New to the Fourth Edition

Our knowledge about how children and adolescents learn and develop—and also about how best to help them learn and develop—grows by leaps and bounds every year. Throughout this fourth edition, I’ve made many changes to reflect new research findings and evidence-based classroom strategies. And in revising Chapter 6, I’ve brought Brett Jones on board to lend his expertise in both motivation and pedagogical strategies.

Many noteworthy changes in this edition are in three general areas:

- **Sociocultural contexts of learning:** The changes here are especially evident in Chapter 3. There you will find a greatly expanded discussion of culture and society as contexts, a new section on technology and media, and new coverage of academic content domains as cultural legacies that create additional contexts for students’ learning. The enhanced sociocultural theme is also evident in discussions of professional learning communities (Chapter 1), transfer (Chapter 4), a new section on “Supporting Students Who Face Exceptional Personal or Social Challenges” (Chapter 7), and a new Classroom Strategies box “Creating and Enhancing a Sense of Classroom Community” (Chapter 9).

- **Neuropsychology and the brain:** The rapidly expanding field of neuropsychology continues to offer new insights into the nature of children’s and adolescents’ thinking processes and cognitive development. Enhanced discussions of the brain’s influences are most apparent in a new section on “Encouraging Optimal Brain Functioning” (Chapter 2), a description of mirror neurons (Chapter 3), an expanded section on brain development (Chapter 5), and a new boldfaced principle regarding effortful control and the brain (Chapter 7).

- **Advances in digital technologies reflected in the book’s content:** The new section on “Technology and Media as Contexts” in Chapter 3 is the most obvious technology-related change in this edition. Yet technological advances permeate many other parts of the book as well, including in the OOPS test (Chapter 1) and in discussions of technological literacy (Chapter 3), simulations (Chapter 4), assistive technology for students with intellectual disabilities (Chapter 5), digital technologies in peer relationships (Chapter 7), class websites (Chapter 8), the National Educational Technology Standards for Students (NETS•S; Chapter 8), and technological tools for facilitating formative assessment and self-assessments (Chapter 10).

More specific, chapter-by-chapter changes are the following additions and modifications:

- **Chapter 1:** New opening case study illustrating action research; revised OOPS test items to include current “hot” topics (e.g., brain research, video games); new discussion of quasi-experimental studies; new rows in Table 1.1 contrasting various research methodologies with respect to general purposes and limitations; discussion of teachers’ professional learning communities.

- **Chapter 2:** Reorganization of Table 2.1, with a new “Contextual Theories” row; expanded discussion of the brain, including discussions of consolidation and reconsolidation and a new “Encouraging Optimal Brain Functioning” section; new discussion of situated learning and situated cognition as factors affecting retrieval (previously these terms didn’t appear until Chapter 3); new discussion of cognitive load as an important consideration in instructional planning.

- **Chapter 3:** New opening case study to highlight the influence of culture in students’ behaviors; discussion of mirror neurons as a neurological basis for learning from models; follow-up discussion of cognitive load; expanded definition and discussion of distributed cognition; new discussion of scaffolding (which previously didn’t appear until Chapter 5); expansion of the third edition’s culture-and-society section into two separate sections;
new sections on technology and media and on academic content domains as contexts for learning; new or expanded discussions of worldviews, communities of practice, legitimate peripheral participation, distributed knowledge, technological literacy, assistive technology, class wikis, and culture shock.

• **Chapter 4:** Greater emphasis on environmental contexts that promote complex cognitive processes, as reflected in a new boldfaced principle in the "Transfer" section and a reorganization of the "Promoting Complex Cognitive Processes" section; discussion of service learning (which previously didn’t appear until Chapter 8); new boldfaced strategy regarding technology as a platform for simulated authentic activities; expanded discussion of nurturing critical thinking in students’ use of Internet websites.

• **Chapter 5:** Expanded discussion of brain development, including a new Figure 5.1 illustrating the interconnectedness of neurons; new discussion of individual differences in brain development as they affect intelligence; expanded discussion of how heredity and environment interact in intellectual development; new boldfaced principle regarding how the general nature of intelligence can change with development; revised discussion of cognitive style to incorporate cultural diversity; new technology-related bullet in the Classroom Strategies box "Working with Students Who Have Significant Delays in Cognitive Development"; new Figure 5.10 illustrating scaffolding in writing instruction; significant revision of the Classroom Strategies box "Promoting Productive Dispositions."

• **Chapter 6:** New introductory section, "Nature of Motivation," including a new Figure 6.1 showing the cyclical nature of motivation, more in-depth discussion of academic engagement, and three overarching motivation principles; new Figure 6.7 providing examples of various attributions; newly titled "Intrinsic and Extrinsic Motivation" section with expanded discussion of extrinsic motivation in two new boldfaced principles and a new Figure 6.3; reorganization of the "Promoting Motivation and Productive Affect" section, with a new Figure 6.9 summarizing many key concepts and a new Figure 6.10 summarizing a MUSIIC mnemonic for organizing motivation strategies; changes from the terms self-determination to autonomy and from emotion self-regulation to emotion regulation, to reflect much of the current literature regarding these topics.

• **Chapter 7:** New boldfaced principle related to the brain’s role in effortful control and adolescent risk taking; expanded discussion of the neurological underpinnings of social cognition; new boldfaced principle regarding the increasing roles of digital technologies in peer relationships; replacement of the term peer pressure with the broader term peer contagion, in line with current thinking about the nature of peer influences; replacement of the term relational aggression with the broader term psychological aggression; expanded discussion of cyberbullying; replacement of Kohlberg’s "Heinz dilemma" with a school-age dilemma about bullying; new boldfaced recommendation on helping students reframe what it means to be "popular"; new section on "Supporting Students Who Face Exceptional Personal or Social Challenges," encompassing a broadened perspective of students who are at risk for school failure; new section on cheating (which previously wasn’t mentioned until Chapter 10).

• **Chapter 8:** New discussion of the Common Core state standards, including their incorporation into Table 8.1; expanded discussion of class websites; new discussion of the National Educational Technology Standards for Students (NETS•S); new discussion of cognitive-load concerns in the section on task analysis; expanded discussion of computer-based instruction, including Internet-based resources and new illustrative examples; new discussion of cultural differences in verbal assertiveness in the Cultural Considerations box.

• **Chapter 9:** New interactive simulations that engage students in making strategic decisions about classroom management problems; new Classroom Strategies box, "Creating and Enhancing a Sense of Classroom Community"; new discussion of schoolwide positive behavior support.

• **Chapter 10:** Return to the opening case study used in the first edition in order to put extra emphasis on the importance of both self-assessment and confidentiality; new Figure 10.1 to illustrate the usefulness of students’ artifacts in diagnosing exceptional learning difficulties; new section on formative assessment, "Enhancing Learning through Classroom Assessment"
Practices”; new discussions of response-to-intervention and curriculum-based assessment; discussion of technological tools for facilitating formative assessment and self-assessment (e.g., AIMSweb, DIBELS); incorporation of the Common Core state standards into Table 10.1; change from the term cultural bias to the broader assessment bias (per Popham, 2006) in order to more clearly communicate that the phenomenon isn’t restricted to minority cultural groups; new See for Yourself exercise regarding cultural bias; expanded discussion of cheating to include technology-based forms of cheating.

Appendixes: New Appendix A on interpreting correlation coefficients; expanded Appendix B (now renamed “Understanding and Interpreting Standardized Test Results”) to include interpretation of a contemporary test-results printout (for the Stanford Achievement Test and the Otis-Lennon School Ability Test) and a graphic strategy for helping parents understand the nature of stanines and NCE scores.

My Rationale for this Book

Ever since my first encounter with psychology as a first-semester college student many years ago, I’ve found psychological concepts and principles to be invaluable in helping me understand and work effectively with my fellow human beings. After earning my bachelor’s degree in psychology, I was determined to apply my discipline to an enterprise about which I care deeply: the education of children. And I’ve been doing so, and in a variety of ways, ever since.

My undergraduate training in psychology in the late 1960s focused largely on theory and research in the behaviorist tradition. In contrast, my graduate training in educational psychology in the early 1970s had a strong information processing bent. Since then I’ve come to know (and love) not only behaviorism and information processing theory but also a host of other theoretical perspectives. And as a teacher, school psychologist, and parent—and now also as a grandparent (picture a smiley face here)—I’ve found all of these perspectives to be useful in my work with children, adolescents, and adult learners.

The traditional approach to teaching and writing about educational psychology is to take one theory at a time, explaining its assumptions and principles and then identifying implications for educational practice. I take this approach myself in my book Educational Psychology: Developing Learners, now in its eighth edition. But as I gained increasing experience teaching educational psychology to college students, I began to teach my courses differently, focusing more on commonalities than differences among theories. In fact, although researchers from different traditions have approached human cognition and behavior from many different angles, they sometimes arrive at more or less the same conclusions. The language they use to describe their observations is often different, to be sure, but beneath all the words are certain nuggets of truth that can be remarkably similar.

In this book I’ve tried to bring educational psychology to the real world of children, teachers, and classrooms. I’ve also tried to integrate ideas from many theoretical perspectives into what is, for me, a general set of principles and strategies that psychology as a whole can offer beginning teachers. These are the Big Ideas I’ve spoken about—and increasingly heard others speak about as well—at professional meetings. After a short introduction to research and its importance (Chapter 1), I proceed to a discussion of the very essence of human experience: cognition (Chapter 2). From that foundation I go in five different directions—to learning in various contexts (Chapter 3), complex cognitive processes (Chapter 4), cognitive development (Chapter 5), motivation (Chapter 6), and personal and social development (Chapter 7)—but always returning to basic cognitive processes that underlie these other universal human phenomena. The last three chapters of the book build on the earlier ones to offer recommendations in instruction (Chapter 8), classroom management (Chapter 9), and assessment (Chapter 10).

Some of my colleagues may be surprised at my use of footnotes rather than APA style throughout the book. My decision was strictly a pedagogical one. Yes, students need to know that the principles and recommendations in this book are research-based. But I’ve found that APA style can be quite distracting for someone who is reading about psychology for the first time and trying to sort out what things are and are not important to learn and remember. Novice psychologists should be concerned more with the ideas themselves than with the people behind the ideas, and by putting most of the people in small print at the bottom of the page, I can...
help novices better focus their attention on what things truly are most important to know and understand.

Features of the Book

ADVANCES IN DIGITAL TECHNOLOGIES REFLECTED IN THE BOOK’S PEDAGOGY

Technological advances have given me and the people at Pearson a wide variety of new tools for enhancing readers’ learning and understanding of the topics in this book. In order to take advantage of these interactive features of the work, readers must have purchased the Pearson etext. There are three types of resources available in the etext that enable readers to (1) assess how well they understand the concepts in the book, (2) see classroom artifacts that serve as examples of concepts and strategies, and (3) apply what they’ve learned in the book to samples of teaching and to simulations. These three types of resources are:

- Embedded assessments with feedback
- Content extensions and examples
- Learning objects called modules

Embedded assessments with feedback. In each chapter, readers will find three to six Check your understanding features at the ends of major chapter sections. These self-quizzes can help readers assess how well they have mastered content related to the chapter’s learning outcomes. Readers of the etext click on the Check your understanding in the Pearson etext link and are taken to a multiple-choice quiz. After they answer the questions, they get feedback on questions they’ve answered correctly, questions they’ve answered incorrectly, and rationales for the correct and incorrect answers. At the ends of Chapters 2 through 10, readers will see two additional types of assessments. First, they will find two application exercises called Practice Using What You Have Learned, such as the ones shown below.

These scaffolded analysis exercises challenge readers to use chapter content to reflect on teaching and learning in real classrooms. The questions that readers answer in these exercises are usually open-ended. Once readers provide their own answers to these questions, they receive feedback in the form of model answers written by experts.

PRACTICE USING WHAT YOU HAVE LEARNED

In the Pearson etext, apply these ideas to teaching.

Facilitating Long-Term Memory Storage Processes

Promoting Knowledge Construction and Conceptual Change
Also at the end of each chapter is an assessment called *Practice for Your Licensure Exam* such as the one below.

**PRACTICE FOR YOUR LICENSURE EXAM**

**Vision Unit**

Ms. Kontos is teaching a unit on human vision to her fifth-grade class. She shows her students a diagram of the various parts of the human eye: lens, cornea, retina, and so on. She then explains that people can see objects because light from the sun or another light source bounces off those objects and into the eye. To illustrate this idea, she shows them the first picture to the right.

“Do you all understand how our eyes work?” she asks. Her students nod that they do.

The next day Ms. Kontos gives her students the second picture shown here.

She asks them to draw how light travels so that the child can see the tree. More than half of the students draw lines like the one shown in the third picture.100

100 The case presented in this exercise is based on a study by Eaton, Anderson, & Smith, 1984.

These assessments, which are modeled after the types of questions found on teacher licensure exams, are designed to give readers practice using the concepts and strategies they’ve learned in the book. They will, I hope, help students prepare for the high-stakes tests that most of them will need to pass in order to acquire their teaching credential. Here, too, readers receive feedback after answering the questions.

**Content extensions and examples.** Readers will also find opportunities to extend their learning of certain topics through supplementary readings. These are marked in the margins by this icon. Readers of the etext will also note that, whereas previous editions included simple photographs to illustrate certain concepts, the present edition includes actual videos. The use of videos instead of static photos enables readers of *Essentials of Educational Psychology* to see many concepts and principles in action—for instance, in students’ behaviors and verbal reflections, in teachers’ classroom strategies, and in adult–child interactions.

**Learning objects called modules.** In select chapters of the etext, readers will find interactive, application-oriented modules.

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1. **Constructed-response question**
   
   Obviously, most of Ms. Kontos’s students have not learned what she thought she had taught them about human vision.
   
   A. Explain why many students believe the opposite of what Ms. Kontos has taught them. Base your response on contemporary principles and theories of learning and cognition.
   
   B. Describe two different ways in which you might improve on the lesson to help students gain a more accurate understanding of human vision. Base your strategies on contemporary principles and theories of learning and cognition.

2. **Multiple-choice question**
   
   Many elementary school children think of human vision in the way that Ms. Kontos’s fifth graders do—that is, as a process that originates in the eye and goes outward toward objects that are seen. When students revise their thinking to be more consistent with commonly accepted scientific explanations, they are said to be:
   
   a. Acquiring a new script
   
   b. Developing automaticity
   
   c. Undergoing conceptual change
   
   d. Acquiring procedural knowledge

   **Answer questions and receive instant feedback in your Pearson etext.**
on such topics as memory, mediated learning experiences, the zone of proximal development, and formative assessment. Written by me, these modules present content through screen-capture videos that include animations, worked examples, and classroom videos. Each module begins with a **Learn** section that presents several key concepts and strategies. This section is followed by an **Apply** section aimed at giving readers practice in applying the concepts and strategies to actual teaching and learning scenarios. After a short **Summary**, each module also includes a multiple-choice test in the **Assess** section. This test includes higher-order questions that assess not only what readers can remember about the module’s content but also how well they can apply the concepts and strategies they’ve learned to real-life classroom situations.

In chapters dealing with classroom environments, etext readers will also be able to access interactive simulations that engage readers in decision making about classroom management strategies. Below is an example of such an exercise.

**OTHER BOOK FEATURES**

The book’s 10 chapters have a variety of features that can help readers better understand, remember, and apply what they’re reading. First, each chapter begins with three to six **Big Ideas**—overarching principles that guide much of the chapter’s discussion, serve as advance organizers for readers, and provide an organizational scheme for the end-of-chapter summary. Then, boldfaced **Guiding Principles** and **Key Strategies** throughout the book highlight key principles and concrete recommendations that can guide teachers in their decision making and classroom practices.
Immediately following each chapter’s Big Ideas is a case study that introduces some of the ideas and issues that the chapter addresses. Throughout each chapter I periodically revisit the case to offer new insights and interpretations.

I often put readers themselves in the position of “learner” and ask them to engage in a short learning or thinking activity. Most of these See for Yourself exercises are similar to ones I’ve used in my own educational psychology classes. My students have found them to be quite helpful in making concepts and principles more “real” for them—and hence more vivid, understandable, and memorable. Below is an example of such an exercise.

