involved.

Far transfer

means the transfer of learning to a situation very diff erent from the one in which the initial learning took place. For instance, if a student gets a part-time job in an architect's offi ce and applies what he learned in geometry class to helping the architect analyze a spatial problem diff erent from any problem he encountered in geometry class, far transfer has occurred.

Low-Road or High-Road Transfer

Gabriel Salomon and David Perkins (1989) distinguished between low-road and high-road transfer. **Low-road transfer** occurs when previous learning automatically, oft en unconsciously, transfers to another situation. Th is occurs typically with highly practiced skills in which there is little need for reflective thinking. For example, when competent readers encounter new sentences in their native language, they read them automatically. By contrast, **high-road transfer** is conscious and effortful. Students consciously establish connections between what they learned in a previous situation and the new situation they now face. High-road transfer is mindful—that is, students have to be aware of what they are doing and think about the connection between contexts. Highroad transfer implies abstracting a general rule or principle from previous experience and then applying it to the new problem in the new context. For example, students might learn about the concept of sub-goaling (setting intermediate goals) in math class.

Several months later, one of the students thinks about how subgoaling might help him complete a lengthy homework assignment in history. Th is is high-road transfer. Salomon and Perkins (1989) subdivide high-road transfer into forward-reaching and backward-reaching transfer. **Forward-reaching transfer** occurs when students think about how they can apply what they have learned to new situations (from their current situation, they look "forward" to apply information to a new situation ahead). For forward-reaching transfer to take place, students have to know something about the situations to which they will transfer learning.

Backward-reaching transfer

occurs when students look back to a previous ("old") situation for information that will help them solve a problem in a new context. To better understand these two types of high-road transfer, imagine a student sitting in English class who has just learned some writing strategies for making sentences and paragraphs come alive and "sing." Th e student begins to reflect on how she could use those strategies to engage readers next year, when she plans to become a writer for the school newspaper. Th at is forward-reaching transfer. Now consider a student who is at his first day on the job as editor of the school newspaper. He is trying to figure out how to construct the layout of the pages. He reflects for a few moments and thinks about some geography and geometry classes he has previously taken. He draws on those past experiences for insights into constructing the layout of the student newspaper. Th at is backward-reaching transfer.

Teaching for Positive Transfer

Here is a great perspective on transfer from David Perkins and Gavriel Salomon (2012): Schools are supposed to be stopovers in life, not ends in themselves. The information, skills, and understandings they offer are knowledge-to-go, not just to use on site. To be sure, often Monday's topics most conspicuously serve the Tuesday problem set, the Friday quiz, or the exam at the end of the year. However, in principle those topics are an investment toward thriving in family, civic, cultural, and professional lives. (p. 248) Years of research and experience show that students will not always take advantage of knowledge-to-go. They may (seem to) learn new concepts, problem-solving procedures, and learning strategies Monday, but they may not use them for the year-end exam or even Friday unless prompted or guided. For example, studies of real-world mathematics show that people do not always apply math procedures learned in school to solve practical problems in their homes or at grocery stores (Lave, 1988; Lave & Wenger, 1991).

This happens because learning is *situated*—tied to specific situations. Because knowledge is learned as a tool to solve particular problems, we may not realize that the knowledge is relevant when we encounter a problem that seems different, at least on the surface (Driscoll, 2005; Singley & Anderson, 1989). How can you make sure your students will use what they learn, even when situations change? First, you must answer the question "What is worth learning?"

The learning of basic skills such as reading, writing, computing, cooperating, and speaking will definitely transfer to other situations, because these skills are necessary for later work both in and out of school—writing job applications, reading novels, paying bills, working on a team, locating and evaluating health care services, among others. All later learning depends on positive transfer of these basic skills to new situations.

Teachers must also be aware of what the future is likely to hold for their students, both as a group and as individuals. What will society require of them as adults? As a child growing up in Texas in the 1950s and 1960s, I studied nothing about computers, even though my father was a computer systems analyst; yet now I spend hours at my Mac each day. Back then I learned to use a slide rule. Now, calculators and computers have made this skill obsolete. My mom encouraged me to take advanced math and physics instead of typing in high school. Those were great classes, but I struggle with typing every day at my computer—who knew? Undoubtedly, changes as extreme and unpredictable as these await the students you will teach. For this reason, the general transfer of principles, attitudes, learning strategies, self-motivation, time management skills, and problem solving will be just as important for your students as the specific transfer of basic skills.

