PEARSON NEW
INTERNATIONAL EDITION

Essentials of Educational Psychology
Big Ideas to Guide Effective Teaching
Jeanne Ellis Ormrod
Third Edition

ALWAYS LEARNING

PEARSON

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Introduction to Educational Psychology

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CHAPTER OUTLINE

MEGA-IDEAS TO MASTER IN THIS CHAPTER

Effective teachers use research findings and research-based theories to make decisions about instruction, classroom management, and assessment practices.

Effective teachers continually work to enhance their professional knowledge and skills.

Learners read, study, and learn more effectively when they actively try to make sense of new information.

CASE STUDY Starting High School

Anna is an intelligent Mexican American student enrolled in Chicago's public school system. Anna has certainly had more than her share of life's challenges; for instance, her parents have divorced, and several of her friends have been victims of gang violence. Teachers and other staff members at Anna's local K–8 elementary/middle school provide considerable social and emotional support for her during such traumatic times. They also give her regular feedback and guidance to help her improve her academic skills. By eighth grade, Anna's performance on a standardized achievement test places her reading skills at a ninth-grade level—seemingly confirming that she's well equipped to tackle the high school grades.

Yet when Anna makes the transition to ninth grade at a large city high school, her academic performance quickly deteriorates, and her first-semester final grades include several Ds and an F. Anna seems overwhelmed by the new demands that high school places on her, as reflected in the following explanations she gives a researcher:

> In geography, "he said the reason why I got a lower grade is 'cause I missed one assignment and I had to do a report, and I forgot that one." In English, "I got a C . . . 'cause we were supposed to keep a journal, and I keep on forgetting it 'cause I don't have a locker. Well I do, but my locker partner she lets her cousins use it, and I lost my two books there. . . . I would forget to buy a notebook, and then I would have them on separate pieces of paper, and I would lose them." And, in biology, "the reason I failed was because I lost my folder . . . it had everything I needed, and I had to do it again, and, by the time I had to turn in the new folder, I did, but he said it was too late . . . 'cause I didn't have the folder, and the folder has everything, all the work. . . . That's why I got an F."[1]

Although Anna's math teacher offers to find tutors for struggling students, Anna perceives most of her teachers as being uncaring, unaware of how students are progressing, and inflexible in evaluating students' achievement. Twice she goes to the school counselor's office—visits that get her in trouble for being late to her next class—but the counselor isn't available to meet with her on either occasion.

Despite her rocky start, Anna hopes to earn her high school diploma and attend college. But her first-semester performance isn't a good sign. In a study of 27,000 students in Chicago's public schools (including Anna), Roderick and Camburn found that more than 40% of first-semester ninth graders (males especially) failed at least one course, and students who achieved at low levels early in their high school career were at higher-than-average risk for dropping out before graduation.[2]

- Why does Anna's academic performance drop so dramatically in ninth grade? Drawing both from information presented in the case study and from your own experiences in middle school and high school, identify several factors that might be contributing to her academic decline.
- What things might Anna's teachers do to help her succeed in high school?

[1] Roderick & Camburn, 1999, p. 305.
[2] Roderick & Camburn, 1999.

Bob Daemmrich Photography

When students begin high school, they face many new challenges—classes with unfamiliar peers, more stringent course requirements, less individualized guidance and instruction, and so on—while also dealing with the unsettling physiological and social changes that come with puberty and adolescence.

A variety of factors might be contributing to the decline in Anna's school performance. For example, perhaps the subject matter and assignments in her high school classes are more challenging than those in middle school. Perhaps the high school teachers have such large classes that they have little time to give students one-on-one assistance. Given that Anna is now attending classes with many students she doesn't know, perhaps she's more focused on making friends and fitting in with her new peer group than she is on mastering school subject matter. Furthermore, Anna apparently doesn't have the organizational skills she needs to keep track of class materials and assignments.

Although students themselves certainly play a key role in their academic success, teachers can do many things to make students' success more likely. For example, they can get students genuinely interested in and excited about classroom topics. They can present information in such a way that students truly understand it, rather than simply memorize it. They can give students opportunities to practice new skills within the context of real-life situations and problems. They can teach students how to keep track of assignments and due dates, organize study materials, take good class notes, and in other ways gain self-sufficiency in academic pursuits. And they can regularly monitor students' progress and provide ongoing feedback to help students improve.

Teaching children and adolescents—whether in an elementary or secondary school classroom, in a preschool or after-school child care facility, on the playing field, or elsewhere—is one of the most rewarding activities on the planet. Yet to actually help young people *learn* what you want to teach them, you cannot be concerned only about your subject matter. You must also consider how children and adolescents typically think and learn, what abilities different age-groups are likely to have, and what conditions are likely to motivate young people to master important knowledge and skills. And you must have a large toolbox of strategies for planning and carrying out instruction, creating an environment that keeps everyone working toward important instructional goals, and regularly assessing everyone's progress and achievement.

In this book we'll explore the field of **educational psychology**, which applies concepts and theories of psychology to instructional practice and offers a wide variety of strategies that can help students of all ages succeed in the classroom.

educational psychology Academic discipline that (a) systematically studies the nature of learning, child development, motivation, and related topics and (b) applies its research findings to the identification and development of effective instructional practices.

General Guiding Principles of Educational Psychology

The field of educational psychology focuses on those aspects of psychology—thinking, learning, child and adolescent development, motivation, assessment of human characteristics, and so on—that have particular relevance for classroom practice. Underlying this seemingly diverse set of topics are several guiding principles that unify educational psychology as a discipline.

An in-depth knowledge of students must drive teacher decision making.

How children and adolescents think and learn, what knowledge and skills they have and have not mastered, where they are in their developmental journeys, what their interests and priorities are—all of these factors influence the effectiveness of various classroom strategies. Thus, the decisions teachers make in the classroom—decisions about what topics and skills to teach (*planning*), how to teach those topics and skills (*instruction*), how to keep students on task and supportive of one another's learning efforts (creating an effective *classroom environment*), and how best to determine what students have learned (*assessment*)—must ultimately depend on students' existing characteristics and behaviors.

Of course, teachers' classroom strategies also *change* what students know, think, and can do. Thus, the relationship between student characteristics and behaviors, on the one hand, and teacher strategies, on the other, is a two-way street. Furthermore, planning, instruction, the classroom environment, and assessment practices influence one another as well.

Figure 1.1 depicts how student characteristics and behaviors, planning, instruction, the classroom environment, and assessment mutually affect one another. Notice how student characteristics and behaviors are at the center of the figure, because these must drive almost everything that teachers do in the classroom. Such an approach to teaching is sometimes known as **learner-centered instruction**.[3]

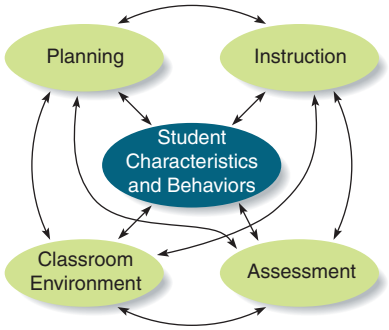

FIGURE 1.1 A learner-centered model of instruction

[3] For good general discussions of learner-centered instructional practices, see McCombs, 2005; National Research Council, 2000. You may also want to look at the American Psychological Association's (APA's) 14 *Learner-Centered Psychological Principles* on the APA website at http://www.apa.org. Type "learner-centered principles" in the search box on APA's home page.)

learner-centered instruction Approach to teaching in which instructional strategies are chosen largely on the basis of students' existing abilities, predispositions, and needs.

In many instances teachers can accommodate students' unique characteristics within the context of typical classroom practices and activities. Yet some students, known as **students with special needs**, are different enough that they require specially adapted instructional materials or practices to help them maximize their learning and development. Now, more than ever before, many of these students are in general education classrooms, a practice called **inclusion**. Regardless of the grade level or subject matter, teachers should expect to have students with a wide variety of special needs in their classrooms at one time or another. At several points in the book we'll consider students with particular kinds of special needs and identify strategies that may be especially useful in working with them.

The effectiveness of various classroom practices can best be determined through systematic research.

You yourself have been a student for many years now, and in the process you've undoubtedly learned a great deal about how children learn and develop and about how teachers can foster their learning and development. But exactly how much *do* you know? To help you find out, I've developed a short pretest, Ormrod's Own Psychological Survey (OOPS).

SEE FOR YOURSELF Ormrod's Own Psychological Survey (OOPS)

Decide whether each of the following statements is *true* or *false.*

True/False

_____ 1. The best way to learn and remember a new fact is to repeat it over and over again.

_____ 2. Most children 5 years of age and older are natural learners: They know the best way to learn something without having to be taught how to learn it.

_____ 3. When a teacher rewards one student for appropriate behavior, the behavior of other students usually suffers as a result.

_____ 4. Students are often poor judges of how much they've learned.

_____ 5. Anxiety sometimes helps students learn and perform more successfully in the classroom.

_____ 6. When teachers have children tutor their classmates in academic subject matter, the tutors gain very little from the process.

_____ 7. The ways in which teachers assess students' learning influence what and how the students actually learn.

Now let's see how well you did on the OOPS. The answers, along with an explanation for each one, are as follows:

1. The best way to learn and remember a new fact is to repeat it over and over again. FALSE—Although repeating information over and over is better than doing nothing at all, repetition is a relatively *in*effective way to learn specific pieces of information. Students learn new information more easily and remember it longer when they connect it with things they already know and when they engage in **elaboration**—that is, when they embellish on the information in some way, perhaps by drawing inferences from a historical fact, identifying new examples of a mathematical concept, or thinking of possible ways they might apply a scientific principle.

2. Most children 5 years of age and older are natural learners: They know the best way to learn something without having to be taught how to learn it. FALSE—Many students of all ages are relatively naive about how they can best learn something, and they often use inefficient strategies when they study. For example, most elementary students and a

student with special needs Student who is different enough from peers that he or she requires specially adapted instructional materials and practices.

inclusion The practice of educating all students, including those with severe and multiple disabilities, in neighborhood schools and general education classrooms.

elaboration Cognitive process in which learners embellish on new information based on what they already know.

substantial number of high school students don't engage in elaboration as they study classroom material—that is, they don't analyze, interpret, or otherwise add their own ideas to the things they need to learn.

3. When a teacher rewards one student for appropriate behavior, the behavior of other students usually suffers as a result. FALSE—When teachers reward one student for behaving in a particular way, other students who have observed that student being rewarded sometimes begin to behave in a similar manner.

4. Students are often poor judges of how much they've learned. TRUE—Contrary to popular opinion, students are usually *not* the best judges of what they do and do not know. For example, many students think that if they've spent a long time studying a textbook chapter, they must know its contents very well. Yet if they have spent most of their study time inefficiently (perhaps by "reading" while thinking about something else altogether or by mindlessly copying definitions), they may know far less than they think they do.

5. Anxiety sometimes helps students learn and perform more successfully in the classroom. TRUE—Many people think that anxiety is always a bad thing. Yet for some classroom tasks, and especially for relatively easy tasks, a moderate level of anxiety actually *improves* students' learning and performance.

6. When teachers have children tutor their classmates in academic subject matter, the tutors gain very little from the process. FALSE—When students teach one another, the tutors often benefit as much as the students being tutored. For instance, in one research study,[4] when low-achieving fourth graders tutored first and second graders in basic arithmetic skills, the tutors themselves showed a substantial improvement in arithmetic.

7. The ways in which teachers assess students' learning influence what and how the students actually learn. TRUE—What and how students learn depend, in part, on how they expect their learning to be assessed. For example, students typically spend more time studying the things they think will be on a test than the things they think the test won't cover. And they're more likely to pull class material into an integrated, meaningful whole if they expect assessment activities to require such integration.

How many of the OOPS items did you answer correctly? Did some of the false items seem convincing enough that you marked them true? Did some of the true items contradict certain beliefs you had? If either of these was the case, you're hardly alone. College students often agree with statements that seem obvious but are, in fact, partially or completely incorrect.[5] Furthermore, many students in teacher education classes reject research findings when those findings appear to contradict their personal beliefs and experiences.[6]

It's easy to be persuaded by "common sense" and assume that what seems logical must be reality. Yet common sense and logic don't always give us the real scoop about how people actually learn and develop, nor do they always give us appropriate guidance about how best to help students succeed in the classroom. Educational psychologists believe that knowledge about teaching and

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When one student tutors another, the tutor often learns as much from the experience as the student being tutored.

[4] Inglis & Biemiller, 1997.

[5] Gage, 1991; L. S. Goldstein & Lake, 2000; Woolfolk Hoy, Davis, & Pape, 2006.

[6] Gregoire, 2003; Holt-Reynolds, 1992; T. McDevitt & Ormrod, 2008; Patrick & Pintrich, 2001.

learning should come from a more objective source of information—that is, from systematic research. Increasingly, educators and policy makers alike are calling for **evidence-based practices**—the use of instructional methods and other classroom strategies that research has consistently shown to bring about significant gains in students' development and academic achievement.[7]

When educational psychologists describe human learning, development, and motivation, and when they suggest particular instructional practices, classroom management strategies, and assessment techniques, they usually identify the particular research articles, books, conference presentations, and other sources on which they base their claims. Typically they follow **APA style,** guidelines prescribed by the American Psychological Association for identifying sources and preparing references. In APA style a source is cited by presenting the author(s) and date of publication in the body of the text. For example, let's return to the earlier paragraph that begins "How many of the OOPS items. . . ." If I had written that paragraph using APA style, it would have looked like this:[8]

> How many of the OOPS items did you answer correctly? Did some of the false items seem convincing enough that you marked them true? Did some of the true items contradict certain beliefs you had? If either of these was the case, you're hardly alone. College students often agree with statements that seem obvious but are, in fact, partially or completely incorrect (Gage, 1991; L. S. Goldstein & Lake, 2000; Woolfolk Hoy, Davis, & Pape, 2006). Furthermore, many students in teacher education classes reject research findings when those findings appear to contradict their personal beliefs and experiences (Gregoire, 2003; Holt-Reynolds, 1992; T. McDevitt & Ormrod, 2008; Patrick & Pintrich, 2001).

Notice how I've included initials for only two authors: Lisa Goldstein and Teresa McDevitt. When two or more first authors listed in the references have the same surname (as is true for the surnames Goldstein and McDevitt in this book), APA style dictates that initials be included to distinguish among those authors, making it easier for readers to find the relevant source(s) in the reference list.

Most books in the field of educational psychology use the APA style of referencing, but I've intentionally deviated from APA style in this book for pedagogical reasons. When I assign books that have citations sprinkled throughout the text, I find that some students focus too much on the names and dates and not enough on what's really important for them to learn and remember: the *ideas.* Rather than presenting my sources within the text, then, I'm presenting them in footnotes. When you find some of the book's ideas especially interesting, exciting, or surprising, I urge you to read my footnoted sources firsthand.

Research can provide quantitative information, qualitative information, or both.

Many research studies involve **quantitative research**: They yield numbers that reflect percentages, frequencies, or averages related to certain characteristics or phenomena. For example, a quantitative study might provide information about students' performance on achievement tests, students' responses to rating-scale questionnaires, or school district records of students' attendance and dropout rates.

Other studies involve **qualitative research**: They yield nonnumeric information—perhaps in the form of verbal reports, written documents, pictures, or maps—that captures many aspects of a complex situation. For example, a qualitative study might involve lengthy interviews in which students describe their hopes for the future, a detailed case study of interpersonal relationships within a tight-knit clique of adolescent girls, or in-depth observations of several teachers who create distinctly different psychological atmospheres in their classrooms.

Ultimately, teachers gain a better understanding of students and effective classroom practices when they consider findings from *both* quantitative and qualitative research. And

evidence-based practice Instructional method or other classroom strategy that research has consistently shown to bring about significant gains in students' development and/or academic achievement.

APA style Rules and guidelines on referencing, editorial style, and manuscript format prescribed by the American Psychological Association.

quantitative research Research yielding information that is inherently numerical in nature or can easily be reduced to numbers.

qualitative research Research yielding information that cannot be easily reduced to numbers; typically involves an in-depth examination of a complex phenomenon.

[7] For example, see Darling-Hammond & Bransford, 2005; Waterhouse, 2006.

[8] For more information on APA style, see its *Publication Manual* (2010) or visit http://www.apastyle.org.

in fact, many studies provide both quantitative and qualitative information. For example, the study by Roderick and Camburn mentioned in the opening case study included both quantitative information (e.g., percentages of students who failed at least one course each semester) and qualitative information (e.g., students' explanations of why they were having difficulty in high school).

descriptive study Research study that enables researchers to draw conclusions about the current state of affairs but not about correlational or cause–and–effect relationships.

correlational study Research study that explores possible relationships among variables.

correlation Extent to which two variables are associated, such that when one variable increases, the other either increases or decreases somewhat predictably.

