Pfeiffer
Essential resources for training and HR professionals

GRAPHICS *for* Learning

Proven Guidelines for Planning, Designing, and Evaluating Visuals in Training Materials

SECOND EDITION

RUTH COLVIN CLARK | CHOPETA LYONS

ABOUT THIS BOOK

Why is this topic important?

There's no question that everyone reacts to visuals. And more often than not, people's opinions have little to do with the learning potential of a graphic. Although we've had years to build verbal literacy, most of us have had little training in visual literacy. As a result, training materials either underutilize or abuse visuals. In some cases, visuals included in books and online courses actually depress learning! In an age of highly visual media like computers, as well as abundant access to visuals through clip art, we need guidance on the best use of visuals for learning. Whether you are an instructor, instructional designer, or graphic artist, in this book you will find evidence-based guidelines you need to plan effective visuals in your instructional materials.

What can you achieve with this book?

The second edition of Graphics for Learning reveals the processes and most recent research-based principles involved in designing effective graphics for print or computer instructional materials. We answer questions such as:

- Does an investment in visuals pay off in better learning?
- What kinds of graphics are proved to improve learning?
- What process should I use to ensure the most appropriate visuals in my instructional materials?
- What is the truth about visual learning styles?
- How can visuals be used for motivation?
- How can I select or design visuals that boost rather than corrupt learning?
- When is it best to use animations or still videos?

How is this book organized?

The first section of the book includes three chapters that lay the foundation by introducing three views of graphics and overviewing a visual design model. Section Two looks at the ways that graphics interact with the brain to support or disrupt psychological learning processes. In Section Three you will learn how to best leverage graphics to illustrate your content, including procedures, concepts, facts, processes, and principles. Last, in Section Four we guide you through a visual design model that illustrates how to plan your visuals from the start of your project to the production phase.

About Pfeiffer

Pfeiffer serves the professional development and hands-on resource needs of training and human resource practitioners and gives them products to do their jobs better. We deliver proven ideas and solutions from experts in HR development and HR management, and we offer effective and customizable tools to improve workplace performance. From novice to seasoned professional, Pfeiffer is the source you can trust to make yourself and your organization more successful.

Essential Knowledge Pfeiffer produces insightful, practical, and comprehensive materials on topics that matter the most to training and HR professionals. Our Essential Knowledge resources translate the expertise of seasoned professionals into practical, how-to guidance on critical workplace issues and problems. These resources are supported by case studies, worksheets, and job aids and are frequently supplemented with CD-ROMs, websites, and other means of making the content easier to read, understand, and use.

Essential Tools Pfeiffer's Essential Tools resources save time and expense by offering proven, ready-to-use materials—including exercises, activities, games, instruments, and assessments—for use during a training or team-learning event. These resources are frequently offered in looseleaf or CD-ROM format to facilitate copying and customization of the material.

Pfeiffer also recognizes the remarkable power of new technologies in expanding the reach and effectiveness of training. While e-hype has often created whizbang solutions in search of a problem, we are dedicated to bringing convenience and enhancements to proven training solutions. All our e-tools comply with rigorous functionality standards. The most appropriate technology wrapped around essential content yields the perfect solution for today's on-the-go trainers and human resource professionals.

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Pfeiffer
A Wiley Imprint
www.pfeiffer.com

Published by Pfeiffer

An Imprint of Wiley
989 Market Street, San Francisco, CA 94103-1741
www.pfeiffer.com

For additional copies/bulk purchases of this book in the U.S. please contact 800-274-4434.

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Library of Congress Cataloging-in-Publication Data

Graphics for learning : proven guidelines for planning, designing, and evaluating visuals in training materials/ Ruth Colvin Clark, Chopeta Lyons.— 2nd ed.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-470-54744-1 (pbk.)
1. Visual aids—Handbooks, manuals, etc. 2. Visual education—Handbooks, manuals, etc. 3. Business education—Audio-visual aids—Handbooks, manuals, etc. 4. Learning, Psychology of. I. Lyons, Chopeta C. II. Title.
LB1043.5.C53 2011 371.33'5—dc22

2010034665

Acquiring Editor: Matthew Davis
Production Editor: Dawn Kilgore
Editorial Assistant: Lindsay Morton
Director of Development: Kathleen Dolan Davies
Editor: Rebecca Taff
Manufacturing Supervisor: Becky Morgan

Printed in the United States of America

Printing 10 9 8 7 6 5 4 3 2 1

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ACKNOWLEDGMENTS

One of the goals of our work and this book in particular is to illustrate how research on graphics and graphic design can be implemented in practice. We appreciate the contributions of the instructional professionals who have allowed us to reprint graphic examples from their training programs to illustrate the ideas in this second edition, including:

Dale Bambrick, Raytheon Professional Services

Mimi Banks, L'Oreal

Kevin Hadlock, Moody's Analytics

Doug LeFlamme, WellPoint

Stephanie Olson, University of Phoenix

We also thank Mark A. Palmer, who created art, including our section organizers for this book, and our editors and production support staff at Pfeiffer, including Matt Davis, Dawn Kilgore, and Rebecca Taff.

FOREWORD TO THE SECOND EDITION OF GRAPHICS FOR LEARNING

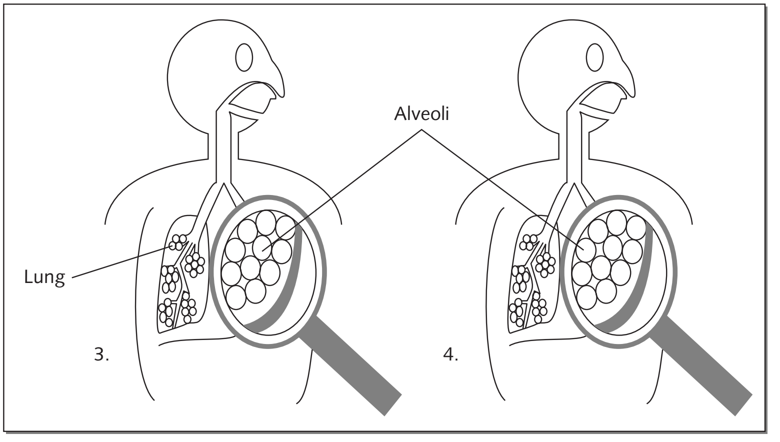
People learn better from graphics and words than from words alone. This idea—the multimedia principle—is the premise of this book. In short, this book's theme is that you can help people learn better if you include appropriately designed graphics in instructional presentations.

For example, consider how you would teach someone a simple fact, such as, "The alveoli are tiny air sacs in the lungs." Although these words give a correct definition, you might have some difficulty understanding what they mean. Figure F.1 shows a map of the lungs, including the alveoli, and thus helps you make sense of the verbal definition.

As another example, consider how you would teach someone a process such as how a car's braking system works. Using words, you could say, "When the driver steps on a car's brake pedal, a piston moves forward inside the master cylinder. The piston forces brake fluid out of the master cylinder and through the tubes to the wheel cylinders. In the wheel cylinders, the increase in fluid pressure makes a smaller set of pistons move. These smaller pistons activate the brake shoes. When the brake shoes press against the drum, both the drum and wheel stop or slow down." However, this explanation, although accurate, is somewhat hard to follow. The frames in Figure F.2 may help you visualize the actions described in the words and thus may help you come to a better understanding of how brakes work.

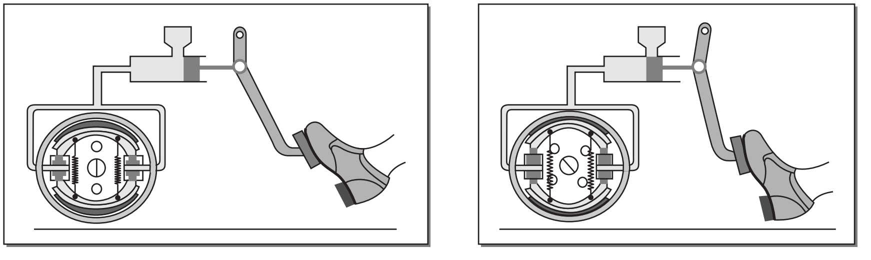
As you can see in these examples, sometimes words alone are not enough to promote learning. In short, these examples show how adding graphics can promote the process of learning. Recent research confirms that, in some cases, people can learn better from graphics and words than from words alone (Mayer, 2009).

Figure F.1. A Visual to Promote Understanding of Lung Structure



Source: Mayer and Sims, 1994.

Figure F.2. Visuals to Promote Understanding of How a Car's Braking System Works



Source: Mayer, Mathias, and Wetzell, 2002.

Although graphics can serve as aids to human learning, understanding and reasoning, it is important to consider that all graphics are not equally effective. How can you design graphics that help people learn, understand, or reason?

Until fairly recently, the best advice you could get about how to design graphics came from the opinions of experts. This is because, until fairly recently, there was not a large research base or a cognitive theory of how people learn from words and pictures. However, today there is a growing research base and an educationally relevant science of learning that can be used to help you figure out how to design graphics. The second edition of *Graphics for Learning* takes advantage of today's research evidence and learning theories and shows you how to design graphics that are aids to human learning, understanding, and reasoning.

How is this book different from other books on the design of graphics? The second edition of *Graphics for learning* is

Evidence-based—It shows how research evidence can be used to help you design graphics that help people learn.

Theoretically grounded—It shows you how the science of learning can be used to help you design graphics that are consistent with how people learn.

Practically relevant—It shows how research evidence and cognitive theory can be used to design graphics that help people learn in real learning situations.

Clearly presented—It is presented in a clear and consistent style containing many useful, concrete examples.

Current—It provides up-to-date coverage and lets you know the current state of the field.

Thus, the distinguishing features of this book are that the guidelines it presents are based on rigorous empirical research, are consistent with the cognitive theories of how people learn, are tied to realistic learning situations, are presented clearly with concrete examples, and reflect the current state of knowledge in the field.

Of course, it is not possible to provide design principles that apply in all situations because you have to adapt instructional graphics to the needs of individual learners, specific content, and particular learning contexts. Thus, *Graphics for Learning* helps you understand which kinds of graphics are best for helping which kinds of learners with which kinds of learning material under which kinds of learning conditions.

This new edition of the book adds coverage of exciting new research—particularly on animation and video—that has appeared since the previous edition was published in 2003. This new edition also expands coverage of graphics using new media such as mobile learning and virtual worlds. You will also find that this new edition is more concise and visually appealing than the previous edition; yet it retains the same basic structure and message.

The power of computer graphics is impressive and growing, but there is more than cutting-edge technology involved in designing graphics that actually help people learn. *Graphics for Learning* gives you an excellent survey of evidence-based principles for how to design effective instructional graphics.

Richard E. Mayer

Santa Barbara, California

INTRODUCTION: GETTING THE MOST FROM THIS RESOURCE

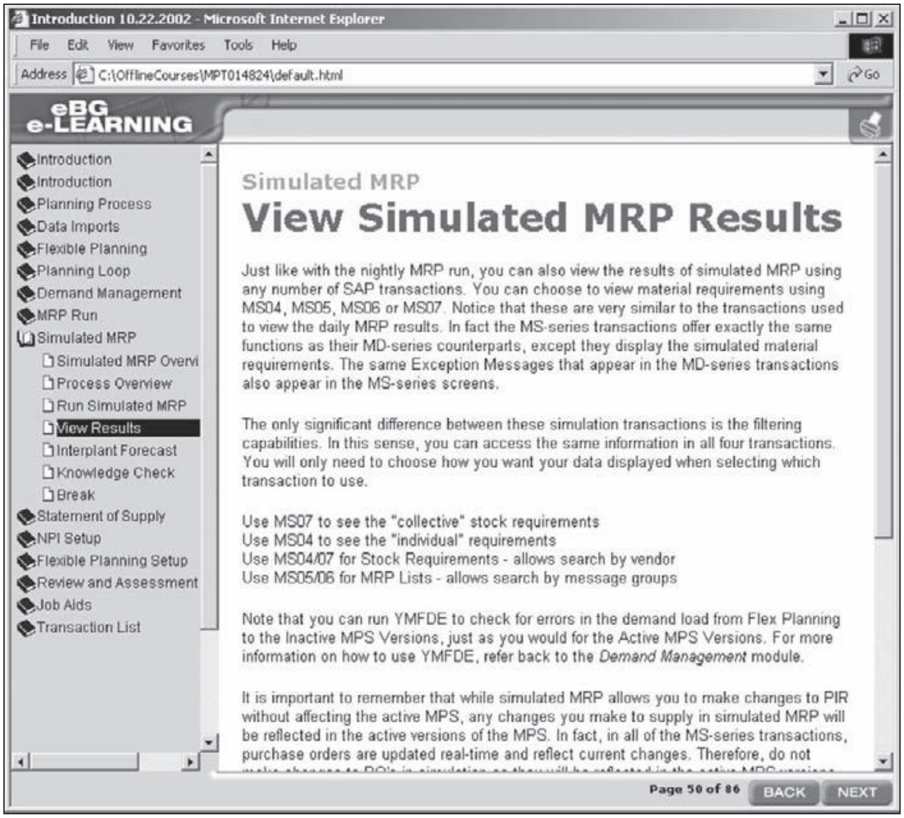
THE LOST POTENTIAL OF INSTRUCTIONAL VISUALS

More often than not, the potential of visuals to increase learning and improve work performance is unrealized. Some training materials are a *wall of words* where visuals are almost nonexistent. (See Figure I.1.) At the other extreme, some e-learning lessons wrap lesson content in visually rich thematic *edutainment* treatments to improve motivation. Both of these options defeat learning. Alternatively, many instructional materials, in print and on computers, add visuals for merely decorative purposes. Although decorative visuals may not depress learning, they do not promote it either. When we settle for a decorative graphic, we lose opportunities to increase learner comprehension. (See Figure I.2.)

Why is the potential of visuals to improve learning so under-realized? We believe that a root cause is our educational emphasis on words. We have all spent years learning verbal language skills. From the early grades through graduate school, we spend much of our instructional time learning the production and analysis of language. In contrast to language arts, the visual arts are generally considered an elective or a relief activity to offer an occasional break from the serious skills of reading, writing, and mathematics. It's not surprising then that most of us find it much easier to *express* our ideas with words, even though we may *respond* more readily to pictures.

Related to this emphasis on verbal language is a general misconception that visual literacy belongs to the domain of a talented few. After the instruction is analyzed, designed, and developed, training professionals who want to include

Figure I.1. A Wall of Words Lesson.



graphics often have someone else create them. If the project or company is large, they are likely to have the luxury of a graphic artist to create the visuals. More frequently, those without professional graphics support use the clip art and stock photographs abundantly available on the Internet to spice up their pages or screens. Other times, training professionals are forced to use existing graphics from the source materials or some other set prescribed by the client or production team.

No matter the source, in many cases the graphics are added as something either to decorate (Figure I.3) the interface or to provide a picture of what is being discussed. All too often visuals are planned haphazardly late in the course development

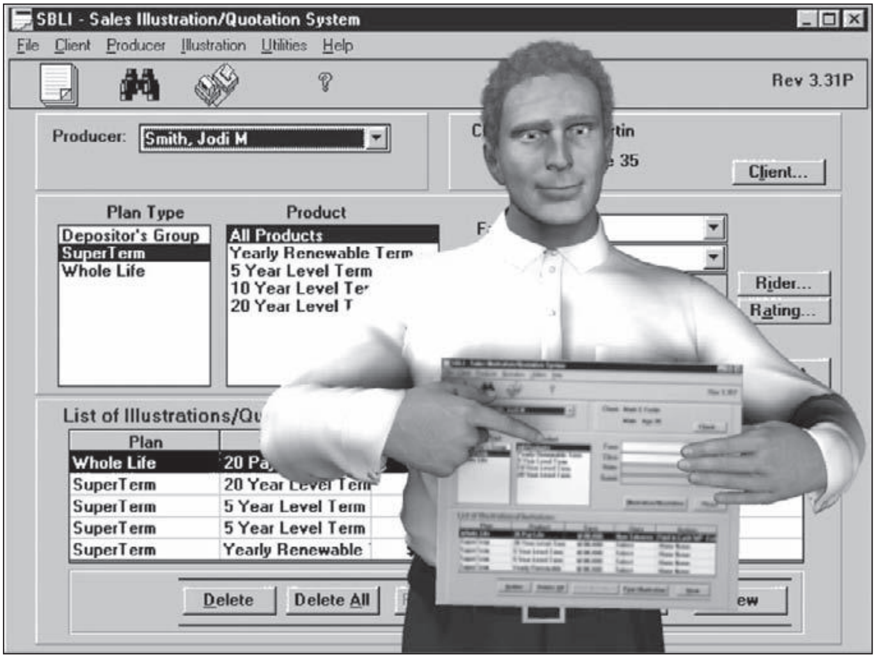
Figure I.2. A Thematic Treatment Used to Motivate Learners.

