- Use lots of examples and analogies (to foster elaboration).
- Prompt students to elaborate by asking them to put ideas in their own words, relate new ideas to personal experience, and create their own analogies.

pause & reflect

In Chapter 8, on information-processing theory, we noted that elementary-grade teachers rarely give students instruction in how to process information effectively. One reason is that teacher-education programs typically provide little or no coursework on this subject. Is this true of your program? What can you do when you teach to make full use of information-processing principles?

Practice What You Preach As we pointed out in discussing social learning theory, a great deal of learning takes place by observing and emulating a model. Because teachers are generally perceived by students as being competent, in a high-status occupation, and having power, their behaviors are likely to be noticed and imitated. This is especially true when the behaviors that teachers model are important to a student's classroom success. If you are convinced that how students process information plays a major role in how well they learn that information, then you should clearly and explicitly demonstrate how to analyze a task, formulate a learning plan, use a variety of learning tactics (such as mnemonics, summarizing, self-questioning, note taking, concept mapping), monitor the effectiveness of those tactics, and make changes when the results are unsatisfactory. •

The Nature and Elements of a Constructivist Approach

In previous chapters, we noted that the essence of constructivist theory is that people learn best by creating their own understanding of reality. Using such characteristics as existing knowledge, attitudes, values, and experiences as filters, people interpret current experience in a way that seems to make sense to them at the time. As Figure 11.2 demonstrates by constructing two different concept maps from an identical set of concepts, knowledge can be organized in any number of ways, and the scheme one creates will reflect one's purpose or focal point. Thus some students understand that the Jane Austen novel *Sense and Sensibility* is as much a satire of the paternalistic class system of 1800s England as it is a love story, whereas other students see it only as a love story, and a boring one at that. The goal of constructivist-oriented teaching, then, is to provide a set of conditions that will lead students to construct a view of reality that both makes sense to them and addresses the essence of your objectives (Delgarno, 2001).

A brief description of five of the more prominent elements that help define a constructivist-oriented classroom follows. Although two of these elements reflect a social constructivist orientation, bear in mind that the goal of both cognitive and social constructivism is the same: to help students become more effective thinkers and problem solvers by helping them construct richer and more meaningful schemes. A social constructivist orientation simply gives greater weight to the role of social interaction in this process.

JOURNAL ENTRY
Using a Constructivist Approach to Instruction

Provide Scaffolded Instruction Within the Zone of Proximal Development To review quickly what we said previously in the book, the zone of proximal development is the difference between what a learner can accomplish without assistance and what can be accomplished with assistance. As an example, consider the case of a youngster who has been given her first bicycle. Because the child has no experience with balancing herself on a two-wheeled bike, her parents know she will fall quite a few times before learning how to balance, steer, and pedal at the same time. To avoid injury and loss of motivation, one parent holds the bike upright and helps the child steer in a straight line while she figures out how to monitor her balance and make the necessary adjustments. This is done initially at very low speeds, with the parent firmly holding the frame of the bike. Gradually, the child is allowed to pedal faster, and the parent loosens his grip on the bike. Eventually, the parent does little more than run alongside the bike, and then he withdraws altogether.

The value of scaffolding was demonstrated in a study (Hardy, Jonen, Möller, & Stern, 2006) in which third graders received either high or low levels of instructional support on a lesson about density and buoyancy (e.g., Why does a large iron ship float?). In the high-instructional-support condition, the teacher sequenced the material into consecutive units, decided when certain instructional materials and objects would be available, pointed out contradictory statements made by the students, and summarized their conclusions. In the low-instructional-support condition, students were given a variety of materials and objects and worked in small groups to conduct experiments. The teacher's major role in the low-support condition was to provide support for the process of investigation. When tested on their understanding of the concepts of density and buoyancy, both groups significantly outscored an uninstructed control group. But one year later, the high-support group demonstrated a better grasp of these concepts than did the low-support group.