For reasons that aren’t entirely clear, the amount of information children can hold in working memory increases somewhat with age. Yet even adults have only so much room to simultaneously hold and think about information. To see what I mean, put your 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 close your eyes—no peeking!—as you try to calculate the answer:

\[ \frac{5943}{383} \]

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 it down, because working memory doesn’t have enough space both to (1) hold all the numbers and (2) do all the math the problem requires. Like attention, working memory has a limited capacity—perhaps just enough for a telephone number or very short grocery list.

An additional feature comes in the form of margin questions that encourage readers to connect chapter content to their past experiences or current beliefs and in some cases also encourage readers to take concepts and principles in new directions.

If you quickly flip through the book, you’ll see many classroom artifacts—that is, examples of work created by actual students and teachers. I use artifacts throughout the book to help readers connect concepts, principles, and strategies to students’ behavior and to classroom practices.

To a considerable degree, I talk about concepts and principles that apply to children and adolescents at all grade levels. Yet first graders often think and act very differently than sixth graders do, and sixth graders can, in turn, be quite different from eleventh graders. Chapters 2 through 10 each have one or more Developmental Trends tables that highlight and illustrate developmental differences that teachers are apt to see in grades K–2, 3–5, 6–8, and 9–12.

Chapters 2 through 10 also each have two or more Classroom Strategies boxes that offer concrete suggestions and examples of how teachers might apply a particular concept or principle. These features should provide yet another mechanism to help my readers apply educational psychology to actual classroom practices.

In Chapter 3 I describe some of the ways in which culture influences children’s learning and development. As follow-ups to that discussion, Cultural Considerations features describe cultural differences in specific areas—for instance, in behavior, reasoning, or motivation. These features appear in Chapters 3 through 10.

Although my approach in this book is to integrate the concepts, principles, and educational strategies that diverse theoretical perspectives offer, it’s also important for future teachers to have some familiarity with specific psychological theories and with a few prominent theorists who have had a significant influence on psychological thinking (e.g., Jean Piaget, Lev Vygotsky, B. F. Skinner). I occasionally mention these theories and theorists in the text discussion, but I also highlight them in Theoretical Perspectives tables in Chapters 2, 5, and 6.
Supplementary Materials

Many supplements to the textbook are available to enhance readers' learning and development as teachers.

**Online Instructor's Manual.** Available to instructors for download at www.pearsonhighered.com/educator is an *Instructor’s Manual* with suggestions for learning activities, supplementary lectures, group activities, and additional media resources. These have been carefully selected to provide opportunities to support, enrich, and expand on what students read in the textbook.

**Online PowerPoint® Slides.** PowerPoint slides are available to instructors for download on www.pearsonhighered.com/educator. These slides include key concept summarizations and other graphic aids to help students understand, organize, and remember core concepts and ideas.

**Online Test Bank.** The *Test Bank* that accompanies this text contains both multiple-choice and essay questions. Some items (lower-level questions) simply ask students to identify or explain concepts and principles they have learned. But many others (higher-level questions) ask students to apply those same concepts and principles to specific classroom situations—that is, to actual student behaviors and teaching strategies. The lower-level questions assess basic knowledge of educational psychology. But ultimately it is the higher-level questions that can best assess students’ ability to use principles of educational psychology in their own teaching practice.

**TestGen.** TestGen is a powerful test generator available exclusively from Pearson Education publishers. You install TestGen on your personal computer (Windows or Macintosh) and create your own tests for classroom testing and for other specialized delivery options, such as over a local area network or on the web. A test bank, which is also called a Test Item File (TIF), typically contains a large set of test items, organized by chapter and ready for your use in creating a test, based on the associated textbook material. Assessments—including equations, graphs, and scientific notation—may be created in either paper-and-pencil or online form.

The tests can be downloaded in the following formats:
- TestGen Testbank file—PC
- TestGen Testbank file—MAC
- TestGen Testbank—Blackboard 9 TIF
- TestGen Testbank—Blackboard CE/Vista (WebCT) TIF
- Angel Test Bank (zip)
- D2L Test Bank (zip)
- Moodle Test Bank
- Sakai Test Bank (zip)

**Artifact Case Studies: Interpreting Children’s Work and Teachers’ Classroom Strategies.** I have written *Artifact Case Studies* (ISBN 0-13-114671-8) as a supplement to the textbook. It’s especially useful for helping students learn to apply psychological concepts and principles related to learning, motivation, development, instruction, and assessment. The case studies, or *artifact cases*, within this text offer work samples and instructional materials that cover a broad range of topics, including literacy, mathematics, science, social studies, and art. Every artifact case includes background information and questions to consider as readers examine and interpret the artifact. Instructors should contact their local Pearson Education sales representative to order a copy of this book and its accompanying Instructor’s Manual.

**Case Studies: Applying Educational Psychology.** With the assistance of Linda Pallock and Brian Harper, Dinah Jackson McGuire and I have coauthored *Case Studies: Applying Educational Psychology* (2nd ed., ISBN 0-13-198046-7) to give students more in-depth practice in applying educational psychology to real children, teachers, and classrooms. The 48 cases
in the book address many topics in educational psychology (learning and cognition, child and adolescent development, student diversity, motivation, instruction, classroom management, and assessment) across a variety of grade levels (preschool through high school). This book, too, is accompanied by an Instructor’s Manual.

Acknowledgments

Although the title page lists me as the sole author of this book, I’ve hardly written it alone. As mentioned earlier, Brett Jones, Associate Professor of Educational Psychology at Virginia Tech, has contributed in significant ways to Chapter 6. In addition, Brett has updated the Instructor’s Manual, Test Bank, and PowerPoint slides for this edition of the book. I’m also greatly indebted to the innumerable psychologists, educators, and other scholars whose insights and research findings I have pulled together in these pages. And Kevin Davis, my editor at Pearson for more than twenty years, has continued to stand by my side to guide me as I’ve tried to navigate through the myriad new topics, controversies, and technological changes that have encompassed both the field of educational psychology and the publishing world. Others at Pearson have also helped to turn my vision into reality. Early in my writing efforts, developmental editor Christie Robb was my day-to-day counsel and sounding board for the many little things that need doing in any book revision. A bit later, Gail Gottfried took over the “D.E.” role and—sharing my own obsessive-compulsiveness for detail (thank you, Gail)—modified and added to my manuscript to accommodate the many technological pedagogical tools that you will see referred to throughout the book. Gail has tirelessly worked to turn what was originally just an abstract ebook idea into a groundbreaking—and truly exciting—reality! Program Manager Carrie Mollette—with equal obsessive-compulsiveness (thank you, Carrie)—tackled countless details regarding permission forms, arts and figures, and other nitty-gritties of the book. Impossible to count, too, are the number of times that Lauren Carlson has come to my rescue, perhaps to connect me with the right forms or with the right people; always prompt and dependable, Lauren has done a lot of the behind-the-scenes work in organizing the project and promoting cross-communication, especially with regard to the etext. And I’ve been thrilled to be working once again with Lynda Griffiths, who has painstakingly copyedited my words, double-checked every reference (possibly the world’s most thankless job), and then steered the manuscript to the final product you see before you now. The fact that Lynda seemingly never tires of seeing new pictures of my grandchildren has been an additional bonus.

It’s equally important to acknowledge the people who have made significant contributions to the new online modules that accompany this fourth edition. Gail Gottfried and Kevin Davis carefully read my initial scripts for the modules, offering many suggestions for enhancing clarity and focus. Furthermore, Gail patiently coached me as I made my initial forays into the voiceover business, and she made my scripts come alive on the screen with animated, engaging graphics. I must also thank two gentlemen who generously give me many hours of pro bono assistance: My friend Ken Geremia offered his recording studio, recording software know-how, and trained ear for the voiceovers, and my husband Richard created many PowerPoint slides that Gail was able to use or adapt in her work with the graphics. These four individuals provided scaffolding I couldn’t have done without, as I was definitely working at the upper limits of my zone of proximal development most of the time!

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Finally, of course, I must thank my husband Richard and children Tina, Alex, and Jeff, who have all shaped my life—and so also this book—in ways too numerous to recall.
1 Introduction to Educational Psychology

BIG IDEAS TO MASTER IN THIS CHAPTER

1.1: Effective teachers use research findings and research-based theories to make decisions about instructional strategies, classroom management, and assessment practices.

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

1.3: Learners read, study, and learn more effectively when they actively try to make sense of new information.
Case Study: The “No D” Policy

Anne Smith is a ninth-grade English teacher with 10 years of teaching experience, and by all accounts she’s an excellent teacher. Even so, in previous years many of her students haven’t invested much time or energy in their writing assignments and seemingly haven’t been bothered by the Cs and Ds they’ve earned in her classes. In an effort to more fully engage this year’s students in their schoolwork, Ms. Smith begins fall semester by initiating two new policies. First, to pass her course, students must earn at least a C; she won’t give anyone a final grade of D. Second, students will have multiple opportunities to revise and resubmit assignments; she’ll give whatever feedback students need—and, if necessary, one-on-one instruction—to help them improve their work. She solicits students’ questions and concerns about the new policies, gains their agreement to “try something new,” and engages them in a discussion of specific, concrete characteristics of A-quality, B-quality, and C-quality work. Then, as the semester progresses, she regularly administers brief surveys to get students’ feedback about her innovations, asking such questions as “How is the ‘no D’ working for you?” “Do you think your grade is an accurate reflection of your learning?” and “Any suggestions?”

Students’ responses on the surveys are overwhelmingly positive. Students mention noticeable improvements in the quality of their writing and increasingly report that they believe themselves to be in control of both their learning and their grades. Furthermore, they begin to see their teacher in a new light—“as one who will help them achieve their best work, not as one who just gives out grades . . . as a coach encouraging them along the long race of learning.” Final course grades also confirm the value of the new policies: A much higher percentage of students earn grades of C or better than has been true in past years.1

- Effective teachers don’t simply transmit new information and skills to students; they also work hard to help students master the information and skills. In the case study just presented, what various strategies does Ms. Smith use to foster her students’ writing development?

Teaching other people—especially teaching the generation that will follow you into the adult world—can be one of the most rewarding professions on the planet. It can also be a very challenging profession. Certainly effective teaching involves presenting a topic or skill in such a way that students can understand and master it. Yet it involves many other things as well. For instance, teachers must motivate students to want to learn the subject matter, must help students recognize what true mastery involves, and—in order to appropriately individualize instruction—must assess where each student currently is in his or her learning and development. And, in general, effective teachers create an environment in which students believe that if they work hard and have reasonable support, they can achieve at high levels. In the opening case study, Anne Smith does all of these things.

Mastering the multifaceted nature of teaching takes time and practice, of course. But it also takes knowledge about human learning and motivation, developmental trends, individual and group differences, and effective classroom practices. Such topics are the domain of educational psychology. This book will help you understand children and adolescents—how they learn and

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1 Action research project described in A. K. Smith, 2009.
Developing as a Teacher

Strategies for Learning and Studying Effectively

Summary

Practice Using What You Have Learned

Practice for Your Licensure Exam: New Software

develop, how they’re likely to be similar to but also different from one another, what activities and assignments are apt to engage them in the classroom, and so on. It will also give you a toolbox of strategies for planning and carrying out instruction, creating an environment that keeps students motivated and on task, and assessing students’ progress and achievement.

GENERAL GUIDING PRINCIPLES OF EDUCATIONAL PSYCHOLOGY

Underlying the seemingly diverse set of topics that educational psychology encompasses are several guiding principles that unify the discipline.

How children and adolescents think and learn, what knowledge and skills they have and haven't 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, as you’ll discover, 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.2

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).

2 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 (APAs) 14 Learner-Centered Psychological Principles on the APA website at www.apa.org; type “learner-centered principles” in the search box on APAs home page.
Now let’s see how well you did on the OOPS. The answers, along with an explanation for each one, are as follows:

1. Some children are predominantly left-brain thinkers, whereas others are predominantly right-brain thinkers. FALSE—With the development of new medical technologies in recent years, researchers have learned a great deal about how the human brain works and which parts of it specialize in which aspects of human thinking. As we’ll discover in Chapter 2, the two halves, or hemispheres, of the brain do seem to have somewhat different specialties, but they continually communicate and collaborate in tackling even the simplest of daily tasks. Practically speaking, there’s no such thing as left-brain or right-brain thinking.

2. The best way to learn and remember a new fact is to repeat it over and over. FALSE—Although repeating new information several times is better than doing nothing at all with it, repetition of specific facts is a relatively ineffective way to learn. Students learn new information more easily and remember it longer when they connect it with things they already know. One especially effective strategy is elaboration: using prior knowledge to expand or embellish on a new idea in some way, perhaps by drawing inferences from a historical fact, identifying new examples of a scientific concept, or thinking of situations in which a mathematical procedure might be helpful. Chapter 2 describes several cognitive processes that effectively help students learn and remember school subject matter.

3. 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 naïve about how they can best learn something, and they often use inefficient strategies when they study. For example, most elementary students and a 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 unless they have considerable prompting to do so. We’ll look at developmental trends in elaboration and other learning strategies in Chapter 2.

4. Students often misjudge how much they have learned. TRUE—Contrary to popular opinion, students are usually not the best judges of what they do and don’t 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’ve 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. We’ll consider this illusion of knowing further in Chapter 4.

5. Anxiety sometimes helps students learn and perform more successfully in the classroom. TRUE—Many people think that anxiety is always a bad thing. In fact, a little bit of anxiety
can actually improve learning and performance, especially when students perceive a task to be something they can accomplish with reasonable effort. For instance, a small, manageable amount of anxiety can spur students to complete their work carefully and to study for tests. We'll explore the effects of anxiety and other emotions in Chapter 6.

6. Children’s personalities are largely the result of their home environments. FALSE—Certainly children’s home environments mold their behaviors to some extent. But heredity also has a significant impact. From Day 1 infants are noticeably different in the extent to which they’re calm or fussy, shy or outgoing, fearful or adventurous, and so on. As we’ll see in Chapter 7, such differences in temperament appear to have their roots in biology and genetics, and they persist throughout the childhood years and into adulthood.

7. Playing video games interferes with children’s cognitive development and school achievement. FALSE, or more accurately, NOT NECESSARILY—A great deal of time spent playing video games instead of reading, doing homework, and engaging in other school-related activities can definitely interfere with children’s long-term academic success. But some video games can be powerful tools for promoting important cognitive abilities, such as sustained attention and spatial reasoning. And educational technologists have increasingly been designing highly motivating video games that simulate real-world problems and foster complex problem-solving skills. In upcoming chapters (especially Chapter 3 and Chapter 8), we’ll examine many ways in which computer technologies can support students’ learning and cognitive development.

8. The ways in which teachers assess students’ learning influence what students actually learn. TRUE—What and how students learn depend, in part, on how they expect their learning to be assessed. For example, in the opening case study, Anne Smith’s “No D” and multiple-submission policies encourage students to seek feedback about their work, benefit from their mistakes, and enhance their writing skills. In Chapter 10 we’ll look more closely at the potential effects of classroom assessment practices on students’ learning.

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. Furthermore, many students in teacher education classes reject research findings when those findings appear to contradict their personal beliefs and experiences.

It’s easy to be persuaded by “common sense” and assume that what seems logical must be true. 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 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.

When educational psychologists describe human learning, development, and motivation, and when they suggest certain 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

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3 Rothbart, 2011; Tobias & Fletcher, 2011.
6 For example, see Darling-Hammond & Bransford, 2005; Waterhouse, 2006.
many of the OOPS items...?" If I had written that paragraph using APA style, it would have looked like this:

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; 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; McDevitt & Ormrod, 2008; Patrick & Pintrich, 2001).

When two or more first authors listed in the references have the same surname, 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. Because this book has separate reference lists for each chapter, you’ll see initials for authors only when two different authors in the same chapter have the same surname.

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. You can find the detailed citations for all of them in the book’s References list.