Credit: Mark A. Palmer.

process. The result is a product that does not fully utilize the potential of graphics to improve learning or, worse yet, uses visuals in ways that actually defeat learning.

This is a book about how to improve learning through the effective use of visuals. We draw our guidelines from two main sources: research evidence and a systematic design process. First, there is a wealth of recent research that illustrates what kinds of visuals are best to communicate instructional messages and to support psychological learning processes. As relevant as this research is to instructional professionals, it is buried in diverse academic journals and often presented in difficult-to-understand language. Throughout this book we summarize this research to help you make good decisions about visuals and explain your decisions to others. Second, we offer a visual design process that will help you plan your graphics in a systematic manner. Our guidelines and examples apply to

Figure I.3. A Decorative Visual. Decorative visuals like this one are related to the topic but serve no useful instructional purpose.



Credit: Mark A. Palmer.

a variety of media, including books, presentation slides, and online learning screens. Finally, while our guidelines can apply to any learning setting, our focus is graphics to support the building of job knowledge and skills in organizational work settings.

WHAT MAKES OUR BOOK DIFFERENT FROM OTHER BOOKS ON GRAPHICS?

Our guidelines for graphics are all based on empirical research studies. For "how-to," we suggest numerous other resources that offer instruction about layout, design, and human interface factors. These suggested materials focus on the elements of graphics: contrast, line, color, perspective, depth, arrangement, and composition.

They even zero in on how to use them to communicate specific points, ideas, images, or moods for advertising, communication, or training. However, here we talk about how to select or plan visuals effectively to illustrate specific instructional content as well as to support psychological processes of learning.

IS THIS BOOK FOR YOU?

This book is written for anyone involved in either the selection or the production of instructional materials. Some readers may work alone to produce training handouts or slides for their own presentations. Others may be part of project teams involved in production of e-learning courses. Some readers may be skilled in instructional design processes. Others may be graphic professionals who have unique visualization skills but wonder what the best ways are to use their skills to support learning. Alternatively, other readers might be involved in the selection rather than production of instructional materials for their organizations. Our book answers the following questions that these individuals typically have when planning instructional materials:

- Visuals add time and cost to any instructional project. Is there any evidence that the investment pays off in better learning?
- Besides showing pictures of objects such as system screen captures, what other kinds of visuals can I use to promote learning?
- What is the best way to display words and visuals together?
- What is wrong with using visuals to illustrate dramatic themes or puzzles to build interest in the training?
- I think visuals are great, but I have no graphics talent! When should I start to think about my visuals and how do I begin?
- When should I use animations, and when are stills more effective?
- Who profits the most from visuals in instructional materials?

AN OVERVIEW OF OUR BOOK

Our book has four sections, as illustrated in Figure I.4. Section One includes three chapters that serve as the foundation for the book. The first chapter defines instructional graphics and identifies their value. By summarizing three unique views of visuals, the second chapter lays the conceptual foundation. The third chapter lays the practical groundwork with an overview of our visual design model that you can apply to systematically plan and design graphics in your instructional projects.

Section Two builds on this foundation. It begins by summarizing research evidence for the design of visuals that support human psychological learning processes. Chapter 4 outlines human learning processes, followed by six chapters, one on each of the six critical learning stages. Specifically, Chapters 5 through 10 review research and illustrate how to use graphics to support attention, awaken prior knowledge, manage cognitive load, build mental models, support transfer of learning, and motivate learners in ways that do not defeat learning. Chapter 11 describes psychological differences in individuals that shape how they process visuals and recommends ways to design visuals of optimal value for all learners.

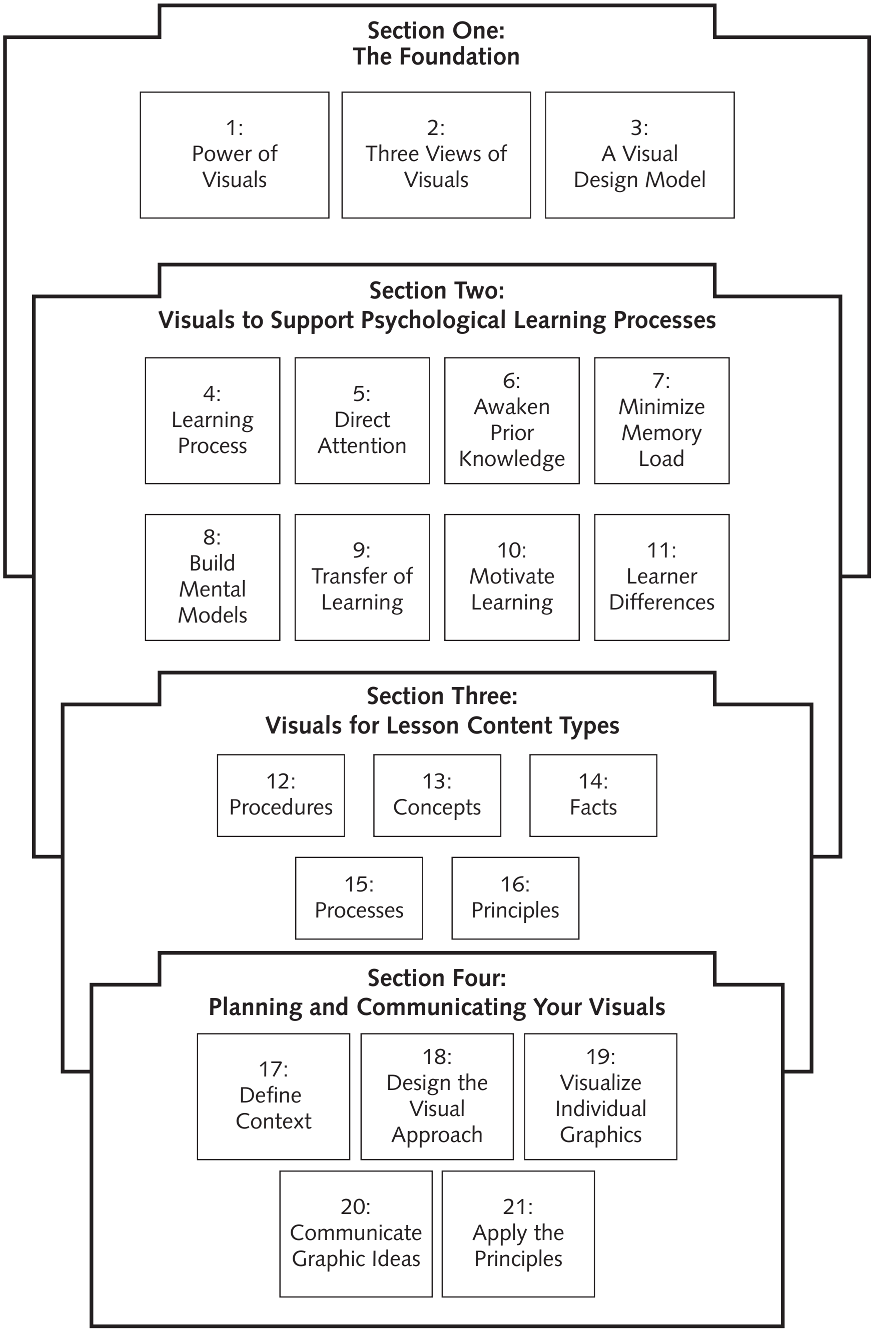
Section Three looks at how to visualize five common content types found in organizational training. These are procedures, concepts, facts, processes, and principles. Each chapter describes the content type and provides several guidelines for visualizing that content. Examples are drawn from paper materials such as manuals as well as online courseware and help screens.

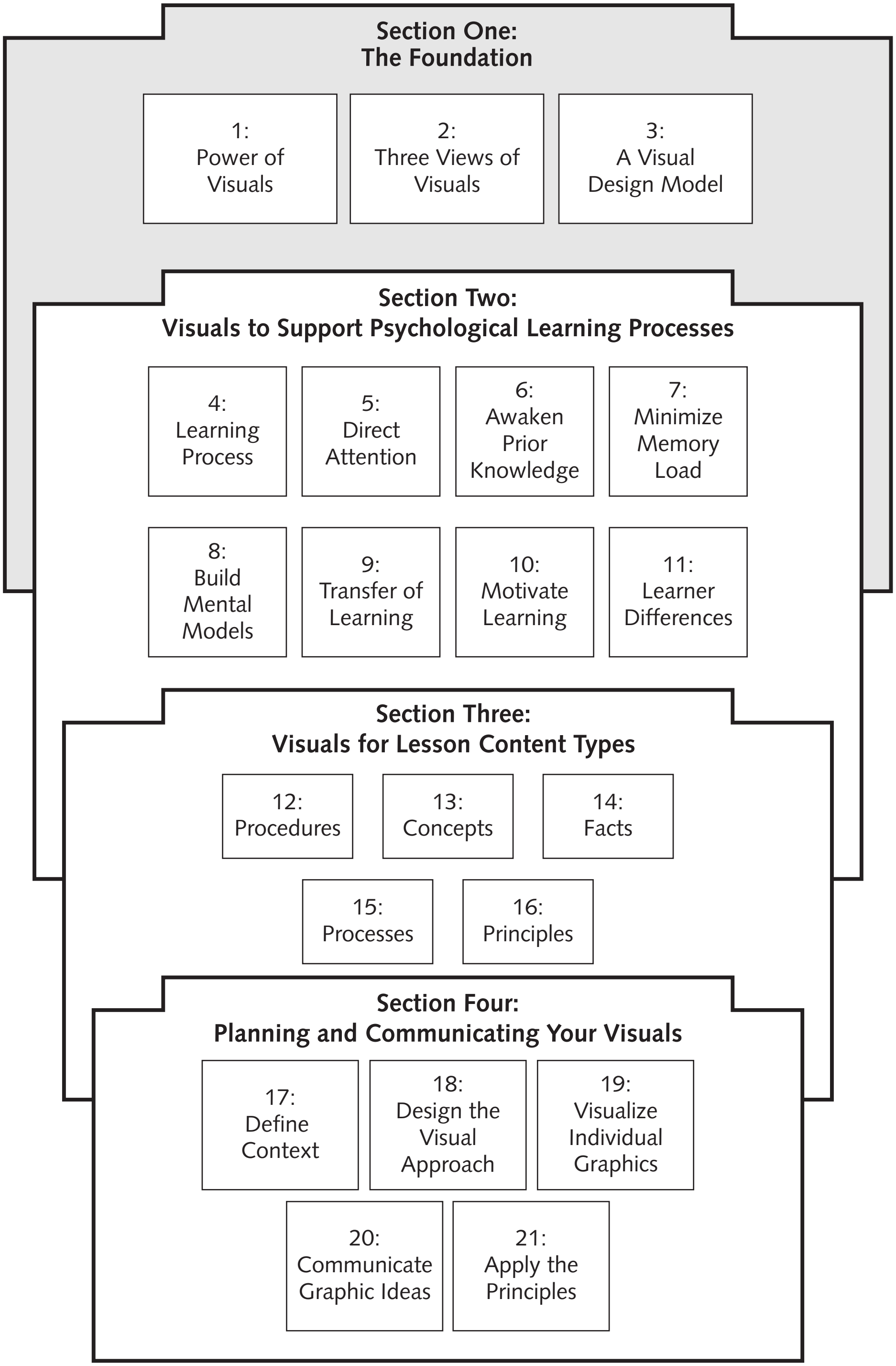
Section Four turns to the practical side of planning your instructional visuals. The chapters in this section expand on the visual design model introduced in Chapter 3. Examples and checklists are provided to help you (1) define your instructional context early in the process, (2) decide what visual approach will work best within your instructional context, (3) develop individual visuals, and (4) communicate your visual ideas to graphic artists who will implement them.

Our last chapter uses two different types of tasks, procedures and principles, to illustrate how to apply the design model and the research of all of the earlier chapters in a systematic way. Look to this chapter for running examples that model the processes and guidelines described throughout the book. Here you will see alternative treatments of the same content for different media such as paper versus computer; for different instructional strategies, such as directive versus guided discovery; and for different learning contexts, such as high and low bandwidth, visual and text dominant layouts, as well as serious and light styles.

To see many of our graphics in color, please check www.pfeiffer.com/go/ruthclark.

Figure I.4. A Visual Map of Graphics for Learning

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Introduction to Section One: The Foundation

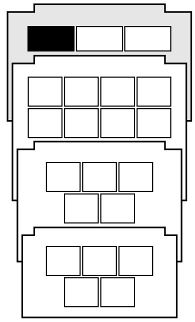
The three chapters in this section provide an overview of the major themes of the book. In Chapter 1 we begin the case for our premise that graphic effectiveness depends on graphic functionality. Most of us think of graphics in terms of their surface features such as line art or animation To expand the utility of visuals for learning, we propose two additional categories based on their functions. One focuses on the communication functions of graphics and the second focuses on ways graphics support psychological learning processes. In Chapters 1 and 2 we introduce these three views of graphics. We also summarize three guiding principles that reflect our most basic assumptions about what kinds of visuals are most effective for learning.

The second theme of our book focuses on a process for designing effective visuals for instructional purposes. Often visuals are considered late in the lesson development process and therefore must be compromised as a result of not considering the entire instructional context up-front. In Chapter 3 we overview a visual design process that includes the following major phases:

- Define instructional goals
- Define learning environment
- Design the visual approach
- Identify visuals to match lesson content
- Apply psychological learning guidelines to visual design decisions

We augment this overview in Section Four that elaborates on the visual design-process in greater detail.

CHAPTER OUTLINE



The Unrealized Potential of Visuals

What Is a Graphic?

Which Visuals Are Best? No Yellow Brick Road

- Factor 1: Functions of Visuals
  - Surface Features of Visuals
  - Communication Functions of Visuals
  - Psychological Functions of Visuals
- Factor 2: Instructional Goals and Lesson Content
- Factor 3: Visuals and Learner Differences

Graphics in the Instructional Landscape

CHAPTER 1

The Power of Visuals

In this chapter we define instructional graphics as pictorial expressions of information designed to promote learning and improve performance in work settings. The learning value of any visual will depend on three interactive factors: (1) the features of the visual, (2) the content and goal of the lesson, and (3) characteristics of the learners. We introduce three views of graphics based on their surface features, their communication functions, and their interactions with important psychological learning processes. We know that your decisions about graphics cannot be based on psychological factors alone. You must also take into consideration the entire instructional landscape including delivery media, learning environment, and pragmatic factors such as schedules and budget.

THE UNREALIZED POTENTIAL OF VISUALS

Words and graphics are your two basic tools to help learners build new knowledge and skills. Of these two, most of us have greater expertise with words since we are trained to read and to write from an early age. The use and interpretation of graphics is a more neglected skill. Often graphics in instructional materials are afterthoughts used primarily to add visual interest to the page or screen. Consequently, the power of illustrations to promote learning is often unrealized. In fact, some instructional materials include graphics that actually depress learning!