This common example illustrates two related points about teaching from a constructivist perspective: instruction should demand more than what a student is capable of doing independently, and, because of these demands, instruction should be scaffolded. That is, teachers should provide just enough support, through such devices as explanations, modeling, prompting, offering clarifications, and verifying the accuracy of responses, that the learner can successfully complete the task. As students indicate that they have begun to internalize the basic ideas and procedures of the lesson, the scaffolding is gradually withdrawn (Brooks & Brooks, 2001; Shapiro, 2003).

Constructivist approach: students discover how to be autonomous, self-directed learners

Provide Opportunities for Learning by Discovery By its very nature, constructivism implies the need to let students discover things for themselves. But what things? According to Jerome Bruner, whose pioneering work we mentioned in Chapter 10, on constructivist learning theory, the process of discovery should be reserved for those outcomes that allow learners to be autonomous and self-directed. These include understanding how ideas connect with one another, knowing how to analyze and frame problems, asking appropriate questions, recognizing when what we already know is relevant to what we are trying to learn, and evaluating the effectiveness of our strategies. The case we cited in the previous chapter of the fifth-grade teacher who wanted his students to understand the relationship between the circumference of a circle and its diameter is a good example of how these outcomes can be learned by guided discovery.

Meaningful learning aided by exposure to multiple points of view

Foster Multiple Viewpoints Given the basic constructivist premise that all meaningful learning is constructed and that everyone uses a slightly different set of filters

Adopting a constructivist approach to teaching means arranging for students to work collaboratively in small groups on relevant problems and tasks, encouraging diverse points of view, and providing scaffolded instruction.

with which to build his or her view of reality, what we refer to as knowledge is actually a consensus of slightly different points of view. Thus another element of a constructivist approach to teaching is to help students understand that different views of the same phenomena exist and that they can often be reconciled to produce a broader understanding.

The technique of **cooperative learning** is another way to expose students to peers who may have different views about the "right" way to do something or the "truth" of some matter and help them forge a broader understanding that is acceptable to all members of the group. Consider, for example, a group of college students who, as part of a science methods course, were asked to figure out how to generate electricity for a home using windmills, with the condition that batteries could not be used. Some members of the group were stumped because they couldn't figure out how to supply the house with a constant supply of electricity in the absence of a battery. Their inability to solve this problem was due to their narrow conception of an energy storage device—the kinds of batteries that are used to power such things as toys, flashlights, and cars. But other members of the group maintained that the function of a battery could be performed by any device that stored energy, such as a spring or a tank of hot water, thereby helping the rest of the group to see a different and broader truth (Brooks & Brooks, 2001). In the last major section of this chapter, we describe cooperative learning in considerable detail.

Emphasize Relevant Problems and Tasks Can you recall completing a class assignment or reading a chapter out of a textbook that had no apparent relevance to anything that concerned you? Not very interesting or exciting, was it? Unfortunately, too many students perceive too much of schooling in that light. One constructivist remedy is to create interest and relevance by posing problems or assigning tasks that are both challenging and realistic (see our Case in Print for an illustration of how one teacher accomplishes this goal). One basic purpose of emphasizing problems and tasks that are relevant to the lives of students is to overcome the problem of inert knowledge, mentioned in Chapter 10 on constructivism. Constructivists believe that the best way to prepare students to function effectively in real-life contexts is to embed tasks in contexts that come as close as possible to those of real life (Delgarno, 2001; Duffy & Cunningham, 1996).

Problems can be challenging either because the correct answer is not immediately apparent or because there is no correct answer. The ill-structured problems and issues that we described previously are, by their nature, challenging and realistic and do not have solutions that everyone perceives as being appropriate and useful. But if you assign students an ill-structured task to investigate, pose it in such a way that they will see its relevance. For example, instead of asking high school students to debate the general pros and cons of laws that restrict personal freedoms, have them interview their community's mayor, chief of police, business owners, and peers about the pros and cons of laws that specify curfews for individuals under a certain age and that prohibit such activities as loitering and the purchase of alcohol and tobacco. Because many adolescents consider themselves mature enough to regulate their own behavior, analyzing and debating laws that are intended to restrict certain adolescent behaviors is likely to produce a fair amount of disequilibrium.