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’ scores 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, educators gain a better understanding of students and effective classroom practices when they consider findings from both quantitative and qualitative research. And in fact, some studies have both quantitative and qualitative elements. For example, in the research project described in the opening case study, Anne Smith tabulates students’ responses to various survey questions and computes the percentages of various final class grades—all of which are quantitative information. But when she collects students’ completed surveys, she also looks closely at their specific comments and suggestions—qualitative information.

Different kinds of research lead to different kinds of conclusions.

In addition to yielding either quantitative or qualitative data (or both), research studies typically fall into one of four general categories: descriptive, correlational, experimental, and quasi-experimental. These various kinds of studies enable different kinds of conclusions and are appropriate for different kinds of research questions (see Table 1.1).

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.

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7 For more information on APA style, see its Publication Manual (2010) or visit http://www.apastyle.org.
### Table 1.1 • Contrasting Various Types of Research

<table>
<thead>
<tr>
<th>General Nature and Purposes</th>
<th>QUANTITATIVE RESEARCH</th>
<th>QUALITATIVE RESEARCH (DESCRIPTIVE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Descriptive Studies</td>
<td>Correlational Studies</td>
</tr>
<tr>
<td>Capture the current state of affairs regarding a real-world issue or problem</td>
<td>Identify associations among characteristics, behaviors, and/or environmental conditions</td>
<td>Manipulate one (independent) variable in order to observe its possible effect on another (dependent) variable</td>
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<tr>
<td></td>
<td>Enable predictions about one variable, given knowledge of the degree or quantity of another variable</td>
<td>Eliminate other plausible explanations for observed outcomes (especially in carefully controlled experimental studies)</td>
</tr>
<tr>
<td></td>
<td>Provide an alternative when experimental manipulations are unethical or impossible</td>
<td>Enable conclusions about cause–and–effect relationships</td>
</tr>
<tr>
<td>Limitations</td>
<td>Don’t enable either (1) predictions about one variable based on another variable or (2) conclusions about cause–and–effect relationships</td>
<td>Enable only imprecise predictions, with many exceptions to the general relationships observed</td>
</tr>
<tr>
<td></td>
<td>Don’t enable conclusions about cause–and–effect relationships</td>
<td>Don’t enable conclusions about cause–and–effect relationships</td>
</tr>
<tr>
<td>Examples of Questions That Might Be Addressed</td>
<td>How pervasive are gender stereotypes in popular children’s literature?</td>
<td>Are better readers also better spellers?</td>
</tr>
<tr>
<td></td>
<td>What kinds of aggressive behaviors occur in schools, and with what frequencies?</td>
<td>Are students more likely to be aggressive at school if they often see violence at home or in their neighborhoods?</td>
</tr>
<tr>
<td></td>
<td>How well have students performed on a recent national achievement test?</td>
<td>To what extent are students’ class grades correlated with their scores on achievement tests?</td>
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</table>

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.

A **correlational study** explores possible relationships among two or more variables. For example, it might tell us how closely various 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 increases as the other increases (a positive correlation) or when one decreases as the other increases (a negative correlation) in a somewhat predictable manner. The third column in Table 1.1 presents three examples of possible correlational relationships: those between (1) reading and spelling ability,
(2) aggressive behavior at school and violence on the home front, and (3) class grades and achievement test scores. Correlations are often described numerically with statistics known as correlation coefficients, described in Appendix A.

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 a correlation between reading ability and spelling ability, we can predict that, on average, students who are proficient readers will also be good spellers. Our predictions will be imprecise ones at best, with exceptions to the general rule; for instance, we may occasionally see very good readers who are poor spellers.

A more significant limitation of correlational studies is that, although they may demonstrate that a relationship exists, they never tell us for certain why it exists. They don’t tell us what specific factors—previous experiences, personality, motivation, or perhaps other things we haven’t thought of—are the cause of the relationship we see. In other words, correlation does not necessarily indicate causation.

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 often 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 keeping 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 the following examples:

- A researcher uses two different instructional methods to teach reading comprehension skills to two different groups of students. (Instructional method is the independent variable.) The researcher then assesses students’ reading ability (the dependent variable) and compares the average reading-ability 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 instructional program designed to improve their study skills. The researcher gives another group either no instruction or, better still, instruction in subject matter unrelated to study skills. (Presence or absence of instruction in study skills is the independent variable.) The researcher later (1) assesses the quality of students’ study skills and (2) obtains their grade point averages (two dependent variables) to see whether the program had an effect.

Each of these examples includes one or more treatment groups that are recipients of an intervention. The third example also includes a control group that receives either no intervention or a placebo intervention that’s 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 is apt to yield groups that are, on average, roughly equivalent on other variables (pre-existing ability levels, personality characteristics, motivation, etc.) that might affect the dependent variable.

Random assignment to groups isn’t always possible or practical, however, especially in research studies conducted in actual schools and classrooms. For example, when studying the potential benefits of a new teaching technique or therapeutic intervention, a researcher may not be able to completely control which students receive the experimental treatment and which do not, or a particular treatment or intervention may have important benefits for all students. In

\[You \ might \ think \ of \ the \ distinction \ this \ way: \ Student \ behavior \ (the \ dependent \ variable) \ depends \ on \ instructional \ practice \ or \ some \ other \ aspect \ of \ the \ environment \ (the \ independent \ variable).]
such situations, researchers often conduct a quasi-experimental study, in which they take into account but don’t complete control other influential factors. The following are examples:

- A researcher implements a new after-school homework program at one high school and identifies a comparable high school without such a program to serve as a control group. The researcher obtains achievement test data for students at both schools both before and after the program’s implementation. Ideally, to document the homework program’s effectiveness, the average test scores for the two high schools should be the same before the program begins but different after its implementation.

- A team of researchers wants to study the effects of safety instructions on children’s behaviors on the playground. The researchers present the instructional intervention to first graders one week, second graders the following week, and kindergartners and third graders the week after that. The researchers monitor students’ playground behavior before, during, and after the intervention to determine whether each grade-level group’s risky playground behavior decreases immediately following the intervention.9

When researchers conduct such quasi-experimental studies, they don’t control for all potentially influential variables and therefore can’t completely rule out alternative explanations for the results they obtain. For instance, in the after-school homework program example, possibly the school getting the new homework program—but only that school—has simultaneously begun to use more effective instructional methods during the school day, and those methods are the reason for any increase in achievement scores. And in the playground safety example, perhaps certain other things coincidentally happened in the four classrooms during their respective safety-instructions weeks, and those things were the true causes of children’s behavior improvements.

When carefully designed and conducted, experimental studies and, to a lesser degree, quasi-experimental studies enable us to draw conclusions about causation—about why behaviors occur. Yet for practical or ethical reasons, many important questions in education don’t easily lend themselves to experimental manipulation and tight control of other potentially influential variables. For instance, although we might reasonably hypothesize that children can better master difficult math concepts if they receive individual tutoring, most public 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 although we might find a correlation between children’s aggression levels at school and the amount of violence in their home environments, it would be highly unethical to conduct an experimental study in which some children are intentionally placed in a violent environment. Some important educational questions, then, can be addressed only with descriptive or correlational studies, even though such studies don’t let us pin down precise cause-and-effect relationships.

Research can be seamlessly integrated into teachers’ ongoing classroom practices.

Certainly the collection and interpretation of research data aren’t restricted only to individuals who work in universities and research laboratories. Like Anne Smith in the opening case study, practicing teachers sometimes have questions that existing research findings don’t fully answer. In action research, teachers conduct systematic studies of issues and problems in their own schools, with the goal of seeking more effective strategies for working with students. For example, an action research project might involve examining the effectiveness of a new teaching technique, seeking students’ opinions on a new classroom policy (as Ms. Smith does), or ascertaining reasons why many students rarely complete homework assignments.

Any action research study typically involves the following steps:10

1. Identify an area of focus. The teacher–researcher begins with a problem and gathers preliminary information that might shed light on the problem, perhaps by reading relevant books or journal articles, surfing the Internet, or discussing the issue with colleagues or students. The

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9 Here I’m describing a study conducted by Heck, Collins, and Peterson (2001).
10 Steps based on those recommended by Mills (2011).
teacher–researcher then identifies one or more specific questions to address and develops a research plan for answering those questions (data collection techniques, necessary resources, schedule, etc.). At this point, the teacher also seeks permission to conduct the study from school administrators and any other appropriate authorities. Depending on the nature of the study, parents’ permission may be necessary as well.

2. **Collect data.** The teacher–researcher collects data relevant to the research questions. Such data might, for example, be obtained from questionnaires, interviews, achievement tests, students’ journals or portfolios, existing school records (e.g., attendance patterns, school suspension rates), observations, or any combination of these.

3. **Analyze and interpret the data.** The teacher–researcher looks for patterns in the data. Sometimes the analysis involves computing particular statistics (e.g., percentages, averages, correlation coefficients)—this would be a quantitative study. At other times the analysis involves an in-depth, non-numeric inspection of the data—this would be a qualitative study. In either case the teacher–researcher relates the findings to the original research questions.

4. **Develop an action plan.** The final step distinguishes action research from the more traditional research studies described earlier. In particular, the teacher–researcher uses the information collected to take action—for instance, to change instructional strategies, school policies, or the classroom environment.

Many colleges and universities now offer courses in action research. You can also find inexpensive books on the topic.

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

Whenever we look at the results of a research study—regardless of who has conducted the study and regardless of whether it has been described in a professional journal or other credible media source—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 advanced 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? Or, perhaps, did the RIG teachers have students who were, on average, better readers to begin with? If the RIG and RAY classes were different from each other in any of these ways—or perhaps different in some other way we haven’t thought of—then the district hasn’t eliminated alternative explanations for why the RIG students have outperformed the RAY students. A better way to study the causal influence of reading program on reading comprehension would be to randomly assign third-grade classes to the RIG and RAY programs, thereby making the two groups similar (on average) in terms of student abilities and teacher characteristics.

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 research reports 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.

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

Some research studies have obvious, direct implications for educational practice. Other studies contribute to educational practice indirectly through the theories researchers develop to integrate and explain their findings. In these 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 underlying 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. In Chapter 2 we’ll discover that 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; in the words of a popular expression, the information goes “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 presenting interesting reading materials or intriguing real-world problems—are apt to enhance students’ learning and achievement.

Psychological theories are rarely, if ever, set in stone. Instead they’re continually revised as additional data come to light, and in some cases one theory may be abandoned in favor of another one that better explains certain phenomena. Furthermore, various theories tend to focus on different aspects of human functioning, and psychologists haven’t yet pulled them together into a single “mega-theory” that adequately accounts for all the diverse phenomena and experiences that comprise human existence.

Although current theories related to thinking, learning, development, motivation, and behavior will inevitably change in the future, they can be quite useful even in their unfinished forms. They help us integrate thousands of research studies into concise understandings of how children typically learn and develop, and they enable us to make reasonable guesses about how students are likely to perform and achieve in particular classroom contexts. In general, then, 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.

✓ Check your understanding in the Pearson etext.

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. It’s only a start, however. True expertise in any profession, including teaching, takes many years of experience to acquire, although even a single year of teaching experience can make a significant difference. So be patient with yourself, and recognize that occasionally feeling a bit unsure and making mistakes is par for the course. As you gain experience, you’ll gradually become able to make decisions about routine situations and problems quickly and efficiently, giving you time and energy to think creatively and flexibly about how best to help classroom subject matter.

Conducting action research is, of course, one effective way of developing your knowledge and skills as a teacher. Here I offer several additional strategies—all of them based on research on teacher effectiveness.

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

Occasional university coursework and in-service training sessions are two good ways to enhance teaching effectiveness. 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 solid understanding of classroom topics, convey obvious enthusiasm for whatever they are teaching, and so on—we typically find teachers who know their subject matter extremely well. Effective teachers also have many strategies for teaching particular topics and skills—strategies collectively known as *pedagogical content knowledge.* And good teachers can usually anticipate—and thus can also address—the difficulties students will have and the kinds of errors students will make in the process of mastering a certain skill or body of knowledge.

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

In Cultural Considerations boxes throughout the book, 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 might 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.

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

In the opening case study, Anne Smith reflects on her students’ performance in previous years and then institutes new assessment policies that might be more motivating and productive. Like Ms. Smith, 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.

**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—through face-to-face meetings, e-mail, regional or national conferences, and professional websites (e.g., www.tappedin.org, www.oercommons.org). Ideally, too, teachers and administrators at a single school create a *professional learning community,* in which they share a common vision for students’ learning and achievement, work collaboratively to achieve desired outcomes for all students, and regularly communicate with one another about their strategies and progress.

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 you may initially have. Most experienced teachers are happy to offer you advice and support during challenging times. In fact, they’re apt to be flattered that you’re asking them!

**Believe that you can make a difference in students’ lives.**

In Chapter 6 you’ll discover the importance of having 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 believe they *can* learn it—in other words, if they have high self-efficacy.

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14 Baumert et al., 2010; Cochran & Jones, 1998; Krauss et al., 2008; Shulman, 1986.
16 Castagno & Brayboy, 2008; McIntyre, 2010; Rogoff, 2003.
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, as teachers, can do—both individually and collectively—for their students. Ultimately, what teachers do in the classroom matters for students, not only in the short term but for years to come.

✓ Check your understanding in the Pearson etext.

STRATEGIES FOR LEARNING AND STUDYING EFFECTIVELY

The book includes many features that will, I hope, help you read about, study, and apply what researchers and experienced educators have learned about learning, development, motivation, and effective classroom practices. For example, each chapter begins with three to six Big Ideas that capture the chapter’s underlying themes. Each chapter also presents its major premises (Guiding Principles) and recommendations (Key Strategies) as boldfaced headings. 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 new ideas. I’m optimistic that you’ll become a better student after reading those chapters, but in the meantime here are five general strategies you can use as you read and study this book.

Relate what you read to your existing knowledge and prior experiences.

Try to connect the ideas you read in the book with things you already know and believe. For example, connect new concepts and principles with memorable childhood events, previous coursework, or your general knowledge about human beings and their behavior. I’ll occasionally assist you in this process by asking questions that encourage you to reflect on your prior experiences, knowledge, and beliefs.

Actively consider how some new information might contradict your existing beliefs.

As my earlier OOPS test may have shown you, some of what you currently “know” and believe may be sort-of-but-not-quite accurate or even downright inaccurate. People’s existing beliefs can occasionally wreak havoc with new learning. For example, many students in teacher education classes adamantly reject research findings that appear to be inconsistent with their personal beliefs and experiences.

As you read this book, then, think about how some ideas and research findings might actually contradict your prior “knowledge.” When you encounter puzzling or seemingly “wrong” ideas and findings, I hope you’ll keep an open mind and consider how and why they might have some merit. Truly effective learners occasionally undergo conceptual change, revising their current understandings and beliefs in light of new and trustworthy evidence. You’ll learn more about this process in Chapter 2.

Tie abstract concepts and principles to concrete examples.

As you’ll discover in Chapter 5, 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 when they tie it to concrete objects and events. Short examples and lengthier case studies that involve real children and teachers, videos that depict classrooms in action, See for Yourself exercises such as my OOPS test—all of these can enhance your understanding and memory of

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22 Hattie, 2009; Konstantopoulos & Chung, 2011.
new concepts and help you recognize them when you see them in your own work with children and adolescents.

**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.

**Periodically check yourself to make sure you remember and understand what you have 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 thought about and understood the things you’ve been reading. Try to summarize the material. Ask yourself questions about it. Make sure everything makes sense to you. And when you’ve finished reading a chapter, tackle the Practice for Your Licensure Exam exercise that appears after the chapter summary, and check your mastery of various concepts by doing activities and taking quizzes available in the Pearson etext. You’ll discover the nature and advantages of such comprehension monitoring in Chapter 4.

✓ Check your understanding in the Pearson etext.

### 1 SUMMARY

Each chapter in this book includes a summary organized around the Big Ideas listed at the beginning of the chapter. Following are the Big Ideas for Chapter 1.

- **1.1: Effective teachers use research findings and research-based theories to make decisions about instructional strategies, 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 what various phenomena and events are like (qualitative and quantitative descriptive 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. In addition, many teachers now conduct their own research to address specific questions they have about their students and their classroom practices.