How effective are the graphics in your organizations' reference and training materials? Mayer, Sims, and Tajika (1995) and Woodward (1993) independently found that only a small proportion of the visuals included in textbooks serve any important instructional purpose. More often than not, graphics are either underutilized or misapplied in a range of instructional materials from books to e-learning.

This book is about graphics and learning. Our goal is to help you plan or select the types of visuals that have proven to improve learning and workplace performance and to avoid the types of visuals shown to disrupt learning. Although a great deal of research has been done on visuals and learning in the last thirty years, most guidelines published prior to 1990 are ambiguous. For example, a summary of hundreds of research experiments conducted in the 1970s and 1980s that involved over 48,000 students offered the rather vague conclusion that "visuals are effective some of the time under some conditions" (Rieber, 1994, p. 132).

In the last twenty years, however, research on visuals has yielded significantly more helpful guidelines. Unfortunately, most of this research is scattered in diverse academic journals not typically read by practitioners. To make this knowledge accessible we summarize guidelines based on recent research that direct you toward graphics that have proven effective and away from visuals that are proven to depress learning. The increasing use of highly visual media such as computers, combined with easy to use video and screen capture tools as well as cheap access to professional visuals through online art sites, make this an ideal time to translate this research for individuals who plan, develop, or select instructional materials.

WHAT IS A GRAPHIC?

For the purposes of this book, we use the terms graphics, pictures, visuals, and illustrations interchangeably. Graphics specialists of course have a very specific meaning for these terms. But we will use them here interchangeably to reference most any non-textual element added to training materials. We include a wide range of iconic displays commonly found in instructional materials, including photographs, line drawings, animations, graphs such as pie charts, and video. Specifically, we focus on visuals designed to improve learning and performance on the job.

We define instructional graphics as *iconic expressions of content* that are designed to *optimize learning and performance* in ways that improve the *bottom-line performance of organizations.* Our definition incorporates three ideas.

1. By *iconic* we refer to expressions of content that are pictorial. As shown in Table 1.1, the surface features of such visuals may be static or dynamic and they may have high or low degrees of correspondence to real things. Thus a photograph is a highly realistic static representation, while an animation is a dynamic visual that may be realistic or abstract.
2. The second point in our definition, "designed to optimize learning and performance," refers to the purpose of the visual. We focus on graphics that are intended to support learning or improve performance in the workplace. Thus we include examples from a range of instructional materials such as text pages and online screens as well as from work aids such as online help and web screens designed to help workers complete job tasks more effectively.
3. Finally, by "bottom line performance" we mean visuals that improve learning or performance in ways that pay off in improved organizational results. Visuals, especially original art, are often more expensive to produce than words. To achieve a return on investment from your training or work aids, you must be sure that they fill a gap in knowledge or skills or support work tasks that align with organizational goals. All too often training is used as a silver bullet to solve organizational problems that have little to do with knowledge and skills. As we describe the best use of visuals for learning, we assume that a performance analysis has shown that training or performance support is an appropriate solution.

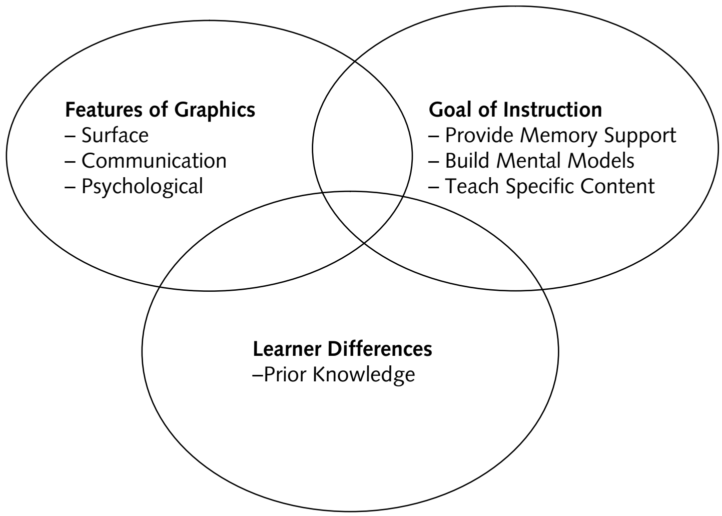
WHICH VISUALS ARE BEST? NO YELLOW BRICK ROAD

There is no simple formula you can use to design or select visuals that improve learning and performance in all situations. Instead, the learning value of a visual will depend on three interactive factors summarized in Figure 1.1, including: (1) properties of the visual itself, including its surface features, communication functions and psychological functions, (2) the goal of the instruction, and (3) differences in prior knowledge of the learners.

Table 1.1. Surface Features of Graphics

Types	Salient Feature	Definition	Example
Static Art	Illustration	Depiction of visual elements, using various media and techniques such as pen and ink, watercolor, and computer drawing packages	Pen and ink outline art; Two-dimensional watercolor of flower parts; Diagrams and charts
	Photographic	Captured image, using photographic or digital technologies	Screen capture of a software screen; Photo of person answering phones
	Modeled	Computer-generated (CG)—A faithful reproduction of reality, using various media, included computer assisted drawing packages	Three-dimensional representation of an office; Three-dimensional representation of combustion engine
Dynamic Art	Animation	Series of images that simulate motion	Demonstration of steps in a software procedure; Process of ammunition detonation shown through line art
	Video	Series of images, captured as they occur, digitally or on film or magnetic tape, displayed serially, over time	Capture of the hydrogen bomb test explosion at White Sands, New Mexico; Film of human resources director interviewing a job applicant
	Virtual Reality	Interactive three-dimensional world that dynamically changes as the "user" moves through and views it	Simulated walkthrough of the human heart

Figure 1.1. Factors That Shape the Effectiveness of Graphics.



Factor 1: Functions of Visuals

In describing graphics, most of us use terms such as line art or photograph that refer to their surface features. But for learning purposes, the functional characteristics that affect how the illustration communicates information or how it facilitates psychological learning processes are as important as its surface features. Therefore, we present three different views of visuals based on their (1) surface features that focus on what they look like and how they are created, (2) communication functions that focus on how they convey information, and (3) psychological functions that focus on how they facilitate human learning processes. Table 1.2 summarizes these three views. The three views are interrelated. For example, different surface features such as static or animated visuals will influence their psychological effects. Additionally, different communication functions will have different psychological effects.

Surface Features of Visuals

We have new evidence that the surface features of visuals influence their psychological effectiveness. For example, do you think you should illustrate motion with a series of static visuals or with an animation? Which would be better

Table 1.2. Three Views of Graphics for Instruction

View	Classification based on:
Surface	The salient features of visuals such as static art (illustration, rendered, photograph), dynamic art (video, animation), and true virtual reality
Communication Function	The communication purpose to show motion or represent illustrate quantitative relationships
Cognitive Psychological Function	Interactions. How visuals interact with human learning processes such as attention or retrieval from memory

for learning? It turns out that a series of still visuals can be more effective for some learning goals such as teaching how things work (Mayer, Sims, & Tajika, 2005). On the other hand, animations are more effective for teaching skills involving motion (Ayres, Marcus, Chan, & Qian, 2009). Therefore, we cannot ignore surface features of visuals—either from a pragmatic production standpoint or from a psychological effectiveness perspective.

Communication Functions of Visuals

Just as we rely on language grammars to help us assemble words correctly, we need classification systems for visuals that go beyond surface features. To help you plan graphics based on their functional properties, we describe our adaptation of a taxonomy of illustration summarized by Carney and Levin (2002) and illustrated by Lohr (2007). The taxonomy is summarized in Table 1.3. This taxonomy will help you plan visuals based on their *communication functions*—not just their surface features. In Chapter 2, we describe the communication taxonomy in greater detail.

Psychological Functions of Visuals

In addition to communicating effectively, your visuals also must support critical psychological learning processes. Visuals that disrupt these processes have been

Table 1.3. Communication Functions of Graphics

Function	A Graphic Used to	Examples
Decorative	Add aesthetic appeal or humor	Art on the cover of a book Visual of a general in a military lesson on ammunition
Representational	Depict an object in a realistic fashion	A screen capture of a software screen A photograph of equipment
Mnemonic	Provide retrieval cues for factual information	A picture of a stamped letter in a shopping cart to recall the meaning of the Spanish word, Carta (letter)
Organizational	Show qualitative relationships among content	A two-dimensional course map A concept tree
Relational	Show quantitative relationships among two or more variables	A line graph A pie chart
Transformational	Show changes in objects over time or space	An animation of the weather cycle A video showing how to operate equipment
Interpretive	Illustrate a theory, principle, or cause-and-effect relationships	A schematic diagram of equipment An animation of molecular movement

shown to depress learning. For example, Harp and Mayer (1998) found that adding visuals and text that were topically related to the lesson but extraneous to the learning goal depressed learning. They created two versions of a lesson that taught the process of lightning formation. The basic lesson version used words and relevant visuals to depict the process. The enhanced lesson version added short narrative vignettes with visuals such as a video of lightning striking trees, an ambulance arriving near the trees, and a lightning victim being carried in a stretcher to the ambulance. At the same time, the narrator said: "Approximately 10,000 Americans are injured by lightning every year. . . ." (p. 415). Learning was about 30 percent better for students using the *basic lesson version lacking the graphic enhancements.* The enhancements actually depressed learning because they distracted attention from the main content aligned to the learning goal.

To promote the design and planning of graphics that work *with* rather than *against* human learning processes, we describe a third way to catalog illustrations based on learning processes. This classification system, summarized in Table 1.4 organizes graphics according to how they support the *six psychological events* of learning overviewed in Chapter 2 and described in greater detail in Chapter 3.

Factor 2: Instructional Goals and Lesson Content

The goal of the training is a second factor that influences the value of a given graphic. For example, animations have proven to be effective to teach skills involving motion but not to help learners build an understanding of how things work. If your goal is to build understanding of a process such as how an engine works, you would be better served by a visual that is different from a graphic best suited to teach how to replace a part in an engine.

In Section Three of our book, we describe visuals to support five content types (facts, concepts, processes, procedures, and principles) that make up much of the information linked to training and performance goals.

Factor 3: Visuals and Learner Differences

Although the idea of learning styles may suggest that some learners are more "visual" and some more "auditory," evidence discounts the learning style notion (Clark, 2010; Kratzig & Arbuthnott, 2006). Instead, prior knowledge of the lesson content is the most important individual difference affecting the value of graphics. Mayer and Gallini (1990) compared learning how brakes work from a lesson with text alone to learning from a lesson with text and graphics. They compared learning of two different groups. One group had no knowledge of the topic (novice learners) and the other had mechanical experience. Not surprisingly, the lessons with added graphics greatly improved learning of novices. However, adding graphics did not help individuals with prior knowledge.

Table 1.4. Psychological Functions of Graphics

Function	Description	Samples
Support Attention	Graphics and graphic design that draw attention to important elements in an instructional display and that minimize divided attention	A circle to point out the relevant part of a computer screen Placement of descriptive text close to graphic
Activate or Build Prior Knowledge	Graphics that engage existing mental models or provide high-level models to support acquisition of new content	Visual analogy between new content and familiar knowledge Graphic overview of new content
Minimize Cognitive Load	Graphics and graphic design that minimize extraneous mental work imposed on working memory during learning	Line art versus photograph Relevant graphic versus decorative graphic
Build Mental Models	Graphics that help learners construct new memories in long-term memory that support understanding.	Visuals to illustrate how things work Visual simulations to build cause and effect mental models
Support Transfer of Learning	Graphics that incorporate key features of the work environment; graphics that promote deeper understanding	Use of software screen simulation that looks and acts like actual software Use of a visual simulation to build a cause and effect mental model
Support Motivation	Graphics that make material interesting and at the same time do not depress learning	A graphic that makes the relevance of the skills to the job obvious An organizing visual that clarifies the structure of the material

Being familiar with the terms and appearance of mechanical systems, the more experienced learners could form their own visual images as they read the text. A number of other research studies comparing learning of novices with learning of individuals with higher prior knowledge have shown similar results (Canham & Hegarty, 2010; Kalyuga, 2005; Kalyuga & Renkl, 2010). The bottom line for training professionals: Invest more graphic resources in introductory courses and/or lessons intended for learners who are new to the content!

In summary, there are no hard and fast rules about which visuals are best for all situations. Instead, several factors interact to determine the influence of any given visual on learning. These include the surface and functional features of the graphics, the intended learning outcome (such as learning how to do something or learning how something works) and the learners' prior knowledge of the lesson content. Throughout the book we provide guidelines that will help you plan or select visuals that are likely to improve learning. You will need to adapt these guidelines to your own unique mix of learners, learning goals, and lesson content.

GRAPHICS IN THE INSTRUCTIONAL LANDSCAPE

In addition to the features of the visual, learning goals, and prior knowledge of learners, we cannot ignore the context in which graphics will be displayed and used. The landscape of your instructional program and the placement of visuals in that landscape will be influenced by several factors, including technological parameters such as bandwidth; pragmatic constraints such as budget and graphics resources; and even organizational standards and style guides for print and online designs. Therefore, we will discuss how decisions about graphics are influenced by other components of your instructional program such as requirements and conventions for on-screen text, narrated words, and screen design. All of these components make up an instructional context. Your selection of graphics will shape and be shaped by this overall context.

THE BOTTOM LINE

Effective leveraging of graphics for learning will depend on a match among several factors, including the surface features of the visual such as whether it is a static or animated graphic, communication functions of the visual such as representational or interpretive, the psychological functions of visual design elements such as an arrow to support attention or a simpler visual to help manage mental load, your learning goal, and individual differences among learners. In addition, the context in which a visual is placed—on a page, a slide, or a screen—will shape your graphic decisions.

COMING NEXT

Now that we see that selecting the best visual can depend on variations in features and functions of that visual, in Chapter 2 we will expand on three views of visuals, including surface features, communication purpose, and psychological functionality. We will also summarize three guiding principles for the selection of any visual for learning or reference purposes.

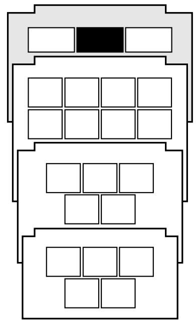
For More Information

Carney, R.N., & Levin, J.R. (2002). Pictorial illustrations still improve students' learning from text. *Educational Psychology Review*, *14*(1), 5–26.

Clark, R.C. (2010). *Evidence-based training methods*. Alexandria, VA: ASTD Press.

Kalyuga, S., & Renkl, A. (2010). Expertise reversal effect and its instructional implications: Introduction to the special issue. *Instructional Science, 38*, 209–215.

CHAPTER OUTLINE



Three Views of Visuals

Communication Functions of Graphics

- Decorative
- Representational
- Mnemonic
- Organizational
- Relational
- Transformational
- Interpretive

Graphics to Support Psychological Events of Learning

- How Learning Happens

Our Guiding Principles

- Assumption One: Graphic Effectiveness Depends on Graphic Functionality
- Assumption Two: Guidelines for Graphics Should Be Based on Research Evidence
    - What Is Useful Evidence?
    - New Insights from Eye-Tracking Data
    - New Insights from Effect Sizes
- Assumption Three: Context Will Influence Use of Visuals

CHAPTER 2

Three Views of Instructional Visuals

In this chapter we dig more deeply into three views of graphics introduced in Chapter 1: surface features, communication goals, and psychological functions. We also describe three guiding principles underlying the recommendations throughout the book:

- Graphic effectiveness depends on graphic functionality.
- Guidelines for graphics should be based on research evidence.
- Context will influence the best use of visuals in any specific training or reference product.

THREE VIEWS OF VISUALS

In Chapter 1 we introduced three views of graphics. Table 1.1 summarized the surface features of visuals such as static or dynamic art, which are how graphics are most commonly described. Because you are familiar with these terms, we will not elaborate more on surface features. In this chapter, we will see that surface features do affect psychological functionality. For example, compared to line drawings, a three-dimensional detailed drawing can add extraneous mental load as a result of irrelevant visual noise. In addition, surface features have important technical, cost, and production implications. For example, to create and deploy an animated visual typically requires greater bandwidth, and greater cost and involves different production issues than using a static illustration. Therefore, when planning more elaborate visuals such as animations, you want to be sure that you get learning payoff from their functional features. In the next sections we summarize the communication and psychological functions of visuals.