Encourage Students to Become Self-Directed Learners According to constructivist and humanistic theory (which we discuss later in this chapter), students should, under the right circumstances, be able to direct more of their learning than they typically do. One important condition that paves the way for students becoming more self-directed is the way in which teachers interact with students. Students in one study (Reeve & Jang, 2006) were more likely to feel as if they were in control of their own learning when teachers engaged in such behaviors as giving students time to work on a task in their own ways, giving students the opportunity to talk, encouraging students to complete tasks, listening to students, and being responsive to students' questions. By contrast, student autonomy was more likely to be negatively related to such teacher behaviors as giving students the solutions to problems or the answers to questions, giving students commands and directions, telling students they should or should not do something, and asking students such controlling questions as, "Can you do it the way I showed you?"

If you still believe, despite the findings cited in the preceding paragraph, that school-age children simply don't have the emotional maturity and cognitive skills necessary to direct more of their own learning, a program for eighth graders in Radnor, Pennsylvania, called *Soundings* has illustrated its feasibility (Brown, 2002). The program is built around a set of questions that students have identified as being of interest and importance to them. Students then help the teacher develop the curriculum, study methods, and assessments.

In line with humanistic theory, the first goal of every school year is the development of safe and trusting relationships among students and between the students and the teacher. This goal is accomplished by having pairs of students interview each other and then introduce the other student to the class; by having students interview the teacher; and by using cooperative games. Then the teachers, who act as coordinators of the students' efforts, train students to ask meaningful and insightful questions (for example, "Why do we eat breakfast?" "Who decided which foods would be breakfast foods?" "Do people in all cultures eat the same foods for breakfast?") that flow from two general questions: "What questions and concerns do you have about yourself?" and "What questions and concerns do you have about the world?"

Working in small groups, students examine their own questions as well as those of their classmates, identify common questions that will be the subject of a large-group discussion, and write their questions on large sheets that are posted on a wall and viewed by the other students in class. After viewing all the lists and discussing common themes and their importance, the students create a prioritized list of themes to study throughout the year (such as violence in our culture, medical issues affecting our lives, and surviving alien environments). Students then develop a timeline for studying the selected topics, block out time periods on the calendar, and join a small group that is interested in one of the topics.

The Challenges to Being a Constructivist Teacher

Constructivist-oriented approaches to teaching run counter to the dominant didactic approach in which the teacher transmits established, accumulated knowledge to students through lecture and demonstration and students incorporate that knowledge largely through drill-and-practice exercises. Consequently, teachers interested in adopting a constructivist approach will have to successfully negotiate a set of challenges that Mark Windschitl (2002) describes as conceptual, pedagogical, cultural, and political.

The conceptual challenge is to fully understand the theoretical foundation on which constructivism rests and to reconcile current pedagogical beliefs with constructivist beliefs. This involves, for example, understanding the difference between cognitive and social constructivism and such concepts as cognitive apprenticeship, scaffolding, situated learning, and negotiated meaning. A solid grasp of constructivist theory will also help teachers avoid misconceptions: for instance, that direct instruction can never be used, that students must always be physically and socially active to learn, that all ideas and interpretations offered by students are equally valid, and that constructivist teaching avoids rigorous assessment practices.

The pedagogical challenge has several facets:

- Constructivist teachers need to understand how different students think, how complete each student's knowledge is about a subject, how accurate that knowledge is, and how aware students are about the state of their own knowledge.

Case in Print

Constructing Meaningful Learning Tasks

Can you recall completing a class assignment or reading a chapter out of a textbook that had no apparent relevance to anything that concerned you? Not very interesting or exciting, was it? Unfortunately, too many students perceive too much of schooling in that light. One constructivist remedy is to create interest and relevance by posing problems or assigning tasks that are both challenging and realistic. . . . One basic purpose of emphasizing problems and tasks that are relevant to the lives of students is to overcome the problem of inert knowledge, mentioned in Chapter 10 on constructivism. (p. 380)

HM TeacherPrepSPACE

See both this Case in Print and a bonus case for this chapter at the textbook's student website.