- **1.2: 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 cultural groups in which your students live. Some of these things you can learn about through books, professional journals, advanced coursework, the Internet, and collaboration with professional 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 important, 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 successes.

- **1.3: 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 (1) relate new information to your existing knowledge and prior experiences, (2) consider how some new information might contradict—and perhaps have greater validity than—your current beliefs, (3) tie abstract ideas to concrete examples, (4) embellish (elaborate) on what you’re learning—for instance, by generating new examples and applications—and (5) occasionally stop to monitor your understandings of what you’ve read and studied.

**think about it**

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?

For additional strategies, read “Study Tips” in the Pearson etext.
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. "You know how these kids are; they just aren't used to doing it on their own," Ken responds.

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
Strategies for Learning and Studying Effectively

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.

Answer questions and receive instant feedback in your Pearson eText.
2 Learning, Cognition, and Memory

2.1: Much of human learning involves a process of actively constructing knowledge, rather than passively absorbing it.

2.2: Knowing how the brain works is helpful, but some well-meaning educators have misinterpreted findings from brain research.

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

2.4: Human memory is fallible: Learners don’t remember everything they learn, and sometimes they misremember what they’ve learned.

2.5: Effective teachers help students mentally process new information and skills in ways that facilitate long-term memory storage and retrieval.
Case Study: Making Mountains

Where do mountains come from? Seven-year-old Rob has an interesting take on the matter, as he reveals in the following conversation with an adult:

Adult: How were the mountains made?
Rob: Some dirt was taken from outside and it was put on the mountain and then mountains were made with it.

Adult: Who did that?
Rob: It takes a lot of men to make mountains—there must have been at least four. They gave them the dirt and then they made themselves all alone.

Adult: But if they wanted to make another mountain?
Rob: They pull one mountain down and then they could make a prettier one.¹

• Rob’s basic premise—that human beings are actively involved in mountain formation—is clearly incorrect. Nevertheless, his “knowledge” about mountains does have a few elements of truth. What things does Rob correctly know about mountains?
• What general principles about human learning might Rob’s conception of mountain formation reveal?

Given what Rob tells the adult, it’s hard to know exactly what he believes about mountains. He first talks about dirt being “put” on a mountain and about men “making” mountains. However, when he says, “they made themselves all alone,” perhaps he’s talking about the mountains making themselves, albeit with the assistance of a few men who “give” them dirt. Despite Rob’s obviously naive notions, he has learned a few correct facts about mountains. In particular, he knows that (1) mountains are fairly big (requiring the work of “a lot of men”), (2) they’re comprised of dirt (which is true, at least in part), and (3) they can be quite pretty to look at.

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 Rob’s depiction of mountain formation illustrates, learning is often a matter of creating knowledge, rather than receiving and absorbing it directly from other sources. In other words, learning is a constructive process.

Learning as a Constructive Process

A good general definition of learning is: 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 make a phone call—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 four general viewpoints, listed largely in the order in which they’ve gained prominence in educational psychology. For the most part, these diverse perspectives complement rather than contradict one another, and together they can give us a rich, multifaceted picture of human learning.

¹Piaget, 1929, p. 348.
Accordingly, as you can see in the right-most column of the table, they’ll all contribute considerably to upcoming discussions of what learning involves and how teachers can better enhance students’ classroom performance and long-term success.

In this chapter we’ll look primarily at what goes on inside the learner during the learning process. In doing so, we’ll make good use of cognitive psychology, a group of research-based theories that address a variety of mental phenomena underlying human behavior—perception, memory, reasoning, and so on. Several basic principles, described in the following sections, underlie much of what cognitive psychologists have learned about learning.

By the time they reach school age, young learners are actively involved in much of their own learning. Sometimes children learn from an experience without really giving the situation 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 such implicit learning; even older children and adults continue to learn some things about their environments in a nonintentional, “thoughtless” way. But as children grow, they increasingly engage in intentional, explicit learning: They consciously think about, interpret, and reconfigure what they see and hear in their environment. As a simple example, try the following exercise.

**SEE FOR YOURSELF**

**TWOELVE WORDS**

Study the 12 words below for a few seconds. 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 specific things people mentally do as they try to interpret and remember what they see, hear, and study—that is, their cognitive processes—have a profound effect on what they specifically learn and remember. 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. In the preceding “Twelve Words” exercise, sorting the words into categories was one possible encoding strategy. But perhaps, instead, you encoded the word list by creating a story or poem (e.g., “As Daisy and Tulip were walking, they ran across Dandy and Rose . . .”), or perhaps you formed a mental image of the 12 items in an elaborate, if not entirely edible, fruit salad (see Figure 2.1).

Cognitive psychologists have offered numerous explanations of how people mentally process and remember new information and events—explanations that fall into the general category of encoding.
# THEORETICAL PERSPECTIVES

<table>
<thead>
<tr>
<th>THEORETICAL PERSPECTIVE</th>
<th>GENERAL DESCRIPTION</th>
<th>EXAMPLES OF PROMINENT THEORISTS</th>
<th>WHERE YOU WILL SEE THIS PERSPECTIVE IN THE BOOK</th>
</tr>
</thead>
</table>
| Behaviorism             | Early behaviorists argued that thought processes cannot be directly observed and thus cannot be studied objectively and scientifically. Accordingly, most behaviorists downplay the role of cognitive processes in learning and instead focus on two things researchers can observe and measure: people's behaviors (responses) and the environmental events (stimuli) that precede and follow those behaviors. 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 Thordike
Ivan Pavlov
Supplementary Reading 2.1 (For example, read “B. F. Skinner’s Operant Conditioning” in the Pearson etext.) | We’ll examine learning from a stimulus–response perspective early in Chapter 3 (see the first four principles in the section “Immediate Stimuli as Context”). We’ll also draw from behaviorist ideas when we address classroom management in Chapter 9 (see the discussions of cueing, punishment, applied behavior analysis, functional analysis, and positive behavior support in the section “Reducing Unproductive Behaviors”). |
| 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) play a significant role as well. Often 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 | The social cognitive perspective will come into play in our discussions of modeling, vicarious consequences, incentives, and reciprocal causation in Chapter 3, as well as in our discussion of self-regulation in Chapter 4. Later, we’ll sometimes draw from social cognitive theory as we examine motivation (and especially as we focus on self-efficacy and goals) in Chapter 6. |
| Cognitive Psychology    | 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 people’s responses to various situations and tasks, these theorists draw inferences about how people may perceive, interpret, and mentally manipulate information they encounter in the environment. Many cognitive psychologists speculate about what internal mechanisms underlie human cognition (e.g., working memory and long-term memory) and about how people mentally process new information (e.g., through elaboration and visual imagery); this approach is called information processing theory. Other cognitive theorists focus on how individual learners create knowledge through their interactions with the environment; this approach is known as individual constructivism. | Richard Atkinson
Richard Shiffrin
Jean Piaget
Jerome Bruner
John Bransford
Supplementary Reading 2.2 (For example, read “Jean Piaget’s Theory of Cognitive Development” in the Pearson etext.) | Cognitive psychology provides the basis for most of the discussion of learning and memory in this chapter. It will also be central to our discussion of complex cognitive processes in Chapter 4. It will be influential, too, in our discussions of cognitive development and intelligence in Chapter 5, cognitive factors influencing motivation in Chapter 6, social cognition in Chapter 7, and instructional strategies in Chapter 8. |
| Contextual Theories     | Contextual theorists place considerable emphasis on the influence of learners’ physical and social environments on cognition and learning. But rather than talk about specific stimuli (as behaviorists do), they focus on more general factors—physical, social, and cultural—that support “thoughtful” (i.e., cognition-based) learning. Some contextual theorists suggest that young learners initially use sophisticated thinking strategies in social interactions and gradually internalize these strategies for their own, personal use; this approach is known as sociocultural theory. Other contextual theorists emphasize that by working together, two or more people can often gain better understandings than anyone could gain alone; this approach is sometimes called social constructivism. Still other theorists propose that various ways of thinking are inextricably tied to particular physical or social circumstances; this approach goes by a variety of labels, including situated learning and distributed cognition. | Lev Vygotsky
Jean Lave
Barbara Rogoff
Roy Pea
Gavriel Salomon
James Greeno
Supplementary Reading 2.3 (For example, read “Lev Vygotsky’s Theory of Cognitive Development” in the Pearson etext.) | In Chapter 3, contextual theories will underlie our discussions of cultural and societal factors and technological advancements that significantly influence people’s learning and thinking. Sociocultural theory will play a prominent role in our discussion of cognitive development in Chapter 5. We’ll also bring contextual perspectives into play as we discuss complex cognitive processes in Chapter 4, motivation in Chapter 6, instructional strategies in Chapter 8, and classroom management in Chapter 9. Furthermore, the “Cultural Considerations” boxes in Chapters 3 through 10 will continually remind us how students’ cultural backgrounds are likely to influence their thoughts, perceptions, and behaviors. |
of information processing theory. Many of their early explanations portrayed human thinking and learning as being similar to the ways computers operate. It has since become clear, however, that the computer analogy is too simple: People often think about and interpret information in ways that are difficult to explain in the one-thing-always-leads-to-another ways that characterize computers.3

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—the many letters on this page, the many other objects you can see while you’re reading, the various sounds reaching your ears, the articles of clothing touching your skin, and so on. I suspect that you’ve been ignoring most of these stimuli until just now, when I specifically asked you to think about them. 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.

As an analogy, consider the hundreds of items a typical adult receives in the mail each year, not only in paper form from the post office but also in electronic form through e-mail. Do you open, examine, and respond to every piece of mail? Probably not. If you’re like me, you look closely at a few key items, inspect other items long enough to know that you don’t need them, and discard still others 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’s most important to learn and what can reasonably be cast aside as “junk mail.”

Learners actively create—rather than passively absorb—much of what they know and believe about the world.

People learn some things simply by mindlessly “soaking up” certain regularities in their environment.4 However, a good deal of human learning involves a process of construction: In an effort to make sense of their experiences, learners use many separate tidbits of information to create a general understanding, interpretation, or recollection of some aspect of their world.5 As the conversation with 7-year-old Rob in the opening case study illustrates, learners are apt to construct their own, unique understandings of any given topic or situation, and these understandings may be accurate—or not—to varying degrees. Theories that focus primarily on the nature of constructive processes in learning are collectively known as constructivism, and a subset of them that address how learners idiosyncratically construct knowledge on their own (rather than in collaboration with other people) are known as individual constructivism.

In the following exercise, you’ll almost certainly be able to see the process of construction in your own learning.

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**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

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3 For example, see Hacker, Dunlosky, & Graesser, 2009a; Marcus, 2008; Minsley, 2006.

4 For example, see Aslin & Newport, 2012.

5 For two classic works on constructive processes in learning, see Bransford & Franks, 1971; Neisser, 1967.
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.6

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

Were you able to make sense of the passage? What did you think it was about? A prison escape? A wrestling match? Or something else altogether? The passage 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 find meaning of one sort or another in the passage.

Active, constructive processes in learning—what theorists sometimes refer to as meaning making—are 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.

Objectively speaking, the three configurations of black splotches, and especially the two right-most ones, leave a lot to the imagination. 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 what human faces typically look like may have been enough to enable you to mentally add the missing pieces 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 trouble perceiving them originally.

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 completed, 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.

When different learners construct different meanings from the same situation, it’s often because they each bring unique prior experiences and knowledge to the situation. For instance, 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. Not only do learners bring different areas of expertise to a learning task, but they also bring different childhood experiences, cultural backgrounds, and general knowledge and assumptions about the world, and such differences are apt to have a significant impact on their meaning-making efforts. For example, we might reasonably guess that 7-year-old Rob had seen people moving large mounds of dirt around—perhaps at construction sites—but he probably had no knowledge of the geological processes (e.g., erosion, plate tectonics) that underlie mountain formation.

The brain is, of course, the place where human beings think about, make sense of, and learn from their environment. We now take a look at the brain and some of its key characteristics.

✓ Check your understanding in the Pearson etext.

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 countless 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 messages across the tiny spaces—synapses—between them. Any single neuron may have synaptic connections with hundreds or even thousands of other neurons.

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). Figure 2.3 can give you a sense of what neurons and astrocytes look like.

As you’ll discover in Chapter 5, the brain changes in important ways over the course of childhood and adolescence. Yet four 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.

7Anderson et al., 1977.
8Goodman & Tessier-Lavigne, 1997; Lichtman, 2001; Mareschal et al., 2007.
9Koob, 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. 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’s 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.

The brain functions in close collaboration with—rather than in relative isolation from—the rest of the body. Obviously the brain can’t function without the nutrition and health of the rest of the body, and it gets new information from the eyes, ears, and other sensory organs. But in addition, thinking and learning are often intimately intertwined with people’s physical actions and reactions. For example, when people think about throwing a baseball—even if they aren’t actually throwing one—they activate parts of the brain that control arm and hand muscles involved in throwing. And when people are pondering complex situations—perhaps math problems or perhaps the shapes and locations of various objects in space—gestures with their hands or arms can sometimes help them think and talk about the situations more effectively.

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

From a physiological standpoint, how and where does learning occur? Until recently, the great majority of learning theorists believed that the physiological basis for most learning lies primarily in changes in the interconnections among neurons. In particular, learning may involve strengthening existing synapses, forming new ones, or, in some cases, 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.

Within the past few years, some researchers have begun to speculate that astrocytes are just as important as neurons in learning and memory—possibly even more important. 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 many 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.

Many new astrocytes form throughout our lifetimes. 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. Learning experiences seem to stimulate the formation of new brain cells, although researchers don’t yet know exactly how these new cells are related to learning and memory.

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

As you’ll see in upcoming sections of the chapter, recent research on the human brain has yielded helpful insights regarding human memory and effective instructional practices. It has also enhanced our knowledge about the typical course of cognitive development (see Chapter 5) and the neurological bases of certain disabilities (e.g., dyslexia, autism spectrum disorders).

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 example, brain research can’t tell us much about what information and skills are most important for people to have in a particular community and culture. Nor does it provide much specific guidance about how teachers can best help their students acquire such information and skills. 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 learning and identify effective ways of helping children and adolescents learn more effectively, we must look primarily at what psychologists, rather than neurologists, have discovered. Hence, we continue our exploration of learning and cognitive processes by looking at what psychologists have discovered about human memory.

✓ Check your understanding in the Pearson etext.

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 particular “locations” where knowledge is held—for instance, in working memory or long-term memory.

The process of “putting” something into memory is called storage. In contrast, 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

How quickly can you 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.

Human memory is a complex, multifaceted phenomenon 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...

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21 Bloom & Tinker, 2001; Chalmers, 1996; Gardner, 2000b.
22 Beck, 2010; Byrnes, 2007; Miller, 2010; Schenck, 2011.
How Human Memory Operates

感官输入只保持原始形式的时间很短。

如果你曾经在夜晚玩过烟火棒——一种金属棒，点燃后会产生短暂的火花——你见过它被挥舞时所发出的明亮尾光。如果你曾经在课堂上做白日梦，你可能已经注意到，当你重新关注到你的老师时，你仍然能“听到”那三四个单词。烟火的尾光和这些残留的词并不实际存在于环境中。相反，它们被记录在你的感觉登记中。

感觉登记是存储你接收的信息的地方，这些信息以原始的、未编码的形式保持。你的身体所看到的、听到的，或以其他方式感知到的大部分信息都被存入感觉登记中。换句话说，感觉登记具有大量的容量。它可以将信息以任何时间存储。

那是个好消息。坏消息是，被存储在感觉登记中的信息不会持续很长时间。视觉信息（你所看到的）可能只持续不到一秒钟。作为一个孩子，我从来没有能够用烟火棒拼出我的全名（Jeanne）——不管是J还是n，不管我写得多快，J总是在我写第一个n之前就消失了。听觉信息（你所听到的）可能稍微长一些，大约两到三秒钟。为了在所有时间保持信息，学习者需要将它移动到工作记忆中。

注意是大多数学习和记忆所必需的。

最近接收到的感觉信息——如烟火的亮光——不会持续很长时间，无论是什么。但我们可以通过编码将它存储在记忆中，以在最可能的情况下进行处理。例如，通过识别字母或熟悉形状的烟火棒的卷曲尾巴。在模型中，如图2.5所示，处理的第1步是注意。无论学习者如何保持注意，它都会持续到工作记忆。如果信息没有被注意，它很可能会从记忆系统中消失。

23 For example, see R. C. Atkinson & Shiffrin, 1968; Reisberg, 1997; Willingham, 2004.
24 Findings from recent brain research reveal that the various components of memory depicted in Figure 2.5 aren’t completely separate entities; for example, see Baddeley, 2001; Nee, Berman, Moore, & Jonides, 2008; Ozkem, Davachi, & McElre, 2010.
26 Some nonattended-to information may remain, but without the learner’s conscious awareness of it, it can be extremely difficult to recall, especially over the long run; for example, see Cowan, 2007.
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 though your eyes were focused on the words in your book, you weren’t mentally attending to the words.