COMMUNICATION FUNCTIONS OF GRAPHICS

Figure 2.1 illustrates seven communication functions of visuals that we introduced in Chapter 1. The key communication functions of graphics are decorative, representational, mnemonic, organizational, relational, transformational, and interpretive. Four of these (organizational, relational, transformational, and interpretive) we subcategorize as explanatory visuals because they depict relationships in your content. As a result they are especially useful to build deeper levels of understanding. Let's take a quick look at each of the seven communication functions.

Decorative

Decorative graphics such as the one shown in the book introduction (Figure I.3) and in Figure 2.2 are usually added for aesthetic, humorous, or motivational purposes. No doubt you've seen many of these types of graphics, and perhaps have used a few yourself. Although they may be related topically to the content of the lesson, decorative visuals are largely extraneous to its goals. Because self-paced multimedia lessons, in particular, are subject to high learner attrition, visual "eye candy" is often added to spice up the materials. However, excessive use of decorative graphics risks interfering with essential mental learning processes needed to promote learning. Therefore, we discourage their overuse.

Figure 2.1. A Summary of Communication Functions of Graphics.

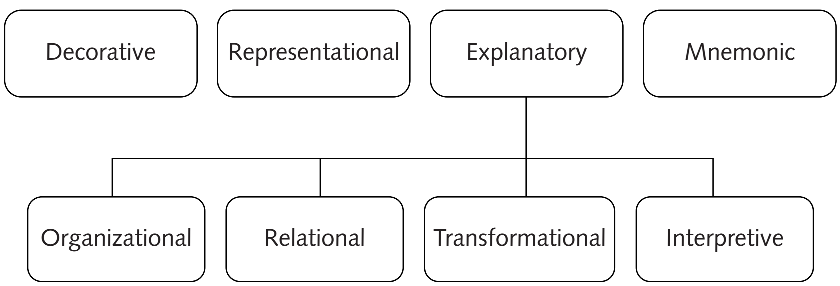


Figure 2.2. A Decorative Graphic.

From Clark, 2009. Used with permission from *Training & Development*.

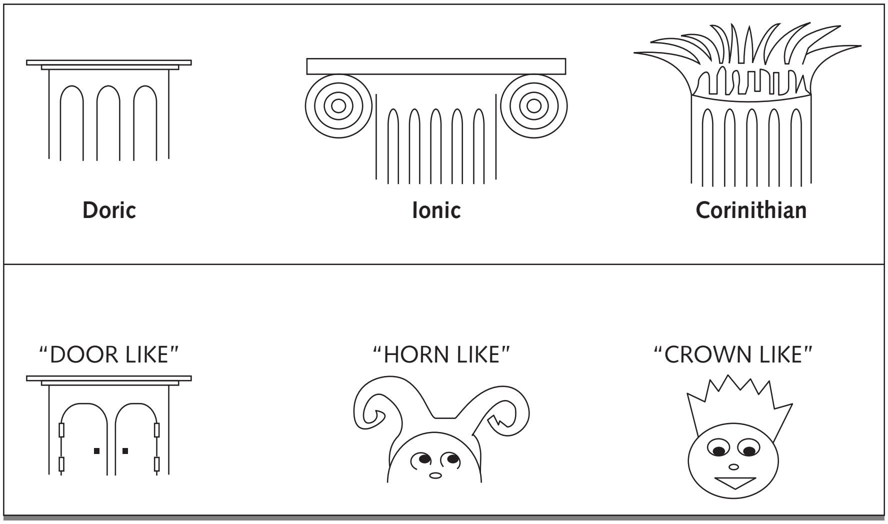
Representational

Representational visuals portray the actual appearance of lesson content. The goal is to illustrate what the content looks like in a realistic manner. Some examples include illustrations of a keyboard, a line drawing of a braking system, or a software application screen. These kinds of visuals are very depictive. By that we mean that they have a high degree of fidelity to the details of the "real" items as in photographs or screen captures. They can also omit extraneous detail such as in a line drawing. The key to representational graphics is that they are intended to faithfully represent the "real" object.

Mnemonic

Mnemonic visuals aid in the recall of lesson facts and concepts. For example, Figure 2.3 shows a visual mnemonic used to illustrate the concepts of three types of columns: Doric, Ionic, and Corinthian.

Figure 2.3. A Visual Mnemonic. The best mnemonic incorporates both an auditory and a visual cue such as door-like for Doric.



Adapted from Wileman, 1980.

Mnemonic graphics capture the meaning of facts or concepts and link them visually to a different concept that provides a bridge to their meaning—in other words a visual analogy. Thus, we see the visual representation of a "door" in the mnemonic visual that leads you to the name and look of a Doric column. Mnemonics have proven to be very powerful memory retrieval devices (Carney & Levin, 2002). One limitation to mnemonics is their cultural or linguistic specificity. "Door" works as a mnemonic for an English-speaking audience, but not perhaps for a Chinese- or German-speaking one. This specificity can make a mnemonic visual difficult to disseminate to a global audience.

Organizational

Organizational visuals illustrate qualitative relationships among lesson content. They are typically represented in trees, organizational charts, or in knowledge maps made up of nodes and links. Figure 2.1 is an organizational graphic in the form of a tree diagram that we used to summarize the basic communication functions of visuals.

Another common type of organizational visual is representation of lesson structure in a two-dimensional menu that communicates not only the topics but the relationship of topics to one another. Robinson and Molina (2002) report that some organizational visuals actually improve learning of conceptual relations better than do outlines that include the same information but lack the two-dimensional spatial representations.

Relational

Relational visuals are used to communicate quantitative relationships among two or more variables and include charts and diagrams such as pie charts, line graphs, and bar charts. The use of relational graphics grew from 900 billion in 1983 to 2.2 trillion in 1994 (Jones & Careras, 1994). However, only recently has controlled research focused on the kinds of graphs and charts that are most effective for specific purposes. In Chapter 8 we summarize the most recent research on how best to design relational visuals.

Transformational

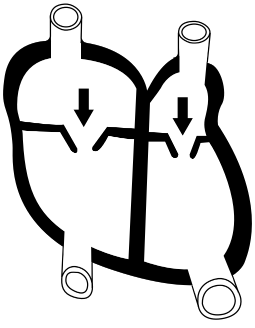
Transformational visuals communicate change over time or over space. The surface features of transformational graphics can include animations, video, or line drawings with movement indicators. A common use of transformational visuals is to teach or provide reference to the steps needed to perform a procedural task. Recent research has shown that animations can be superior to still visuals to teach skills involving motion (Ayres, Marcus, Chan, & Qian, 2009).

Interpretive

Interpretive graphics help learners build understanding of events or processes that are invisible, abstract, or both. Figure 2.4 shows an interpretive visual in the form of a line drawing illustrating how blood circulates through the heart. Butcher (2006) found better learning from a drawing like this than from a text-only description.

Throughout the book we will summarize research that supports the use of these functional categories of visuals for specific instructional purposes. We offer this classification model as a starting point to help you plan graphics based on how they communicate your lesson content.

Figure 2.4. An Interpretive Graphic for Blood Circulation.



From Butcher, 2006.

GRAPHICS TO SUPPORT PSYCHOLOGICAL EVENTS OF LEARNING

For learning to occur, all instructional methods including graphics must support several critical psychological events. These include:

- Directing learner attention to important information in the lesson
- Activating prior knowledge in memory
- Managing mental load to free resources for learning
- Building new or expanded mental models in memory
- Supporting transfer of learning after the training event
- Motivating learners to initiate and complete learning goals

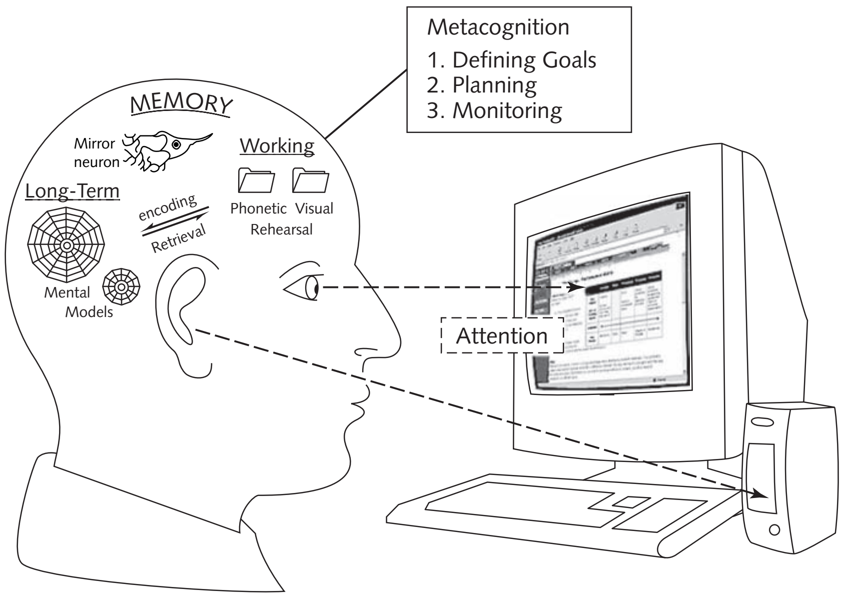
Visuals and graphic design devices that support one or more of these processes will improve learning. Conversely, visuals that disrupt one or more of these processes will depress learning.

How Learning Happens

Learning is based on a transformation of new information from the environment into long-term memory, as summarized in Figure 2.5. Two central memories are involved in this process: working memory and long-term memory. If attention is directed toward new incoming information, the information is stored in a visual and/or phonetic (auditory) storage area in working memory. Working memory is the center of human thought and active processing. Although it's a powerful processor, its storage capacity for information is quite limited. You may be familiar with the expression *7 +/− 2*. This expression refers to the limits of working memory. Learning takes place when the new content stored in the visual and in the phonetic components of working memory are integrated. First, the visual and phonetic information must be organized to form a cohesive idea. Then this idea must be integrated with prior knowledge that is activated from long-term memory. The outcome is an updated mental model stored in long-term memory.

Good instructional methods promote processes that mediate the transformation of environmental information into new knowledge and skills in long-term memory. In Chapter 4 we describe these events in greater detail.

Figure 2.5. Human Learning Process Overview.



OUR GUIDING PRINCIPLES

There are currently few universal guidelines for the use of graphics that are applicable for all learning purposes and for all learners. However, we base our recommendations on three assumptions regarding best design and selection of graphics.

Assumption One: Graphic Effectiveness Depends on Graphic Functionality

First we emphasize selection and design of graphics based not only on their surface features but also on their communication and psychological functions. These three views will provide you with an expanded way to think about and invest resources in graphics that will provide the most cost-effective alternatives for your instructional goals.

Assumption Two: Guidelines for Graphics Should Be Based on Research Evidence

Second, we draw our recommendations from research evidence. There are many books available on graphics. Most of these include guidelines based on experience and community wisdom. Although intuition is often useful, sometimes evidence does not support these recommendations. For example, Tufte (1983) discourages chart junk defined as a graph that uses a lot of ink to display relatively little data. However, evidence has shown that in some cases, more ink leads to faster interpretations of a chart (Kosslyn, 2006). We believe that the training field is moving toward a professional practice in which decisions will be based on scientific evidence as well as on pragmatic, technical, and political factors.

What Is Useful Evidence?

In this book we have updated the research reported in the first edition. Most of the research we report is based on experiments. In an experimental study, a large group is randomly assigned to a control condition and a treatment condition. For example, twenty-five individuals are randomly assigned to read a lesson consisting of just text (the control group) and another twenty-five are assigned to read the same lesson with graphics added (the treatment group). The random assignment of a large number of individuals to the control and treatment groups ensures that individual differences such as specific interests or abilities are evenly distributed and thus are not a factor in the results. After completing the lesson assignment, the subjects are tested. For the most part we have reported test results that reflect application of knowledge rather than mere content memory. That's because workers in organizations must be able to apply information—not just memorize it. Therefore, application tests are more relevant to workforce learning practitioners.

New Insights from Eye-Tracking Data

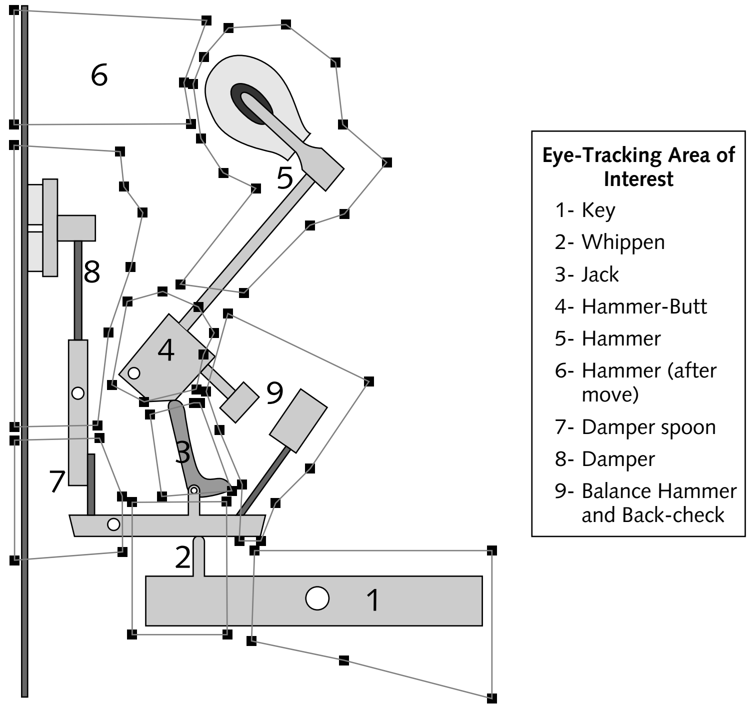
Knowledge tests tell us the value of different experimental treatments such as graphics added to text compared to text alone. However, additional types of data can give us insight into how or why one treatment was more effective than another. Recently, psychologists have used eye-tracking data to indicate where and for how long a subject might attend to a visual or to specific elements of a visual (Van Gog & Scheiter, 2010). Eye tracking works by reflecting invisible infrared light onto the eye of the learner, recording the reflection pattern with a sensor system, and then calculating the exact point of gaze. For example, Figure 2.6 shows the results of eye-tracking data in an animation of how a piano works. The time subjects devote to specific areas of the visual help researchers pinpoint locations of higher attention within a visual. Eye tracking has been used for many years to evaluate the effectiveness of visual elements in advertising and web design. Now it is being applied to training materials. In Chapter 5 we report eye-tracking data used to determine the effectiveness of cues added to graphics to support attention.

New Insights from Effect Sizes

An important addition to this edition is a focus on a statistic called effect size. The effect size offers insight into the practical impact of the results of an experiment. For our purposes, keep in mind that an effect size of less than .3 is probably not large enough to recommend a change in practice. Effect sizes greater than .3 up to around .7 are in the medium range. Effect sizes greater than .7 are high and are good candidates for implementation by practitioners.

Most of the research we report has been conducted with college age subjects. Because of our focus on workplace learning, we have excluded most research on the effects of visuals on children's learning. In this second edition, we update the research we reported previously. Naturally, we will need to continue to update our guidelines in the future based on emerging research.

Figure 2.6. Eye-Tracking Data Indicates Areas of Interest Outlined on This Experimental Visual.



From Boucheix and Lowe, 2010.