Different kinds of research lead to different kinds of conclusions.

Research studies typically fall into one of three general categories: descriptive, correlational, or experimental. These three categories yield different kinds of information and warrant different kinds of conclusions.

A **descriptive study** does exactly what its name implies: It *describes* a situation. Descriptive studies might give us information about the characteristics of students, teachers, or schools. They might also provide information about how frequently certain events or behaviors occur. Descriptive studies allow us to draw conclusions about the way things are—the current state of affairs. Virtually all qualitative studies are primarily descriptive in nature, and some quantitative studies fall into the descriptive category as well. The second and third columns of Table 1.1 present examples of questions we could answer with qualitative and quantitative descriptive studies.

A **correlational study** explores possible relationships among different things. For instance, it might tell us how closely two human characteristics are associated with each other, or it might give us information about the consistency with which certain human behaviors occur in conjunction with certain environmental conditions. In general, correlational studies enable us to draw conclusions about **correlation**: the extent to which two characteristics or phenomena tend to be found together or to change together. Two variables are correlated when one *in*creases as the other increases (a *positive correlation*) or

TABLE 1.1 Examples of Questions We Might Answer with Qualitative and Quantitative Research Studies

Topic	Qualitative Research (Descriptive)	Quantitative Research		
		Descriptive Studies	Correlational Studies	Experimental Studies
Reading	What things do high-achieving students say they do "in their heads" when they read and study their textbooks?	How pervasive are gender stereotypes in books commonly used to teach reading in the elementary grades?	Are better readers also better spellers?	Which of two reading programs produces greater gains in reading comprehension?
Abstract Thinking	What misconceptions are often seen in high school students' explanations of abstract concepts?	What percentage of high school students can think abstractly about academic topics?	Are older students more capable of abstract thought than younger students?	Can abstract thinking skills be improved through specially designed educational programs?
Aggression	What distinct qualities characterize high schools in which members of violence-prone adolescent gangs interact congenially and respectfully?	What kinds of aggressive behaviors occur in schools, and with what frequencies?	Are students more likely to be aggressive at school if they often see violence at home or in their neighborhood?	Which method is most effective in reducing aggressive behavior—rewarding appropriate behavior, punishing aggressive behavior, or a combination of these two strategies?
Achievement Tests	In what ways do teachers' instructional practices change when their jobs and salaries depend on their students' scores on statewide or national achievement tests?	How well have students performed on a recent national achievement test?	Do students who get the highest scores on multiple-choice tests also get the highest scores on essays dealing with the same material?	Do different kinds of tests (e.g., multiple-choice vs. essay tests) encourage students to study in different ways and thereby affect what students actually learn?

when one *de*creases as the other increases (a *negative correlation*) in a somewhat predictable manner. The fourth column of Table 1.1 presents examples of questions we might answer with correlational studies. Notice how each of the questions asks about an association between two variables—between reading and spelling, between age and abstract thought, between student aggression and violence at home, or between multiple-choice and essay scores.

If a correlation exists between two variables, knowing the status of one variable allows us to make *predictions* about the other variable. For example, if we find that older students are more capable of abstract thought than younger students, we can predict that ninth graders will benefit more from an abstract discussion of democratic government than fourth graders. However, a correlational study cannot, in and of itself, explain *why* an association exists. In other words, *correlation does not necessarily indicate causation.* For example, Roderick and Camburn's study of the Chicago public schools had a correlational element: It revealed that early failure in high school was associated with—and so predicted—later school failure and dropping out. But it did not necessarily show that early failure was the *reason* that many students subsequently dropped out of school.

Descriptive and correlational studies describe things as they exist naturally in the environment. In contrast, an **experimental study**, or **experiment**, is a study in which the researcher somehow changes, or *manipulates,* one or more aspects of the environment (often called *independent variables*) and then measures the effects of such changes on something else. In educational research the "something else" being affected (often called the *dependent variable*) is usually some aspect of student behavior—perhaps end-of-semester grades, skill in executing a complex physical movement, persistence in tackling difficult math problems, or ability to interact appropriately with peers. In a good experiment a researcher *separates and controls variables,* testing the possible effects of one variable while holding constant all other potentially influential variables. When carefully designed and conducted, experimental studies enable us to draw conclusions about causation—about what variables cause or influence certain other variables.

Often experimental studies involve two or more groups that are treated differently. Consider these examples:

- A researcher teaches reading comprehension skills to two different groups of students using two different instructional methods. (Instructional method is the independent variable.) The researcher then tests students' reading ability (the dependent variable) and compares the average reading test scores of the two groups.
- A researcher gives three different groups of students varying amounts of practice with woodworking skills. (Amount of practice is the independent variable.) The researcher subsequently scores the quality of each student's woodworking projects (the dependent variable) and compares the average scores of the three groups.
- A researcher gives one group of students an intensive training program designed to improve their study habits. The researcher gives another group either no training at all or, better still, gives the second group training in skills unrelated to study habits. (Presence or absence of study-habits training is the independent variable.) The researcher later assesses study habits and obtains students' grade point averages (these are both dependent variables) to see if the training program had an effect.

Each of these examples includes one or more **treatment groups** that are the recipients of an intervention. The third example also includes a **control group** that receives either no intervention or an intervention that is unlikely to affect the dependent variable(s) in question. In many experimental studies, participants are assigned to groups *randomly*—for instance, by drawing names out of a hat. Such random assignment to groups is apt to yield groups that are, on average, roughly equivalent on other variables (ability levels, personality characteristics, motivation, etc.) that might affect the dependent variable.

The right-most column of Table 1.1 lists examples of questions that might be answered with experimental studies. Notice how each question addresses a cause–and–effect relationship—the effect of a reading program on the development of reading comprehension, the effect of educational programs on abstract thinking, the effect of rewards and punishment on aggressive behavior, or the effect of test-question format on students' learning.

experimental study (experiment) Research study that involves the manipulation of one variable to determine its possible influential effect on another variable.

treatment group Group of people in a research study who are given a particular experimental treatment (e.g., a particular method of instruction).

control group Group of people in a research study who are given either no treatment or a treatment that is unlikely to have an effect on the dependent variable.

Drawing conclusions about cause–and–effect relationships requires that all other possible explanations for an outcome be eliminated.

When we look at the results of a research study, we mustn't be too hasty to draw conclusions about cause–and–effect relationships. As an example, imagine that Hometown School District wants to find out which of two new reading programs, *Reading Is Great* (RIG) or *Reading and You* (RAY), leads to better reading in third grade. The district asks each of its third-grade teachers to choose one of these two reading programs and use it throughout the school year. The district then compares the end-of-year achievement test scores of students in the RIG and RAY classrooms and finds that RIG students have gotten substantially higher reading comprehension scores than RAY students. We might quickly jump to the conclusion that RIG promotes better reading comprehension than RAY—in other words, that a cause–and–effect relationship exists between instructional method and reading comprehension. But is this really so?

Not necessarily. If we look at the study more closely, we realize that the school district hasn't eliminated all other possible explanations for the difference in students' reading comprehension scores. Remember, the third-grade teachers personally *chose* the instructional program they used. Why did some teachers choose RIG and others choose RAY? Were these two groups of teachers different in some way? Had RIG teachers taken more graduate courses in reading instruction, were they more open-minded and enthusiastic about using innovative methods, or did they devote more class time to reading instruction? If the RIG and RAY teacher groups were different from each other in any of these ways—or perhaps different in some other way we might not happen to think of—then the district hasn't eliminated alternative explanations for why the RIG students have developed better reading skills than the RAY students. A better way to study the causal influence of reading program on reading comprehension would be to *randomly assign* teachers to the RIG and RAY programs, thereby making the two groups of teachers roughly equivalent in such areas as graduate-level coursework, personality, motivation, expectations for students, and class time devoted to reading instruction.

What other possible differences between the RIG and RAY teachers might there be? (Compare your response to this question with the response presented in Chapter 1 of the Book-Specific Resources in MyEducationLab.)

Be careful that you don't jump too quickly to conclusions about what factors are affecting students' learning, development, and behavior in particular situations. Scrutinize descriptions of research carefully, always with these questions in mind: *Have the researchers separated and controlled variables that might have an influence on the outcome? Have they ruled out other possible explanations for their results?* Only when the answers to both of these questions are undeniably *yes* should you draw a conclusion about a cause–and–effect relationship.

In this book I draw largely from descriptive and correlational studies to identify characteristics and behaviors that are typical for various age-groups and grade levels. I rely more heavily on experimental studies to identify effective teacher strategies. Keep in mind, however, that for practical or ethical reasons, many important questions about classroom instruction and children's development don't easily lend themselves to carefully controlled experimental studies. For instance, although we might reasonably hypothesize that children can better master difficult math concepts if they receive individualized instruction, most school systems can't afford such a luxury, and it would be unfair to provide tutoring for some students and deny it to a control group of other, equally needy students. And, of course, it would be highly unethical to study the effects of aggression by intentionally placing some children in a violent environment. Some important educational and developmental questions, then, can be addressed only with descriptive or correlational studies, even though such studies cannot help us pin down specific cause–and–effect relationships.

Anthony Magnacca/Merrill

Only systematic research—and ideally, experimental research—can tell us which instructional strategies truly enhance students' learning and development.

Theories can help synthesize, explain, and apply research findings.

As researchers learn more and more about how things are (qualitative studies and descriptive quantitative studies), what variables are associated with one another (correlational studies), and what events cause what outcomes (experimental studies), they begin to

develop **theories** that integrate and explain their findings. In their theories, researchers typically speculate about the underlying (and often unobservable) mechanisms involved in thinking, learning, development, motivation, or some other aspect of human functioning.

By giving us ideas about such mechanisms, theories can ultimately help us create learning environments that facilitate students' learning and achievement to the greatest extent possible. Let's take an example. A particular theory of how people learn—information processing theory—proposes that attention is an essential ingredient in the learning process. If a learner *doesn't* pay attention, information rapidly disappears from memory, essentially going "in one ear and out the other." The importance of attention in information processing theory suggests that strategies that capture and maintain students' attention—perhaps providing interesting reading materials, presenting intriguing problems, or praising good performance—are apt to enhance students' learning and achievement.

Psychological theories are rarely, if ever, set in stone. Instead, they are continually revised as additional data come to light, and in some cases one theory may be abandoned in favor of a very different one that better explains certain phenomena. Furthermore, different theories often focus on different aspects of human functioning, and psychologists have not yet been able to pull them together into a single "mega-theory" that adequately accounts for all of the diverse phenomena and experiences that comprise human existence.

The contents of upcoming chapters are based on a variety of theories related to thinking, learning, development, motivation, and behavior. Although these theories will inevitably continue to evolve over time, they can be quite useful even in their present, unfinished forms. They help us pull together thousands of research studies into concise, integrated understandings of how children typically learn and develop, and they allow us to make inferences and predictions about how students in classrooms are apt to perform and achieve in particular situations. In general, theories can help us both *explain* and *predict* human behavior, and so they will give us numerous ideas about how best to help children and adolescents achieve academic and social success at school.

• Developing as a Teacher

If you are currently enrolled in a teacher education program, you should think of your program as a good start on the road to becoming a skillful teacher.[9] But it is *only* a start. Developing true expertise in any profession, including teaching, takes many years and a great deal of experience to acquire.[10] Research indicates that several strategies can help to make you a better teacher over the long run.

Keep up to date on research findings and innovative practices in education.

Occasional university coursework and in-service training sessions are often good ways to enhance teaching effectiveness.[11] Also, effective teachers typically subscribe to one or more professional journals, and as time allows, they attend professional conferences in their region. Many Internet websites provide additional means through which teachers can gain information and ideas about effective classroom practices. Websites for the National Council of Teachers of Mathematics (www.nctm.org) and the National Council for Geographic Education (www.ncge.org) are just two of the many helpful online resources.

Learn as much as you can both about the subject matter you teach and about strategies for teaching it effectively.

When we look at effective teachers—those who are flexible in their approaches to instruction, help students develop a thorough understanding of classroom topics, convey obvious

theory Integrated set of concepts and principles developed to explain a particular phenomenon.

[9] Bransford, Darling-Hammond, & LePage, 2005; Brouwer & Korthagen, 2005.

[10] P. A. Alexander, 2003; Berliner, 2001; Clotfelter, Ladd, & Vigdor, 2007.

[11] Bransford, Darling-Hammond, et al., 2005; Desimone, 2009; Guskey & Sparks, 2002; Hattie, 2009.

enthusiasm for whatever they are teaching, and so on—we typically find teachers who know their subject matter extremely well.[12] Effective teachers also have many strategies for teaching particular topics and skills—strategies that are collectively known as **pedagogical content knowledge**.[13] And they can usually anticipate—and so can also address—the difficulties students will have and the kinds of errors students will make in the process of mastering a skill or body of knowledge.[14] Some teachers keep journals or other records of the strategies they develop and use in particular situations and then reuse these strategies as needed.[15]

Conduct your own research regarding questions and issues at your own school.

In their day-to-day work with students, teachers sometimes encounter problems that researchers haven't previously addressed. In **action research**, teachers conduct systematic studies of issues in their own schools, with the goal of seeking more effective strategies in working with students.[16] For instance, an action research project might involve examining the effectiveness of a new teaching technique, seeking students' opinions about a controversial school policy, or ascertaining reasons why many students rarely complete homework assignments.

Many colleges and universities now offer courses in action research. You can also find inexpensive paperback books that provide helpful guidance for novice teacher–researchers.[17]

Learn as much as you can about the culture(s) of the community in which you are working.

In Cultural Considerations boxes, I'll describe numerous ways in which children from diverse cultural groups may think and behave differently than *you* did as a child. But a textbook can offer only a sampling of the many cultural differences you may encounter. You can become more informed about students' cultural beliefs and practices if you participate in local community activities and converse frequently with parents and other community members.[18]

Continually reflect on and critically examine your assumptions, inferences, and teaching practices.

One important goal of education is to nurture students' critical thinking abilities. Yet teachers must think critically as well, both about why students might be behaving in particular ways and achieving at particular levels and also about how current classroom practices might be influencing students' behavior and achievement. Effective teachers engage in **reflective teaching**: They continually examine and critique their assumptions, inferences, and instructional practices, and they regularly adjust their beliefs and strategies in light of new evidence.[19]

Communicate and collaborate with colleagues.

Good teachers rarely work in isolation. Instead, they frequently communicate with colleagues in their own school district and across the nation—perhaps with colleagues in other countries as well—and effective teachers at any single school regularly coordinate their efforts to enhance students' learning and personal well-being.[20] Thanks to both teacher lounges and the Internet, communication with professional colleagues is often quick and easy. One especially helpful website is www.tappedin.org, an online community of educators from around the world.

pedagogical content knowledge Knowledge about effective methods of teaching a specific topic or content area.

action research Research conducted by teachers and other school personnel to address issues and problems in their own schools or classrooms.

reflective teaching Regular, ongoing examination and critique of one's assumptions and instructional strategies, and revision of them as necessary to enhance students' learning and development.

[12] Borko & Putnam, 1996; Cochran & Jones, 1998; H. C. Hill et al., 2008; Windschitl, 2002.
[13] Cochran & Jones, 1998; Krauss et al., 2008; L. S. Shulman, 1986.
[14] Borko & Putnam, 1996; D. C. Smith & Neale, 1991.
[15] Berliner, 1988.
[16] Cochran-Smith & Lytle, 1993; G. E. Mills, 2007.
[17] For example, see Craig, 2009; Mertler, 2009; G. E. Mills, 2007; Stringer, 2008.
[18] Castagno & Brayboy, 2008; National Research Council, 2000; Rogoff, 2003.
[19] Hammerness, Darling-Hammond, & Bransford, 2005; T. Hogan, Rabinowitz, & Craven, 2003; Larrivee, 2006.
[20] Bransford, Darling-Hammond, et al., 2005; Raudenbush, 2009.

Keep in mind that even the most masterful of teachers had to begin their teaching careers as novices, and they probably entered their first classroom with the same concerns and uncertainties that you may initially have. Most experienced teachers will be quite willing to offer you advice and support during challenging times. In fact, they'll probably be flattered that you've asked them!

Believe that you can make a difference in students' lives.