HOW CAN TEACHERS HELP? For basic skills, greater transfer can also be ensured by overlearning, practicing a skill past the point of mastery. Many of the basic facts students learn in elementary school, such as the multiplication tables, are traditionally overlearned. For higher-level transfer, students must first learn and understand. Students will be more likely to transfer knowledge to new situations if they have been actively involved in the learning process. Strategies include having students compare and contrast two examples, then identify the underlying principles; asking student to explain to themselves or each other the worked-out examples provided by the teacher; or identify for each step in a problem solution the underlying principle at work (Chi & VanLehn, 2012). Students should be encouraged to form abstractions that they will apply later, so they know transfer is an important goal. It also helps if students form deep connections between the new knowledge and their existing structures of knowledge as well as connections to their everyday experiences (Perkins & Salomon, 2012; Pugh & Phillips,, 2011). Erik De Corte (2003) believes that teachers support transfer, the productive use of cognitive tools and motivations, when they create powerful teaching–learning environments using these design principles:

- The environments should support constructive learning processes in all students.
- The environments should encourage the development of student self-regulation,so that teachers gradually give over more and more responsibilities to the students.
- Learning should involve interaction and collaboration.
- Learners should deal with problems that have personal meaning for them, that are similar to those they will face in the future.
- The classroom culture should encourage students to become aware of and develop their cognitive and motivational processes. To be productive users of these tools, students must know about and value them.

One last kind of transfer is especially important for students—the transfer of the *learning strategies* we encountered earlier. Learning strategies are meant to be applied across a wide range of situations.

STAGES OF TRANSFER FOR STRATEGIES. Gary Phye (1992, 2001; Phye & Sanders, 1994) describes three stages in developing strategic transfer. In the *acquisition phase,* students should not only receive instruction about a strategy and how to use it, but also rehearse the strategy and practice being aware of when and how they are using it. In the *retention phase*, more practice with feedback helps students hone their strategy use. In the *transfer phase,* students should be given new problems that they can solve with the same strategy, even though the problems appear different on the surface. To enhance motivation, teachers should point out to students how using the strategy will help them solve many problems and accomplish different tasks. These steps help build both procedural and self-regulatory knowledge—*how* to use the strategy as well as *when and why.* For all students, there is a positive relationship between using learning strategies and academic gains such as high school GPA and retention in college (Robbins, Le, & Lauver, 2005). Some students will learn productive strategies on their own, but all students can benefit from direct teaching, modeling, and practice of learning strategies and study skills. This is one important way to prepare all of your students for the future. Newly mastered concepts, principles, and strategies must be applied in a wide variety of situations and with many types of problems (Z. Chen & Mo, 2004). Positive transfer is encouraged when skills are practiced under authentic conditions, similar to those that will exist when the skills are needed later. Students can learn to write by corresponding with e-mail pen pals in other countries. They can learn historical research methods by studying their own family history. Some of these applications should involve complex, ill-defined, unstructured problems, because many of the problems to be faced in later life, both in school and out, will not come to students complete with instructions. The Guidelines: Family and Community Partnerships give ideas for enlisting the support of families in encouraging transfer.

REASONING

Reasoning is logical thinking that uses induction and deduction to reach a conclusion. We begin by focusing on inductive reasoning. Inductive Reasoning Reasoning from the specifi c to the general is inductive reasoning. It consists of drawing conclusions (forming concepts) about all members of a category based on observing only some of its members (Goswami, 2011; Heit, 2008). Researchers have found that inductive-reasoning skill is oft en a good predictor of academic achievement (Kinshuk & McNab, 2006). What are some examples of the use of inductive reasoning in classrooms? When a student in English class reads only a few Emily Dickinson poems and is asked to draw conclusions from them about the general nature of Dickinson’s poems, inductive reasoning is being requested. When a student is asked whether a concept in a math class applies to other contexts, such as business or science, again, inductive reasoning is being called for. Educational psychology research is inductive when it studies a sample of participants to draw conclusions about the population from which the sample is drawn. It is also inductive in that scientists rarely take a single study as strong enough evidence to reach a conclusion about a topic, instead requiring a number of studies on the same topic to have more confidence in a conclusion. Indeed, an important aspect of inductive reasoning is repeated observation. Th rough repeated observation, information about similar experiences accumulates to the point that a repetitive pattern can be detected and a more accurate conclusion drawn about it. To study this aspect of inductive reasoning, researchers have examined whether inductive inferences are justified based on evidence about a single instance of two co-occurring events (Kuhn, Katz, & Dean, 2004). When two events occur together in time and space, we oft en conclude that one has caused the other, despite the possibility that other factors are involved. For example, a parent might conclude, "Harry is a bad influence on my daughter; Sharon didn't drink before she met him." Th e boy might be the cause, but the event may have been a coincidence. Of course, if there is repeated evidence (for example, every girl Harry has ever gone out with develops a drinking problem), then the argument becomes more persuasive. Consider also a child who observes a black snake and concludes, "All snakes are black." Th e child's cousin sends him an e-mail about a pet snake she recently bought, and he concludes that the pet snake must be black. However, he clearly has not observed all of the snakes in the world—actually, only one in this case—so he has seen only a small sample of the world's snake population. Of course, he would be forced to change his mind if he saw a gray snake or a white snake. Th e conclusions drawn as a result of inductive reasoning are never finally certain, only more or less probable. But induction can provide conclusive negative results—for example, seeing a yellow snake proves that the assertion "All snakes are black" is false. As just stated, inductive conclusions are never entirely certain—that is, they may be inconclusive. An inductive conclusion may be very likely, but there always is a chance that it is wrong, just as a sample does not perfectly represent its population (Kuhn, 2009). Teachers can help students improve their inductive reasoning by encouraging them to consider that the conclusion they reach depends on the quality and the quantity of the information available. Students oft en overstate a conclusion, making it more definitive than the evidence indicates. Let's now consider another aspect of inductive reasoning: it is basic to analogies. An analogy is a correspondence between otherwise dissimilar things. Analogies can be used to improve students' understanding of new concepts by comparing them with already learned concepts. One type of analogy involves formal reasoning and has four parts, with the relation between the fi rst two parts being the same as, or very similar to, the relation between the last two. For example, solve this analogy: Beethoven is to music as Picasso is to