Assumption Three: Context Will Influence Use of Visuals

Third, we recognize that decisions about graphics cannot be made independently of the entire instructional context. The selection or design of graphics is influenced by decisions regarding the environment in which the materials will be used, whether words will be included and in what format (text or audio), and the instructional medium such as computers or books. As new technology such as mobile devices and virtual worlds evolve, so will our opportunities to use graphics with new functionalities and features. The initial uses of virtual worlds to replicate a classroom, as shown in Figure 2.7, reflect a tendency to pour old wine into new bottles. However, as we gain experience with new capabilities, so will we mature in

Figure 2.7. A Virtual World Classroom. Replicating existing environments with new technology represents the first-generation use of most new technologies.

Credit: Mark A. Palmer.

effectively exploiting them. In Section Four we summarize a systematic process for design of graphics as part of an instructional landscape that must factor in these types of variables.

THE BOTTOM LINE

An effective visual will depend on which communication function that visual serves and how the features of the visual support basic psychological learning processes. Fortunately we have a considerable body of experimental research to guide our graphic design and development decisions. Recent research offers us new statistical techniques including effect sizes as well as new measurement techniques including eye-tracking studies to deepen the scope and depth of guidelines for graphics.

COMING NEXT

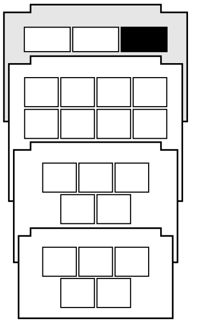
If you are responsible for planning or designing visuals for an instructional product, whether on your own or as part of a production team, you will be interested in Chapter 3. Here we overview a graphics design model that summarizes the various stages needed to plan and design visuals for instructional products. This model is expanded in Section Four.

For More Information

Mayer, R.E. (2010). Unique contributions of eye-tracking research to the study of learning with graphics. *Learning & Instruction, 20*, 167–171.

Van Gog, T., & Scheiter, K. (2010). Eye tracking as a tool to study and enhance multimedia learning. *Learning and Instruction*, *20*, 95–99.

CHAPTER OUTLINE



Three Facets of Graphics

What Can Happen Without a Systematic Approach

What Happens When Instructional Designers Follow a Systematic Process

A Visual Design Model

I. Define the Goal

II. Determine the Context

- Who Are the Learners?
- What Is the Learning Environment?
- What Is the Delivery Medium?
- What Are Your Constraints?

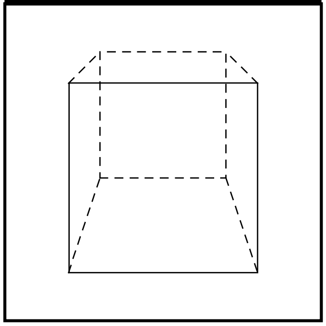
III. Design the Visual Approach

- Make a Preliminary Assessment of Content Graphic Requirements
- Determine the Image the Package Should Project

IV. Identify Communication Function of Visuals to Match Content Types

V. Apply Principles of Psychological Instructional Events to Visual Design Decisions

CHAPTER 3



A Visual Design Model for Planning Graphics Systematically

Whether you are the sole developer working to already established templates or a member of a design team whose been given carte blanche and a blank canvas, early analysis and planning of all your graphic needs can help you integrate the visual elements to promote learning.

Our five-phase iterative design process weds up-front decisions regarding the goals, delivery media, and audience to subsequent decisions regarding the instructional and psychological needs of individual content-specific visuals. This design model provides a structure to help you:

- Define the instructional goal.
- Determine the context.
- Design the visual approach.
- Identify the communication function needed to match content type.
- Apply principles of psychological instructional events.

We introduce the model here in order to set the stage for Sections Two and Three of this book. Later, in Section Four, we return to this planning model for the "how to's" of designing the visual treatment for your course.

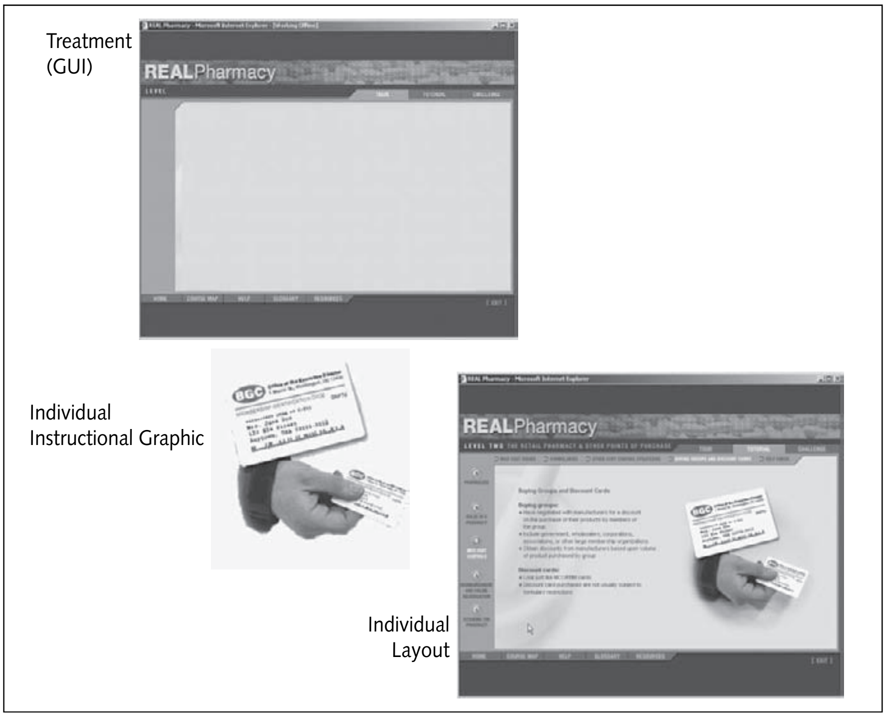
THREE FACETS OF GRAPHICS

In any media project, there are basically three facets of graphic design to consider (Figure 3.1). Although often developed separately and by different people, these facets are interrelated:

- Treatment—the "look and feel," display framework, or template. In e-learning, treatment is often called the graphical user interface (GUI) or the "skin."
- Individual art—the unique illustrations for specific content topics.
- Layout—the arrangement of the art in relation to the other aspects, such as text, white space, of the page or screen display as well as to the template.

Each of these facets affects the impact of your instruction. For example, a great instructional graphic can be overpowered by a highly ornate template or undermined by a poor layout, and thus be less effective.

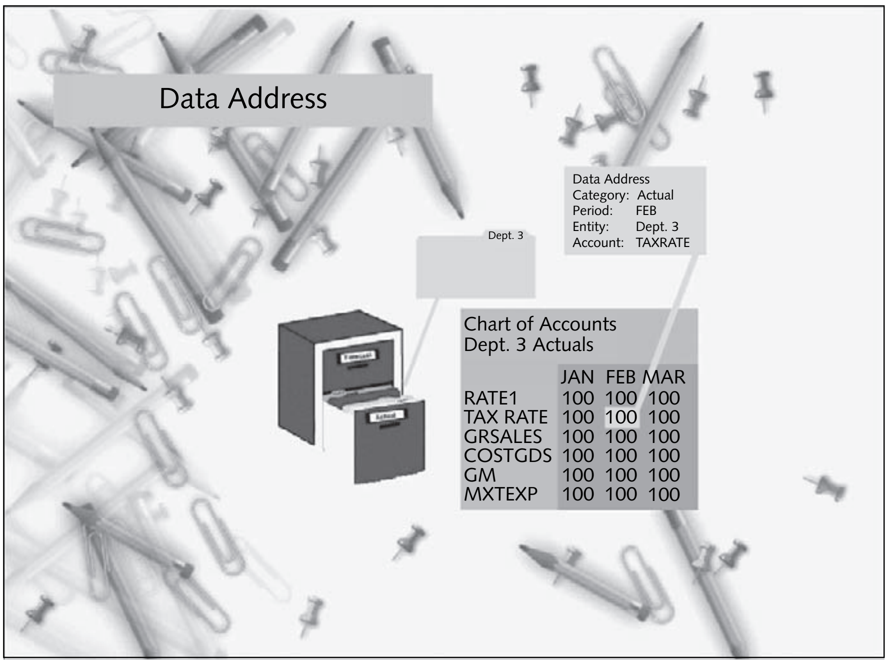
Figure 3.1. Three Facets of Graphics.



WHAT CAN HAPPEN WITHOUT A SYSTEMATIC APPROACH

Ever been in the back of the class and strained to see a slide similar to the one in Figure 3.2? You might have been frustrated trying to interpret a blurry chart with tiny text while plenty of space was devoted to decoration. You might have been unsure of where to look or even whether there was anything critical on the screen at all. If you ever have had a similar experience, you probably realized that such space-hogging decorations were created before anyone really thought about the environment in which the slideshow would be used or considered the individual graphics the slideshow had to accommodate. As another example, perhaps you have taken a course in which the materials looked like a random patchwork of photographs, cartoons, and three-dimensional images, as well as the same clip art you have seen in hundreds of slideshow presentations and homegrown documents. In both of these examples, the weak designs were the result of the lack of a systematic approach.

Figure 3.2. Slideshow Presentation Slide.



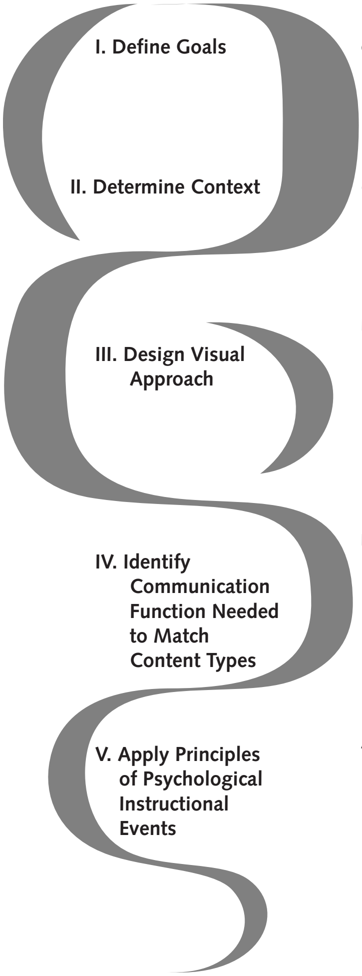
WHAT HAPPENS WHEN INSTRUCTIONAL DESIGNERS FOLLOW A SYSTEMATIC PROCESS

The design model in Figure 3.3 summarizes a process that helps you ensure that you are planning your graphics to best support instructional needs. The five-phase model starts with defining the instructional goals for the entire course and ends with planning individual displays that communicate specific content effectively, support psychological learning processes, and fit into the overall visual landscape of your training. This process is a little bit like decorating the rooms in a new home. To create the look and feel for the entire house, a decorator studies each room's unique requirements in terms of size, shape, use, and relationship to other rooms in the home. He looks at the furniture and other possessions that need to fit within the style of each room and the other décor of the house. He also considers the architecture and style of the home as a whole as well as the available space, budget, and preferences of the owners. Only then does he begin selecting fabrics, paint, and individual pieces of furniture.

The first three phases in Figure 3.3 illustrate how a front-end analysis effort nails down the parameters and requirements for all the graphic elements. In Phase One, the training professional or design team defines the goals of the instructional materials. Is the instruction primarily to inform or motivate? Or is it to build skills and provide the associated knowledge needed in order to do so? In Phase Two, the team determines the context in which the instructional materials will be used, including any corporate, academic, or organizational requirements and expectations. In Phase Three, the team previews the graphic needs of the entire package to assess the specific space, color, and style requirements of the individual graphics. Phase Four concentrates on the individual content—identifying the type of communication functionality that your content requires. Finally, Phase Five focuses on planning and laying out the graphics and graphical elements that are needed to support psychological events of learning.

Suppose the training professional who created Figure 3.2 had consciously followed this design model. She might have defined the goal as building the knowledge needed for the procedure of locating and updating chart of account information. She would have recognized that her template should accommodate detailed tables and charts. Next, her analysis of context might have identified the visual limitations of her audience, the type of monitor or projection unit,

Figure 3.3. A Visual Design Model. If you are used to following an instructional design methodology, the process in this graphic design model may be familiar. Note the emphasis here is on the planning and design, not on the actual development of the graphics themselves.



Goals are:
To inform or motivate
To build near-transfer (procedural) skills and associated knowledge
To build far-transfer (problem-solving) skills and associated knowledge
Can include procedural skills that support far-transfer tasks

Context Includes:

LearderProfile	- e.g., novice, advanced, mixed
Learning landscape	- e.g., classroom, self-study computer
Delivery media	- e.g., book, computer (resolution, bandwidth, etc.)
Pragmatic issues	- e.g., budget, style guides, etc.

Designing the Visual Approach Includes:
Determine the image
Assess general graphic requirements of content
Design Treatment—includes decisions about:
- Instructional strategy:
- Text dominant or visual dominant
- Layout or Interface for media (style, orientation, real estate)
- Navigation and functionality (for online learning)
- Surface features that align with context and goals

Identify Communication Function for:

Multiple content	—use organizational visuals
Procedures	—use representational, transformational visuals
Concept	—use diverse representational or interpretive visuals
Facts	—use representational and mnemonic visuals
Process	—use transformational visuals
Principles	—use explanatory visuals, such as relational, interpretive, or transformational

Apply Principles:
For all instructional goals,
Apply principles to awaken prior knowledge and support transfer

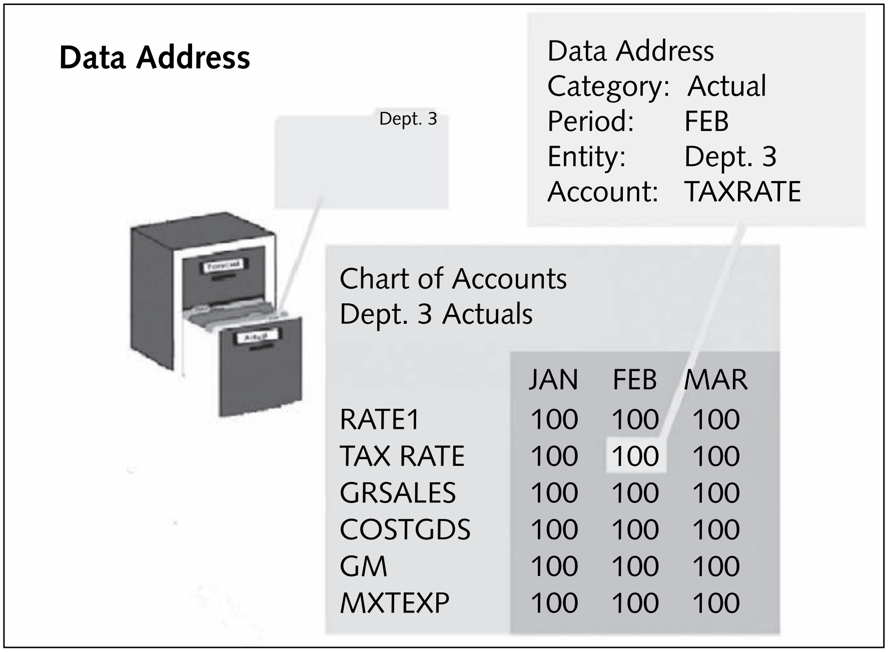
If complex content, novice audience, or runs outside learner control
Then apply attention and cognitive load principles

If building far-transfer skills
Then apply mental model principles

If building near-transfer skills
Then apply transfer principles

If learners low in personal motivation
Then apply motivational visual principles

Figure 3.4. The Designer's Revision of Figure 3.2.



the room, and even the screen size and how far the learners might typically be sitting from the screen. As she began to design the graphic approach, she would have identified the real estate (space, location, and emphasis) requirements of the graphics to be displayed, the role of visuals and text, and any design treatment issues such sequencing and timing for the display of callouts and arrows. Her resulting design might have looked more like the one in Figure 3.4.

A VISUAL DESIGN MODEL

The design model presented below blends the evidence-based guidelines we discuss throughout this book into the traditional production phases commonly employed in most development. For example, when designing the treatment, along with assessing audience, delivery, and production issues, designers need to also consider the goal, the instructional strategy, and multimedia principles.