Top Teacher Thrives on Unorthodox

ELAINE RIVERA
Washington Post, 11/6/03

Arlington County science teacher Laurie Sullivan may be Virginia's 2004 Teacher of the Year, but she'll be the first to tell you that she wasn't quite the stellar student herself.

"There were some things I didn't get right away," said Sullivan, who teaches math and science at Barrett Elementary School. "So I can empathize with the student who doesn't get it at first. If I can think of another way of teaching them, I will."

Spend time with Sullivan, and it becomes clear that her empathy for students who learn differently comes from the fact that she herself thinks differently. With her quirky sense of humor and vision, she finds usefulness in things others might not.

Take the elongated cardboard boxes in which her bookcases had been packed two years ago. Most people would have thrown out them out. Not Sullivan. She kept them, knowing that she would find use for them at some point. "I don't throw anything away," she said.

Last week, she found the perfect use for the boxes.

"These are going to be our ramps for racing cans," she said excitedly, referring to her fifth-grade class's current science experiment with speed, mass, and weight.

"I don't think I was ever traditional," she added, almost sheepishly.

Sullivan's non-traditional teaching style has captivated students, colleagues and supervisors over the last 10 years and led to her being named the state's top teacher Oct. 24 in Richmond.

"She has all the qualities of a great teacher," said Barrett Principal Terry Bratt. "She gets the students interested right away, and she gets them to persevere." Sullivan's ability to keep students engaged and tuned in, Bratt said, is "better than all the highly paid actors on television."

But Bratt and Sullivan know that teaching is not about entertaining but about ensuring that kids learn.

"I want it to be always, 'Why are we learning this? How does it apply to what's going on outside of the classroom?'" Sullivan said about her goal to teach children how the physical world works.

During her fifth-grade class, it was clear that her students were engaged. Sullivan posed this science problem to them: Which of the assorted-size cans would roll down the ramp fastest?

"The hypothesis can be: Will the biggest or the smallest go fastest?" volunteered 10-year-old Christian Rodriguez.

The class was broken up into five teams, each armed with a cardboard ramp, tape to mark the starting line and stopwatches.

Sullivan was attempting to teach her students about "rotational inertia," as well as how to use a stopwatch, how to make a fair test and how to record and interpret data. The end result was that several of the students reached the correct conclusion—it's the weight, not the size of an object, that determines its speed.

"She fascinates me," said Ronald Velez, 10, one of the first students to figure out that the lighter the contents in the can, the faster it will go (beef broth defeated the beans). "She can always give me a science fact, and she always helps me out when I have questions."

Fifth-grader Roxana Hernandez said Sullivan "treats us so nice, and we all learn a lot from her. She made me like science."

Rodriguez offered Sullivan his own kind of compliment: "Her room might be messy, but cool things are in it."

As it nears time for the students' next class, they stop and look at the flowers, balloons, congratulatory cards and articles about their favorite teacher that have been piled on a table—stuff that may one day be used in another unique classroom lesson.

Questions and Activities

1. Teacher Laurie Sullivan is described by the author of this article as having a non-traditional teaching style. Educational psychologists would describe her as having a constructivist teaching style. How is her approach consistent with constructivist learning theory?
2. How would you respond to someone who argued that in the time it took to carry out and set up the racing cans experiment, Laurie Sullivan could have taught her students two to three times as much information using more direct methods?
3. Besides her nontraditional teaching methods, what other qualities does Laurie Sullivan have that warranted her selection as Virginia's Teacher of the Year?