It is important to have high **self-efficacy**—that is, of believing oneself capable of executing certain behaviors or reaching certain goals. Students are more likely to try to learn something if they have confidence that they can learn it. But teachers, too, must have high self-efficacy about what they can accomplish. Students who achieve at high levels are apt to be those whose teachers have confidence in what *they* can do, both individually and collectively, for their students.[21] And, in fact, high-quality instruction and teacher–student relationships can have a huge impact on students' academic success and personal well-being.[22]

• Strategies for Learning and Studying Effectively

As I've written the book, I've included many features that will, I hope, help you read about, study, and apply what researchers have learned about learning, development, motivation, and effective classroom practices. For example, I present key principles and strategies—the Big Ideas of educational psychology—as boldfaced sentences that begin new sections. I present even bigger, more general ideas—which I call Mega-Ideas—at the beginning of each chapter and then return to them in a chapter summary. In addition, the opening case studies and the figures, tables, exercises, concrete examples, and margin questions interspersed throughout the book are all designed to enhance your understanding and memory of what you're reading.

Yet ultimately, how much you learn from the book is up to you. In the next three chapters you'll learn a great deal about how human beings—including you—typically think about, learn, and remember things, and I hope you'll become a better student after reading them. But I'd like to get you off to a good start by offering four general strategies you can use as you read and study this book.

Relate what you read to things you already know.

Try to connect the ideas you read in the book with things you already know and believe. For example, relate new concepts and principles to your past experiences, your previous coursework, or your general knowledge about people and their behaviors. I'll occasionally assist you in this process by asking questions that encourage you to reflect on your prior experience, knowledge, and beliefs.

Be careful, however. As my earlier OOPS test may already have shown you, some of what you currently "know" and believe may be sort-of-but-not-quite accurate or even downright *in*accurate. As you read this book, then, think about how some ideas and research findings may actually contradict your current beliefs. In such instances I hope you'll revise your understanding of the topic at hand. That is, I hope you'll undergo *conceptual change*.

Tie abstract concepts and principles to concrete examples.

Children become increasingly able to think about abstract ideas as they get older, but people of *all* ages can more readily understand and remember abstract information if they tie it to concrete objects and events. Thus I will often illustrate new concepts and principles with opening case studies or brief vignettes that describe specific student and teacher behaviors in classroom settings. In addition, I will occasionally ask

self-efficacy Belief that one is capable of executing certain behaviors or reaching certain goals.

[21] Brophy, 2006; J. A. Langer, 2000; Skaalvik & Skaalvik, 2008; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998.

[22] Hattie, 2009; Raudenbush, 2009.

you to view certain videos in MyEducationLab, the online course that accompanies the book. I'll signal such requests with an icon like the one shown in the margin. Seeing psychological concepts and principles in action in the videos can enhance your understanding of them and help you recognize them when you see them in your own work with children and adolescents.

Sometimes it's even better to see a concept or principle in action in *oneself.* Thus I will occasionally ask you to relate a concept or principle to your own past experiences as a student. In some instances I will actually *give* you illustrative experiences in the form of See for Yourself exercises. You've completed one of these exercises—the OOPS test—already and will encounter many additional ones throughout the book.

View Video Examples in the Book-Specific Resources section of MyEducationLab to help you tie concepts and theories of educational psychology to real children, adolescents, and classroom practices.

Elaborate on what you read, going beyond it and adding to it.

Earlier I described the benefits of elaboration—embellishing on new information in some way—for learning and memory. So try to think *beyond* the things you read. Draw inferences from the ideas presented. Generate new examples of concepts. Identify your own educational applications of various principles of learning, development, and motivation.

? How often do you elaborate while reading your textbooks? Do you learn and remember information more effectively when you elaborate on what you're reading?

Periodically check yourself to make sure you remember and understand what you've read.

There are times when even the most diligent students don't concentrate on what they're reading—when they're actually thinking about something else as their eyes go down the page. So stop once in a while (perhaps once every two or three pages) to make sure you've really learned and understood the things you've been reading. Try to summarize the material. Ask yourself questions about it. Make sure everything makes logical sense to you.

Find several study aids in the Book-Specific Resources in MyEducationLab—including focus questions, self-check quizzes, and practice exercises—that can help you monitor your comprehension. Also, find additional suggestions for reading and studying in the supplementary reading "General Study Tips" in Chapter 1 of the Book-Specific Resources.

SUMMARY

Following are the Mega-Ideas for this chapter.

- ***Effective teachers use research findings and research-based theories to make decisions about instruction, classroom management, and assessment practices.*** Effective classroom practices are *learner-centered*—that is, they're chosen with students' current abilities, understandings, behaviors, and needs in mind. Effective classroom practices are also *evidence-based*—that is, they encompass strategies that research has consistently shown to bring about significant gains in students' development, academic achievement, and personal well-being. As researchers learn more and more about how things are (qualitative studies and descriptive quantitative studies), what variables are associated with one another (correlational studies), and what events cause what outcomes (experimental studies), they gradually develop and continually modify theories that integrate and explain their findings. Teachers can—and *should*—draw on research findings and well-supported theories about children's learning and development in their day-to-day and long-term instructional decision making.

- ***Effective teachers continually work to enhance their professional knowledge and skills.*** As a teacher, you must think of yourself as a life-long learner who always has new things to discover about effective educational practices, the subject matter you teach, and the out-of-school environments and cultures in which your students live. Some of these things you can learn about through books, professional journals, advanced coursework, the Internet, and consultations with colleagues, but others may require immersing yourself in the local community or conducting action research. You must also be willing to reflect on and critically analyze your current assumptions, inferences, and instructional practices—good teachers acknowledge that they can sometimes be wrong, and they adjust their beliefs and strategies accordingly. Most importantly, you must remember that, as a teacher, the many little things you do every day can have a huge impact—either positive or negative—on students' academic and personal success.

- ***Learners read, study, and learn more effectively when they actively try to make sense of new information.*** You can use what you learn about thinking and learning not only to help children and adolescents be successful in the classroom but also to help *you* learn successfully. For example, you should relate new information to what you already know, tie abstract ideas to concrete examples, embellish (elaborate) on what you're learning, and occasionally stop to test yourself on what you've read and studied.

PRACTICE FOR YOUR LICENSURE EXAM

New Software

High school math teacher Mr. Gualtieri begins his class one Monday with an important announcement: "Our school has just purchased a new instructional software program for our computer lab. This program, called 'Problem-Excel,' will give you practice in applying the concepts and procedures we'll be studying this year. I strongly encourage you to stay after school once or twice a week to get extra practice with the software whenever you're having trouble with the assignments I give you."

Mr. Gualtieri is firmly convinced that the new instructional software will help his students better understand and apply mathematics. To test his hypothesis, he keeps a record of which students report to the computer lab after school and which students do not. Later, he looks at how well the two groups of students have performed on his tests and quizzes. Much to his surprise, he discovers that, on average, the students who have stayed after school to use the computer software have gotten *lower* scores than those who haven't used the software. "How can this be?" he puzzles. "Is the computer software actually doing more harm than good?"

1. Constructed-response question

Mr. Gualtieri wonders if the computer software is hurting rather than helping his students. Assume that the software has been carefully designed by an experienced educator and that Mr. Gualtieri's tests and quizzes are good measures of how well his students have learned the material they've been studying. Then:

A. Explain why Mr. Gualtieri cannot draw a conclusion about a cause–and–effect relationship from the evidence he has. Base your response on principles of psychological and educational research.

B. Identify another plausible explanation for the results Mr. Gualtieri has obtained.

2. Multiple-choice question

Which one of the following research findings would provide the most convincing evidence that the Problem-Excel software enhances students' mathematics achievement?

a. Ten high schools in New York City purchase Problem-Excel and make it available to their students. Students at these high schools get higher mathematics achievement test scores than students at 10 other high schools that haven't purchased the software.

b. A high school purchases Problem-Excel, but only four of the eight math teachers at the school decide to have their students use it. Students of these four teachers score at higher levels on a mathematics achievement test than students of the other four teachers.

c. All tenth graders at a large high school take a mathematics achievement test in September. At some point during the next two months, they each spend 20 hours working with Problem-Excel. The students all take the same math achievement test again in December and, on average, get substantially higher scores than they did in September.

d. Students at a high school are randomly assigned to two groups. One group works with Problem-Excel, and the other group works with a software program called "Write-Away," designed to teach better writing skills. The Problem-Excel group scores higher than the Write-Away group on a subsequent mathematics achievement test.

Go to Chapter 1 of the Book-Specific Resources in MyEducationLab and click on "Practice for Your Licensure Exam" to answer these questions. Compare your responses with the feedback provided.

PEARSON myeducationlab

Go to the Topic "Research Methods & Teacher Reflection" in the MyEducationLab (www.myeducationlab.com) for your course, where you can:

- Find learning outcomes for "Research Methods & Teacher Reflection," along with the national standards that connect to these outcomes.
- Complete Assignments and Activities that can help you more deeply understand the chapter content.
- Apply and practice your understanding of the core teaching skills identified in the chapter with the Building Teaching Skills and Dispositions learning units.
- Access video clips of CCSSO National Teachers of the Year award winners responding to the question, "Why Do I Teach?" in the Teacher Talk section.
- Check your comprehension of the content covered in the chapter by going to the Study Plan in the Book Resources for your text. Here you will be able to take a chapter quiz, receive feedback on your answers, and then access Review, Practice, and Enrichment activities to enhance your understanding of chapter content. Flashcards are also available to help you study definitions and key terms.
- Access additional Book Resources, including:
  - Focus Questions to guide your reading, a Practice for Your Licensure Exam exercise that resembles the kinds of questions appearing on many teacher licensure tests, Margin Note Questions that help you connect chapter content to your past experiences or current beliefs, and Supplementary Readings that enable you to pursue certain topics in greater depth.

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Learning, Cognition, and Memory

Learning, Cognition, and Memory

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CHAPTER OUTLINE

MEGA-IDEAS TO MASTER IN THIS CHAPTER

Much of human learning involves a process of actively constructing—not passively absorbing—knowledge.

Knowledge about the brain is helpful, but some well-meaning educators have misinterpreted findings from brain research.

Human memory is a complex, multifaceted information processing system that is, to a considerable degree, under learners' control.

Human memory is fallible: Learners don't remember everything they learn, and sometimes they *mis*remember what they've learned.

Effective teachers help students mentally process new information and skills in ways that facilitate long-term memory storage and retrieval.

CASE STUDY The New World

Rita's fourth-grade class in Michigan recently had a unit on her state's history. Rita still knows little about U.S. history; she will study that subject as a fifth grader next year. Yet she willingly responds when an interviewer asks her if she knows why America was once called the "New World."

Rita: Because they used to live in England, the British, and they didn't know about . . . they wanted to get to China 'cause China had some things they wanted. They had some cups or whatever—no, they had furs. They had fur and stuff like that and they wanted to have a shorter way to get to China so they took it and they landed in Michigan, but it wasn't called Michigan. I think it was the British that landed in Michigan and they were there first and so they tried to claim that land, but it didn't work out for some reason so they took some furs and brought them back to Britain and they sold them, but they mostly wanted it for the furs. So then the English landed there and they claimed the land and they wanted to make it a state, and so they got it signed by the government or whoever, the big boss, then they were just starting to make it a state so the British just went up to the Upper Peninsula and they thought they could stay there for a little while. Then they had to fight a war, then the farmers, they were just volunteers, so the farmers went right back and tried to get their family put together back again.

Interviewer: Did you learn all this in state history this year?

Rita: Um hum.[1]

- Which parts of Rita's response accurately describe the history of the New World? Which parts are clearly inaccurate?
- At the time British colonists were first settling in Michigan, merchants in England were seeking a new trade route to the Far East so they could more easily secure the tea, spices, and silk available there. Why might Rita initially suggest that the British wanted to get cups from China? Why might she then say that they wanted to get furs?

[1] VanSledright & Brophy, 1992, p. 849.

Rita has certainly learned some facts about her state and its history. For example, she's aware that part of Michigan is called the Upper Peninsula, and she knows that many of the state's early European settlers were British. But she has used what she's learned to weave a tale that could give a historian heart failure. To some extent, Rita's lack of information about certain other things is limiting her ability to make sense of what she's learned about Michigan's history. Specifically, Rita doesn't know that the British and the English were the *same people.* Thinking of them as two different groups, she assumes that the arrival of the latter group drove the former group to the Upper Peninsula. Occasionally, what Rita *does* know is also a

learning Long-term change in mental representations or associations due to experience.

source of difficulty. For instance, she apparently associates China with dinnerware (including cups), and she has learned that some early European explorers sought exotic animal furs to send back to their homeland. She uses such information to draw logical but incorrect inferences about why the British were so eager to find a new route to China.

To understand how children and adolescents acquire understandings about their physical and social worlds, about academic subject matter, and about themselves as human beings, we must first understand the nature of learning. As Rita's depiction of Michigan's history clearly illustrates, learning is often a matter of creating, rather than absorbing, knowledge about the world. In other words, learning is a *constructive process,* as we shall see now.

• Learning as a Constructive Process

A good general definition of **learning** is this one: a long-term change in mental representations or associations due to experience. Let's divide this definition into its three parts. First, learning is a *long-term change* in that it isn't just a brief, transitory use of information—such as remembering a phone number only long enough to dial it—but it doesn't necessarily last forever. Second, learning involves *mental representations or associations* and so presumably has its basis in the brain. Third, learning is a change *due to experience,* rather than the result of physiological maturation, fatigue, alcohol or drugs, or onset of mental illness.

Psychologists have been studying the nature of learning for more than a century, and in the process they've taken a variety of theoretical perspectives. Table 2.1 summarizes five diverse perspectives that will contribute considerably to our understanding of what learning involves. The table also lists examples of theorists associated with each perspective. You'll find many of these theorists cited in footnotes in this chapter.

THEORETICAL PERSPECTIVES

TABLE 2.1 General Theoretical Approaches to the Study of Learning

Theoretical Perspective	General Description	Examples of Prominent Theorists	
Behaviorism	Behaviorists argue that because thought processes cannot be directly observed and measured, it is difficult to study thinking objectively and scientifically. Instead, they focus on two things that researchers *can* observe and measure: people's behaviors (*responses*) and the environmental events (*stimuli, reinforcement*) that precede and follow those responses. Learning is viewed as a process of acquiring and modifying associations among stimuli and responses, largely through a learner's direct interactions with the environment.	B. F. Skinner Edward Thorndike Ivan Pavlov *A supplementary reading on Skinner's theory appears in Chapter 3 of the Book-Specific Resources section in MyEducationLab.*	
Social Cognitive Theory	Historically social cognitive theorists have focused largely on the ways in which people learn from observing one another. Environmental stimuli affect behavior, but cognitive processes (e.g., *awareness* of stimulus–response relationships, *expectations* about future events) also play a significant role. Oftentimes people learn through *modeling:* They watch and imitate what others do. Whether people learn and perform effectively is also a function of their *self-efficacy,* the extent to which they believe they can successfully accomplish a particular task or activity. As social cognitive theory has evolved over time, it has increasingly incorporated the concept of *self-regulation,* in which people take charge of and direct their own actions.	Albert Bandura Dale Schunk Barry Zimmerman	

(continued)

Theoretical Perspective	General Description	Examples of Prominent Theorists	Where You Will See This Perspective in the Book
Information Processing Theory	While not denying that the environment plays a critical role in learning, information processing theorists concern themselves with what goes on *inside* learners, focusing on the cognitive processes involved in learning, memory, and performance. From observations of how people execute various tasks and behave in various situations, these theorists draw inferences about how people may perceive, interpret, and mentally manipulate information they encounter in the environment. They speculate about what internal mechanisms underlie human cognition (e.g., *working memory* and *long-term memory*) and about how people mentally process information (e.g., through *elaboration* and *visual imagery*). Initially, some information processing theorists believed that human thinking is similar to how a computer works (hence, they borrowed terms such as *encoding, storage,* and *retrieval* from computer lingo), but in recent years many theorists have abandoned the computer analogy.	Richard Atkinson Richard Shiffrin John Anderson Alan Baddeley Elizabeth Loftus	Information processing theory is most evident in the model of human memory presented in Figure 2.5; this model provides the basis for much of the discussion of learning and memory in this chapter.
Constructivism	Constructivists, like information processing theorists, concern themselves with internal aspects of learning. They propose that people create (rather than absorb) knowledge from their observations and experiences. They suggest that people combine much of what they learn into integrated bodies of knowledge and beliefs (e.g., these might take the form of *schemas* and *theories*) that may or may not be accurate, useful understandings of the world. Some constructivists focus on how individual learners create knowledge through their interactions with the environment; this approach is known as **individual constructivism**. Others emphasize that by working together, two or more people can often gain better understandings than anyone could gain alone; this approach is called **social constructivism**.	Jean Piaget Jerome Bruner John Bransford Giyoo Hatano *A supplementary reading on Piaget's theory appears in Chapter 5 of the Book-Specific Resources section in MyEducationLab.*	Constructivist ideas are intermingled with information processing theory throughout this chapter, and in fact many contemporary information processing theorists have a constructivist bent.
Sociocultural Theory	Sociocultural theorists emphasize that the social, cultural, and historical contexts in which children grow up have profound influences on thinking, learning, and effective instructional practice. In social interactions within their communities, young learners encounter culturally appropriate ways of thinking about and interpreting objects and events. With time and practice, these ways of thinking—which are first used in a social context—are gradually *internalized* into nonspoken, mental processes that learners use on their own. Because of their varying environments, historical circumstances, and needs, children in different cultures acquire somewhat different ways of thinking, learning, and teaching.	Lev Vygotsky Barbara Rogoff Mary Gauvain Jean Lave *A supplementary reading on Vygotsky's theory appears in Chapter 5 of the Book Specific Resources section in MyEducationLab.*	

For the most part, diverse perspectives of learning complement rather than contradict one another, and together they can give us a rich, multifaceted picture of human learning. As we explore the nature of learning in this book, then, we'll draw useful ideas from all five perspectives. In this chapter, however, we'll be looking primarily at what goes on *inside* the learner, and so we will find the information processing and constructivist approaches most helpful.

individual constructivism Theoretical perspective that focuses on how people as individuals, construct meaning from their experiences.

social constructivism Theoretical perspective that focuses on people's collective efforts to impose meaning on the world.