If they are working to existing standards, they gauge the requirements for the yet-uncreated individual visuals. When designing individual graphics, designers need to consider the communication functionality that best supports each type of content. And when laying out screens or pages integrating the graphic and content elements, designers will want to factor in the psychological principles of learning—such as managing load, directing attention, and awakening prior knowledge.

I. Define the Goal

Visual design for instruction starts with the anticipated outcomes. Defining the goal of your instruction determines the direction of your graphic design process. The instructional goals that drive the design of most training materials are

- To inform or motivate (often described as building awareness)
- To build procedural skills and teach the associated knowledge required
- To build principle-based or problem-solving skills and teach the associated knowledge required

Information or motivation campaigns are often high profile, requiring a polished presentation in keeping with the company branding. When organizations launch new initiatives, for customer satisfaction, quality control, or corporate strategy, they often introduce them with company-wide training. Other examples include product knowledge programs to create awareness and motivation for the sales force. Because these programs are central to the company's vision, they often have big budgets, have high visibility, and require slick graphic treatment.

On the other hand, when the goal of the training is skill building, especially for internal processes such as insurance claims adjudication or automotive engine diagnostics, the emphasis is on the accuracy of the instructional content as well as on the effectiveness of the instructional strategies used. Generally, these types of courses are the bread and butter offerings of training departments and have lower budgets and less visibility.

Skill-building courses may focus on building procedural knowledge, also known as near-transfer skills. Much software training falls into this category. The goal is to help learners perform step-by-step tasks in a consistent manner. Other skill-building courses are more concerned with building principle-based knowledge, also known as far-transfer skills. Far-transfer tasks are those that involve problem solving and judgment, such as deciding whether to fund a bank loan applicant or how to sell a new product. Such problem-solving instruction might benefit from graphic representation of the real-world work environment.

It's important to clarify whether the skill to be taught is near or far transfer or a combination of both, as the instructional approach is quite different for each (Clark, 2008). It seems basic, but simply articulating the goals of the material is a crucial first step, especially in making sure there is a consensus about what is the outcome of the learning program. Sometimes the sponsor sees the goal as building awareness and motivation, but the instructional designers realize it should be to build skills. So make sure you define and agree on the true goal of the training early in the process. Otherwise, your "client" or the sponsoring organization may be looking for glitter, sizzle, and dancing pop bottles when what is really needed is a clean animation of a procedure. Even if you are working solo, articulating the goal will help keep you true to your purpose.

II. Determine the Context

If a graphic can't be seen, it has no impact. If it can't be viewed because of low bandwidth, poor lighting, or low resolution, your message is lost. As you determine your context, you will need to define your audience, the physical surroundings in which the visuals will be used, and the delivery medium such as book, computer screen, or mobile device where it will be displayed. And, of course, the greatest visual designs in the world are always shaped by the practical realities—the budget, the resources, the deadlines, and the corporate guidelines. Let's look briefly at each of these factors that shape the visual landscape. You will find more details and guidance in Section Four: How to Plan and Communicate Your Visuals.

Who Are the Learners?

Consider the target audience's prior knowledge of the course content. Research shows that visuals benefit low prior knowledge learners the most. And, in fact, visuals can actually depress learning for advanced learners and experts. Exert more time and effort on visual design for courses that teach novices than you would on courses intended for advanced learners or as refreshers. Analyzing the learners as to their culture, age group, or education also helps you identify any potential problems they may have perceiving visuals. The classic example is a target audience of older adult males, who statistically have a higher percentage of color blindness than any other segment of the population. Consider, for example, an e-learning interaction that indicates correct answers in green feedback text and incorrect answers in red feedback text. If no other cueing technique is used (such as labels, shapes, or color intensity), the colorblind male has difficulty discerning which answers are right and which are not. Still, year after year, designers create interfaces that rely on precisely this color-coding schema of "green text is good, red text is bad."

What Is the Learning Environment?

We traditionally think of the learning environment as the classroom or the computer. But in these days of just-in-time training and on-the-job performance support, the learning environment can be the learners' desks in the office, their break room in a manufacturing plant, or their work area—be it a cubicle, specific patient treatment setting in a hospital, or a station on the assembly line, or even their cars. Because of this variety, the learning environment itself has a strong impact on what are appropriate surface features for the graphics.

Perhaps the learning environment is a garage bay for busy mechanics. Knowing this is the learning environment, the training professionals can create graphics with clear, simple, and bold surface features that can be interpreted despite grease and ink smudges. As another example, if the learning environment is a clean room, where the technicians are encumbered with gloves and masks, designers may choose bold graphics that make the instructional content easily discernable through face plates.

What Is the Delivery Medium?

Delivery medium refers to the material or equipment on which the instructional material is displayed and is a major factor that shapes your choice of visuals. Suppose the material is a line-drawn cartoon. The cartoon can be delivered on any number of media: on a page in a book or manual, a computer screen, a flip chart, a smart phone, or white board at the front of the room. For the garage bay environment described above, perhaps the best delivery medium is a laminated wall chart.

The delivery platform that currently requires the most scrutiny so that the end product is not compromised is, of course, the computer with its wide variety of configurations and connectivity. Perhaps you have taken an e-learning module and experienced a long download time for a highly ornate graphic (and may have even abandoned the training after becoming frustrated by the wait). As the world moves to mobile computing, designers may need to pay attention to the size and display of cell phones, tablets, and pocket computers. In Chapter 17, Determine the Context, we describe some of the specific issues you will need to consider about the delivery platform.

What Are Your Constraints?

Very few instructional projects start with a blank check or are created in a vacuum. Usually, there are budgets, time tables, accessibility requirements, templates, and even corporate style guides that must be adhered to. For example, some training materials, such as those that support yearly software releases, are essentially disposable. They have small budgets, immovable deadlines, and often must conform to a set of standards already in place. All these pragmatic considerations can severely restrict your graphic design. Be realistic about these issues and don't try to design the Taj Mahal on a pauper's paycheck.

III. Design the Visual Approach

Once the team has defined the goal and completed its initial analysis of the environment, it is ready to put on its graphics hat. Every instructional package has a "look and feel"—the first facet of graphics that we mentioned at the beginning of this chapter. Even if the "look" is no more than a mishmash of random choices, it is still a style. Ideally, however, the look and feel is the culmination of careful consideration of all the elements we identify in this chapter and developed into templates.

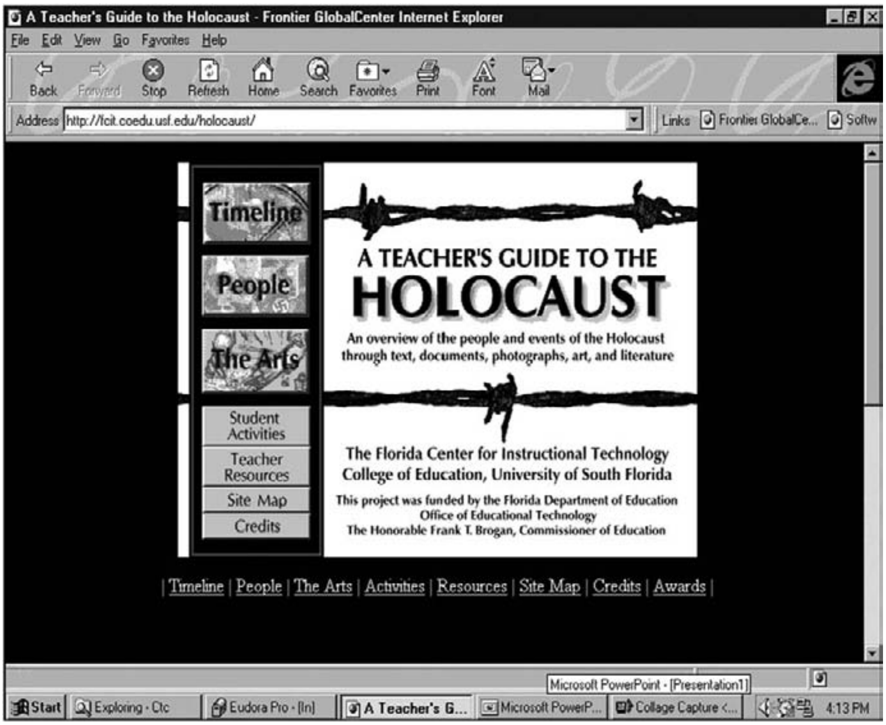
Make a Preliminary Assessment of Content Graphic Requirements

Earlier, we talked about the importance of assessing the requirements of the individual graphics before settling on a treatment or display framework that ultimately must accommodate them. This need is especially great in big projects, with multiple instructional designers, writers, and artists. Often, too, organizations establish one overall look and feel for their family of training products. For these reasons, experienced training professionals typically assess what they deem the "worst" case graphic—in terms of its real estate, page orientation, colors, and functionality needs.

Determine the Image the Package Should Project

Look at the three e-learning display frameworks (Figure 3.5, Figure 3.6, and Figure 3.7). Each has been designed after careful consideration of the instructional content and the desired impact on the audience. The display for Figure 3.5, through use of somber colors and severe lines, communicates the seriousness of the Holocaust content. In Figure 3.6, the 3-D modeled "real-world environment" matches the problem-solving nature of content. The colors and fonts reflect the company branding. Figure 3.7 uses a cartoon-like display with instructional

Figure 3.5. A Somber Treatment for a Serious Subject.



Source: Anne Barron

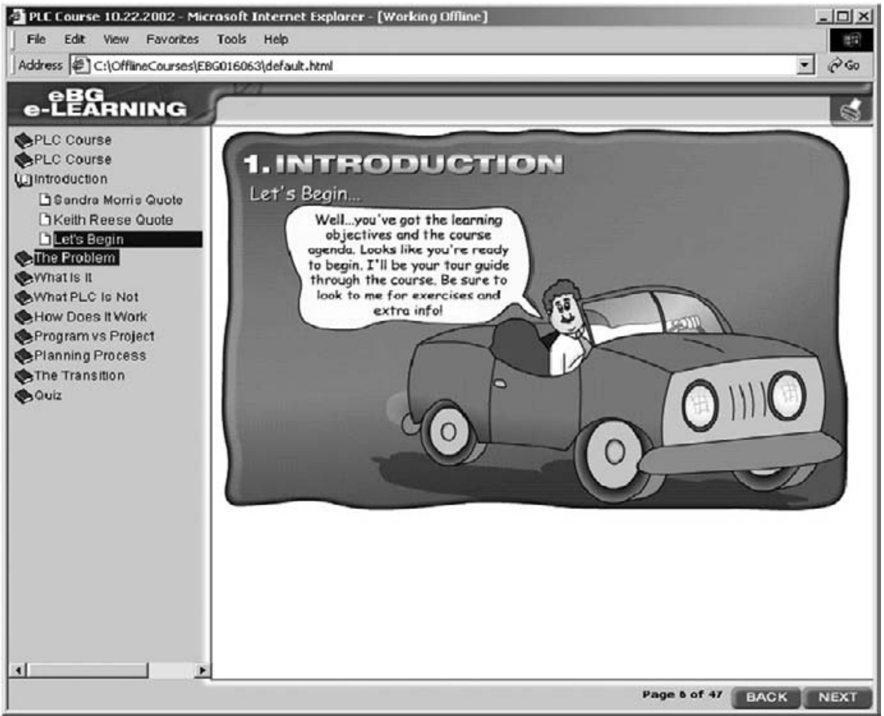
Figure 3.6. An Industry-Specific Treatment, 3D Modeled.

With permission from Raytheon Professional Services.

content contained in speech balloons. Its style mirrors the image projected by one of the company ad campaigns.

Additionally, the display framework projects the piece's credibility. If the display framework is haphazard and piecemeal, the content may seem careless and less than reliable. If it is polished and serious, it lends authority to the instruction. Often the sponsoring organizations have strong opinions about this image. For example, some organizations may believe a comic book treatment undermines the seriousness of the subject matter. On the other hand, other organizations may feel that same comic book treatment may make the material accessible and less overwhelming to the learner. Determine the image the sponsor wishes to project and whether it is appropriate for your learner profile.

Figure 3.7. A Cartoon Treatment.



IV. Identify Communication Function of Visuals to Match Content Types

In this phase of our design model, you evaluate your content to determine the individual graphics that will illustrate the content's key instructional points. In Section Three: How to Visualize Lesson Content, we describe the visuals that are best suited to help learners master five content types: procedure, concepts, fact, process, and principle (Clark, 2008). Often, at this point in the development schedule, your interface or treatment is designed and the parameters within which you must work are established. Now you can focus on how best to illustrate a key content point. To do so effectively, rather than just mindlessly grabbing stock art, refer to the content types (fact, concept, process, procedure, principle) to get an idea of the best visuals to illustrate them.

For example, if your goal is to teach procedures, you will want to use representational and transformational graphics to illustrate demonstrations of how to apply steps to the equipment involved in the procedure. If your instruction is to be presented on a computer, you may use animations to show the step the learner should take and the consequence of taking that step (the *step-action-consequence* cycle). If, on the other hand, your instruction is to be presented on paper, you may want to display a series of screen shots across the top of the manual pages with text callouts on each screen that summarize the action to take. As we mentioned in Chapter 2, Three Views of Instructional Visuals, research demonstrates that a series of stills is effective for showing how things work; animation is useful for demonstrating skills involving motion. Finally, matching the right graphic to instructional purpose follows a basic process from conception, through "roughs" or mockups, trying it out with representatives of the intended audience, and then revising it.

V. Apply Principles of Psychological Instructional Events to Visual Design Decisions

This phase focuses on the third facet, the layout of the individual graphic within the template display. In Section Two: How to Use Visuals to Support Psychological Learning Processes, we provide more detail on how to best use visuals to support six key instructional events of learning, including focusing attention and avoiding mental overload without disrupting learning. The layout of the various elements helps direct the user's learning—graphics for cueing, white space to eliminate distraction and add emphasis, as well as grouping or proximity to show relationship or to provide visual contiguity.

For dynamic media, these psychological principles encompass sequencing and audio as well. For example, if you are creating e-learning on how to use a new software system, you may decide to use animations to demonstrate the procedure. But we know that animations can easily result in cognitive overload. To help manage that load, you can provide explanations via audio narration rather than on-screen text; insert a pause and replay button to provide for learner control of action sequences; and use visual cues to draw attention to the parts of the screen being discussed.