- Teachers must know how to use a variety of methods to support understanding during problem-based activities. These methods include modeling; providing prompts, probes, and suggestions that differ in their explicitness; providing problem-solving rules of thumb; and using technology to organize and represent information.
- Teachers must guide students to choose meaningful projects or issues to investigate that are sufficiently complex, intellectually challenging, and related to the theme of the particular subject under study.
- Teachers have to teach students how to work productively in collaborative activities even though some students may be uninterested in or even opposed to working with others.
- Teachers need to have a deep enough understanding of a subject to be able to guide students who become puzzled by an observation to an explanation (as in the case of students who wonder why seedlings grow taller under weaker light than under stronger light).
- Last, constructivist teachers need to know how to use a wide range of alternative assessment devices, such as interviews, observations, student journals, peer reviews, research reports, art projects, the building of physical models, and participation in plays, debates, and dances.

The cultural challenge pertains to the implicit classroom norms that govern the behavior of teachers and students. As noted, the dominant approach to instruction is a didactic one in which established facts and procedures are transmitted from an expert (the teacher) to novices (students). The classroom culture that flows from this model is one in which teachers talk most of the time while students sit, are quiet and attentive, do seatwork, and take tests. A constructivist classroom, on the other hand, is characterized by inquiry, collaboration among students, use of the teacher as a resource, explanations of points of view and solutions to problems to others, and attempts to reach consensus about answers and solutions. The major challenge for teachers is to recognize that their beliefs about what constitutes an ideal classroom are likely to have been shaped by their experiences as students in traditional classrooms.

The political challenge is to convince those who control the curriculum and influence teaching methods (school board members, administrators, other teachers, and parents) that constructivist teaching will satisfy state learning standards, is consistent with the content of high-stakes tests, and will help students meaningfully learn the key ideas that underlie various subjects. Should you run into this problem, you might cite a research study or two that supports constructivist teaching. For example, third graders in Germany whose teachers used a constructivist approach scored higher on a test of mathematical word problems and at the same level on a test of arithmetic computation problems as third graders whose teachers used the traditional direct-transmission approach (Staub & Stern, 2002).

The technology section that follows presents some additional ideas for embedding learning in realistic settings.

Using Technology to Support Cognitive Approaches to Instruction

As educators begin to understand and address cognitive learning theories, the focus of computer technology is shifting from remediating learner skill deficiencies and rehearsing basic skills to finding ways to help the learner build, extend, and amplify new knowledge (Grabe & Grabe, 2007; Jonassen et al., 2003). Your willingness and readiness to use today's technology for this purpose is likely to be partly a function of the extent to which you use computer technology to meet personal and professional goals. Fourth- and eighth-grade teachers who reported higher levels of classroom technology use and personal computer use were more likely to use constructivist teaching practices than their peers who reported lower levels of technology use (Rakes, Fields, & Cox, 2006).

Technology supports a cognitive approach to instruction by helping students code, store, and retrieve information

Helping Students Process Information An information-processing approach to instruction uses technology to minimize the cognitive demands of a task; to help learners form schemas, or patterns, of information; to extend or augment thinking in new directions; and to supply information overviews and memory cues (Grabe & Grabe, 2007). The programs for outlining and note taking mentioned in Chapter 8 on information-processing theory are consistent with this approach, as are electronic encyclopedias (for example, Grolier's *Multimedia Encyclopedia*), hypermedia databases that contain conceptual resources such as timelines, information maps, and overviews, and concept mapping software such as Inspiration that helps students organize their knowledge and ideas (Delgarno, 2001).

Discovery and Exploratory Environments Computers are not just tools to transmit or represent information for the learner; they also provide environments that allow for discoveries and insights. In such an **exploratory environment,** students might explore exciting information resources on the Web, enter simulations or microworlds like LEGO-LOGO, browse and rotate objects in a hypermedia or web database, and use imaging technologies to explore inaccessible places (such as underwater canyons or planet surfaces).