. To answer correctly (“art”), you had to induce the relation between Beethoven and music (the former created the latter) and apply this relationship to Picasso (what did he create?). How good are children and adolescents at inductive reasoning? Adolescents are better at many aspects of inductive reasoning than are children, including analogies and false inclusion when generalizing from a single event, but not as good as young adults (Kuhn, 2009). Deductive Reasoning In contrast to inductive reasoning, deductive reasoning is reasoning from the general to the specific. Figure 9.4 provides a visual representation of the difference between inductive and deductive reasoning. When you solve puzzles or riddles, you are engaging in deductive reasoning. When you learn about a general rule and then understand how it applies in some situations but not others, you are engaging in deductive reasoning (Goswami, 2011; Johnson-Laird, 2008). Deductive reasoning is always certain in the sense that if the initial rules or assumptions are true, then the conclusion will be correct (Ricco, 2011). When educators and psychologists use theories and intuitions to make predictions, then evaluate these predictions by making further observations, they are using deductive reasoning. Many aspects of deductive reasoning have been studied, including the occasions when knowledge and reasoning conflict. During adolescence, individuals are increasingly able to reason deductively even when the premises being reasoned about are false (Kuhn, 2009). Consider this deductive inference problem: All basketball players are motorcycle drivers. All motorcycle drivers are women. Assuming that these two statements are true, decide if the following statement is true or false: All basketball players are women. Children rarely realize that such conclusions are valid deductions from the premises. From early adolescence through early adulthood, individuals improve in their ability to make accurate conclusions when knowledge and reasoning confl ict. Th at is, they can “reason independently of the truth status of the premises” (Kuhn & Franklin, 2006).

CRITICAL THINKING

Currently, there is considerable interest in critical thinking among psychologists and educators, although it is not an entirely new idea (Assaf, 2009; Bensley & others, 2010). Critical thinking involves thinking reflectively and productively and evaluating the evidence. Many of the “Reflect” questions that appear in every section of this book call for critical thinking. Mindfulness According to Ellen Langer (1997, 2005), mindfulness is a key to critical thinking. Mindfulness means being alert, mentally present, and cognitively flexible while going through life’s everyday activities and tasks. Mindful students maintain an active awareness of the circumstances in their lives. Mindful students create new ideas, are open to new information, and are aware of more than one perspective. In contrast, mindless students are entrapped in old ideas, engage in automatic behavior, and operate from a single perspective. Mindless students accept what they read or hear without questioning the accuracy of the information. Mindless students become trapped in rigid mindsets, not taking into account possible variations in contexts and perspectives. Langer emphasizes that asking good questions is an important ingredient of mindful thinking. She also stresses that it is important to focus on the process of learning rather than the outcome. For example, Trisha didn't do well on her math test earlier this week. All she can think about is how poorly she did. If she were engaging in mindfulness, Trisha would evaluate why she did so poorly and think about what changes she could adopt to do better on the next test.

Critical Thinking in Schools Here are some ways teachers can consciously build critical thinking into their lesson plans:

- Ask not only what happened but also "how" and "why."
- Examine supposed "facts" to determine whether there is evidence to support them.
- Argue in a reasoned way rather than through emotions.
- Recognize that there is sometimes more than one good answer or explanation.
- Compare various answers to a question and judge which is really the best answer.
- Evaluate and possibly question what other people say rather than immediately accepting it as the truth.
- Ask questions and speculate beyond what we already know to create new ideas and new information.