Several basic principles, described in the following sections, underlie much of what information processing and constructivist theorists have learned about learning.

By the time they reach school age, young learners are usually actively involved in their own learning.

Sometimes children learn from an experience without really giving the experience much thought. For example, as infants and toddlers acquire the basic vocabulary and syntax of their first language, they seem to do so without consciously trying to acquire these things or thinking about what they're learning. Much of the learning that occurs during infancy and toddlerhood is *implicit learning*, and even older children and adults continue to learn some things about their environments in a nonintentional, "thoughtless" way.[2] But as children grow, they increasingly engage in intentional, *explicit learning:* They actively think about, interpret, and reconfigure what they see and hear in their environment. As a simple example, try the following exercise.

SEE FOR YOURSELF Remembering Words

Study the 12 words below. Then cover up the page, and write down the words in the order they come to mind.

daisy	apple	dandelion
hammer	pear	wrench
tulip	pliers	watermelon
banana	rose	screwdriver

In what order did you remember the words? Did you recall them in their original order, or did you rearrange them somehow? If you're like most people, you grouped the words into three categories—flowers, fruit, and tools—and remembered one category at a time. In other words, you *organized* the words. As children get older, they're more likely to organize what they learn, and learners of all ages learn more effectively when they organize the subject matter at hand.

Cognitive processes influence what is learned.

The various ways in which people think about what they're seeing, hearing, studying, and learning are collectively known as **cognition**. The more specific things people do in their heads—which can have a profound effect on what they learn and can remember—are called **cognitive processes**.

An example of a cognitive process is **encoding**, in which a learner changes or adds to incoming information in some way in order to remember it more easily. For example, in the preceding "Remembering Words" exercise, chances are that you imposed a categorical structure on the words. But let's consider some alternative strategies you might have used to encode and remember the list. For instance, you might have created a story or poem that included all 12 words (e.g., "As *Daisy* and *Tulip* were walking, they ran across *Dandy* and *Rose.* They stopped in dismay when they noticed that Dandy had *pliers* on her nose . . ."). Or you might have formed a mental image of the 12 items in an elaborate, if not entirely edible, fruit salad (see Figure 2.1). All of these approaches are forms of encoding the 12-word list.

cognition Various ways of thinking about information and events.

cognitive process Particular way of mentally responding to or thinking about information or an event.

encoding Changing the format of information being stored in memory in order to remember it more easily.

[2] P. A. Alexander, Schallert, & Reynolds, 2009; S. W. Kelly, Burton, Kato, & Akamatsu, 2001.

Learners must be selective about what they focus on and learn.

People are constantly bombarded with information. Consider the many stimuli you're encountering at this very moment. How many separate stimuli appear on the two open pages of your book? How many objects do you see in addition to the book? How many sounds are reaching your ears? How many objects—perhaps on your fingertips, on your toes, or around your waist—do you feel? I suspect that you've been ignoring most of these stimuli until just now; you weren't actively processing them until I asked you to do so. People can handle only so much information at any one time, and so they must be selective. Effective learners focus on what they think is important and ignore almost everything else.

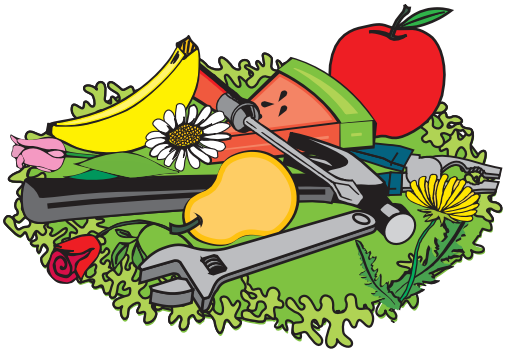


FIGURE 2.1 A visual image for encoding a list of 12 words

As an analogy, consider the hundreds of items a typical adult receives in the mail each year, including all the packages, letters, bills, brochures, catalogs, credit card offers, and donation requests. Do you open, examine, and respond to every piece of mail? Probably not. If you're like me, you "process" only a few key items (e.g., packages, letters, bills, and a few miscellaneous things that catch your eye). You may inspect other items long enough to know that you don't need them. You may discard some items without even opening them.

People don't always make good choices about what to attend to, of course. Just as they might overlook a small, inconspicuous rebate check while opening a colorful "You May Already Have Won . . ." sweepstakes announcement, so, too, might they fail to catch an important idea in a classroom lesson because they're focusing on trivial details in the lesson or on a classmate's attention-getting behavior across the room. An important job for teachers, then, is to help students understand what is most important to learn and what can reasonably be cast aside as "junk mail."

Learners create (rather than receive) knowledge.

As was apparent in Rita's depiction of Michigan's history, learning isn't simply a process of absorbing information from the environment. Rather, it's a process of *making*—actively and intentionally constructing—knowledge and understandings.[3] As an example, try the following exercise.

SEE FOR YOURSELF Rocky

Read the following passage *one time only:*

> Rocky slowly got up from the mat, planning his escape. He hesitated a moment and thought. Things were not going well. What bothered him most was being held, especially since the charge against him had been weak. He considered his present situation. The lock that held him was strong but he thought he could break it. He knew, however, that his timing would have to be perfect. Rocky was aware that it was because of his early roughness that he had been penalized so severely—much too severely from his point of view. The situation was becoming frustrating; the pressure had been grinding on him for too long. He was being ridden unmercifully. Rocky was getting angry now. He felt he was ready to make his move. He knew that his success or failure would depend on what he did in the next few seconds.[4]

Now summarize what you've just read in two or three sentences.

[3] For example, see Brainerd & Reyna, 2005; Neisser, 1967; Segalowitz, 2007.

[4] R. C. Anderson, Reynolds, Schallert, & Goetz, 1977, p. 372.

Were you able to make sense of the passage? What did you think it was about? A prison escape? A wrestling match? Or perhaps something else altogether? The passage includes a number of facts but leaves a lot unsaid. For instance, it tells us nothing about where Rocky was, what kind of "lock" was holding him, or why timing was important. Yet you were probably able to use the information you were given to construct an overall understanding of Rocky's situation. Most people do find meaning of one sort or another in the passage.

This active sense-making process—what theorists sometimes refer to as *constructing meaning*—is hardly limited to verbal material. For another example, try the following exercise.

SEE FOR YOURSELF Three Faces

Look at the three pictures in Figure 2.2. What do you see in each one? Most people perceive the picture on the left as being that of a woman, even though many of her features are missing. Enough features are visible—an eye and parts of her nose, mouth, chin, and hair—that you can construct a meaningful perception from them. Do the other two pictures provide enough information to enable you to construct two more faces? Constructing a face from the figure on the right may take you a while, but it can be done.

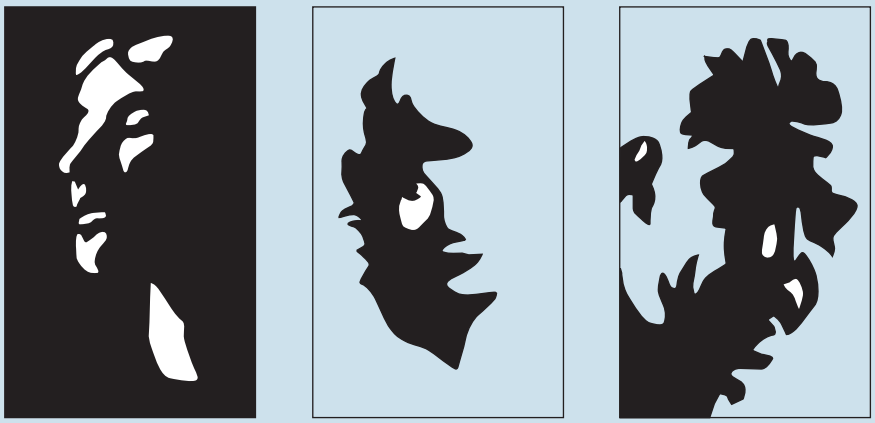


FIGURE 2.2 Can you construct a person from each of these pictures?
Source: From "Age in the Development of Closure Ability in Children," by C. M. Mooney, 1957, *Canadian Journal of Psychology, 11*, p. 220. Copyright 1957. Canadian Psychological Association. Reprinted with permission.

Objectively speaking, the three configurations of black splotches in Figure 2.2, and especially the two rightmost ones, leave a lot to the imagination. For example, the woman in the middle is missing half of her face, and the man on the right is missing the top of his head. Yet knowing how human faces typically appear is probably enough to enable you to add the missing features (mentally) and perceive complete pictures. Curiously, once you've constructed faces from the figures, they then seem obvious. If you were to close this book now and not pick it up again for a week or more, you would probably see the faces almost immediately, even if you had had considerable difficulty perceiving them originally.

Skillful readers typically skip some of the words on the page and yet accurately understand what they read. How is this possible? (Compare your response to this question with the response presented in Chapter 2 of the Book-Specific Resources in MyEducationLab.)

Learners use what they already know and believe to help them make sense of new experiences.

In the "Rocky" and "Three Faces" exercises you just did, you were able to make sense of situations even though a lot of information was missing. Your prior knowledge—perhaps about typical prison escapes or wrestling matches and certainly about how human facial features are arranged—allowed you to fill in many missing details. Prior knowledge and beliefs usually play a major role in the meanings people construct.

On many occasions different people construct different meanings from the same situation, in part because they each bring unique prior experiences and knowledge to the situation. For example, when the "Rocky" passage was used in an experiment with college students, physical education majors frequently interpreted it as a wrestling match, but music education majors (most of whom had little or no knowledge of wrestling) were more likely to think it was about a prison break.[5] Not only do learners bring different areas of expertise to a learning task, but they also bring different childhood experiences, cultural backgrounds, and assumptions about the world, and such differences are apt to have a significant impact on how they interpret new information.

The brain is, of course, the place where human beings think about, make sense of, and learn from their environment. We now look briefly at what the brain is like and how it functions.

Thinking and Learning in the Brain

The brain is an incredibly complicated mechanism that includes several *trillion* cells. About one hundred billion of them are nerve cells—**neurons**—that are microscopic in size and interconnected in innumerable ways. Some neurons receive information from the rest of the body, others synthesize and interpret the information, and still others send messages that tell the body how to respond to its present circumstances. Curiously, neurons don't actually touch one another. Instead, they use a variety of chemical substances to send chemical messages across the tiny spaces—**synapses**—between them. Any single neuron may have synaptic connections with hundreds or even thousands of other neurons.[6]

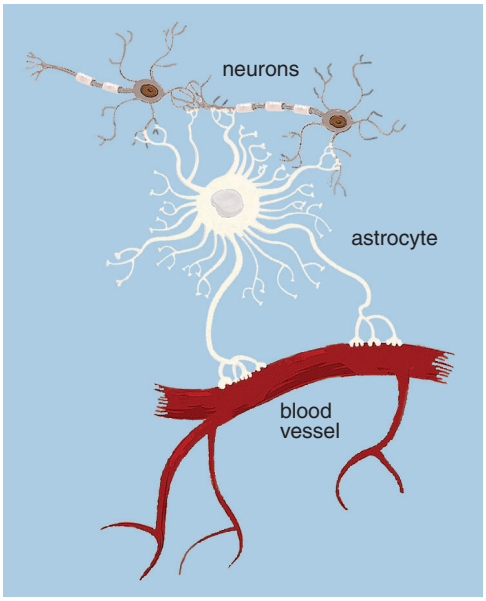


FIGURE 2.3 Two neurons, an astrocyte, and their interconnections

Accompanying neurons are perhaps one to five trillion *glial cells,* which serve a variety of specialized functions. Some act as clean-up crew for unwanted garbage, others are "nutritionists" that control blood flow to neurons or "doctors" that tend to infections and injuries, and still others provide a substance known as *myelin* that enhances the efficiency of many neurons. And certain glial cells—star-shaped ones known as **astrocytes**—seem to be intimately involved in learning and memory (more about this point shortly).[7] Figure 2.3 can give you a sense of what neurons and astrocytes look like.

The brain changes in important ways over the course of childhood and adolescence. Yet three basic points about the brain are important to keep in mind as we explore cognition and learning in this chapter.

The various parts of the brain work closely with one another.

Groups of neurons and glial cells in different parts of the brain seem to specialize in different things. Structures in the lower and middle parts of the brain specialize in essential physiological processes (e.g., breathing, heart rate), body movements (e.g., walking, riding a bicycle), and basic perceptual skills (e.g., coordinating eye movements, diverting attention to potentially life-threatening stimuli). Complex thinking, learning, and knowledge are located primarily in the upper and outer parts of the brain collectively known as the **cortex**, which rests on the top and sides of the brain like a thick, bumpy toupee (see Figure 2.4). The portion of the cortex located near the forehead, known as the *prefrontal cortex,* is largely responsible for a wide variety of distinctly human activities, including sustained attention, reasoning, planning, decision making, coordinating complex activities, and inhibiting nonproductive thoughts and behaviors. Other parts of the cortex are important as well, being actively involved in interpreting visual and auditory information, identifying the spatial characteristics of objects and events, and keeping track of general knowledge about the world.

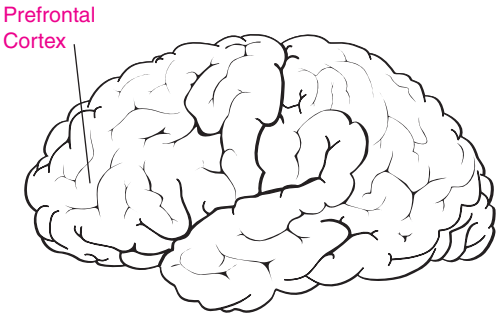


FIGURE 2.4 Cortex of the human brain

neuron Cell in the brain or another part of the nervous system that specializes in transmitting information to other cells.

synapse Tiny space across which one neuron regularly communicates with another; reflects an ongoing but modifiable connection between the two neurons.

astrocyte Star-shaped brain cell hypothesized to be involved in learning and memory; has chemically mediated connections with many other astrocytes and with neurons.

cortex Upper and outer parts of the human brain, which are largely responsible for conscious and complex cognitive processes.

[5] R. C. Anderson et al., 1977.
[6] C. S. Goodman & Tessier-Lavigne, 1997; Lichtman, 2001; Mareschal et al., 2007.
[7] Koob, 2009; Oberheim et al., 2009; Verkhratsky & Butt, 2007.

To some degree, the left and right halves of the cortex—its two *hemispheres*—have different specialties.[8] For most people, the left hemisphere takes primary responsibility for language and logical thinking, whereas the right hemisphere is more dominant in visual and spatial tasks. Yet contrary to popular belief, people rarely if ever think exclusively in one hemisphere. There is no such thing as "left-brain" or "right-brain" thinking: The two hemispheres constantly collaborate in day-to-day tasks. In fact, learning or thinking about virtually anything tends to be *distributed* across many parts of the brain. A task as seemingly simple as identifying a particular word in speech or print involves numerous areas of the cortex.[9]

Most learning probably involves changes in neurons, astrocytes, and their interconnections.