Young children’s attention often moves quickly from one thing to another and is easily drawn to objects and events unrelated to the task at hand. As children grow older, they become better able to focus their attention on a particular task and keep it there, and they’re less distracted by irrelevant thoughts and events. Yet even adult learners can’t keep their minds on a single task all the time.27

Furthermore, even when learners are paying attention, they can attend to only a very small amount of information at any one time. For example, if you’re sitting in front of the television with your textbook open in your lap, you can attend to the rerun of *The Simpsons* playing on the TV screen or to your book, but you can’t attend to both simultaneously. And if you’re preoccupied in class with your instructor’s ghastly taste in clothing and desperate need for a fashion makeover, you’ll have a hard time paying attention to what your instructor is saying.

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 at the same time, and you can probably drink a cup of coffee while you’re driving a car. But when a stimulus or event is detailed and complex (as is true for both textbooks and *Simpsons* reruns) or when a task requires considerable thought and concentration (as is true for understanding a lecture in a college class or driving a car on a busy city street), then people can usually attend to only one thing at a time.28

Let’s return to a point made earlier: 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 and e-mail we receive every day.

**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 time so that learners can make better sense of it. It’s also where much of learners’ active cognitive processing occurs. It’s where they 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*.

Rather than being a single entity, working memory probably has several components for holding and working with different kinds of information—for example, visual information, auditory information, and the underlying meanings of events—as well as a component that integrates multiple kinds of information. As shown in Figure 2.5, working memory may also include a central executive that focuses attention, oversees the flow of information throughout the memory system, selects and controls complex voluntary behaviors, and inhibits counterproductive thoughts and actions.29

Information stored in working memory doesn’t last very long—perhaps 5 to 20 seconds at most—unless learners do something more with it.30 Accordingly, it’s sometimes called *short-term memory*. For example, imagine that you need to call a neighbor, so you look up the neighbor’s number.

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27 Barron, Riby, Greer, & Smallwood, 2011; Dempster & Corkill, 1999; Reichle, Reineberg, & Schoolder, 2010.
30 For example, see Baddeley, 2001; Peterson & Peterson, 1959; Zhang & Luck, 2009.
number in the telephone book. Because you’ve paid attention to the number, it’s presumably in your working memory. But then you discover that you can’t find your cell phone, nor do you have any paper and pencil handy. How might you remember the number until you can make the phone call? One common strategy is **rehearsal**—repeating it over and over—which can help you keep information in working memory until you need to use it. But once you stop talking to yourself, the information may quickly disappear.

For reasons that aren’t entirely clear, the amount of information children can hold in working memory increases somewhat with age. Yet even adults have only so much room to simultaneously hold and think about information. To see what I mean, put your 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 close your eyes—no peeking!—as you try to calculate the answer:

\[
59 \div 49,383
\]

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 it down, because working memory doesn’t have enough space both to (1) hold all the numbers and (2) do all the math the problem requires. Like attention, working memory has a **limited capacity**—perhaps just enough for a telephone number or very short grocery list.

I sometimes hear students talk about 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 definitely 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 learners store general knowledge and beliefs about the world, recollections of past experiences, and facts learned in school. Such knowledge about what and how things are is known as **declarative knowledge**. Long-term memory is also where learners store knowledge about how to perform various behaviors, such as how to ride a bicycle, swing a baseball bat, or write a cursive letter. 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’s 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, learners can’t always find (retrieve) it when they need it. As we’ll see in upcoming sections, the ability to retrieve previously learned information from long-term memory depends on both the way in which learners have 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’s 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.

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32 Cowan, 2010; Logie, 2011; Miller, 1956.
information in long-term memory is interconnected and organized to some extent.

As you should recall from our earlier discussion of the brain, neurons have many, many synaptic connections with one another, and thinking about virtually any topic tends to involve many parts of the brain. It shouldn’t surprise you to learn, then, that people’s knowledge, beliefs, and skills tend to be interconnected in long-term memory. To get a glimpse of how ideas in your own long-term memory are interconnected and organized, try the following exercise.

**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.

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. For instance, beginning in infancy, they form **concepts** that enable them to categorize objects and events. Some concepts, such as butterfly, chair, and backstroke, encompass a fairly narrow range of objects or events. Others, such as insect, furniture, and swimming, have a broad scope and may subsume a number of more specific concepts, as illustrated by Noah’s butterfly-is-an-insect drawing in Figure 2.7. Noah might, of course, associate butterfly with swimming as well as with insect—because one form of swimming is the butterfly stroke—in which case he could have a train of thought such as this:

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

horses eat oats and carrots, love grazing and running, and frequent appearance on farms 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. When a schema involves a predictable sequence of events related to a particular activity, it’s sometimes called a **script**. The next exercise provides an example.

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**REFERENCES**

2. For example, see Kalyuga, 2010; Rumelhart & Ortony, 1977; Schraw, 2006.
How Human Memory Operates

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.

You probably had no trouble making sense of the passage because you’ve been to a doctor’s office yourself and have a schema for how those visits usually unfold. You can therefore fill in a number of details that the passage doesn’t tell you. For example, you probably inferred that John went 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 critical information is missing, as is true in the story about John, schemas and scripts often enable learners to fill in the gaps in a reasonable way.

On a much larger scale, human beings—young children included—construct general understandings and belief systems, or theories, about how the world operates. Such theories include many concepts and the relationships among them (e.g., correlation, cause–and–effect). To see what some of your own theories are like, try the next exercise.

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. Was the object now 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. Next 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. At this point, was the animal a skunk or a raccoon?

You probably 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. 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). 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

35 Bower, Black, & Turner, 1979, p. 190.
37 Both scenarios based on Keil, 1989, p. 184.
brought them into being, their DNA).39 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 can’t possibly be a skunk.

By the time children reach school age, they’ve constructed basic theories about their physical, biological, and social worlds.40 For example, in the opening case study, we get a glimpse of 7-year-old Rob’s theory about the earth’s topography—a theory in which human beings apparently play a critical role. By school age, too, children have 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 (see Chapter 7). In general, self-constructed theories help children make sense of and remember personal experiences, classroom subject matter, and other new information.41 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 a bit later).

How well long-term memory is integrated and in what ways it’s 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 model of memory presented in Figure 2.5, the arrow between working memory and long-term memory points in both directions. Effectively storing new information in long-term memory usually involves connecting it to relevant information that’s already in long-term memory—a process that requires bringing the “old” information back into working memory.42 The next exercise illustrates this point.

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**SEE FOR YOURSELF**

**LETTERS AND A PICTURE**

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

2. Study the line drawing shown here until you can reproduce it accurately from memory.

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No doubt you found the second letter string easier to remember because you could relate it to something you already knew: the words familiar words. How easily were you able to learn and remember the picture? Do you think you could draw it from memory a week from now? Do you think you could remember it more easily if it had the title “Bird’s Eye View of a Cowboy Riding a Bicycle”? The answer to the last question is almost certainly yes, because the title would help you relate the picture to familiar shapes, such as those of a bicycle and a cowboy hat.43

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). Learners engage in rote learning when they try to learn and remember something without attaching much meaning to it. For example, you’d be engaging in rote learning if you tried to remember the letter string FAMILIARWORDS simply as a list of isolated letters or if you tried to remember the cowboy/bicycle drawing as a collection of random, unrelated lines and curves.

One common form of rote learning is rehearsal, repeating something over and over within a short timeframe (typically a few minutes or less), either by saying it aloud or by continuously

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42 For a good discussion of this point, see Kirschner, Sweller, & Clark, 2006.
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thinking about it in an unaltered, verbatim fashion. We’ve previously seen that rehearsal can help learners keep information in working memory indefinitely. Contrary to what many students think, 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 I’ll identify later, people who use rehearsal and other forms of rote learning often have trouble remembering what they’ve learned.

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 a bicycle-riding cowboy in a line drawing 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 history student might see parallels between the “ethnic cleansing” in eastern Europe in the 1990s and the Nazis’ belief in white supremacy in the 1930s and 1940s. In the vast majority of cases, meaningful learning is more effective than rote learning for storing information in long-term memory. It’s especially effective when learners relate ideas to themselves as human beings.

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 some species of dinosaurs had powerful jaws and sharp teeth might correctly deduce that those species 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 scared when they continued to travel west day after day without ever seeing signs of land.”

Another form of meaningful learning is organization, in which learners pull new information together into an integrated, logical structure. For example, they might group information into categories (recall the earlier “Twelve Words” exercise with daisy, apple, etc.). Alternatively, learners 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 × t) and that an object’s force is determined by both the object’s mass and its acceleration (f = m × a). The goal

| TABLE 2.2 • Long-Term Memory Storage Processes |
|---------------|----------------|----------------|
| PROCESS       | DEFINITION       | EXAMPLE                        |
| 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 |
| 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 |

45 Ausubel et al., 1978; Ghetti & Angelini, 2008; Marley, Szabo, Levin, & Glenberg, 2008; Mayer, 2010b; Wittrock, 1974.
46 Heatherton, Macrae, & Kelley, 2004; Kesebir & Oishi, 2010; Rogers, Kuiper, & Kirker, 1977.
47 Notice that I’m 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.
There isn’t simply to memorize the formulas (that would be rote learning) but rather to make sense of the relationships 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. 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.

### 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).

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

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

Did the Chinese words remind you of the visual images you stored? Did the images, in turn, help you remember the English meanings? You may have easily remembered all five words, 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. Especially for people in the former category, visual imagery can be a powerful means of storing information in long-term memory.

The three forms of meaningful learning just described—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.

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As noted earlier, rehearsal—repeating information over and over within the course of a few seconds or minutes—is a relatively ineffective 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.51

Practice is especially important for gaining procedural knowledge. As an example, think about driving a car, a complicated skill that many people in today’s world have mastered. If you’re an accomplished driver, I’m guessing that your first attempts at driving required a great deal of mental energy and effort but 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.52

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

Sometimes learners engage in effective long-term memory storage processes without intentionally trying to do so. For example, 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’re automatically engaging in elaboration and visual imagery: My statement 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 “Twelve Words” exercise near the beginning of the chapter, you may have quickly noticed the categorical nature of the 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’re using a learning strategy.

A general inclination to relate new information to prior knowledge—meaningful learning—occurs in one form or another at virtually all age levels.53 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.

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’ve visited a doctor many times and know how such visits typically go. Generally speaking, people who

### DEVELOPMENTAL TRENDS

#### TABLE 2.3 • Typical Learning Strategies at Different Grade Levels

<table>
<thead>
<tr>
<th>GRADE LEVEL</th>
<th>AGE-TYPICAL CHARACTERISTICS</th>
<th>EXAMPLE</th>
<th>SUGGESTED STRATEGIES</th>
</tr>
</thead>
</table>
| K–2         | • Organization of physical objects as a way to remember them  
              • Occasional rehearsal to remember verbal material; used infrequently and relatively ineffectively  
              • Emerging ability to use visual imagery to enhance memory, especially with adult prompting  
              • Few intentional efforts to learn new information; learning and memory are a byproduct of other things children do (creating things, talking about events, 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 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 do things (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 photos of four 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. . . .” | • Emphasize the importance of making sense of information.  
• Encourage students to organize what they’re learning; suggest possible organizational structures.  
• Provide visual aids to facilitate visual imagery, and suggest that students create their own drawings or visual images of things they need to remember. |
| 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 | Raj and Owen are studying for a middle school science quiz on kinds of rocks. “Let’s group them somehow,” Raj says. Owen suggests grouping them by color (gray, reddish, etc.). But after further discussion, the boys agree that sorting them into sedimentary, igneous, and metamorphic would be a better 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 a high school history class, Kate focuses her studying on memorizing names, dates, and places. In contrast, Jamika 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 to 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. |


Already know something about a topic learn new information about the topic more effectively than people who have little relevant background.14

Occasionally, however, prior knowledge interferes with new learning. In some cases it may do so because learners make inappropriate connections. For example, when a fourth grader named Rita was asked why America was once called the “New World,” she responded that some of the early European explorers “wanted to get to China ’cause China had some things they wanted. They had some cups or whatever—no, they had furs.” Rita apparently associated the

word China with dinnerware—including cups—and also knew that some early explorers sought exotic animal furs. In fact, the early explorers who were seeking a quick route to China wanted to get certain spices and other commodities unavailable at home—not cups or furs.

At other times learners’ prior knowledge is either insufficient or incorrect. For example, imagine a group of children who think the earth is flat. This idea might be 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 2.8).56

As you can see, then, learners sometimes construct misconceptions—beliefs that are inconsistent with widely accepted and well-validated explanations of certain phenomena or events. Figure 2.9 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 have little impact.57 Instead, thanks to the process of elaboration—a process that usually facilitates learning—learners may...

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**FIGURE 2.9 Common student misconceptions**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Fact</th>
<th>Misconception</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASTRONOMY</strong></td>
<td>The earth revolves around the sun.</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>The earth is shaped more or less like a sphere.</td>
<td>The earth is shaped like a round, flat disk or the earth is a hollow sphere with people living on a flat surface inside.</td>
</tr>
<tr>
<td></td>
<td>The earth is at the center of the solar system.</td>
<td>The earth is at the center of the solar system.</td>
</tr>
<tr>
<td></td>
<td>The sun is the center of the solar system.</td>
<td>The sun is at the center of the solar system.</td>
</tr>
<tr>
<td><strong>BIOLOGY</strong></td>
<td>A living thing is something that carries on such life processes as metabolism, growth, and reproduction.</td>
<td>A living thing is something that moves and/or grows.</td>
</tr>
<tr>
<td></td>
<td>A plant takes in food from the ground.</td>
<td>A plant takes in food from the ground.</td>
</tr>
<tr>
<td></td>
<td>It grows in a garden and is relatively small.</td>
<td>It grows in a garden and is relatively small.</td>
</tr>
<tr>
<td><strong>PHYSICS</strong></td>
<td>An object remains in uniform motion until a force acts on it; a force is needed only to change speed or direction.</td>
<td>Any moving object has a force acting on it.</td>
</tr>
<tr>
<td></td>
<td>Light objects and heavy objects fall at the same rate unless other forces (e.g., air resistance) differentially affect the objects</td>
<td>Light objects and heavy objects fall at the same rate unless other forces (e.g., air resistance) differentially affect the objects</td>
</tr>
</tbody>
</table>


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56 Brewer, 2008; Vosniadou, Vamvakoussi, & Skopeliti, 2008.
57 Derry, 1996; Murphy & Mason, 2006; Sinatra & Pintrich, 2003; C. L. Smith, Maclin, Grosslight, & Davis, 1997.
Chapter 2  •  Learning, Cognition, and Memory

interpret or distort the new information to be consistent with what they already “know” and thus continue to believe what they’ve always believed. For example, one eleventh-grade physics class was studying the idea that an object’s mass and weight do not, by themselves, affect the speed at which the object falls. Students were asked to 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, a student named 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.”

This tendency to look for what one thinks is true and to ignore evidence to the contrary is known as confirmation bias. For example, 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.” 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.

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

✓ Check your understanding in the Pearson etext.