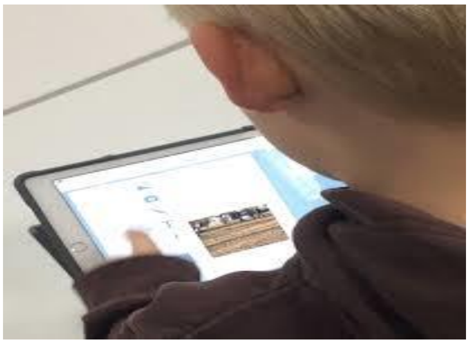
Jacqueline and Martin Brooks (1993, 2001) lament that few schools really teach students to think critically. In their view, schools spend too much time on getting students to give a single correct answer in an imitative way rather than encouraging students to expand their thinking by coming up with new ideas and rethinking earlier conclusions. They believe that too oft en teachers ask students to recite, defi ne, describe, state, and list rather than to analyze, infer, connect, synthesize, criticize, create, evaluate, think, and rethink. One way to encourage students to think critically is to present them with controversial topics or articles that present both sides of an issue to discuss. Some teachers shy away from having students engage in these types of critical-thinking debates or discussions because it is not "polite" or "nice" (Winn, 2004). However, critical thinking is promoted when students encounter conflicting accounts of arguments and debates because it can motivate them to delve more deeply into a topic and attempt to resolve an issue (Kuhn, 2009). In these circumstances, students often benefit when teachers refrain from stating their own views, allowing students to more freely explore diff erent sides of issues and multiple perspectives on topics. Getting students to think critically is not always an easy task (Willingham, 2008). Many students come into a class with a history of passive learning, having been encouraged to recite the correct answer to a question rather than put forth the intellectual eff ort to think in more complex ways (Noddings, 2008). By using more assignments that require students to focus on an issue, a question, or a problem instead of just reciting facts, teachers stimulate students’ ability to think critically.

Critical Thinking in Adolescence Adolescence is an important transitional period in the development of critical thinking (Kuhn, 2009). Several cognitive changes occur during adolescence that allow improved critical thinking, including the following (Keating, 1990):

- Increased speed, automaticity, and capacity of information processing, which frees cognitive resources for other purposes (See Chapter 8.)
- More knowledge in a variety of domains
- An increased ability to construct new combinations of knowledge
- A greater range and more spontaneous use of strategies or procedures such as planning, considering alternatives, and cognitive monitoring

Students in the Research Center for Educational Technology’s AT&T classroom at Kent State University studying energy by designing an energy-efficient home using *Better Homes and Gardens Home Designer* software.

Educational Technology’s AT&T classroom at Kent State University exploring patterns by programming the Logo Robotic Turtle.



Unfortunately, if a solid basis of fundamental skills (such as literacy and math skills) is not developed during childhood, critical-thinking skills are unlikely to mature in adolescence. For those adolescents who lack fundamental skills, potential gains in adolescent thinking are not likely. Technology and Critical Thinking An increasing number of technology applications are available to improve students' critical thinking skills. David Jonassen (2006, 2010) argues that one of the best uses of technology in education involves computer applications that encourage students to think critically about the content they are studying. He calls such applications "mindtools," and sees them as constructivist tools that scaff old student creation of knowledge and reasoning about subject content. Jonassen distinguishes several categories of mindtools, including semantic organization tools, dynamic modeling tools, information interpretation tools, and conversation and collaboration tools. Semantic organization tools, such as databases and concept mapping tools, help students organize, analyze, and visualize information they are studying. For example, students studying climate can query global databases to test their hypotheses concerning links between climate and population. Inspiration and Kidspiration are concept mapping tools for K–12 students that are relatively inexpensive and easy to use (see www.inspiration.com). Dynamic modeling tools help students explore connections between concepts. Th ese include spreadsheets, expert systems, systems modeling tools, and microworlds. For example, spreadsheets have been used in mathematics classes to help students explore mathematical relations between numbers. Microworlds simulate real-world phenomena, such as genetic combinations. Information interpretation tools help learners' access and interpret information, and include visualization and knowledge construction tools. For example, visualization tools are visual models of complex phenomena that make those phenomena more comprehensible. Knowledge construction tools, such as hypermedia, video editing, or Web design programs, scaffold student construction of knowledge in various forms. An example of a knowledge construction tool would be WebQuests, which are inquiry-oriented lessons with a particular format in which most of the information students.