For instance, the Geometric Supposer is an exploratory tool that students can use to construct, manipulate, and measure different geometric figures and relationships. High school juniors and seniors who used the Geometric Supposer for an academic year in their plane geometry course achieved significantly higher scores on a geometry test than a comparable group that covered the same topics without the aid of any computer programs (Funkhouser, 2002/2003). Another exploratory tool, GenScope, was designed to help students better understand the principles of genetics. High school students in technical biology and general life science courses who used the GenScope program performed significantly better than did students in classes without the program on a test of genetic reasoning (Hickey, Kindfield, Horwitz, & Christie, 2003).

Guided Learning Although students can use modeling programs and simulations to plan experiments, take measurements, analyze data, and graph findings, there is still a need for teacher scaffolding and guidance in support of the learning process (Delgarno, 2001). In these **guided learning** environments, teachers might help students set goals, ask questions, encourage discussions, and provide models of problem-solving processes. Such teachers provide a clear road map of the unit at the beginning, clear expectations and sequencing of activities, continued reinforcement and guidance, teacher modeling, opportunities for students to practice problem-solving steps, reflection on learning, and regular checking and sharing of student progress. (Note how this approach combines elements of the behavioral and social cognitive approaches.)

One guided learning environment, the Higher Order Thinking Skills program (HOTS), focuses on higher-order thinking skills among at-risk youths in grades 4 through 8 (Pogrow, 1990, 1999, 2005). HOTS was designed around active learning, Socratic questioning, and reflection activities in using computers, and attempts to improve four key thinking processes: (1) metacognition, (2) inferential thinking, (3) transfer of learning, and (4) synthesis, or combining information from different sources into a coherent whole. Instead of the rote computer-based drills that these students would normally receive, they are prompted to reflect on their decision-making process while using computer tools. Teachers do not give away the answers but instead draw out key concepts by questioning students or telling them to go back and read the information on the computer screen. The developer of HOTS, Stanley Pogrow, calls this "controlled floundering," or leading students into frustration so that they have to reflect on the information on the screen to solve a problem. In effect, the learning dialogues and conversations between the teacher and student are the keys to learning here, not student use of the computer, as small-group discussion allows students to compare strategies and reflect on those that work. One reason for this program's emphasis on Socratic questioning and reflection is the finding, mentioned in Chapter 5 on cultural and socioeconomic diversity, that the amount of discourse in low-SES households is often significantly less than in middle- and upper-SES households and that this factor is thought to contribute to these students' lower levels of achievement in school.

Pogrow (1999) reports that students in the HOTS program record year-to-year gains that are twice those of the national average on standardized tests of reading and math and three times those of control groups on tests of reading comprehension. Approximately 15 percent of HOTS students make the honor rolls in their schools. Gains in self-concept, as well as in thinking skills, have also been reported (Eisenman & Payne, 1997). Additional information on the HOTS program can be found at **www.hots.org**.

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For direct links to the HOTS site and others mentioned in this chapter, go to the Weblinks section at the textbook's student website.

Problem- and Project-Based Learning Another way to implement constructivist trends in education is to use technology for **problem-based learning (PBL)**, an instructional method that requires learners to develop solutions to real-life problems. Computer-based problem-solving programs typically provide students with story problems, laboratory problems, or investigation problems. Story problem programs are usually tutorials and are very much like the math story problems you probably encountered in school. Laboratory problems are typically simulations of laboratory science problems, such as chemistry or biology. Investigation problems are set in realistic environments (microworlds) and may involve such varied subject areas as astronomy, social studies, environmental science, and anthropology (Jonassen et al., 2003). When using PBL with technology, students can plan and organize their own research while working collaboratively with others.

Although PBL has its roots in medical and business school settings, it has been successfully adapted to the elementary, middle school, and high school grades. Problem-solving programs that are based on constructivist principles and are most likely to foster meaningful learning will do the following:

- Encourage students to be active learners, engaging in such behaviors as making observations, manipulating objects, and recording the results of their manipulations
- Encourage students to reflect on their experiences and begin to construct mental models of the world
- Provide students with complex tasks that are situated in real-world settings
- Require students to state their learning goals, the decisions they make, the strategies they use, and the answers they formulate