From a physiological standpoint, how and where does learning occur? Historically, many theorists and researchers have believed that the physiological basis for most learning lies in changes in the interconnections among neurons. In particular, learning may involve strengthening existing synapses or forming new ones.[10] In some instances, however, learning may actually involve *eliminating* synapses. Effective learning requires not only that people think and do certain things but also that they *not* think or do other things—in other words, that they inhibit tendencies to think or behave in particular ways.[11]

Recently some researchers have begun to speculate that astrocytes are just as important as—possibly even more important than—neurons in learning and memory. In humans, astrocytes outnumber neurons by at least 10 to 1—a ratio much larger than that for, say, mice and rats—and they have innumerable chemically mediated connections with one another and with neurons. Astrocytes appear to have some control over what neurons do and don't do and how much neurons communicate with one another.[12]

Many new astrocytes form throughout our lifetimes.[13] Some new neurons form throughout life as well, especially in the *hippocampus* (a small, seahorse-shaped structure in the middle of the brain) and possibly also in certain areas of the cortex.[14] Learning experiences seem to stimulate the formation of new brain cells, but exactly how these new cells are related to learning and memory is still unclear.[15]

As for *where* learning occurs, the answer is: many places. The prefrontal cortex is active when people must pay attention to and think about new information and events, and all of the cortex may be active to a greater or lesser extent in interpreting new input in light of previously acquired knowledge.[16] The hippocampus also seems to be a central figure in learning, in that it pulls together the information it simultaneously receives from various parts of the brain.[17]

Knowing how the brain functions and develops tells us only so much about learning and instruction.

Recent research on the human brain has given us helpful insights into the course of cognitive development and the neurological bases of certain disabilities (e.g., dyslexia, autism spectrum disorders).[18] Yet even as researchers pin down how and where learning occurs, current knowledge of brain physiology doesn't begin to tell us everything we need to know about learning or how to foster it. For instance, brain research can't tell us much about what information and skills are most important for people to have in a particular

[8] Byrnes, 2001; R. Ornstein, 1997; T. Roberts & Kraft, 1987; M. S. C. Thomas & Johnson, 2008.
[9] Bressler, 2002; Huey, Krueger, & Grafman, 2006; Posner & Rothbart, 2007.
[10] Byrnes & Fox, 1998; Greenough, Black, & Wallace, 1987; Merzenich, 2001; C. A. Nelson, Thomas, & de Haan, 2006.
[11] Bruer & Greenough, 2001; Byrnes, 2001; Dempster, 1992; Haier, 2001.
[12] Koob, 2009; Oberheim et al., 2009; Verkhratsky & Butt, 2007.
[13] Koob, 2009.
[14] Gould, Beylin, Tanapat, Reeves, & Shors, 1999; C. A. Nelson et al., 2006; Sapolsky, 1999.
[15] Most newly acquired information and skills seem to need some time to "firm up" in the brain—a process called *consolidation.* An event that interferes with this consolidation (e.g., a serious brain injury) may cause a learner to forget things that happened several seconds, minutes, days, or months prior to the event; see Rasch & Born, 2008; Wixted, 2005.
[16] Byrnes, 2001; Huey et al., 2006.
[17] Bauer, 2002; Squire & Alvarez, 1998.
[18] Tager-Flusberg, 2007; Varma, McCandliss, & Schwartz, 2008.

community and culture.[19] Nor does it provide many clues about how teachers can best help their students acquire important information and skills.[20] In fact, educators who speak of "using brain research" or "brain-based learning" are, in most instances, actually talking about what psychologists have learned from studies of human *behavior* rather than from studies of brain anatomy and physiology.

By and large, if we want to understand the nature of human cognition and identify effective ways of helping children and adolescents learn more effectively, we must look primarily at what psychologists, rather than neurologists, have discovered.[21] We begin our exploration of cognitive processes by looking at what psychologists have learned about human memory.

How Human Memory Operates

The term **memory** refers to learners' ability to mentally "save" newly acquired information and behaviors. In some cases we'll use the term to refer to the actual process of saving knowledge or skills for a period of time. In other instances we'll use it to talk about a particular "location" where knowledge is held. For instance, we will soon be talking about two components of the human memory system known as *working memory* and *long-term memory.*

The process of "putting" something into memory is called **storage**. Just as you might store groceries in a kitchen cabinet, so, too, do you store newly acquired knowledge in your memory. At some later time, you may find that you need to use what you've learned. The process of remembering previously stored information—that is, "finding" it in memory—is **retrieval**. The following exercise illustrates the retrieval process.

SEE FOR YOURSELF Retrieval Practice

See how quickly you can answer each of the following questions:

1. What is your name?
2. What is the capital of France?
3. In what year did Christopher Columbus first sail across the Atlantic Ocean to reach the New World?
4. What did you have for dinner three years ago today?
5. When talking about serving appetizers at a party, people sometimes use a French term instead of the word *appetizer.* What is that French term, and how is it spelled?

As you probably noticed when you tried to answer these questions, retrieving some information from memory (e.g., your name) is an easy, effortless process. But other things can be retrieved only after some thought and effort. For example, it may have taken you a few seconds to recall that the capital of France is Paris and that Columbus first sailed across the Atlantic in 1492. Still other pieces of information—even though you certainly stored them in memory at one time—may be almost impossible to retrieve. Perhaps a dinner menu three years ago and the correct spelling of *hors d'oeuvre* fall into this category.

As you might guess from the preceding discussion of the brain, human memory is a very complex, multifaceted mechanism that is still somewhat of a mystery. But many psychologists have found it helpful to think of the human memory system as having three general components that hold information for different lengths of time (see Figure 2.5).[22]

[19] L. Bloom & Tinker, 2001; Chalmers, 1996; Gardner, 2000b.
[20] Byrnes, 2001, 2007; R. E. Mayer, 1998.
[21] For a classic article on this topic, see Bruer, 1997.
[22] For example, see R. C. Atkinson & Shiffrin, 1968; Reisberg, 1997; Willingham, 2004.

memory Ability to save something (mentally) that has been previously learned; also, the mental "location" where such information is saved.

storage Process of "putting" new information into memory.

retrieval Process of "finding" information previously stored in memory.

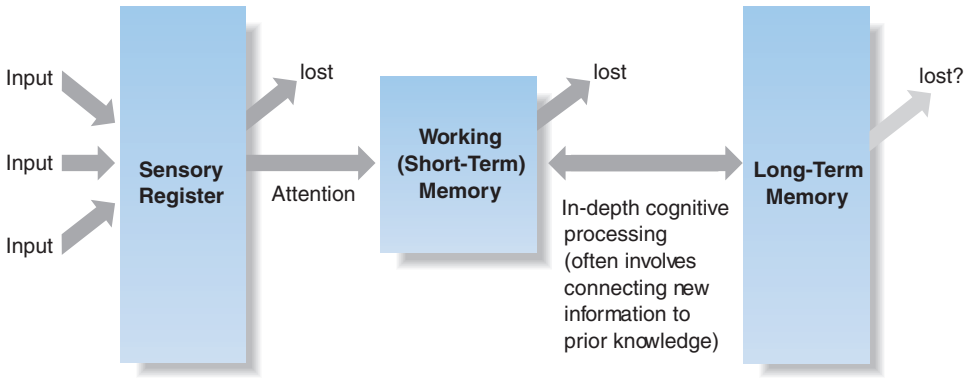


FIGURE 2.5 A model of human memory

Oversimplified as this model undoubtedly is, we can use it in combination with countless research studies to derive some general principles about how human memory operates.

Sensory input stays in a raw form only briefly.

If you have ever played with a lighted sparkler at night, then you've seen the tail of light that follows a sparkler as you wave it about. If you have ever daydreamed in class, then you may have noticed that when you tune back in to a lecture, you can still "hear" the three or four words that were spoken just *before* you started paying attention to your instructor again. The sparkler's tail and the words that linger are not "out there" in the environment. Instead, they are recorded in your sensory register.

The **sensory register** is the component of memory that holds the information you receive—*input*—in more or less its original, *un*encoded form. Much of what your body sees, hears, and otherwise senses is stored in the sensory register. In other words, the sensory register has a *large capacity:* It can hold a great deal of information at one time.

That's the good news. The bad news is that information stored in the sensory register doesn't last very long.[23] Visual information (what you see) probably lasts for less than a second. As a child, I never could spell out my entire first name (Jeanne) with a sparkler; the *J* had always faded before I got to the first *n,* no matter how quickly I wrote. Auditory information (what you hear) probably lasts slightly longer, perhaps for two or three seconds. To keep information for any time at all, then, learners need to move it to *working memory.*

Attention is essential for most learning and memory.

Information received directly from the environment, such as a sparkler's glittery light, doesn't last very long no matter what we do. But we can preserve a memory of it by encoding it in some minimal way—for instance, by interpreting a sparkler's curlicue tail as the letters *Jea.* The first step in this process is **attention**: *Whatever people pay attention to (mentally) moves into working memory.* Information in the sensory register that doesn't get a person's attention typically disappears from the memory system.[24]

Paying attention involves directing not only the appropriate sensory receptors (in the eyes, ears, fingertips, etc.) but also the *mind* toward whatever needs to be learned and remembered. Imagine yourself reading a textbook for one of your classes. Your eyes are moving down each page, but meanwhile you're thinking about something altogether different—a recent argument with a friend, a high-paying job advertised in the newspaper, or your growling stomach. What will you remember from the textbook? Absolutely nothing. Even

Observe David's realization that attention affects memory in the "Memory and Metacognition: Middle Childhood" video in Chapter 2 of the Book-Specific Resources in MyEducationLab. When David says, "My brain was turned off right now," he really means that his *attention* was turned off, or at least not focused on the interviewer's memory task.

sensory register Component of memory that holds incoming information in an unanalyzed form for a very brief time (perhaps one to two seconds).

attention Focusing of mental processes on particular stimuli.

[23] Cowan, 1995; Darwin, Turvey, & Crowder, 1972; Sperling, 1960.

[24] Some nonattended-to information may remain, but without the learner's conscious awareness of it, it may be extremely difficult to recall, especially over the long run; for example, see Cowan, 2007.

though your eyes were focused on the words in your book, you weren't *mentally* paying attention to the words.

Unfortunately, people can attend to only a very small amount of information at any one time. In other words, attention has a *limited capacity.*[25] For example, if you're in a room where several conversations are going on at once, you can usually attend to—and therefore can learn from—only one of the conversations. If you're sitting in front of the television with your textbook open in your lap, you can attend to the *Friends* rerun playing on the TV screen *or* to your book but not to both simultaneously. If, in class, you're preoccupied with your instructor's ghastly taste in clothing and desperate need for a fashion makeover, you'll have a hard time paying attention to the content of the instructor's lecture.

Jim Cummins/Taxi/Getty Images

Children learn effectively only when they pay attention, both physically and mentally, to the subject matter.

Exactly *how* limited is the limited capacity of human attention? People can often perform two or three well-learned, automatic tasks at once. For example, you can walk and chew gum simultaneously, and you can probably drive a car and drink a cup of coffee at the same time. But when a stimulus or event is detailed and complex (as is true for both textbooks and *Friends* reruns) or when a task requires considerable thought (understanding a lecture and driving a car on an icy mountain road are examples of tasks requiring considerable concentration), then people can usually attend to only *one* thing at a time.

Let's return to a point made earlier in the chapter: Learners must be selective about what they focus on and learn. Now we see the reason why: Attention has a limited capacity, allowing only a very small amount of information stored in the sensory register to move on to working memory. The vast majority of information that the body initially receives is quickly lost from the memory system, much as we might quickly discard most of that junk mail we receive every day.

Using what you've just learned about attention, explain why talking on a mobile (cellular) phone while driving is illegal in many places. (Compare your response to this question with the response presented in Chapter 2 of the Book-Specific Resources in MyEducationLab.)

Working memory—where the action is in thinking and learning—has a short duration and limited capacity.

Working memory is the component of memory where attended-to information stays for a short while so that we can make better sense of it. It's also where much of our thinking, or cognitive processing, occurs. It's where we try to understand new concepts presented in a lecture, draw inferences from ideas encountered in a textbook passage, or solve a problem. Basically, this is the component that does most of the mental work of the memory system—hence its name *working* memory.[26]

Information stored in working memory doesn't last very long—perhaps 5 to 20 seconds at most—unless people do something more with it.[27] Accordingly, it is sometimes called *short-term memory.* For example, imagine that you need to call a neighbor, so you look up the neighbor's number in the telephone book. Because you've paid attention to the number, it's presumably in your working memory. But you discover that you can't find your cell phone. You have no paper and pencil handy. What do you do to remember the number until you have access to a telephone?

To keep the number in your memory while you look for a phone, you might simply repeat it to yourself over and over. This process, known as **rehearsal**, keeps information in working memory for as long as you're willing to continue talking to yourself. But once you stop, the number may disappear fairly quickly.

[25] J. R. Anderson, 2005; Cowan, 2007; Reisberg, 1997.
[26] Working memory probably has several components for holding and working with different kinds of information (e.g., visual, auditory, semantic) plus a component that integrates multiple kinds of information; see Alloway, Gathercole, Kirkwood, & Elliott, 2009; Baddeley, 2001; Cowan, Saults, & Morey, 2006; E. E. Smith, 2000.
[27] For example, see Baddeley, 2001; L. R. Peterson & Peterson, 1959.

working memory Component of memory that holds and actively thinks about and processes a limited amount of information for a short time period.

rehearsal Cognitive process in which information is repeated over and over as a possible way of learning and remembering it.

To get a better sense of the nature of working memory, put your own working memory to work for a moment in the following exercise.

SEE FOR YOURSELF A Divisive Situation

Try computing the answer to this division problem *in your head*—put the numbers in your working memory and then *don't peek* as you try to calculate the answer:

$$59\overline{)49{,}383}$$

Did you find yourself having trouble remembering some parts of the problem while you were dealing with other parts? Did you arrive at the correct answer of 837? Most people can't solve a division problem with this many digits unless they write the problem on paper. The fact is, working memory just doesn't have enough space both to hold all that information and to perform mathematical calculations with it. Like attention, working memory has a *limited capacity,* perhaps just enough for a telephone number or very short grocery list.[28] In and of itself, it lets you hold and think about only a very small amount of material at once.

? Did you have these misconceptions about short-term memory before you read this section? If so, have you now revised your understanding?

I sometimes hear students mention putting class material in "short-term memory" so that they can do well on an upcoming exam. Such a statement reflects two common misconceptions: that (1) this component of memory lasts for several days, weeks, or months; and (2) it has a fair amount of "room." Now you know otherwise: Information stored in working memory lasts only a few seconds unless it's processed further, and only a few things can be stored there at one time. Working (short-term) memory is obviously *not* the "place" to leave information you'll need for a class later today, let alone for an exam later in the week. For such memory tasks, storage in long-term memory is in order.

Long-term memory has a long duration and virtually limitless capacity.

Long-term memory is where we store our general knowledge and beliefs about the world, our recollections of past experiences, and things we've learned in school. Such knowledge about *what and how things are* is known as **declarative knowledge**. Long-term memory is also where we store knowledge about how to perform various behaviors, such as how to ride a bicycle, swing a baseball bat, or write a cursive letter *J.* Such knowledge about *how to do things* is known as **procedural knowledge**. When procedural knowledge includes knowing how to respond differently under varying circumstances, it is sometimes called *conditional knowledge.*

Information stored in long-term memory lasts much longer than information stored in working memory—perhaps a day, a week, a month, a year, or a lifetime (more on the "lifetime" point later in the chapter). Even when it's there, however, people can't always find (retrieve) it when they need it. As we'll see in upcoming sections, people's ability to retrieve previously learned information from long-term memory depends on both the way in which they've initially stored it and the context in which they're trying to remember it.

Long-term memory seems to be able to hold as much information as a learner needs to store there. There is probably no such thing as someone "running out of room." In fact, for reasons we'll discover shortly, the more information already stored in long-term memory, the easier it is to learn new things.

long-term memory Component of memory that holds knowledge and skills for a relatively long time.

declarative knowledge Knowledge related to "what is"—that is, to the nature of how things are, were, or will be.

procedural knowledge Knowledge concerning how to do something (e.g., a skill).

Information in long-term memory is interconnected and organized to some extent.

To get a glimpse of how your own long-term memory is organized, try the following exercise.