Table 3.1. Three Facets of Graphics

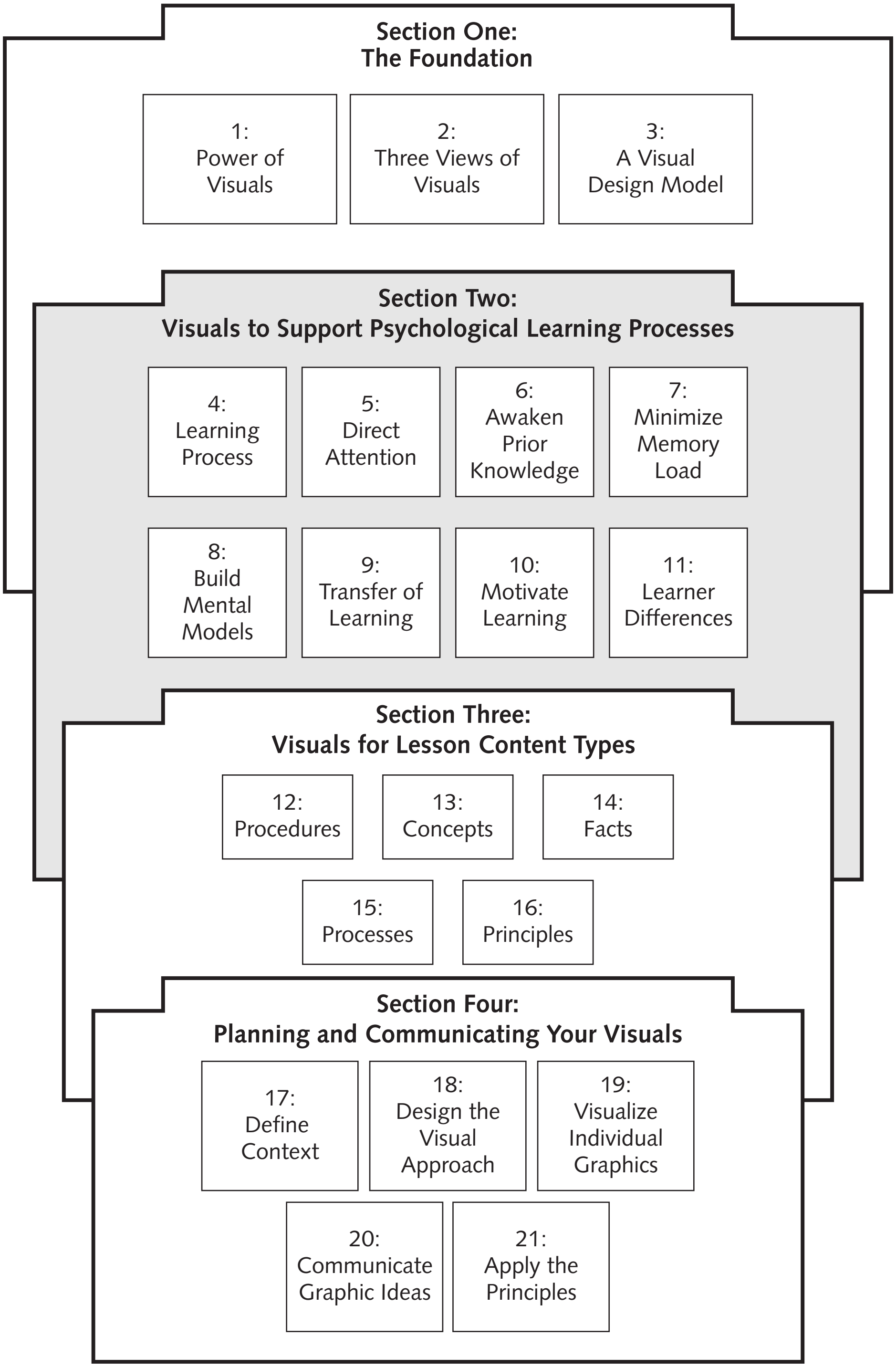
Facet	Description	Also Known as:
Treatment	The overall look and feel of the instructional material. It establishes course-wide graphic conventions such as style, typeface/font, color palette, size, and orientation, etc.	GUI Display framework Skin Template Format Theme
Individual Graphic	Specific graphics with specific communication and psychological functions to support instructional content.	Art Media elements Visuals
Layout	The integration of the specific graphic into the overall look and feel of the instructional materials. In e-learning, includes sequencing of graphic and audio elements.	Page makeup Screen design Storyboards

THE BOTTOM LINE

Even in today's world of rapid development, planning your graphics systematically ensures that your designs contribute to learning. Consider all three facets of your visual presentation—the treatment, the individual instructional graphics, and the layout—as parts of an integrated whole. (See Table 3.1.)

COMING NEXT

In this first section we laid the groundwork for the next three sections of this book by summarizing three views of visuals based on (1) their surface features, (2) their communication and needs, and (3) their psychological functions. We also introduced a design model that should help you adapt a systematic process to planning your visual approach and creating individual instructional graphics. In the next section, we will look at six key psychological events of learning and describe research-based guidelines for designing visuals that support each one.


Section One:
The Foundation
1: Power of Visuals
2: Three Views of Visuals
3: A Visual Design Model
Section Two:
Visuals to Support Psychological Learning Processes
4: Learning Process
5: Direct Attention
6: Awaken Prior Knowledge
7: Minimize Memory Load
8: Build Mental Models
9: Transfer of Learning
10: Motivate Learning
11: Learner Differences
Section Three:
Visuals for Lesson Content Types
12: Procedures
13: Concepts
14: Facts
15: Processes
16: Principles
Section Four:
Planning and Communicating Your Visuals
17: Define Context
18: Design the Visual Approach
19: Visualize Individual Graphics
20: Communicate Graphic Ideas
21: Apply the Principles

Introduction to Section Two: How to Use Visuals to Support Psychological Learning Processes

One of our fundamental premises is that visuals that are effective for learning must promote human psychological learning processes and avoid disrupting those processes. In this section we summarize the research that supports the use and design of visuals that help learners convert lesson content into transferable knowledge and skills in memory. Chapters 4 through 11 describe and illustrate visuals that help learners focus attention on what's important, awaken prior knowledge in memory, avoid overloading working memory, build mental models in long-term memory, transfer new knowledge and skills to the job, and motivate learners to persist in achieving their learning goals.

PROMOTING HUMAN PSYCHOLOGICAL LEARNING PROCESSES

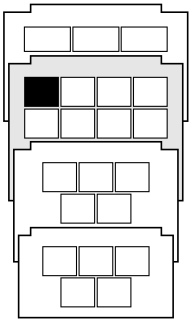
Human learning is constrained by a unique architecture dominated by the properties of the two central memories: working memory and long-term memory. Working memory has a very limited capacity, yet at the same time is the center of all conscious thought and learning. Therefore, the challenge is to optimize the limited capacity of working memory so it can be fully devoted to learning processes. In contrast, long-term memory has a large capacity, but is inert. Therefore, when it's time to use new skills or knowledge back on the job, they must be retrieved out of long-term memory to be processed in working memory.

Good instructional materials must accommodate this unique cognitive architecture by supporting one or more of the following learning processes:

- Attending to important lesson content
- Bringing prior knowledge relevant to the new skills from long-term memory into working memory
- Reducing the load in working memory to utilize its limited capacity for learning processes
- Helping learners build new mental models to be stored in long-term memory
- Transferring new skills stored in long-term memory back into working memory when needed on the job
- Motivating learners to initiate and complete learning goals

Successful instructional visuals support these processes while visuals that disrupt these processes impede learning. Our goal in this section is to describe each of these key processes and to illustrate how selection and design of visuals can affect each stage for better or for worse.

CHAPTER OUTLINE



CHAPTER 4

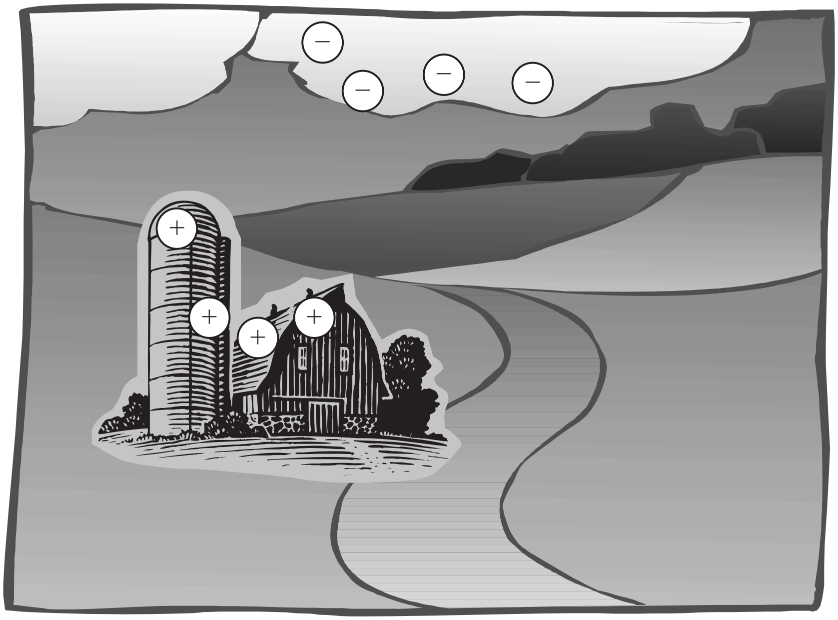
Graphics and Learning

Graphics are only effective to the extent that they support rather than disrupt psychological events of learning. To lay the groundwork for Section Two, in this chapter we overview the psychological processes that underpin learning. We look at the differences and relationships between the two memory siblings involved in learning: working memory and long-term memory. We then overview the six important instructional events that help learners transform content in the training environment into new knowledge and skills in long-term memory. These six events provide a basis for many recommendations on the best design of visuals. We conclude with a summary of six guidelines for selection and design of instructional graphics based on their psychological functions.

NOT ALL GRAPHICS ARE EQUAL

When it comes to learning, not all visuals are equally effective. Graphics that illustrate an instructional text can improve learning. However, different graphics used to illustrate that same text can depress learning. Mayer (2009) compared learning from eleven different lessons that used text alone to lessons that added visuals to the text. The topics included how brakes, pumps, and lightning work. He found that individuals who studied from lessons that included illustrations such as the one shown in Figure 4.1 learned significantly more than those who studied the same lessons without illustrations. The median effect size from all eleven experiments was 1.39, which is a large improvement. Effect sizes over 1.0 suggest that the results should be considered for implementation by practitioners.

Figure 4.1. An Interpretive Illustration from a Lesson on Lightning Formation.



Lightning results from the difference in electrical charges between cloud and ground.

Adapted from Harp and Mayer, 1998.

In contrast, in other research using the same lesson content, Mayer (2009) found that visuals such as the one shown in Figure 4.2 actually depressed learning! Individuals who studied lessons that *omitted these extraneous visuals* learned much more. In six different experiments, lessons *without extraneous visuals* resulted in a median effect size improvement of 1.66, which is very high. Together these experiments show us that visuals are a powerful instructional method and their effects can be huge—for better or for worse!

GRAPHICS AND LEARNING

The reasons for the different effects of lesson graphics lie in how they interact with the brain. In order to use visuals to improve learning and performance, you need to select and design them based on how they help or hinder psychological learning

Figure 4.2. An Extraneous Illustration from a Lesson on Lightning Formation.

Metal airplanes conduct lightning very well, but they sustain little damage because the bolt passes right through.

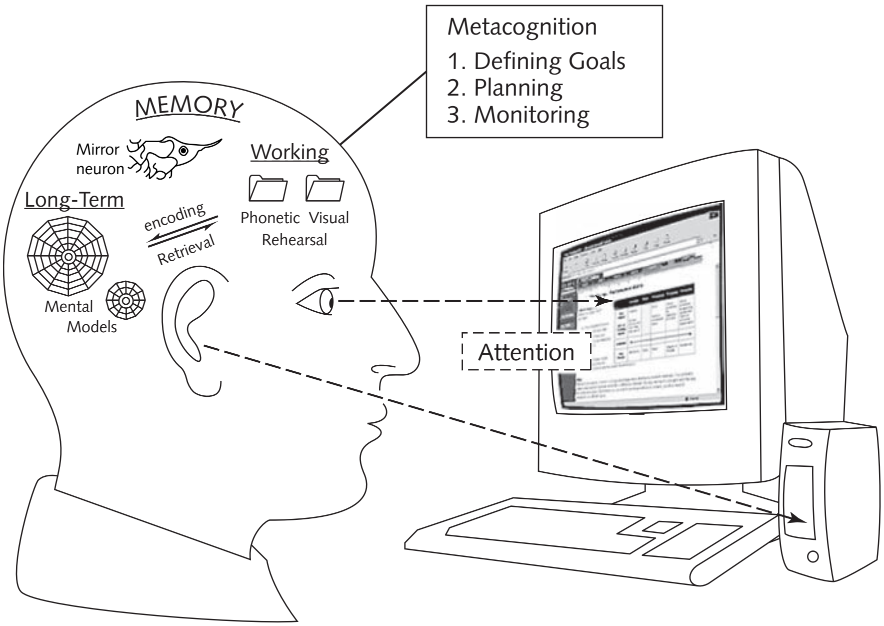
Adapted from Harp and Mayer, 1998.

processes. In this chapter we will overview the major processes involved in human learning and summarize the most recent ideas on how visuals can improve processing of information. In the chapters that follow this one, we describe and illustrate how best to use visuals to support each psychological event overviewed here.

A TALE OF TWO MEMORIES

When planning any training event, you will need to consider the two complementary memory systems illustrated in Figure 4.3—working memory (WM) and long-term memory (LTM). These memory systems have quite different characteristics regarding: (1) their capacities, (2) longevity of stored information, and (3) abilities to process information. First, working memory has a very limited capacity for information, whereas long-term memory contains a vast repository of stored knowledge. The expression "7 +/− 2" refers to the limited number of "chunks"

Figure 4.3. Human Learning Processes.

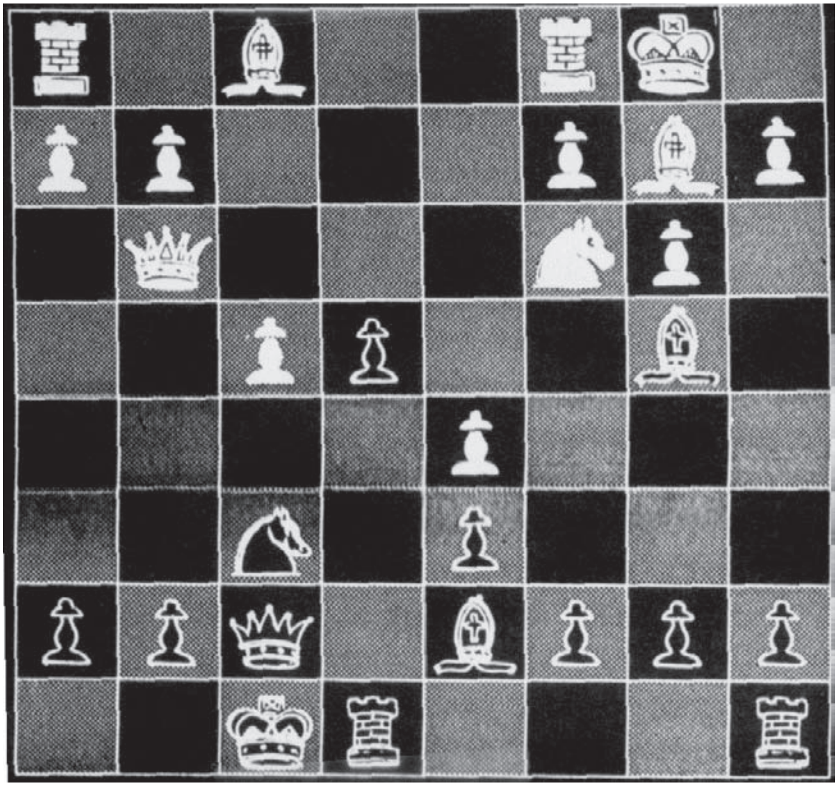


of information that working memory can hold at one time. Second, while information entering working memory will have a short shelf life unless kept active, knowledge in long-term memory lasts indefinitely. Thus the storage capacity of working memory is very limited both in size and duration of information compared to long-term memory. However, it is in working memory that active mental work, including learning, takes place. Working memory is the site of conscious thought and processing, while long-term memory is a relatively inert repository of our knowledge and memories.

Long-Term Memory Influences the Capacity of Working Memory

While these memory siblings are very different, they work together in complementary ways. Although working memory can hold only a few items of information at a time, its virtual capacity is influenced by knowledge already stored in LTM. For example, look at the chess board diagrammed in Figure 4.4.

Figure 4.4. A Mid-Play Chess Board.



How many times would you need to refer back to this board in order to accurately reconstruct it from memory? A now-famous experiment compared the number of times master and novice chess players referred back to the board in order to reconstruct it accurately. Not surprisingly, novices needed to look back many more times than did master-level players. However, now the experiment gets interesting! In part two, the memories of experts and novices for board positions were tested again. But this time, the pieces were placed *randomly on the board.* How would a meaningless board affect memory of the experts and the novices? Unexpectedly, the experts now actually required more times to review the board than did the novices! The novices needed about the same number of referrals back to the random board that they needed when working with the mid-play board (Chase & Simon, 1973).