WHY LEARNERS MAY OR MAY NOT REMEMBER WHAT THEY HAVE LEARNED

As we’ve seen, a great deal of the environmental input a learner receives never reaches long-term memory. Perhaps the learner didn’t pay attention in the first place, so the information never went beyond the sensory register. Or perhaps after attending to it, the learner didn’t continue to process it, so it went no further than working memory. Even when information does reach long-term memory, it needs considerable time—often several hours or longer—to completely “firm up,” or consolidate, in the brain. Anything that interferes with this consolidation process—even something as seemingly “minor” as not getting a good night’s sleep—adversely affects long-term memory of new information.

But let’s assume that new information of some sort has had the time and conditions it needs to consolidate in the brain. Under such circumstances, it may or may not be easy to retrieve, as reflected in the following general principles.

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

In order to be memorable, then, a new piece of information must be connected with other things already 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 you routinely get in your mail and e-mail

58 Hynd, 1998a, p. 34.
61 Payne & Kensinger, 2010; Rasch & Born, 2008; Wixted, 2005.
62 As an example of such interference in long-term memory retrieval, see Healey, Campbell, Hasher, & Osher, 2010.
boxes. Imagine that, on average, you receive five important items—five things you really want to save—every day. That adds up to more than 1,800 items a year. Over the course of 15 years, you’d have more than 27,000 important things stashed somewhere in your home, on your computer, or on a flash drive or other back-up storage device.

Now imagine that one day you hear that stock in a clothing company (Mod Bod Jeans) has tripled in value. You recall that your wealthy Uncle Fred bought you some Mod Bod stock for your birthday several years ago, and you presumably decided that the paperwork documenting the purchase was important enough to save. But where did you put it? How easily you find it—in fact, whether you find it 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, all the bills you’ve paid by regular mail on a closet shelf, all banking and investment paperwork in alphabetical order in a file drawer, and all electronic documents from family and friends in labeled folders on your computer—you should quickly locate your uncle’s gift. But if you simply tossed each day’s mail and e-mail randomly about, you might search for a long, long time without ever finding it.

Like a home with 15 years’ worth of mail, long-term memory contains a great deal of information. And like your search for the Mod Bod paperwork, the ease with which information is retrieved from long-term memory depends somewhat on whether the information has been stored in a logical place—that is, whether it’s connected to related ideas. By making connections to existing knowledge—that is, by engaging in meaningful learning—learners know where to look for information when they need it. Otherwise, they 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’ve associated the information with many other things they know and with many different contexts in which they might use it. Making multiple connections is like using cross-references in your mail storage system. You may have filed the Mod Bod paperwork in the banking/investments file drawer, but you may also have written its location on notes-to-self you’ve put in other places—perhaps with your birth certificate (because you received the stock on your birthday) and in a computer folder of family documents and photos (because a family member gave you the stock). By looking in one of these logical places, you’ll discover where to find the Mod Bod documentation.

**Remembering depends on the context.**

Sometimes learners acquire and practice certain behaviors and ways of thinking in a very limited set of environments—say, in their math classes or science labs. When this happens, the learners may associate those behaviors and ways of thinking only with those particular environments and therefore don’t retrieve what they’ve learned when they’re in other contexts. This tendency for some responses and cognitive processes to be associated with and retrieved only in a very limited range of circumstances is known as **situated learning** or **situated cognition**. For example, if students associate principles of geometry only with math classes, they may not retrieve those principles at times when geometry would come in handy—say, when trying to determine whether a 10-inch pizza that costs eight dollars is a better value than an 8-inch pizza that costs six dollars.

In general, learners are more likely to retrieve previously acquired knowledge and skills in a new context if that context provides one or more **retrieval cues** that trigger “travel” along potentially helpful pathways in long-term memory. You can see what I mean in the next exercise.

**SEE FOR YOURSELF**

**THE GREAT LAKES**

1. If you went to school 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 can you recall all five lakes?

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63 For classic works related to this topic, see Brown, Collins, & Duguid, 1989; Greeno, Collins, & Resnick, 1996; Light & Butterworth, 1993; Säljö & Wyndhamn, 1992.
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.

Fortunately, not all school learning is "stuck" in a particular classroom. People use many of the skills they've learned at school—reading, writing, arithmetic, map interpretation, and so on—in a variety of everyday situations in the outside world. Nevertheless, people don't use what they've learned in the classroom as often as they might. We'll explore this issue further in discussions of transfer in Chapter 4.

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" later 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. For example, fourth graders who encounter the multiplication problem

\[
87 \times 59
\]

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 \(\text{Na}_2\text{CO}_3\) (sodium carbonate) if they don’t have to stop to think about what the symbols Na, C, and O represent.

Recall often involves construction or 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. 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-we
4. hors d'o--

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. 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 -ence spelling pattern in such words as adolescence and effervescence, in which case you would have spelled adolescence correctly. But if you applied the common spelling pattern -ance to Word 1, 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 can recall based on what seems logical, they often make mistakes—a phenomenon known as reconstruction error. Sometimes, of course, they never learned the missing information to begin with, and so their constructions are merely “best guesses” about the facts. Such is undoubtedly the case for 7-year-old Rob when he explains mountain formation in the opening case study. Regardless of how accurate a “retrieved” memory is, however, the very process of thinking or rethinking about it promotes further consolidation—in many instances reconsolidation—that strengthens whatever a person previously knew or decided must be true.69

Long-term memory isn’t necessarily forever.
People certainly don’t need to remember everything. For example, you might have no reason to remember the phone number of a classmate you called yesterday, the plot of last week’s rerun of The Simpsons, 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 haul.

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.70 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 eventually disappear altogether, especially if it isn’t used very often.71 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.

✓ Check your understanding in the Pearson etext.

PROMOTING EFFECTIVE COGNITIVE PROCESSES

Given the selective and constructive nature of human learning and memory, the things students learn in instructional settings are rarely complete, precise reproductions 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’re given. 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 certainly help them think and learn more effectively. I’ve organized teacher strategies into five general categories: supporting optimal brain functioning, remembering how the human memory system works, encouraging effective long-term memory storage processes, facilitating retrieval, and monitoring students’ progress.

Supporting Optimal Brain Functioning

I urge you to be cautious when you read books, articles, and websites about promoting “brain-based learning,” because many of them are speculative at best. Following are three recommendations that have a solid foundation in brain research.

69 Monfils, Cowansage, Klann, & LeDoux, 2009; Schiller et al., 2010.
Provide ongoing intellectual stimulation, but don’t overdo it.

New challenges and learning opportunities—age-appropriate ones, of course—seem to enhance brain functioning, in part by nourishing existing neurons, synapses, and astrocytes and in part by stimulating the growth of new ones.72 At the same time, teachers shouldn’t inundate students with nonstop challenging tasks and assignments, to the point that students have little or no time for mental “relaxation.” Human beings seem to benefit from a certain amount of mental down-time—enough that they have a chance to reflect on their academic and personal experiences, identify new interconnections among things they’ve learned, and identify future plans and goals for their performance.73

Providing an occasional opportunity for mental down-time doesn’t mean giving students lots of time in which they have nothing to do. Instead, such an opportunity might take the form of a reflective essay or small-group discussion about a topic or issue related to the day’s lessons. When students have nothing to do in the classroom, many of them may have insufficient self-regulation skills to use the time productively, and thus they may engage in behaviors that interfere with their own and their classmates’ learning (more on this point in Chapter 4 and Chapter 14).

Encourage physical exercise.

Physical exercise appears to be beneficial for brain health, especially if it includes aerobic activities that keep the cardiovascular system in good working order. A particular benefit is that it enhances the functioning of the central executive—the component of working memory that helps learners keep their minds productively engaged in the task at hand.74

Encourage students to get plenty of sleep.

As you well know, a good night’s sleep improves mental alertness and can help people ward off germs that intend to do them harm. But in addition, sleep supports the brain’s efforts to consolidate new memories, rendering them more memorable over the long run.75

Unfortunately, typical school schedules, especially their early-morning starting times, are poor matches with the sleeping patterns of many high school students. But teachers can support good sleeping habits in another way—in particular, by minimizing the likelihood that students will “pull an all-nighter” to prepare for a test or complete a complex assignment. For example, teachers might give numerous short quizzes—each on a small amount of classroom subject matter—rather than giving two or three comprehensive tests that each cover a large body of material (more on this point in Chapter 10). And teachers might break a 10-page term paper into several small pieces, each of which is due on a different date.

Remembering How the Human Memory System Works

The model of human memory we’ve examined 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 making connections between new information and prior knowledge. These points have several implications for classroom practice.

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’ curiosity about a topic, perhaps by building on students’ existing interests and concerns, presenting unusual or puzzling phenomena, or modeling their own enthusiastic interest. Incorporating a wide variety of instructional methods into the weekly schedule—discovery learning sessions, debates about controversial issues, cooperative problem-solving activities, and so on—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.

72 Koob, 2009; Nelson et al., 2006.
73 Immordino-Yang, Christodoulou, & Singh, 2012.
74 Castelli, Hillman, Buck, & Erwin, 2007; Cohen, 2005; Tomporowski, Davis, Miller, & Naglieri, 2008.
75 Dinges & Rogers, 2008; Kirby, Maggi, & D’Angiulli, 2011; Payne & Kensinger, 2010; Rasch & Born, 2008.
Keep the limited capacity of working memory in mind.

Virtually any learning activity imposes a cognitive load—a certain amount of information that learners must simultaneously think about, along with certain ways that they must think about it, in order to make sense of and remember what they’re studying.\(^\text{76}\) When teachers design and conduct lessons, then, they must consider just how much of a load students’ working memories can reasonably handle at any given time. For example, they should pace the presentation of important information slowly enough that students have time to effectively process what they’re seeing and hearing. They might repeat the same idea several times (perhaps rewording it each time), stop to write important points on the board, and provide numerous examples and illustrations. And in many instances, tablet computers or other technological devices can provide external memory aids that help students keep track of the ideas they generate—perhaps key points to include in a persuasive essay or alternative research designs for a science project.

Even with such strategies, however, the amount of new information presented in a typical classroom is much more than students can reasonably learn and remember, and students aren’t always the best judges of what things are most important to focus on.\(^\text{77}\) Teachers must help students zero in on the things that truly matter—for example, by emphasizing main ideas, offering guidelines on what and how to study, and omitting irrelevant information and unnecessary details from explanations and lectures.

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\(^\text{76}\) Mayer, 2011; Plass, Moreno, & Brünken, 2010; Sweller, 1988, 2008.

Relate new ideas to students’ prior knowledge and experiences.

Students can more effectively learn and remember classroom subject matter if they connect it to many other things they already know. Yet students don’t always make such connections on their own, and as a result they’re likely to resort to rote learning. Teachers can promote more meaningful learning by encouraging students to relate new material to one or more of the following:

- Concepts and ideas in the same subject area—for example, recognizing that multiplication in arithmetic is simply a variation of addition.
- Concepts and ideas in other subject areas—for example, considering how advances in atomic physics have affected historical events.
- Students’ general knowledge of the world—for example, relating the concept of inertia to how passengers are affected when an automobile quickly turns a sharp corner.
- Students’ personal experiences—for example, identifying similarities between the family feud in *Romeo and Juliet* and students’ own group conflicts.
- Students’ current activities and needs outside of the classroom—for example, applying persuasive writing skills in crafting a personal essay for a college application.

Ideally, teachers should use students’ existing knowledge as a starting point whenever they introduce a new topic—a strategy known as prior knowledge activation. For example, in a first-grade classroom, teachers might begin a unit on plants by asking students to describe what their parents do to keep flowers or vegetable gardens growing. Or, in a secondary English literature class, they might introduce Sir Walter Scott’s *Ivanhoe* (in which Robin Hood is a major character) by asking students to tell the tale of Robin Hood as they know it.

Accommodate diversity in students’ background knowledge.

All students come to school with certain shared understandings about the world. For example, they all know that dogs and cats typically have four legs and that objects fall down (not up) when released. But in many ways students’ prior knowledge and understandings are truly their own, because each one has been exposed to a unique set of experiences, interpersonal relationships, and cultural practices and beliefs. Thus students from diverse backgrounds may come to school with somewhat different knowledge—different concepts, schemas, scripts, self-constructed theories, and so on—that they’ll use to make sense of any new situation. To see what I mean, try the next exercise.

SEE FOR YOURSELF

THE WAR OF THE GHOSTS

Read the following story one time only:

One night two young men from Egulac went down to the river to hunt seals, and while they were there it became foggy and calm. Then they heard war-cries, and they thought, “Maybe this is a war-party.” They escaped to the shore, and hid behind a log. Now canoes came up, and they heard the noise of paddles, and saw one canoe coming up to them. There were five men in the canoe, and they said:

“What do you think? We wish to take you along. We are going up the river to make war on the people.”

One of the young men said: “I have no arrows.”

“Arrows are in the canoe,” they said.

“I will not go along. I might be killed. My relatives do not know where I have gone. But you,” he said, turning to the other, “may go with them.”

So one of the young men went, but the other returned home.

And the warriors went on up the river to a town on the other side of Kalama. The people came down to the water, and they began to fight, and many were killed. But presently the young man heard one of the warriors say, “Quick, let us go home: that Indian has been hit.” Now he thought: “Oh, they are ghosts.” He did not feel sick, but they said he had been shot.

So the canoes went back to Egulac, and the young man went ashore to his house, and made a fire. And he told everybody and said, “Behold I accompanied the ghosts, and we went to fight. Many of our fellows were killed, and many of those who attacked us were killed. They said I was hit, and I did not feel sick.”

Berri, Toneatti, & Rosati, 2010; Fox, 2009; Levstik, 2011; Pritchard, 1990.
He told it all, and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried. He was dead.79

Now cover the story, and write down as much of it as you can remember.

Compare your own rendition of the story with the original. What differences do you notice? Your version is almost certainly the shorter of the two, and you probably left out many details. But did you also find yourself distorting certain parts of the story so that it made more sense to you?

A Native American ghost story, “The War of the Ghosts” may be inconsistent with some of the schemas and scripts you’ve acquired from your own experiences, especially if you were raised in a non–Native American culture. In an early study of long-term memory, students at England’s Cambridge University were asked to read the story twice and then to recall it at various times later on. Students’ recollections of the story often included additions and distortions that made the story more consistent with English culture. For example, people in England rarely go “to the river to hunt seals” because seals are saltwater animals and most rivers have freshwater. Students might therefore say that the men went to the river to fish. Similarly, the ghostly aspect of the story didn’t fit comfortably with most students’ religious beliefs and so was often modified. When one student was asked to recall the story six months after he had read it, he provided the following account:

Four men came down to the water. They were told to get into a boat and to take arms with them. They inquired, “What arms?” and were answered “Arms for battle.” When they came to the battlefield they heard a great noise and shouting, and a voice said: “The black man is dead.” And he was brought to the place where they were, and laid on the ground. And he foamed at the mouth.80

Notice how the student’s version of the story leaves out many of its more puzzling aspects—puzzling, at least, from his own cultural perspective.

All of this is not to say that some students have less knowledge than their peers, but rather that they have different knowledge. For example, some students from low-income families—but only some of them—may lag behind their classmates in such basic academic skills as reading, writing, and computation.81 Yet they’re apt to bring many strengths to the classroom. They may have a wealth of knowledge about pop culture—rap music lyrics, dialogues from popular films, and so on.82 They’re often quite clever at improvising with everyday objects.83 If they work part-time to help their families make ends meet, they may have a good understanding of the working world. If they’re children of single, working parents, they may know far more than their classmates do about cooking, cleaning house, and caring for younger siblings. If financial resources have been particularly scarce, they may have a special appreciation for basic human needs and true empathy for victims of war or famine around the world. In some domains, then, students who’ve grown up in poverty have more knowledge and skills than their economically advantaged peers.

Provide experiences on which students can build.