[28] Awh, Barton, & Vogel, 2007; Baddeley, 2001; Cowan, Chen, & Rouder, 2004; G. A. Miller, 1956; Simon, 1974.

SEE FOR YOURSELF Horse

What's the first word that comes to mind when you see the word *horse?* And what word does that second word remind you of? And what does the third word remind you of? Beginning with the word *horse,* follow your train of thought, letting each word remind you of a new word or short phrase, for a sequence of at least eight words or phrases. Write down the sequence of things that come to mind.

concept Mental grouping of objects or events that have something in common.

schema Tightly organized set of facts about a specific concept or phenomenon.

You probably found yourself easily following a train of thought from the word *horse,* perhaps something like the route I followed:

horse → cowboy → lasso → rope → knot → Girl Scouts → cookies → chocolate

The last word in your sequence might be one with little or no obvious relationship to horses. Yet you can probably see a logical connection between each word or phrase and the one that follows it. Related pieces of information tend to be associated with one another in long-term memory, perhaps in a network similar to the one depicted in Figure 2.6.

In the process of constructing knowledge, learners often create well-integrated entities that encompass particular ideas or groups of ideas. Beginning in infancy, they form **concepts** that enable them to categorize objects and events.[29] Some concepts, such as *butterfly, chair,* and *backstroke,* refer to a fairly narrow range of objects or events (e.g., see Figure 2.7). Other concepts are fairly general ones that encompass numerous more specific concepts. For example, the concept *insect* includes ants, bees, and butterflies. The concept *swimming* includes the backstroke, dog paddle, and butterfly. As you can see, some words (such as *butterfly)* can be associated with two very different, more general concepts (such as *insects* and *swimming)* and so might lead someone to follow a train of thought such as this one:

horse → cowboy → lasso → rope → knot → Girl Scouts → camping
→ outdoors → nature → insect → butterfly → swimming

Learners pull some concepts together into general understandings of what things are typically like. Some of these understandings take the form of **schemas**—tightly organized sets of facts related to particular concepts or phenomena.[30] For example, let's return to our friend the horse. You know what horses look like, of course, and you can recognize one when you see one. Hence, you have a concept for *horse.* But now think about the many things you know *about* horses. What do they eat? How do they spend their time? Where are you most likely to see them? You probably have little difficulty retrieving many facts about horses, perhaps including their fondness for oats and carrots, their love of grazing and running, and their frequent appearance in pastures and at racetracks. The various things you know about horses are closely interrelated in your long-term memory in the form of a "horse" schema.

People have schemas not only about objects but also about events. For example, read the following passage about John.

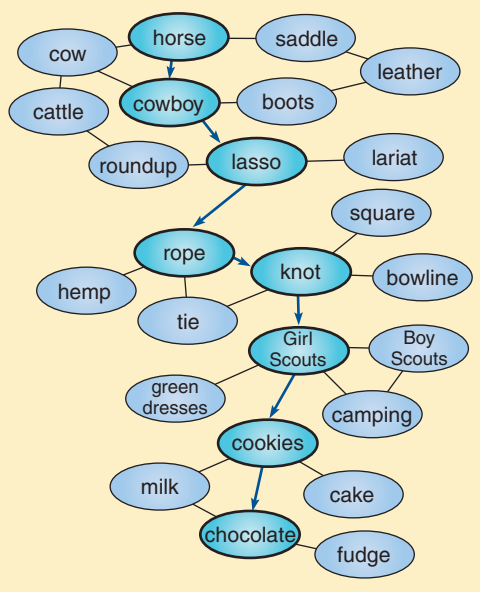


FIGURE 2.6 Related ideas are often associated with one another in long-term memory. Here you see the author's train of thought from *horse* to *chocolate.*

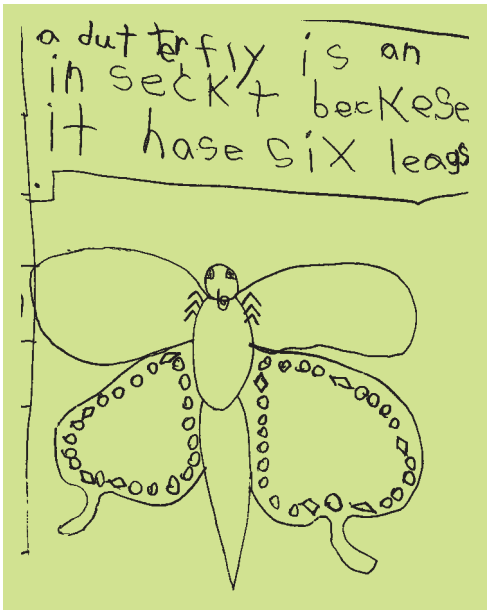


FIGURE 2.7 Eight-year-old Noah depicts organized knowledge related to the concepts *butterfly* and *insect.*

[29] Mandler, 2007; Quinn, 2002.
[30] For example, see Rumelhart & Ortony, 1977; Schraw, 2006; Willingham, 2004.

SEE FOR YOURSELF John

Read the following passage *one time only.*

> John was feeling bad today so he decided to go see the family doctor. He checked in with the doctor's receptionist, and then looked through several medical magazines that were on the table by his chair. Finally the nurse came and asked him to take off his clothes. The doctor was very nice to him. He eventually prescribed some pills for John. Then John left the doctor's office and headed home.[31]

You probably had no trouble making sense of the passage because you have been to a doctor's office yourself and have a schema for how those visits usually go. You can therefore fill in a number of details that the passage doesn't tell you. For example, you probably inferred that John must have *traveled* to the doctor's office, although the story omits this essential step. Likewise, you probably concluded that John took off his clothes in the examination room, *not* in the waiting room, even though the story never makes it clear where John did his striptease. When a schema involves a predictable sequence of events related to a particular activity, such as going to see a doctor, it is sometimes called a **script**.

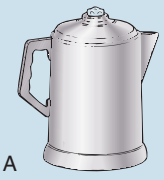
On a much larger scale, human beings—young children included—construct general understandings and belief systems, or **theories**, about how the world operates.[32] People's theories include many concepts and the relationships among them (e.g., frequent co-occurrence, cause–and–effect). To see what some of your own theories are like, try the next exercise.

What is a typical script for a trip to the grocery store? To the movies? To a fast-food restaurant? (Compare your response to this question with the response presented in Chapter 2 of the Book-Specific Resources in MyEducationLab.)

SEE FOR YOURSELF Coffeepots and Raccoons

Consider each of the following situations:

1. People took a coffeepot that looked like Drawing A. They removed the handle, sealed the top, took off the top knob, sealed the opening to the spout, and removed the spout. They also sliced off the base and attached a flat piece of metal. They attached a little stick, cut out a window, and filled the metal container with birdseed. When they were done, it looked like Drawing B.

   
   A

   
   B

   After these changes, was this a coffeepot or a bird feeder?

2. Doctors took the raccoon in Drawing C and shaved away some of its fur. They dyed what was left black. Then they bleached a single stripe all white down the center of the animal's back. Then, with surgery, they put in its body a sac of supersmelly odor, just like the smell a skunk has. After they were all done, the animal looked like Drawing D.


C


D

After the operation, was this a skunk or a raccoon?[33]

script Schema that involves a predictable sequence of events related to a common activity.

theory Integrated set of concepts and principles developed to explain a particular phenomenon; may be constructed jointly by researchers over time (see Chapter 1) or individually by a single learner.

[31] G. H. Bower, Black, & Turner, 1979, p. 190.
[32] Gelman, 2003; Keil, 1989, 1994; Wellman & Gelman, 1998.
[33] Both scenarios based on Keil, 1989, p. 184.

Chances are, you concluded that the coffeepot had been transformed into a bird feeder but that the raccoon was still a raccoon despite its cosmetic makeover and stinky surgery. Now how is it possible that the coffeepot could be made into something entirely different, whereas the raccoon could not? Even young children seem to make a basic distinction between human-made objects (e.g., coffeepots, bird feeders) and biological entities (e.g., raccoons, skunks).[34] For instance, human-made objects are defined largely by the *functions* they serve (e.g., brewing coffee, feeding birds), whereas biological entities are defined primarily by their origins (e.g., the parents who brought them into being, their DNA).[35] Thus, when a coffeepot begins to hold birdseed rather than coffee, it becomes a bird feeder because its function has changed. But when a raccoon is cosmetically and surgically altered to look and smell like a skunk, it still has raccoon parents and raccoon DNA and so cannot possibly *be* a skunk.

By the time children reach school age, they have constructed basic theories about their physical, biological, and social worlds.[36] They have also constructed preliminary theories about the nature of their own and other people's thinking. For instance, they realize that people's inner thoughts are distinct from external reality, and they understand that the people in their lives have thoughts, emotions, and motives that drive much of what they do. In general, self-constructed theories help children make sense of and remember personal experiences, classroom subject matter, and other new information.[37] Yet because children's theories often evolve with little or no guidance from more knowledgeable individuals, they sometimes include erroneous beliefs about the world that can wreak havoc with new learning (more about this point shortly).

How well long-term memory is integrated and in what ways it is integrated are to some degree the result of how learners first store information in long-term memory, as we'll see in our discussion of the next principle.

Some long-term memory storage processes are more effective than others.

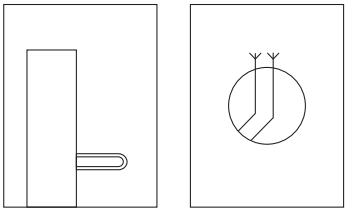
In the memory model presented in Figure 2.5, the arrow between working memory and long-term memory points in both directions. The process of storing new information in long-term memory often involves drawing on "old" information already stored there—that is, it involves using prior knowledge.[38] To see what I mean, try the following exercise.

SEE FOR YOURSELF Two Letter Strings, Two Pictures

1. Study each of the following strings of letters until you can remember them perfectly:

   AIIRODFMLAWRS FAMILIARWORDS

2. Study the two pictures in the margin until you can reproduce them accurately from memory.



Source: Figures from "Comprehension and Memory for Pictures" by G. H. Bower, M. B. Karlin, and A. Dueck, 1975, *Memory and Cognition, 3* p. 217. Reprinted by permission of Psychonomic Society, Inc.

No doubt the second letter string was easier for you to learn because you could relate it to something you already knew: the words *familiar words.* How easily were you able to

[34] Gelman & Kalish, 2006; Inagaki & Hatano, 2006; Keil, 1986, 1989.
[35] Greif, Kemler Nelson, Keil, & Gutierrez, 2006; Inagaki & Hatano, 2006; Keil, 1987, 1989.
[36] Geary, 2005; Torney-Purta, 1994; Wellman & Gelman, 1998.
[37] Gelman, 2003; Reiner, Slotta, Chi, & Resnick, 2000; Wellman & Gelman, 1998.
[38] For a good discussion of this point, see Kirschner, Sweller, & Clark, 2006.

rote learning Cognitive process in which learners try to remember information in a relatively uninterpreted form, with little or no effort to make sense of or attach meaning to it.

meaningful learning Cognitive process in which learners relate new information to things they already know.

learn the two pictures? Could you draw them from memory a week from now? Could you remember them more easily if they had titles such as "a very short man playing a trombone in a telephone booth" and "an early bird who caught a very strong worm"? The answer to the last question is almost certainly *yes,* because the titles help you relate the pictures to familiar shapes, such as those of trombones, telephone booths, and birds' feet.[39]

With the preceding exercise in mind, let's distinguish between two basic types of learning: rote learning and meaningful learning (e.g., see Table 2.2). People engage in **rote learning** when they try to learn and remember something without attaching much meaning to it. This would be the case, for example, if you tried to remember the letter string AIIRODFM-LAWRS without trying to make some kind of "sense" of the sequence—perhaps identifying patterns in the letters or similarities to words you know. You would also be engaging in rote learning if you tried to remember the shapes in the "telephone booth" and "early bird" figures simply by trying to memorize where each line and curve is within each figure.

One common form of rote learning is *rehearsal,* repeating something over and over, perhaps by saying it aloud or perhaps by continuously thinking about it in an unaltered, verbatim fashion. We have already seen that rehearsal can help learners keep information in working memory indefinitely. Unfortunately, however, rehearsal is *not* a very effective way of storing information in *long-term* memory. If learners repeat something often enough, it might eventually "stick," but the process is slow and tedious. Furthermore, for reasons we'll identify later, people who use rehearsal and other forms of rote learning often have trouble remembering what they've learned.[40]

In contrast to rote learning, **meaningful learning** involves recognizing a relationship between new information and something previously stored in long-term memory. Seeing the words *familiar words* in the letter string FAMILIARWORDS and seeing meaningful shapes (a trombone, bird feet, etc.) in simple line drawings are two examples. Similarly, a first grader might connect subtraction facts to previously learned addition facts in the same "family" (e.g., 5 – 3 = 2 is the reverse of 2 + 3 = 5), and a high school student might see parallels between the "ethnic cleansing" in Kosovo in the 1990s and the Nazis' belief in white supremacy in the 1930s and 1940s. In the vast majority of cases, meaningful learning is

TABLE 2.2 Long-Term Memory Storage Processes

Process	Definition	Example	Effectiveness
Rote learning: Learning primarily through repetition and practice, with little or no attempt to make sense of what is being learned			
Rehearsal	Repeating information verbatim, either mentally or aloud	Word-for-word repetition of a formula or definition	Relatively ineffective: Storage is slow, and later retrieval is difficult
Meaningful learning: Making connections between new information and prior knowledge			
Elaboration	Embellishing on new information based on what one already knows	Generating possible reasons that historical figures made the decisions they did	Effective if associations and additions made are appropriate and productive
Organization	Making connections among various pieces of new information	Thinking about how one's lines in a play relate to the play's overall story line	Effective if organizational structure is legitimate and consists of more than just a list of separate facts
Visual imagery	Forming a mental picture of something, either by actually seeing it or by envisioning how it might look	Imagining how various characters and events in a novel might have looked	Individual differences in effectiveness; especially beneficial when used in combination with elaboration or organization

[39] G. H. Bower, Karlin, & Dueck, 1975.
[40] J. R. Anderson, 1995; Ausubel, 1968; Craik & Watkins, 1973.

more effective than rote learning for storing information in long-term memory.[41] It's especially effective when learners relate ideas to *themselves* as human beings.[42]

Meaningful learning can take a variety of forms, and in many cases it involves adding to or restructuring information in some way. For instance, in **elaboration**, learners use their prior knowledge to embellish on a new idea, thereby storing *more* information than was actually presented. For example, a student who reads that allosaurs (a species of dinosaurs) had powerful jaws and sharp teeth might correctly deduce that allosaurs were meat eaters. Similarly, if a student learns that the crew on Columbus's first trip across the Atlantic threatened to revolt and turn the ships back toward Europe, the student might speculate, "I'll bet the men were really frightened when they continued to travel west day after day without ever seeing signs of land."[43]

Another form of meaningful learning is **organization**, in which learners arrange new information in a logical structure. For example, they might group information into categories (recall the earlier "Remembering Words" exercise with the words *daisy, apple, hammer,* etc.). Alternatively, they might identify interrelationships among various pieces of information. As an illustration, students in a physics class might learn that *velocity* is the product of *acceleration* and *time* ($v = a \times t$) and that an object's *force* is determined by both the object's *mass* and its *acceleration* ($f = m \times a$). The trick is not simply to memorize the formulas (this would be rote learning) but rather to make sense of and understand the relationships that the formulas represent. In most instances, learners who learn an organized body of information remember it better—and they can use it more effectively later on—than would be the case if they tried to learn the same information as a list of separate, isolated facts.[44]

Still another effective long-term memory storage process is **visual imagery**, forming a mental picture of objects or ideas. To discover firsthand how effective visual imagery can be, try learning a bit of Mandarin Chinese in the next exercise.

? In your own experiences as a student, how often have classroom assessments encouraged you to memorize information word for word rather than to learn it meaningfully?

SEE FOR YOURSELF Five Chinese Words

Try learning these five Chinese words by forming the visual images I describe (don't worry about learning the tone marks over the words).

Chinese Word	English Meaning	Image
fáng	house	Picture a *house* with *fangs* growing on its roof and walls.
mén	door	Picture a restroom *door* with the word *MEN* painted on it.
ké	guest	Picture a person giving someone else (the *guest*) a *key* to the house.
fàn	food	Picture a plate of *food* being cooled by a *fan.*
shū	book	Picture a *shoe* with a *book* sticking out of it.

Now find something else to do for a couple of minutes. Stand up and stretch, get a glass of water, or use the restroom. But be sure to come back to your reading in just a minute or two. . . .

Now that you're back, cover the list of Chinese words, English meanings, and visual images. Try to remember what each word means:

ké fàn mén fáng shū

elaboration Cognitive process in which learners embellish on new information based on what they already know.

organization Cognitive process in which learners find connections among various pieces of information they need to learn (e.g., by forming categories, identifying hierarchies, determining cause–and–effect relationships).

visual imagery Cognitive process in which learners form mental pictures of objects or ideas.

[41] Ausubel, Novak, & Hanesian, 1978; Ghetti & Angelini, 2008; Marley, Szabo, Levin, & Glenberg, 2008; R. E. Mayer, 1996.

[42] Craik, 2006; Heatherton, Macrae, & Kelley, 2004; T. B. Rogers, Kuiper, & Kirker, 1977.

[43] Notice that I am using the term *elaboration* to describe something that *learners* do, not something that teachers do. Elaboration as a *cognitive process* occurs inside rather than outside the learner. However, teachers can certainly help students engage in elaboration, as you'll discover later in the chapter.

[44] Bjorklund, Schneider, Cassel, & Ashley, 1994; G. H. Bower, Clark, Lesgold, & Winzenz, 1969; P. A. Ornstein, Grammer, & Coffman, 2010.

Did the Chinese words remind you of the visual images you stored? Did the images, in turn, help you remember the English meanings of the Chinese words? You may have remembered all five words easily, or you may have remembered only one or two. People differ in their ability to use visual imagery: Some form images quickly and easily, whereas others form them only slowly and with difficulty.[45] Especially for people in the former category, visual imagery can be a powerful means of storing information in long-term memory.[46]

The three forms of meaningful learning we've just examined—elaboration, organization, and visual imagery—are clearly *constructive* in nature: They all involve combining several pieces of information into a meaningful whole. When you elaborate on new information, you combine it with things you already know to help you make better sense of it. When you organize information, you give it a logical structure (categories, cause–and–effect relationships, etc.). And when you use visual imagery, you create mental pictures (perhaps a house with fangs or a restroom door labeled *MEN*) based on how certain objects typically look.

Practice makes knowledge more automatic and durable.

Storing something in long-term memory on one occasion is hardly the end of the learning process. When people continue to practice the information and skills they acquire—and especially when they do so in a variety of situations and contexts—they gradually become able to use what they've learned quickly, effortlessly, and automatically. In other words, people eventually achieve **automaticity** for well-practiced knowledge and skills.[47]

Learning something to automaticity is *not* the same thing as rote learning. In what important way are these two processes different? (Compare your response to this question with the response presented in Chapter 2 of the Book-Specific Resources in MyEducationLab.)

As noted earlier, rehearsal—repeating information over and over within the course of a few seconds or minutes—is a relatively *in*effective way of getting information into long-term memory. But when we talk about acquiring automaticity, we're talking about repetition over the long run: reviewing and practicing information and procedures at periodic intervals over the course of a few weeks, months, or years. When practice is spread out in this manner, people learn things better and remember them longer.[48]

Practice is especially important for gaining procedural knowledge. As an example, think of driving a car, a complicated skill that most of my readers can probably perform easily. Your first attempts at driving years ago may have required a great deal of mental energy and effort. But I'm guessing that you can now drive without having to pay much attention to what you're doing. Even if your car has a standard (rather than automatic) transmission, driving is, for you, an automatic activity.

Many complex procedures, such as driving a car, may begin largely as explicit, declarative knowledge—in other words, as *information* about how to execute a procedure rather than as the actual *ability* to execute it. When learners use declarative knowledge to guide them as they carry out a new procedure, their performance is slow and laborious, the activity consumes a great deal of mental effort, and learners often talk themselves through their actions. As they continue to practice the activity, however, their declarative knowledge gradually evolves into procedural knowledge. This knowledge becomes fine-tuned over time and eventually allows learners to perform an activity quickly and easily—that is, with automaticity.[49]

With age and experience, children acquire more effective learning strategies.

Sometimes learners engage in effective long-term memory storage processes (elaboration, organization, visual imagery, etc.) without intentionally trying to do so. For instance, if I tell you that *I used to live in Colorado,* you might immediately deduce that I lived in or near the Rocky Mountains, and you might even picture snow-capped mountains in your head. In this case you are automatically engaging in elaboration and visual imagery: My statement

automaticity Ability to respond quickly and efficiently while mentally processing or physically performing a task.

[45] Behrmann, 2000; J. M. Clark & Paivio, 1991; Kosslyn, 1985.
[46] Dewhurst & Conway, 1994; Johnson-Glenberg, 2000; D. B. Mitchell, 2006; Sadoski, Goetz, & Fritz, 1993; Sadoski & Paivio, 2001.
[47] J. R. Anderson, 1983; P. W. Cheng, 1985; Graham, Harris, & Fink, 2000; R. W. Proctor & Dutta, 1995; Semb & Ellis, 1994.
[48] Cepeda, Vul, Rohrer, Wixted, & Pashler, 2008; Dempster, 1991; R. W. Proctor & Dutta, 1995; Rohrer & Pashler, 2007.
[49] J. R. Anderson, 1983, 1987; Beilock & Carr, 2003.

made no mention of the Rockies, so you supplied this information from your own long-term memory.

At other times learners deliberately use certain cognitive processes in their efforts to learn and remember information. For example, in the "Remembering Words" exercise near the beginning of the chapter, you may have quickly noticed the categorical nature of the 12 words in the list and intentionally used the categories *flowers, fruit,* and *tools* to organize them. Similarly, in the "Five Chinese Words" exercise, you intentionally formed visual images in accordance with my instructions. When learners *intentionally* engage in certain cognitive processes to help them learn and remember something, they are using a **learning strategy**.

A general inclination to relate new information to prior knowledge—meaningful learning—probably occurs in one form or another at virtually all age levels.[50] More specific and intentional learning strategies (e.g., rehearsal, organization, visual imagery) are fairly limited in the early elementary years but increase in both frequency and effectiveness over the course of childhood and adolescence. The frequency of elaboration—especially as a process that learners *intentionally* use to help them remember something—picks up a bit later, often not until adolescence, and is more common in high-achieving students. Table 2.3 summarizes developmental trends in learning strategies across the grade levels.

learning strategy Intentional use of one or more cognitive processes for a particular learning task.

Observe how organization improves with age in the early childhood, early adolescence, and late adolescence "Memory and Metacognition" videos in Chapter 2 of the Book-Specific Resources in MyEducationLab.

DEVELOPMENTAL TRENDS

TABLE 2.3 Typical Learning Strategies at Different Grade Levels

Grade Level	Age-Typical Characteristics	Example	Suggested Strategies
 K–2	• Organization of physical objects as a way to remember them • Appearance of rehearsal to remember verbal material; used infrequently and relatively ineffectively • Emerging ability to use visual imagery to enhance memory, especially if an adult suggests this strategy • Few if any intentional efforts to learn and remember verbal material; learning and memory are a byproduct of other things children do (creating things, talking about events, listening to stories, etc.)	At the end of the school day, a first-grade teacher reminds students that they need to bring three things to school tomorrow: an object that begins with the letter *W* (for a phonics lesson), a signed permission slip for a field trip to a local historic site, and a warm jacket to wear on the field trip. Six-year-old Cassie briefly mumbles "jacket" to herself a couple of times and naively assumes she'll remember all three items without any further mental effort.	• Get students actively involved in topics, perhaps through hands-on activities, engaging reading materials, or fantasy play. • Relate new topics to students' prior experiences. • Model rehearsal as a strategy for remembering things over the short run. • Provide pictures that illustrate verbal material. • Give students concrete mechanisms for remembering to bring necessary items to school (see upcoming discussions of *retrieval cues*).
 3–5	• Spontaneous, intentional, and increasingly effective use of rehearsal to remember things for a short time period • Increasing use of organization as an intentional learning strategy for verbal information • Increasing effectiveness in use of visual imagery as a learning strategy	As 10-year-old Jonathan studies for an upcoming quiz on clouds, he looks at the photos of four different kinds of clouds in his science book and says each one's name aloud. Then he repeats the four cloud types several times: "Cumulus, cumulonimbus, cirrus, stratus. Cumulus, cumulonimbus, cirrus, stratus. Cumulus, cumulonimbus, cirrus, stratus."	• Emphasize the importance of making sense of, rather than memorizing, information. • Encourage students to organize what they're learning; suggest possible organizational structures for topics. • Provide a variety of visual aids to facilitate visual imagery, and suggest that students create their own drawings or visual images of things they need to remember.

(*continued*)

[50] Flavell, Miller, & Miller, 2002; Pressley & Hilden, 2006; Siegler & Alibali, 2005.

TABLE 2.3 Continued

Grade Level	Age-Typical Characteristics	Example	Suggested Strategies
 6–8	• Predominance of rehearsal as a learning strategy • Greater abstractness and flexibility in categories used to organize information • Emergence of elaboration as an intentional learning strategy	Two middle school students, Raj and Owen, are studying for a quiz on various kinds of rocks. "Let's group them somehow," Raj says. Owen suggests grouping them by color (gray, white, reddish, etc.). But after further discussion, the boys agree that sorting them into *sedimentary, igneous,* and *metamorphic* would be a more strategic approach.	• Suggest questions that students might ask themselves as they study; emphasize questions that promote elaboration (e.g., "Why would ___ do that?" "How is ____ different from ____?"). • Assess true understanding rather than rote memorization in assignments and quizzes.
 9–12	• Continuing reliance on rehearsal as an intentional learning strategy, especially by low-achieving students • Increasing use of elaboration and organization to learn new material, especially by high-achieving students	In her high school world history class, Kate focuses her studying efforts on memorizing names, dates, and places. Meanwhile, Kate's classmate Janika likes to speculate about the personalities and motives of such historical characters as Alexander the Great, Napoleon Bonaparte, and Adolf Hitler.	• Ask thought-provoking questions that engage students' interest and help students see the relevance of topics for their own lives. • Have students work in mixed-ability cooperative groups, in which high-achieving students can model effective learning strategies for low-achieving students.

Sources: Bjorklund & Coyle, 1995; Bjorklund & Jacobs, 1985; Bjorklund et al., 1994; Cowan et al., 2006; DeLoache & Todd, 1988; Gaskins & Pressley, 2007; Gathercole & Hitch, 1993; Kosslyn, Margolis, Barrett, Goldknopf, & Daly, 1990; Kunzinger, 1985; Lehmann & Hasselhorn, 2007; Lucariello et al., 1992; Marley et al., 2008; L. S. Newman, 1990; P. A. Ornstein, Grammer, & Coffman, 2010; Plumert, 1994; Pressley, 1982; Pressley & Hilden, 2006; Schneider & Pressley, 1989.

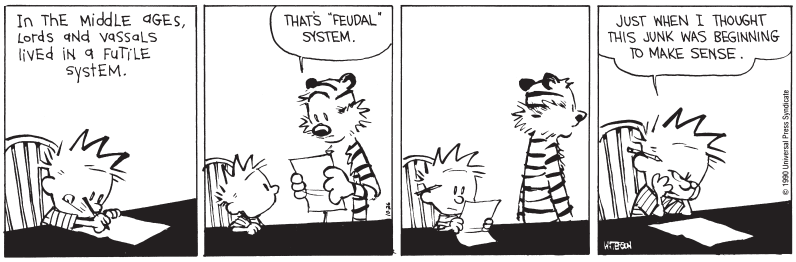


FIGURE 2.8 Learners benefit from their prior knowledge only when they make appropriate connections. Here Calvin is trying to learn new information meaningfully, but his efforts are in vain because he's unfamiliar with the word *feudal.*
Source: CALVIN AND HOBBES © 1990 Watterson. Distributed by UNIVERSAL UCLICK. Reprinted with permission. All rights reserved.

Prior knowledge and beliefs affect new learning, usually for the better but sometimes for the worse.

What learners already know provides a **knowledge base** on which new learning—especially *meaningful* learning—can build. For example, when you read the passage about John's visit to the doctor's office earlier in the chapter, you could make sense of the passage only if you yourself have visited a doctor many times and so know how such visits typically go. Generally speaking, people who already know something about a topic learn new information about the topic more effectively than people who have little relevant background.[51]

Recall how in the case study at the beginning of the chapter, Rita misinterpreted what she learned about Michigan's history in part because she didn't know that two words in her history lessons, *British* and *English,* were essentially synonyms. When learners have little relevant knowledge on which to build, they're apt to struggle in their efforts to make sense of new information.

Occasionally, however, prior knowledge *interferes* with new learning. In some instances, it may do so because a learner makes an inappropriate connection. Figure 2.8 provides an example: Calvin thinks that a *feudal* system is a *futile* system. We see additional examples in the opening case study. Rita initially associates the word *China* with dinnerware and speculates that the Europeans wanted to import cups from the Far East. She also

knowledge base A person's existing knowledge about specific topics and the world in general.

[51] P. A. Alexander, Kulikowich, & Schulze, 1994; Cromley & Azevedo, 2007; Schneider, 1993; Shapiro, 2004.

recalls that furs were an important commodity during the New World's colonial period but mistakenly reports that the furs came from China.

At other times things learned at an earlier time may interfere with new learning because the previous "knowledge" is incorrect. For example, imagine a group of children who think the earth is flat. Such an idea is consistent with their early experiences, especially if they live in, say, Illinois or Kansas. You now tell them that the world is actually round. Rather than replacing the *flat* idea with a *round* one, they might pull both ideas together and conclude that the earth is shaped something like a pancake, which is flat *and* round. Alternatively, they might envision a hollow-sphere version of the earth, with people living on a flat surface within it (see Figure 2.9).[52]

Figure 2.10 presents examples of misconceptions that children and adolescents may bring with them to the classroom. Especially when such misconceptions are embedded in learners' general theories about the world, instruction intended to correct them may do little to change learners' minds.[53] Instead, thanks to the process of elaboration—a process that usually facilitates learning—learners may interpret or distort the new information to be consistent with what they already "know." As a result, they can spend a great deal of time learning the wrong thing! Consider the case of Barry, an eleventh grader whose physics class was studying the idea that an object's mass and weight do *not,* by themselves,

FIGURE 2.9 One way of imagining an earth that is both flat and round

FIGURE 2.10 Common student misconceptions

ASTRONOMY

Fact: The earth revolves around the sun.
Misconception: The sun revolves around the earth. It "rises" in the morning and "sets" in the evening, at which point it "goes" to the other side of the earth.

Fact: The earth is shaped more or less like a sphere.
Misconception: The earth is shaped like a round, flat disk *or* the earth is a hollow sphere with people living on a flat surface inside.

BIOLOGY

Fact: A living thing is something that carries on such life processes as metabolism, growth, and reproduction.
Misconception: A living thing is something that moves and/or grows. The sun, wind, clouds, and fire are living things.

Fact: A plant is a living thing that produces its own food.
Misconception: A plant takes in food from the ground. It grows in a garden and is relatively small.

PHYSICS

Fact: An object remains in uniform motion until a force acts upon it; a force is needed only to *change* speed or direction.
Misconception: Any moving object has a force acting upon it. For example, a ball thrown in the air continues to be pushed upward by the force of the throw until it begins its descent.

Fact: Light objects and heavy objects fall at the same rate unless other forces (e.g., air resistance) differentially affect the objects (e.g., feathers tend to fall slowly because they encounter significant air resistance relative to their mass).
Misconception: Heavy objects fall faster than light objects.

GEOGRAPHY

Fact: The Great Lakes contain freshwater.
Misconception: The Great Lakes contain saltwater.

Fact: Rivers run from higher elevation to lower elevation.
Misconception: Rivers run from north to south (going "down" on a map). For example, rivers can run from Canada into the United States, but not vice versa.

MATHEMATICS

Fact: Multiplication and division can lead to either larger or smaller numbers (e.g., 5 divided by ½ is 10, a number larger than 5).
Misconception: Multiplication always leads to a larger number, and division always leads to a smaller number.

Fact: The size of a fraction is a function of the proportion of the top number relative to the bottom number.
Misconception: Fractions with large numbers indicate larger amounts than fractions with small numbers (e.g., 4/35 is larger than 4/5).

Sources: W. F. Brewer, 2008; S. Carey, 1986; Hynd, 1998a; Kyle & Shymansky, 1989; Maria, 1998; J. Nussbaum, 1985; K. J. Roth & Anderson, 1988; Sneider & Pulos, 1983; Vosniadou, 1994; Vosniadou & Brewer, 1987; Vosniadou et al., 2008; geography misconceptions courtesy of R. K. Ormrod.