In some instances, of course, students simply don’t have the background knowledge they need to understand a new topic. In such cases, teachers can provide concrete experiences that provide a foundation for classroom lessons. For example, students can better understand how large some dinosaurs were if they see a life-size dinosaur skeleton at a natural history museum. They can more easily understand the events of an important battle if they visit the battlefield. Often teachers can create foundational experiences at school, perhaps by offering opportunities to work with physical objects and living creatures (e.g., timing the fall of light versus heavy objects, caring for a class pet), providing computer software that simulates complex activities (e.g., running a lemonade stand, dissecting a frog), or conducting in-class activities similar to those in the adult world (e.g., trying a mock courtroom case, conducting a political campaign).

80 Bartlett, 1932, p. 65.
81 Farkas, 2008; Goldenberg, 2001; Serpell, Baker, & Sonnenschein, 2005; Siegler, 2009.
83 Torrance, 1995.
Encouraging Elaboration of Classroom Topics

- Communicate the belief that students can and should make sense of what they’re studying.

   A junior high school language arts teacher tells his class that he doesn’t expect students to memorize the definitions he gives them for new vocabulary words. “Always put definitions in your own words,” he says, “and practice using your new words in sentences. For example, one of the new words in this week’s list is garish. Look at the definition I just gave you. In what situations might you use garish?”

- Ask questions that require students to draw inferences from what they’re learning.

   Students in a high school first-grade class have learned that when people suffer from traumatic shock, many normal bodily functions are depressed because less blood is circulating through the body. The teacher asks, “Given what you’ve learned about traumatic shock, why do experts recommend that if we find a person in shock, we have them lie down and keep them warm but not hot?”

- Have students apply what they’ve learned to new situations and problems.

   To give her class practice in creating and interpreting bar graphs, a second-grade teacher asks children to write their favorite kind of pet on a self-stick note she has given each of them. “Let’s make a graph that can tell us how many children like different kinds of pets,” she says. On the board the teacher draws a horizontal line and a vertical line to make the graph’s x-axis and y-axis. “Let’s begin by making a column for dogs,” she continues. “How many of you wrote dog as your favorite pet? Seven of you? OK, put your sticky notes on the graph where I’ve written dog. We’ll put them one above another to make a bar.” After the dog lovers have attached their notes to the graph, the teacher follows the same procedure for cats, birds, fish, and so on.

- Focus on an in-depth understanding of a few general principles—the big ideas within a discipline—instead of covering many topics superficially.

   In planning his geography curriculum for the coming school year, a fourth-grade teacher realizes that his students may gain little from studying facts and figures about numerous countries around the globe. Instead, he chooses six countries with very different cultures—Italy, Japan, Morocco, New Zealand, Peru, and Tanzania—that the class will focus on during the year. Through an in-depth study of these countries, the teacher plans to help his students discover how different climates, topographies, cultures, and religions lead to different lifestyles and economies.

- Create opportunities for small-group or whole-class discussions in which students can freely exchange their views.

   In a unit on World War II, a high school history teacher has students meet in small groups to speculate about the problems the Japanese people must have faced after atomic bombs were dropped on Hiroshima and Nagasaki.

Sources: Some strategies based on Brophy et al., 2009; Croninger & Valli, 2009; Middleton & Midgley, 2002; Slavin, Hurley, & Chamberlain, 2003; Webb et al., 2008.

Encouraging Effective Long-Term Memory Storage Processes

Having prior knowledge relevant to a classroom topic is, of course, essential for meaningful learning. But it’s equally important that students actively think about what they’re studying—that they consciously and intentionally engage in such effective learning strategies as elaboration, organization, and visual imagery. The following suggestions should promote active, effective learning.

Present questions and tasks that encourage elaboration.

   The more students elaborate on new material—the more they mentally expand on what they’re learning—the more effectively they’re apt to understand and remember it. The Classroom Strategies box “Encouraging Elaboration of Classroom Topics” describes and illustrates several ways teachers might help students effectively embellish on classroom topics.

Help students make connections among ideas.

   At all grade levels, many students focus on learning isolated facts, without gaining an understanding of how the facts fit together. Yet the more interrelationships students identify within the subject matter they’re learning—in other words, the better they organize it—the more easily they can remember and apply it later on. When students form many logical connections within the specific concepts and ideas of a topic, they gain a conceptual understanding of the topic. For example, rather than simply memorize basic mathematical computation procedures, students should learn how those procedures reflect underlying principles of mathematics. And rather

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84 Carr, 2010; De Corte, Op’t Eynde, Depaepe, & Verschaffel, 2010; Lesgold, 2001; Linn & Eylon, 2011; Paxton, 1999.
than learn historical facts as a list of unrelated people, places, and dates, students should put those facts within the context of major social and religious trends, economic considerations, human personality characteristics, and so on.

One strategy for helping students find interrelationships within a content area is to organize instructional units around a few core ideas and themes, always relating specific ideas back to this core.85 (For example, two core ideas in this chapter are the constructive nature of learning and memory and the importance of meaningful learning.) Another strategy is have students create charts or drawings that require them to pull together what they've been learning, as 9-year-old Trisha has done in the water cycle drawing in Figure 2.10. Still another is to ask students to teach what they've learned to others—a task that may encourage them to focus on main ideas and pull these ideas together in a way that makes sense.86 But ultimately, students are most likely to gain a conceptual understanding of a topic if they explore it in depth—for instance, by considering many examples, examining cause-and-effect relationships, and discovering how specific details relate to general principles. Accordingly, many educators advocate the principle Less is more: Less material studied more thoroughly is learned more completely and with greater understanding.87

Facilitate visual imagery.

As we’ve discovered, visual imagery can be a highly effective way to learn and remember information. Teachers can promote students’ use of visual imagery in a variety of ways. For example, they can ask students to imagine how certain events in literature or history might have looked. They can provide visual materials (pictures, charts, videos, three-dimensional models, computer animations, etc.) that illustrate or graphically organize important ideas. And they can ask students to create their own pictures, diagrams, or models of things they’re learning, as Trisha has done in her water cycle drawing.88

Often teachers better help students remember new ideas when they encourage students to encode classroom subject matter both verbally and visually.89 In Figure 2.11, 9-year-old Nicholas uses both words and a picture to describe his findings from a third-grade science experiment, in which he observed what happened when he dropped small, heavy objects into a glass of water. Nick has difficulties with written language that qualify him for special educational services. Notice how he misspells many words and, in his second sentence, writes up from the bottom of the page. Perhaps by writing upward rather than in the normal top-down fashion, Nick is thinking about how the water traveled up and out of the glass as blocks were dropped into it.

Give students time to think.

We’ve talked about the importance of having students find personal meaning in, elaborate on, organize, and visualize classroom subject matter. Such processes require thought, and thought requires time. Yet some teachers are impatient, giving students very little time—in some cases less than a second—to respond to questions. If students don’t respond in that short time, the teachers speak

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89 Mayer, 2011; Moreno, 2006; Sadoski & Paivio, 2001; Winn, 1991.
again—perhaps by asking a different question or answering a question themselves. Some teachers are equally reluctant to let much time lapse after students answer questions or make comments in class—once again, they may allow one second or less of silence—before responding to a statement or asking another question. The problem here is one of insufficient wait time.

When teachers instead allow at least three seconds to elapse after their own questions and after students’ comments, dramatic changes can occur in students’ behaviors. More students (especially more females and minority students) participate in class, and students begin to respond to one another’s comments and questions. Students are more likely to support their reasoning with evidence or logic and more likely to speculate when they don’t know an answer. Furthermore, students are more motivated to learn classroom subject matter, are better behaved in class, and actually learn more. Such changes are in part due to the fact that with increased wait time, teachers’ behaviors change as well. Teachers ask fewer simplistic questions (e.g., those requiring recall of facts) and more thought-provoking ones (e.g., those requiring elaboration). They modify the direction of a discussion to accommodate students’ comments and questions, and they allow their classes to pursue a topic in greater depth than they had originally planned. And their expectations for many students, especially previously low-achieving ones, begin to improve.

Suggest mnemonics for hard-to-remember facts.

Some things are hard to make sense of—hard to learn meaningfully. For instance, why do bones in the human body have such names as humerus, fibula, and ulna? Why is 方 the Chinese word for house? Why is Augusta the capital of Maine? For all practical purposes, there’s no rhyme or reason to such facts.

When students are likely to have trouble making connections between new material and their prior knowledge, or when a body of information has an organizational structure with no obvious underlying logic (e.g., as is true for many lists), special memory tricks known as mnemonics can help them learn classroom material more effectively. Three commonly used mnemonics are described in Figure 2.12.

Facilitating Retrieval

Even when students engage in meaningful learning, they don’t necessarily retrieve important information when they need it. Remember, retrieval involves following a pathway of mental associations, and students sometimes travel down the wrong path. The next two recommendations can enhance students’ ability to retrieve what they’ve learned.

Provide many opportunities to practice important knowledge and skills.

Some information and skills are so fundamental that students must become able to retrieve and use them quickly and effortlessly—that is, with automaticity. For example, to read well, students must be able to recognize most of the words on the page without having to sound them out or look them up in the dictionary. To solve mathematical word problems, students should have such number facts as 2 + 4 = 6 and 5 × 9 = 45 on the tips of their tongues. And to write well, students should be able to form letters and words without having to stop and think about how to make an uppercase G or spell the. Unless such knowledge and skills are learned to automaticity, a student may use so much working memory capacity retrieving and using them that there’s little “room” to do anything more complex.

Ultimately, students can learn basic information and skills to automaticity only by using and practicing them repeatedly over time. This is not to say that teachers should fill each day with endless drill-and-practice exercises involving isolated facts and procedures. Automaticity can

Mnemonics are helpful for remembering seemingly arbitrary bits of information. Watch two examples in “Using Mnemonics.”

Learn more about long-term memory and then apply your understandings in the interactive module “Human Memory, Part 2.”

93 De La Paz & McCutchen, 2011; R. E. Mayer & Wittrock, 1996; Sweller, 1994; Walczyk et al., 2007.
occur just as readily when the basics are embedded in a variety of stimulating and challenging activities. Furthermore, students should practice new skills within the context of instruction and guidance that help them improve those skills. The Classroom Strategies box “Helping Students Acquire New Skills” provides examples of instructional strategies that can help students more effectively acquire procedural knowledge.

At the same time, teachers must be aware that automaticity has a downside. In particular, students may quickly recall certain ideas or perform certain procedures when other, less automatic ideas or procedures are more useful. Students can be more flexible—and thus more likely to identify unique approaches to situations or creative solutions to problems—if they aren’t automatically “locked in” to a particular response. We’ll revisit this issue in our discussion of mental set in Chapter 4.


### FIGURE 2.12 Common mnemonic techniques

#### VERBAL MEDIATION

A verbal mediator is a word or phrase that creates a logical connection, or “bridge,” between two pieces of information. Verbal mediators can be used for such paired pieces of information as foreign language words and their English meanings, countries and their capitals, chemical elements and their symbols, and words and their spellings. Following are examples:

<table>
<thead>
<tr>
<th>Information to Be Learned</th>
<th>Verbal Mediator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handschuh is German for “glove.”</td>
<td>A glove is a shoe for the hand.</td>
</tr>
<tr>
<td>Quito is the capital of Ecuador.</td>
<td>Mosquitoes are at the equator.</td>
</tr>
<tr>
<td>Au is the symbol for gold.</td>
<td>‘Ay, you stole my gold watch!</td>
</tr>
<tr>
<td>The word principal ends with the letters pal (not ple).</td>
<td>The principal is my pal.</td>
</tr>
<tr>
<td>The humerus bone is the large arm bone above the elbow.</td>
<td>The humorous bone is just above the funny bone.</td>
</tr>
</tbody>
</table>

#### KEYWORD METHOD

Like verbal mediation, the keyword method aids memory by making a connection between two things. This technique is especially helpful when there is no logical verbal mediator to fill the gap—for example, when there is no obvious sentence or phrase to relate a foreign language word to its English meaning. The keyword method involves two steps, which I will illustrate using the Spanish word amor and its English meaning love:

1. Identify a concrete object to represent each piece of information. The object may be either a commonly used symbol (e.g., a heart to symbolize love) or a sound-alike word (e.g., a suit of armor to represent amor). Such objects are keywords.
2. Form a mental image of the two objects together. To remember that amor means love, you might picture a knight in a suit of armor with a huge red heart painted on his chest.

You used the keyword method when you learned the meanings of fáng, mén, ké, fàn, and shū in the “Five Chinese Words” exercise earlier in the chapter. Following are additional examples:

<table>
<thead>
<tr>
<th>Information to Be Learned</th>
<th>Visual Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handschuh is German for “glove.”</td>
<td>Picture a horse driving a Ford.</td>
</tr>
<tr>
<td>Quito is the capital of Ecuador.</td>
<td>Picture a gust of wind blowing through a horse’s mane.</td>
</tr>
<tr>
<td>Au is the symbol for gold.</td>
<td>Picture a swan swimming on a lake, wearing a tie and coughing.</td>
</tr>
</tbody>
</table>

#### SUPERIMPOSED MEANINGFUL STRUCTURE

A larger body of information, such as a list of items, can often be learned by superimposing a meaningful organization—a familiar shape, word, sentence, rhythm, poem, or story—on the information. Following are examples of such superimposed meaningful structures:

<table>
<thead>
<tr>
<th>Information to Be Learned</th>
<th>Superimposed Meaningful Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>The shape of Italy</td>
<td>A “boot”</td>
</tr>
<tr>
<td>The Great Lakes (Huron, Ontario, Michigan, Erie, Superior)</td>
<td>HOMES</td>
</tr>
<tr>
<td>Strings on a guitar (E A D G B E)</td>
<td>Edgar ate dynamite. Good-bye, Edgar.</td>
</tr>
<tr>
<td>The number of days in each month</td>
<td>Thirty days has September . . . .</td>
</tr>
<tr>
<td>How to turn a screw (clockwise to tighten it; counterclockwise to loosen it)</td>
<td>Righty, tighty; lefty, loosey.</td>
</tr>
<tr>
<td>How to multiply in a mathematical expression of the form (ax + b)(cx + d)</td>
<td>FOIL: multiply the first terms within each set of parentheses, then the two outer terms, then the two inner terms, and finally the last terms</td>
</tr>
</tbody>
</table>
Give hints that help students recall or reconstruct what they've learned.

Sometimes forgetting is simply a matter of retrieval difficulty: Students either can't “find” knowledge that's in long-term memory or else neglect to “look” for it altogether. In such situations retrieval cues are often helpful and appropriate. For example, if a student asks how the word liquidation is spelled, a teacher might say, “Liquidation means to make something liquid. How do you spell liquid?” Another example comes from one of my former teacher interns, Jesse Jensen. A student in her eighth-grade history class had been writing about the Battle of New Orleans, a decisive victory for the United States in the War of 1812. The following exchange took place:

Student: Why was the Battle of New Orleans important?
Jesse: Look at the map. Where is New Orleans? (The student points to New Orleans.)
Jesse: Why is it important?
Student: Oh! It’s near the mouth of the Mississippi. It was important for controlling transportation up and down the river.

In the early grades teachers typically provide many retrieval cues: They remind students about the tasks they need to do and when to do them (“I hear the fire alarm. Remember, we all walk quietly during a fire drill”; or “It’s time to go home. Do you all have the field trip permission slip to take to your parents?”). But as students grow older, they must develop greater independence, relying more on themselves and less on their teachers for certain things they need to remember. At all grade levels, teachers can teach students ways of providing retrieval cues for themselves. For example, if second-grade teachers expect children to bring signed permission slips to school the following day, they might ask the children to write a reminder on a piece of masking tape that they attach to their jackets or backpacks. If junior high school teachers give students a major assignment due several weeks later, they might suggest that students help themselves remember the due date by taping a note to the bedside table or typing a reminder in their cell phone calendars. In such instances teachers are fostering self-regulation, a topic we'll explore in Chapter 4.
Promoting Students’ Progress

As you’ll learn in Chapter 10, some classroom assessments—listening to what students say in class, watching students’ body language, and so on—are spontaneous, informal ones. Others—such as in-class quizzes and assigned projects—are more systematic, formal ones that require advance planning. Both informal and formal assessments are important for promoting effective cognitive processes, as the following recommendations reveal.

**Regularly assess students’ understandings.**

Teachers must continually keep in mind that students will each interpret classroom subject matter in their own, idiosyncratic ways, and occasionally they may construct misinformation, as Rob does in the opening case study. They may also interpret nonacademic interactions in ways their teachers didn’t anticipate. For example, the first day that 8-year-old Darcy attended third grade at a new school, she accidentally got egg in her hair. Her teacher, Mrs. Whaley, took her to the nurse’s office to have the egg washed out. As revealed in the journal entries in Figure 2.13, Darcy initially misinterpreted Mrs. Whaley’s comment as unflattering criticism. Not until five days later did she learn Mrs. Whaley’s intended meaning.

It’s essential, then, that teachers regularly monitor students’ understandings about both academic topics and nonacademic issues. Asking questions, encouraging dialogue, listening carefully to students’ ideas and explanations—all of these strategies can help teachers get a handle on the “realities” students have constructed for themselves.

**Identify and address students’ misconceptions.**

Teachers often present new information with the expectation that it will correct students’ erroneous beliefs. Yet students of all ages can hold on quite stubbornly to their existing misconceptions about the world, even after considerable instruction that explicitly contradicts them. In some cases students never make the connection between what they’re learning and what they already believe, perhaps because they’re engaging in rote learning as they study academic subject matter. In other instances students truly try to make sense of classroom material, but—thanks to the process of elaboration—they interpret new information in light of what they already “know” about the topic, and they may reject or discredit something that doesn’t fit. (Recall the earlier discussion of confirmation bias.)

When students hold scientifically inaccurate or in other ways counterproductive beliefs about the world, teachers must work actively and vigorously to help them revise their thinking. That is, teachers must encourage *conceptual change*. The Classroom Strategies box “Promoting Conceptual Change” presents and illustrates several potentially useful techniques.

Convincing students to replace long-held and well-engrained beliefs can be quite a challenge, and ultimately it may require addressing students’ epistemic beliefs and motivation as well as their long-term memory storage processes. We’ll explore these two topics in Chapters 4 and 6, respectively.

**Focus assessments on meaningful learning rather than rote learning.**

As students get older, they increasingly encounter assignments, exams, and other formal assessments that teachers use to determine final class grades. Unfortunately, many teachers’ classroom assessment practices tend to encourage students to learn school subjects in a rote rather than meaningful manner (e.g., see Figure 2.14). When students discover that assignments and exams focus primarily on recall of unrelated facts—rather than on understanding and application of

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Promoting Conceptual Change

- **Probe for misconceptions that may lead students to interpret new information incorrectly.**
  
  When a third-grade teacher asks, “What is gravity?” one student replies that it’s “something that pulls you down.” The teacher points to Australia on a globe and asks, “What do you mean by down? What do you think would happen if we traveled to Australia? Would gravity pull us off the earth and make us fall into space?”

- **Provide information and experiences that explicitly contradict students’ misunderstandings.**
  
  In a lesson about air, a first-grade teacher addresses the common misconception that air has no substance. She asks students to predict what will happen when she submerged an upside-down glass in a large bowl of water, and the children have differing opinions about whether the “empty” glass will fill with water. The teacher stuffs the glass with a crumpled paper towel, turns it upside-down, and pushes it straight down into the water. The paper towel remains dry, leading the class to a discussion of how air takes up space. (You can observe this lesson in “Properties of Air.”)

- **Ask questions that challenge students’ misconceptions.**
  
  A high school physics teacher has just begun a unit on inertia. Some students assert that when a baseball is thrown in the air, a force continues to act on the ball, pushing it upward for a short while. The teacher asks, “What force in the air could possibly be pushing that ball upward after it has left the thrower’s hand?” The students offer several possibilities but acknowledge that none of them provide satisfactory explanations.

- **Show students how an alternative explanation is more plausible and useful—how it makes more sense—than their original belief.**
  
  The same physics teacher points out that the baseball continues to move upward even though no force pushes it in that direction. He brings in the concept of inertia: The ball needs a force only to get it started in a particular direction. Once the force has been exerted, other forces (gravity and air resistance) alter the ball’s speed and direction.

- **Give students corrective feedback about responses that reflect misunderstanding.**
  
  Students in a fourth-grade class have just completed a small-group lab activity in which they observe the reactions of earthworms to varying conditions. Their teacher asks them, “What happens if an earthworm dries out?” One student responds, “They like water, they like to splash around in it . . . if they’re in the hot sun they can die because they’ll dry up . . . their cells will get hard.” The teacher acknowledges that the student is right about the preference for moist conditions while also gently refining the student’s explanation:

> “Absolutely right, good. I don’t think they usually like to splash around in water so much, but they like to stay where it’s moist. (You can observe this lesson in “Earthworm Investigation.”)

- **Build on any kernels of truth in students’ existing understandings.**
  
  When asked “What is rain?” a sixth grader says that it’s “water that falls out of a cloud when the clouds evaporate . . . it comes down at little times like a salt shaker when you turn it upside down . . . there’s little holes [in the cloud] and it just comes out.” The teacher identifies two accurate understandings in the student’s explanation: (1) clouds have water, and (2) evaporation is involved in the water cycle. She uses this knowledge as starting points for further instruction; for instance, she clarifies where in the water cycle evaporation is involved (i.e., in cloud formation) and how a cloud actually is water, not a shaker-like water container.

- **When pointing out misconceptions, do so in a way that maintains students’ self-esteem.**
  
  A fourth-grade teacher begins a lesson on plants by asking, “Where do plants get their food?” Various students suggest that plants get their food from dirt, water, or fertilizer. The teacher responds, “You know, many children think exactly what you think. It’s a very logical way to think. But actually, plants make their food, using sunlight, water, and things in the soil.” The teacher then introduces the process of photosynthesis.

- **Engage students in discussions of the pros and cons of various explanations.**
  
  After students express the stereotypical belief that new immigrants to the country are “lazy,” a middle school social studies teacher invites several recent immigrants to visit the class and describe their efforts to adjust to their new environment. The following day, he asks students to reflect on what the guest speakers told them: “Several of you have expressed the opinion that many immigrants are lazy. Do you think the people you met yesterday were lazy? Why or why not?” In the ensuing discussion the students begin to realize that most immigrants probably work very hard to adapt to and succeed in their new society and its culture.

- **Ask students to apply their revised understandings to new situations and problems.**
  
  When several students express the belief that rivers always run from north to south, a middle school geography teacher reminds them that water travels from higher elevations to lower elevations, not vice versa. She then pulls out a map of Africa. “Let’s look at the Nile River,” she says. “One end of the Nile is here [she points to a spot on Egypt’s Mediterranean coast] and the other end is here [she points to a spot in Uganda]. In which direction must the Nile be flowing?”

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Source: Chan, Burka, & Bereiter, 1997; Chinn & Samarapungavan, 2009; D. B. Clark, 2006; diSessa, 2006; Hattie & Timperley, 2007; Linn & Eylon, 2011; Mason, Gava, & Boldrin, 2008; Murphy & Mason, 2006; Pine & Messner, 2000; Pintrich, Marx, & Boyle, 1993; Putnam, 1992; Slusher & Anderson, 1996; C. L. Smith, 2007; Stepans, 1991, p. 94 (salt shaker example); Vosniadou, 2008; Zohar & Aharon-Kravetsky, 2005.
an integrated body of knowledge—they may rely on rote learning, believing that this approach will yield a higher score and that meaningful learning would be counterproductive. Ultimately, teachers must communicate in every way possible—including in their classroom assessments—that it’s more important to make sense of classroom material than to memorize it. In Chapter 10 we’ll identify numerous strategies for assessing meaningful learning.

Be on the lookout for students who have unusual difficulty with certain cognitive processes.

Some students may show ongoing difficulties in processing and learning from academic lessons or social interactions. Students with learning disabilities have significant deficits in one or more specific cognitive processes. For instance, they may have trouble remembering verbal instructions, recognizing words in print (dyslexia), or thinking about and remembering information involving numbers (dyscalculia). Students with attention-deficit hyperactivity disorder (ADHD) may show marked deficits in attention, have trouble inhibiting inappropriate thoughts and behaviors, or both. Most experts believe that learning disabilities and ADHD have a biological basis, sometimes as a result of genetic inheritance and sometimes as a result of adverse environmental conditions (e.g., exposure to toxic substances) during early brain development.

When students have been officially identified as having a learning disability or ADHD, specialists are often called on to assist them in their learning. Even so, most of these students are in general education classrooms for much or all of the school day. Strategies for working effectively with them include the following:

- Identify and capitalize on the times of day when students learn best.
- Minimize distractions (e.g., provide a quiet work location or headphones that block distracting noises).
- Explicitly present the information students need to learn; also be explicit about how various ideas are organized and interrelated.
- Use multiple modalities to present information (e.g., supplement verbal explanations with pictures or simple diagrams).
- Assertively address students’ areas of weakness (e.g., in reading or math).
- Provide technological aids that can enhance students’ performance (e.g., text-to-speech software for poor readers, spell-checkers for poor spellers).
- Teach mnemonics for important facts and procedures.
- Help students organize and use their time effectively.
- Teach general learning and memory strategies.
- Provide a structure to guide students’ learning efforts (e.g., present a partially filled-in outline for taking notes; suggest questions to answer while reading a textbook chapter; break large projects into small, manageable steps).
- Keep study sessions short; provide frequent breaks so that students can release pent-up energy.
- Regularly monitor students’ recall and understanding of classroom material.

99 Barkley, 2006; Brigham & Scruggs, 1995; Eilam, 2001; Ellis & Friend, 1991; Fletcher, Lyon, Fuchs, & Barnes, 2007; Gregg, 2009; Meltzer, 2007; Pellegrini & Bohn, 2005; Wilder & Williams, 2001.
Some of these strategies should look familiar, as you’ve seen them at earlier points in the chapter. We’ll revisit others when we discuss metacognition and self-regulation in Chapter 4. By and large, the most effective strategies for students with special educational needs are the same ones that are especially effective with any learner.

✔ Check your understanding in the Pearson etext.

Clearly, then, effective instruction involves a lot more than simply telling students what they need to learn. In this chapter we’ve focused primarily on things that happen inside the learner when learning takes place. However, we can better understand how human beings learn when we also consider the broader physical, social, cultural, and academic contexts in which they live and study. We’ll examine such contexts in Chapter 3.

### 2 SUMMARY

As a way of summarizing the contents of the chapter, let’s return to the Big Ideas presented at the beginning of the chapter.

- **2.1: Much of human learning involves a process of actively constructing knowledge, rather than passively absorbing it.** Learning isn’t simply a process of “soaking up” information from the environment. Rather, it’s a process of creating meanings from both informal experiences and formal instruction. In their attempts to make sense of the world, learners combine some (but not all) of what they observe with their existing knowledge and beliefs to create ever-expanding and distinctly unique understandings of the world.

- **2.2: Knowing how the brain works is helpful, but some well-meaning educators have misinterpreted findings from brain research.** At the most basic level, learning probably involves changes in neurons, astrocytes, and their interconnections in the brain. Different parts of the brain specialize in different tasks, but many parts of the brain in both hemispheres tend to work closely together in everyday tasks. Although brain research provides useful insights into cognitive development and the neurological bases of certain disabilities, by and large teachers must look elsewhere—in particular, to psychological and educational research—for guidance about how best to help students learn.

- **2.3: Human memory is a complex, multifaceted information processing system that is, to a considerable degree, under learners’ control.** A somewhat oversimplified model of human memory—but a very useful one nevertheless—has three distinct components. One component, the sensory register, holds incoming sensory information for two or three seconds at most. What a learner pays attention to moves on to working memory, where it’s held for a somewhat longer period while the learner actively thinks about, manipulates, and interprets it. Yet working memory can hold only a small amount of information at one time, and information that isn’t being actively thought about tends to disappear quickly (typically in less than half a minute) unless the learner processes it sufficiently to store it in long-term memory.

  Long-term memory appears to have as much capacity as human beings could ever need. In fact, the more information learners already have there, the more easily they can store new facts and ideas. Effective storage typically involves meaningful learning—that is, connecting new information with existing knowledge and beliefs. By making such connections, learners make better sense of their experiences, retrieve what they’ve learned more easily, and create an increasingly organized and integrated body of knowledge that helps them interpret new experiences. As children grow older, they gradually take charge of their own learning, and most of them increasingly use effective learning strategies to remember classroom subject matter. Sometimes, however, learners of all ages distort new information, such that they construct inaccurate and potentially counterproductive understandings.

- **2.4: Human memory is fallible: Learners don’t remember everything they learn, and sometimes they misremember what they’ve learned.** Learners are more likely to remember new information over the long run if they stored it effectively to begin with—for instance, if they elaborated on, organized, or formed visual images of it—and if they’ve learned it to a level of automaticity. Yet retrieval is also somewhat context dependent: Learners are more likely to remember something if their environment provides retrieval cues that get them “looking” in the right “places” in long-term memory. Retrieval is often a constructive or reconstructive process: Learners recall only part of what they’ve learned or experienced and then fill in the gaps—perhaps correctly, perhaps not—based on their existing knowledge and beliefs about the world.

- **2.5: Effective teachers help students mentally process new information and skills in ways that facilitate long-term memory storage and retrieval.** One way to enhance students’ learning and academic achievement is, of course, to encourage healthful personal habits, such as sleeping well and getting regular physical exercise. But in addition, teachers must use instructional strategies that take into account the general nature of human learning and the strengths and limitations of the human memory system. In particular, teachers must continually emphasize the importance of understanding classroom subject matter—making sense of it, drawing inferences from it, seeing how it all ties together, and so on—rather than simply memorizing it in a rote, “thoughtless” manner. Such an emphasis must be reflected not only in teachers’ words but also in their instructional activities, assignments, and assessment practices. For example, rather than merely presenting important ideas in classroom lectures and asking students to take notes, teachers might ask thought-provoking questions that require students to evaluate, synthesize, or apply what they’re learning. As an alternative to asking
students to memorize procedures for adding two-digit numbers, teachers might ask them to devise at least three different ways they might solve problems such as \(15 + 45\) or \(29 + 68\) and to justify their reasoning. Rather than assessing students’ knowledge of history by asking them to recite names, places, and dates, teachers might ask them to explain why certain historical events happened and how those events altered the course of subsequent history. At the same time, teachers must also be alert to students’ misconceptions about academic topics and work hard to promote conceptual change.

**PRACTICE USING WHAT YOU HAVE LEARNED**

In the Pearson eText, apply these ideas to teaching.

**Facilitating Long-Term Memory Storage Processes**

**Promoting Knowledge Construction and Conceptual Change**

**PRACTICE FOR YOUR LICENSURE EXAM**

**Vision Unit**

Ms. Kontos is teaching a unit on human vision to her fifth-grade class. She shows her students a diagram of the various parts of the human eye: lens, cornea, retina, and so on. She then explains that people can see objects because light from the sun or another light source bounces off those objects and into the eye. To illustrate this idea, she shows them the first picture to the right.

“Do you all understand how our eyes work?” she asks. Her students nod that they do.

The next day Ms. Kontos gives her students the second picture shown here.

She asks them to draw how light travels so that the child can see the tree. More than half of the students draw lines like the one shown in the third picture.100

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100 The case presented in this exercise is based on a study by Eaton, Anderson, & Smith, 1984.

1. **Constructed-response question**

   Obviously, most of Ms. Kontos’s students have not learned what she thought she had taught them about human vision.

   A. Explain why many students believe the opposite of what Ms. Kontos has taught them. Base your response on contemporary principles and theories of learning and cognition.

   B. Describe two different ways in which you might improve on the lesson to help students gain a more accurate understanding of human vision. Base your strategies on contemporary principles and theories of learning and cognition.

2. **Multiple-choice question**

   Many elementary school children think of human vision in the way that Ms. Kontos’s fifth graders do—that is, as a process that originates in the eye and goes outward toward objects that are seen. When students revise their thinking to be more consistent with commonly accepted scientific explanations, they are said to be:

   a. Acquiring a new script
   b. Developing automaticity
   c. Undergoing conceptual change
   d. Acquiring procedural knowledge

   Answer questions and receive instant feedback in your Pearson eText.