[52] W. F. Brewer, 2008; Vosniadou, Vamvakoussi, & Skopeliti, 2008.
[53] Derry, 1996; P. K. Murphy & Mason, 2006; Sinatra & Pintrich, 2003; C. L. Smith, Maclin, Grosslight, & Davis, 1997.

affect the speed at which the object falls. Students were asked to design and build egg containers that would keep eggs from breaking when dropped from a third-floor window. They were told that on the day of the egg drop, they would record the time it took for the eggs to reach the ground. Convinced that heavier objects fall faster, Barry added several nails to his egg's container. Yet when he dropped it, classmates timed its fall at 1.49 seconds, a time very similar to that for other students' lighter containers. Rather than acknowledge that light and heavy objects fall at the same rate, Barry explained the result by rationalizing that "the people weren't timing real good."[54]

This tendency to look for what one thinks is true and to ignore evidence to the contrary is known as **confirmation bias**. For instance, when students in a science lab observe results that are inconsistent with their expectations, many are apt to discredit the results, perhaps complaining that "our equipment isn't working right" or "I can never do science anyway."[55] Similarly, when students in a history class read accounts of a historical event that conflicts with prior, not-quite-accurate beliefs about the event—especially if those beliefs are widely held in their cultural group—they may stick with their initial understandings, perhaps saying, "it is not written here . . . but I think this is what happened."[56]

As you can see, then, although prior knowledge and beliefs about a topic are usually a blessing, they can sometimes be a curse.

Why Learners May or May Not Remember What They've Learned

Retrieving information from long-term memory appears to involve following a pathway of associations. Almost literally, it's a process of going down Memory Lane. One idea reminds you of another idea—that is, one idea *activates* another—the second idea reminds you of a third idea, and so on, in a manner similar to what happened when you followed a train of thought from the word *horse* earlier in the chapter. If the pathway of associations eventually leads you to what you're trying to remember, you do indeed remember it. If the path takes you in other directions, you're out of luck.

How easily and accurately people remember what they've previously learned can be described using the following general principles.

How easily something is recalled depends on how it was initially learned.

People are more likely to remember something they've previously learned if, in the process of storing it, they connected it with something else in long-term memory. Ideally, the "new" and the "old" have a logical relationship. To illustrate this idea, let's return once again to all that mail that arrives in your mailbox. Imagine that, on average, you receive five important items—things you really want to save—every day. At six postal deliveries a week and 52 weeks a year, minus a dozen or so holidays, you save about 1,500 pieces of mail each year. If you save this much mail over the course of 15 years, you eventually have more than 22,000 important things stashed somewhere in your home.

One day you hear that stock in a clothing company (Mod Bod Jeans, Inc.) has tripled in value. You remember that your wealthy Uncle Fred sent you some Mod Bod stock certificates for your birthday several years ago, and you presumably decided they were important enough to save. But where did you put them? How long will it take you to find them among the thousands of other items you've saved?

How easily you find the certificates—in fact, whether you find them at all—depends on how you've been storing your mail as you've accumulated it. If you've been storing it in a logical, organized fashion—for instance, by putting all paid bills on a closet shelf, all mail-order catalogs under your bed, and all items from relatives in a file cabinet (in alphabetical order by last name)—you should be able to retrieve Uncle Fred's gift fairly quickly. But if

confirmation bias Tendency to seek information that confirms rather than discredits one's current beliefs.

[54] Hynd, 1998a, p. 34.
[55] Minstrell & Stimpson, 1996, p. 192.
[56] Porat, 2004, p. 989.

you simply tossed each day's mail randomly around the house, you'll be searching your home for a long, long time, possibly without ever finding a trace of the Mod Bod stock.

Like a home with 15 years' worth of mail, long-term memory contains a great deal of information. And like finding the Mod Bod certificates, the ease with which information is retrieved from long-term memory depends somewhat on whether the information is stored in a logical "place"—that is, whether it's connected with related ideas. Through making those important connections with existing knowledge—through meaningful learning—people know where to "look" for information when they need it. In contrast, learning something by rote is like throwing Uncle Fred's gift randomly among thousands of pieces of unorganized mail: A person may never retrieve it again.

Learners are especially likely to retrieve information when they have *many* possible pathways to it—in other words, when they have associated the information with numerous other ideas in their existing knowledge. Making multiple connections is like having cross-references in your mail storage system. You may have filed the Mod Bod certificates in the "items from relatives" file drawer, but you've also written their location on notes left in many other places—perhaps with your birth certificate (after all, you received the stock on your birthday), with your income tax receipts, and in your safe deposit box. By looking in any one of these logical places, you will discover where to find your valuable stock.

? Think of an exam you've recently taken. Which student would have gotten a higher score: one who had studied course material verbatim or one who had engaged in meaningful learning?

Remembering depends on the context.

When I hear certain "oldies" songs (songs by the Beatles, Supremes, Mamas and Papas, etc.), I immediately recall my college years, when those songs were played regularly at parties, in my dormitory, and on the beach. The songs send me down that Memory Lane of associations that leads me to my stored versions of the people, places, and events that were so important to me in college. You too may find that certain songs, smells, pictures, or words stir up memories of days gone by. Things in the environment that remind people of something they've learned in the past—those things that facilitate retrieval—are **retrieval cues**.

Retrieval cues clearly help learners recall what they've previously learned.[57] As an example, try the following exercise.

SEE FOR YOURSELF The Great Lakes

1. If you were educated in North America, at one time or another you probably learned the names of the five Great Lakes. See if you can recall all of them within a 15-second period.
2. If you had trouble remembering all five lakes within that short time, here's a hint: The first letters of the Great Lakes spell the word *HOMES*. Now see if you can recall all five lakes within 15 seconds.

If you did poorly at Step 1, the word *HOMES* probably helped you at Step 2 because it gave you some ideas about where to "look" in your long-term memory. For example, if you couldn't initially remember Lake Michigan, *HOMES* told you that one of the lakes begins with the letter *M,* leading you to brainstorm *M* words until, possibly, you stumbled on "Michigan." The letters in *HOMES* acted as retrieval cues that started your search of long-term memory in the right directions.

Whether people remember something they've learned when they need it later depends on whether something in their environment sends them down a productive pathway in long-term memory. In some cases the retrieval cue might be something inherent in the task to be done. For example, if I ask you to solve the problem 13 + 24 = ?, the plus sign (+) tells

In the United States, there is only one place where four states come together at a single point. Might a misspelling of the word *canoe*—"CANU"—help you identify these states? (Compare your response to this question with the response presented in Chapter 2 of the Book-Specific Resources in MyEducationLab.)

retrieval cue Stimulus that provides guidance about where to "look" for a piece of information in long-term memory.

[57] Balch, Bowman, & Mohler, 1992; Holland, Hendriks, & Aarts, 2005; Tulving & Thomson, 1973.

David Mager/Pearson Learning Studio

Frequent practice of basic skills, such as addition and subtraction, makes them more durable and automatic.

you that you need to add, and so you retrieve what you know about addition. In other cases someone might give you a hint, just as I did when I suggested that you use *HOMES* to help you remember the Great Lakes. The presence or absence of such retrieval cues plays a critical role in people's ability to apply, or *transfer,* what they've learned to new situations.

How easily something is recalled and used depends on how often it has been recalled and used in the past.

Practice doesn't necessarily make perfect, but as we've seen, it does make knowledge more durable and automatic. Practice also makes knowledge easier to "find" when it's needed. When we use information and skills frequently, we essentially "pave" the pathways we must travel to find them, in some cases creating superhighways.

Knowledge that has been learned to automaticity has another advantage as well. Remember, working memory has a limited capacity: The active, "thinking" part of the human memory system can handle only so much at a time. Thus, when much of its capacity must be used for recalling single facts or carrying out simple procedures, little room remains for addressing more complex aspects of a task. One key reason for learning some facts and procedures to automaticity, then, is to free up working memory capacity for complex tasks and problems that require those facts and procedures.[58] For example, fourth graders who encounter the multiplication problem

$$\begin{array}{r} 87 \\ \times\ 59 \\ \hline \end{array}$$

can solve it more easily if they can quickly retrieve such basic facts as $9 \times 8 = 72$ and $5 \times 7 = 35$. High school chemistry students can more easily interpret Na_2CO_3 (sodium carbonate) if they don't have to stop to think about what the symbols *Na, C,* and *O* represent.

Recall often involves reconstruction.

Have you ever remembered an event very differently than a friend did, even though the two of you had participated actively and equally in the event? Were you and your friend both certain of the accuracy of your own memories and therefore convinced that the other person remembered the situation incorrectly? Like storage, retrieval has a constructive side, which can explain your differing recollections.

Retrieving something from long-term memory isn't necessarily an all-or-none phenomenon. Sometimes people retrieve only certain parts of something they've previously learned. In such situations they may construct their "memory" of an event by combining the tidbits they can recall with their general knowledge and assumptions about the world.[59] The following exercise illustrates this point.

SEE FOR YOURSELF Missing Letters

Fill in the missing letters of the following words:

1. exist-nce
2. adole---nce
3. perc--ve
4. hors d'o-----

[58] D. Jones & Christensen, 1999; R. W. Proctor & Dutta, 1995; L. B. Resnick, 1989; Stanovich, 2000.
[59] Brainerd & Reyna, 2005; Roediger & McDermott, 2000; Schacter, 1999.

Could you retrieve the missing letters from your long-term memory? If not, you may have found yourself making guesses using either your knowledge of how the words are pronounced or your knowledge of how words in the English language are typically spelled. For example, perhaps you used the "*i* before *e* except after *c*" rule for Word 3; if so, you correctly reconstructed *perceive.* Perhaps you also recalled the *-escence* spelling pattern in such words as *obsolescence* and *effervescence,* in which case you would have spelled *adolescence* correctly. But if you applied the common spelling pattern *-ance* to Word 1, then you misspelled *existence.* Neither pronunciation nor typical English spelling patterns would have helped you with *hors d'oeuvre,* a term borrowed from the French.

When people fill in gaps in what they've retrieved based on what seems "logical," they often make mistakes—a phenomenon known as **reconstruction error**. In the opening case study, Rita's version of what she learned in history is a prime example. Rita retrieved certain facts from her history lessons (e.g., the British wanted furs; some of them eventually settled in the Upper Peninsula) and constructed what was, to her, a reasonable scenario.

Long-term memory isn't necessarily forever.

People certainly don't need to remember everything. For example, you probably have no reason to remember the phone number of a florist you called yesterday, the plot of last week's rerun of *Friends,* or the due date of an assignment you turned in last semester. Much of the information you encounter is, like junk mail, not worth keeping for the long run.

Unfortunately, people sometimes forget important things as well as inconsequential ones. Some instances of forgetting may reflect **retrieval failure**: A person simply isn't looking in the right "place" in long-term memory.[60] Perhaps the forgetful person hasn't learned the information in a meaningful way, or perhaps the person doesn't have a good retrieval cue. But other instances of forgetting may be the result of **decay**: Knowledge stored in long-term memory may gradually weaken over time and perhaps disappear altogether, especially if it isn't used very often.[61] To some degree, then, the expression "Use it or lose it" may apply to human memory.

Regardless of whether forgetting is due to retrieval failure or to decay, human beings don't always remember the things they've learned. However, teachers can do many things to increase the odds that their students *do* remember academic subject matter, as we'll see now.

• Promoting Effective Cognitive Processes

As we've seen, learning is an active, constructive process, and what students learn is rarely a carbon copy of what a teacher or textbook has presented. A teacher's goal, then, should not—and in fact *cannot*—be that students absorb all the information they are given. Instead, a more achievable goal is that students construct appropriate and useful understandings of academic subject matter—that they make reasonable *sense* of it.

How effectively students make sense and meaning from what they're studying depends in large part on the cognitive processes in which they engage. Although students are ultimately the ones in control of their own thinking and learning, a teacher can do many things to help them think and learn more effectively. I've organized these strategies into four general categories: remembering how the human memory system works, encouraging effective long-term memory storage, promoting retrieval, and monitoring students' progress.

Remembering How the Human Memory System Works

The model of memory depicted in Figure 2.5 and discussed at length in this chapter tells us several important things about human memory. First, attention is critical for moving information into working memory. Second, working memory has a short duration (less than half a minute) and limited capacity. And third, effective long-term storage typically involves

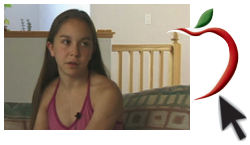
reconstruction error Construction of a logical but incorrect "memory" by combining information retrieved from one's long-term memory with one's general knowledge and beliefs about the world.

retrieval failure Inability to locate information that currently exists in long-term memory.

decay Weakening over time of information stored in long-term memory, especially if the information is used infrequently.

[60] Einstein & McDaniel, 2005; Loftus & Loftus, 1980.
[61] Altmann & Gray, 2002; J. R. Anderson, 2005; Reisberg, 1997; Schacter, 1999.

making connections between new information and prior knowledge. These points have several implications for classroom practice.



Hear 12-year-old Claudia describe things her teachers do that capture or lose her attention in the "Motivation: Early Adolescence" video in Chapter 2 of the Book-Specific Resources in MyEducationLab.

Grab and hold students' attention.

What teachers do in the classroom can have a huge impact on the extent to which students pay attention to the subject matter at hand. For example, teachers can pique students' interest in a topic, perhaps by building on students' existing interests and concerns, presenting unusual or puzzling phenomena, or modeling their own enthusiasm for a topic. Incorporating a wide variety of instructional methods into the weekly schedule (discovery learning sessions, debates about controversial issues, cooperative problem-solving activities, etc.) also helps keep students actively attentive to and engaged in mastering new information and skills. The Classroom Strategies box "Getting and Keeping Students' Attention" offers and illustrates several additional suggestions.

Keep the limited capacity of working memory in mind.

A mistake many new teachers make is to present a great deal of information very quickly, and their students' working memories simply can't handle it all. Students have only limited "space" in their working memories, imposing an upper limit on how much they can think about and learn within a given time interval. Instruction must be paced to accommodate what students' working memories can reasonably accomplish. For example, teachers might repeat the same idea several times (perhaps rewording it each time), stop to write important points on the board, provide numerous examples and illustrations, and have students use the content in a variety of activities and assignments over a period of time.

CLASSROOM STRATEGIES Getting and Keeping Students' Attention

- Create stimulating lessons in which students *want* to pay attention.

  In a unit on nutrition, a high school biology teacher has students determine the nutritional value of various menu items at a popular local fast-food restaurant.

- Get students physically involved with the subject matter.

  A middle school history teacher schedules a day late in the school year when all of his classes "go back in time" to the American Civil War. In preparation for the event, the students spend several weeks learning about the Battle of Gettysburg, researching typical dress and meals of the era, gathering appropriate clothing and equipment, and preparing snacks and lunches. On the day of the "battle," students assume various roles: Union and Confederate soldiers, government officials, journalists, merchants, housewives, doctors and nurses, and so on.

- Incorporate a variety of instructional methods into lessons.

  After explaining how to calculate the areas of squares and rectangles, a fourth-grade teacher has students practice calculating area in a series of increasingly challenging word problems. She then breaks the class into three- to four-member cooperative groups, gives each group a tape measure and calculator, and asks the students to calculate the area of their irregularly shaped classroom floor. To complete the task, the students must divide the room into several smaller rectangles, compute the area of each rectangle separately, and add the "subareas" together.

- Provide frequent breaks from quiet, sedentary activities, especially when working with students in the elementary grades.

  To provide practice with the alphabet, a kindergarten teacher occasionally has students make letters with their bodies: one child standing with arms extended up and out to make a Y, two children bending over and joining hands to form an M, and so on.

- In the middle school and high school grades, encourage students to take notes.

  In a middle school science class, different cooperative groups have been specializing in and researching various endangered species. As each group gives an oral report about its species to the rest of the class, the teacher asks students in the audience to jot down questions about things they would like to know about the animal. On completion of their prepared report, members of the presenting group respond to their classmates' questions.

- Minimize distractions when students must work quietly and independently.

  The windows of several classrooms look out onto an area where a new parking lot is being created. Teachers in those rooms have noticed that many students are being distracted by the construction activity outside. The teachers ask the principal to arrange that the construction company work elsewhere on the day that an important statewide assessment is scheduled to be administered.

Sources: Some strategies based on Di Vesta & Gray, 1972; Kiewra, 1989; Ku, Chan, Wu, & Chen, 2008; Pellegrini & Bjorklund, 1997; Posner & Rothbart, 2007.