The collapse of the master chess player's memory for a random board reveals the unique relationship between WM and LTM. For a novice player each chess piece represents a chunk of information no matter how it is placed on the board. An expert, however, looks at the board for familiar play patterns made up of clusters of four or five individual pieces. The expert player is estimated to have over 50,000 such mid-play patterns resident in LTM (Simon & Gilmartin, 1973). This allows the expert to handle much larger chunks in WM than novices. Therefore, the mid-play board shown in Figure 4.4 includes twenty-four chunks for a novice (one for each piece). However, that same board includes approximately nine to twelve chunks for an expert player.

In summary, the more related knowledge about a domain that is stored in LTM, the larger is the virtual capacity of WM. That's because stored knowledge in LTM supports larger chunks in WM. However, in instructional settings most students are relatively novice. Therefore, they will only be able to handle a few chunks of information at a time before they become overloaded. Since we need free working memory capacity for learning, effective instruction must minimize memory overload.

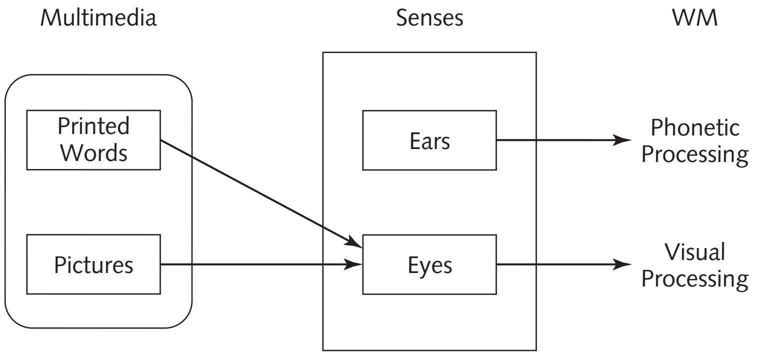
UNIQUE BRAIN STORAGE FOR VISUAL INFORMATION

For a long time, WM was assumed to be a limited capacity active processor that was more or less homogeneous. However, recent research reveals subcomponents of working memory with different roles. Two major subcomponents are illustrated in the visual and phonetic folders in Figure 4.3. One of the subcomponents stores and processes visual information, while the phonetic component stores and processes auditory information. As we will see, these subcomponents have important consequences for how to best display visuals and words for learning.

Divide Content Across the Visual and Auditory Centers

For learning purposes, we can maximize the limited resources available in WM by effectively using both the auditory and the visual subsystems. If a graphic is explained by words presented in audio, learning of complex new information is better than if the same graphic is explained by words presented in text. As shown in Figure 4.5, a graphic and the on-screen text describing it both require resources of the visual subsystem which becomes overloaded. However, if a graphic is explained by words presented in audio, then the processing load is shared between the visual and auditory subsystems. We will discuss additional techniques for use of graphics to manage mental load in Chapter 7.

Figure 4.5. Printed Words and Graphics Both Enter the Visual Processing Centers of WM.



With permission from Clark and Mayer, 2008.

The Mirror Neuron System

In the 1990s a specialized set of nerves in the brain called the *mirror neuron system* was discovered in monkeys. Using brain probes, researchers accidentally discovered that the same neurons that were activated when the monkey grasped an object were also activated when the monkey observed a human grasp an object. The mirror neuron system is the basis for observational learning. When we watch another person perform some task involving motion, for example, folding origami or performing surgery, the mirror neuron system kicks in. It records the activity and stimulates imitation.

We mentioned in Chapter 1 that animations are better than still visuals to teach motion skills but not to build conceptual understanding. The reason for this dichotomy lies in the mirror neuron system that has evolved to support learning by observation and imitation. Although animations are complex visuals that could easily overload working memory, animations that depict motor skills apparently bypass working memory by way of the mirror neuron system (van Gog, Paas, Marcus, Ayres, & Sweller, 2009). Just as you may want to use audio to describe visuals to take advantage of the visual and auditory subsystems in working memory, so might you use animations that leverage the mirror neuron system to depict procedures that involve motion.

HOW LEARNING HAPPENS

Ultimately new knowledge from the learning environment is actively integrated into existing knowledge in LTM in a way that it can readily be accessed after training when needed on the job. As illustrated in Figure 4.3, effective instructional methods, including graphics, support the following psychological learning processes.

Directing Attention

New content in the training materials must be actively attended in order to enter working memory. We have all had the experience of being in a conversation and realizing we did not hear what the speaker said. Too late we realize our attention was directed elsewhere. Attention management is important because working memory capacity is so limited that it can only actively process extremely limited amounts of information. Where you direct your attention, your working memory capacity is used and other unattended information in your internal or external environment is missed.

Because almost any visual will attract attention, it's important that you use visuals in ways that direct learners toward the instructional goals rather than distract them with unrelated themes or content. In addition, in a complex visual, you need to focus attention to the relevant parts using some type of visual signal such as color or a circle.

Awakening Appropriate Prior Knowledge

During learning, new information comes into working memory from the lesson and must be integrated into existing knowledge already in LTM. Therefore, knowledge stored in LTM that is relevant to the new content must be brought into WM where the integration takes place. Psychologists call this process "*activation of prior knowledge.*" For example, suppose you are teaching novices how to use a word processing program to edit online documents. Even computer novices will be familiar with the idea of cutting out words, copying words, and pasting them into different locations in a paper manuscript. Activating these editing concepts early in the lesson will help them acquire the new online editing skills.

An appropriate visual can help learners activate prior knowledge. Also, if learners lack relevant prior knowledge, a visual provided before the main lesson content can help to build an effective base knowledge structure. This skeleton structure provides a frame on which the learner can attach additional lesson details. Finally, a graphic that activates inappropriate prior knowledge will depress learning. For example, in Figure 4.2 we see an image and discussion of how airplanes are affected by lightning strikes. For a lesson on how lightning works, this interesting visual could activate inappropriate prior knowledge and depress learning.

Managing Mental Load

Since working memory is the site of active processing, good instructional materials must preserve its limited capacity for learning. This is especially important for novice learners who can only process small chunks of information as well as for anyone learning highly complex content. We have all had the experience of overload in courses jam-packed with lots of new and complex content presented rapidly in a lecture.

Visuals are one instructional method you can use to manage mental load. The type of graphic selected, how it is designed, and how it interfaces with other components of the instructional environment such as text all influence mental load. For example, a number of experiments show that a simpler visual such as a line drawing can often lead to better learning than a more complex 3D version.

Building Mental Models

The goal of instruction is to build mental models that improve job performance. Mental models are memory structures also called *schemas* that are stored in LTM. Mental models contain the knowledge and skills that help you make discriminations, interpret your environment, draw inferences, and solve problems. As we saw with the chess masters, experts have more mental models and their mental models are both more complex and better organized than the mental models of novices. Chess masters, for example, are estimated to have 50,000 play patterns stored in LTM. Learners build new mental models by integrating new lesson content with existing schemas activated from LTM. The integration of new content with existing mental models is called *encoding*. An effective visual is one that supports encoding of content to yield new and expanded mental models stored in LTM.

Transferring New Skills

It's not enough, however, to encode new mental models in LTM. Unless new skills can be brought back into WM when needed on the job, new mental models do little to improve work performance. Therefore, a process known as *transfer of learning* is critical. Without transfer, all the stored knowledge in the world does little good. Unfortunately, transfer failure is a common outcome of training. Learners may receive an A on a test in class but are unable to apply what they learned back on the job.

Transfer of learning relies on a psychological process called *retrieval*. During retrieval, new mental models built during training are brought back into WM to support completion of work tasks. In Chapter 9 we will see how to use visuals that promote retrieval.

Optimizing Motivation

These core cognitive processes of learning all depend on the learners' motivation. Motivation refers to any factor that encourages learners to initiate and to invest the effort needed to achieve a learning goal. One major source of motivation is interest, and developers of instructional materials often attempt to spice up technical lessons by adding dramatic but unessential vignettes to lessons. For example, an online course may use a popular movie theme in an attempt to make dry material more interesting. In Chapter 10 we will evaluate the effectiveness of these attempts at edutainment.

HOW GRAPHICS PROMOTE LEARNING

Recall that we started the chapter with summaries of some research studies in which some graphics promoted learning and different graphics depressed learning. To be effective, a visual must support any or several of the processes described in the previous section. Visuals that depress learning do so by disrupting one or more of those processes. In the following paragraphs we summarize six general principles for the use of visuals that promote learning and avoidance of graphics that disrupt cognitive processes.

1. Visuals and Text That Are Aligned with the Goals of the Instruction Improve Learning

Dual encoding, as it sounds, means two encodings of information into LTM—one that is based on words and a second one that is visual. Paivio (1990) proposed dual encoding to explain the learning benefits of adding visuals to text. According to dual encoding theory: "There are two distinct and independent but interconnected cognitive systems for processing and storing information: an imagery or nonverbal system for nonverbal information and a verbal system for linguistic information" (Vekiri, 2002, p. 266).

For example, in the lesson on lightning formation, the version that included a relevant visual representation as shown in Figure 4.1 together with a textual explanation of how lightning forms leads to two memory codes—a verbal code and a visual code. The visual is congruent with the text and both match the instructional goal. Therefore, the text and visual combine to increase the encoding opportunities and improve the probability of achieving the instructional goal.

2. Visuals That Are Misaligned with the Goals of the Instruction Depress Learning

Harp and Mayer (1997) found that visuals such as an airplane struck by lightning included in the lightning lesson to add interest depressed learning. The negative effect on learning could be caused by distraction and consequent disruption in building of a coherent mental model. Although visuals like these are added with the good intention of improving motivation, their negative effect on learning is counterproductive. Learners are better served by materials that use graphics that make the main lesson ideas more understandable than materials that add extraneous visuals for purposes of emotional interest.

3. Visuals Are More Efficient to Communicate Spatial Content

We mentioned previously that WM capacity is highly limited and the more those limited resources can be devoted to learning, the better. Often a visual can present information in a more concise way than can text. For example, if you compare the

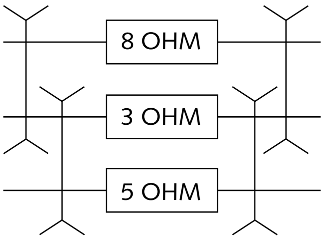
Figure 4.6. Task Directions Presented by Text and by a Graphic.

Text Format:

Using the resistors supplied, make the following connections:

- Connect one end of an 8 ohm resistor to one end of a 3 ohm resistor, and connect the other end of the 8 ohm resistor to the other end of the 3 ohm resistor
- Connect one end of the 3 ohm resistor to one end of a 5 ohm resistor, and connect the other end of the 3 ohm resistor to the other end of the 5 ohm resistor.

Diagrammatic Format:



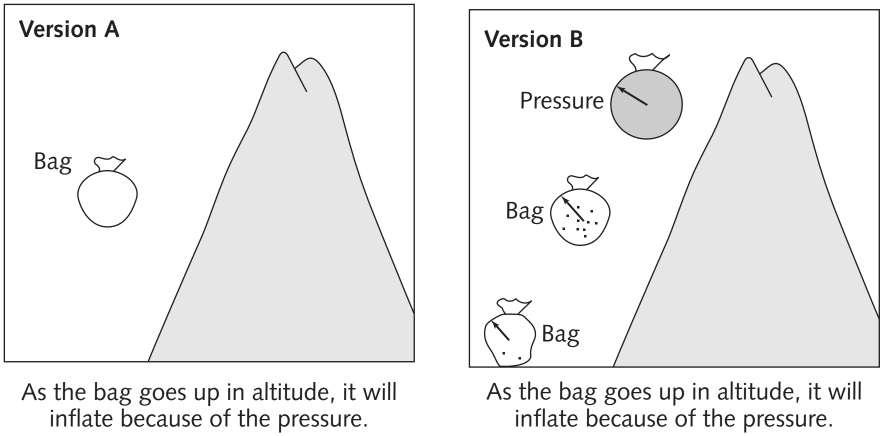
Adapted from Marcus, Cooper, and Sweller, 1996.

visual shown in Figure 4.6 with its textual equivalent, the visual communicates the same information in a more concise way. Marcus, Cooper, and Sweller (1996) compared the time needed to connect several resistors using text instructions to the time needed when using the visual. The visual representation resulted in faster performance.

4. Visuals That Depict Relationships Can Support Deeper Learning

Gyselinck and Tardieu (1999) compared two types of visuals in a science lesson on how gas pressures change at different altitudes. Representational illustrations showed the elements described in the text. For example, a mountain and a bag shown in Figure 4.7A illustrated the following text: "As the bag goes up in altitude, it will inflate because of the pressure" (p. 204). In a second version, the same text

Figure 4.7. A Representational (A) and an Interpretive Graphic (B) to Illustrate Gas Pressure.



From Gyselinck and Tardieu, 1999.

was illustrated by interpretive illustrations that included the mountain, the bag, and arrows depicting the internal and external gas pressures as shown in Figure 4.7B. This interpretive graphic illustrated both the elements described in the text and the relationship among those elements.

The research team found that recall memory was improved by both types of visuals. This may reflect the dual encoding process described above. However, the visual shown in Figure 4.7B that depicted the relationships described in the text resulted in better problem solving than the visuals that only represented elements of the text. Deeper learning will be stimulated by organizational, relational, transformational, and interpretive visuals, all of which depict relationships among lesson content. Collectively we refer to these four categories of visuals as *explanatory visuals* because they communicate relationships among content that promote building of mental models.

5. Simpler Visuals Are Often Better for Learning

We will review experiments in Chapter 7 showing that when your goal is to build understanding, a graphic with a less complex surface feature is often more effective.

For example, a line drawing can be more effective than a more realistic 3D image or photograph. Alternatively, a series of still visuals can be more effective than animations. An exception to this guideline is learning of motion skills that benefit from animated demonstrations processed by the mirror neuron system.

6. Visuals Ignored Don't Teach

None of these learning benefits would be realized if the visuals were ignored. Note in Figure 4.3 the label of *metacognition* in the top part of the visual. Metacognitive skills are the basis for your mental operating system. They manage and control all the learning processes we summarized in this chapter. Some people have better metacognitive skills than others and therefore take full advantage of graphics placed in training materials. Research has shown that learners who take additional time to carefully study visuals learn more from the lesson than those who do not (Gyselinck & Tardieu, 1999; Schnotz, Picard, & Hron, 1993). You can increase the opportunities to learn from your graphics by encouraging active engagement with them. We will describe specific ways to do so in Section Three.

THE BOTTOM LINE

Select and design visuals on the basis of their functionality as well as their surface features to maximize their potential. Based on our communication taxonomy shown in Table 1.3, graphics that depict elements of the text are representational visuals and will improve recall of content by way of dual encoding. The explanatory visuals that show relationships among the lesson concepts will improve problem solving by way of building mental models. Both types of visuals reduce load on working memory and thus improve mental efficiency. However, none of these psychological benefits will be realized unless the learner processes the visual.

COMING NEXT

Now that we have overviewed the major psychological events needed to support learning, in the following chapters we describe in greater detail how you can use graphics to promote each event. In the next chapter we begin with evidence and guidelines for ways you can use visuals and visual elements to focus learner attention.

For More Information

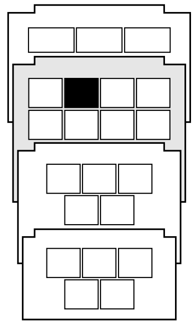
Clark, R.C. (2008) *Building expertise: Cognitive methods for learning and performance* (3rd ed.). San Francisco: Pfeiffer.

Mayer, R.E. (2011). *Applying the science of learning*. Boston: Pearson.

Mayer, R.E. (2009). *Multimedia learning* (2nd ed.). New York: Cambridge University Press. (See Chapters 4 and 12.)

Van Gog, T., Paas, F., Marcus, N., Ayres, P., & Sweller, J. (2009). The mirror neuron system and observational learning: Implications for the effectiveness of dynamic visualizations. *Educational Psychology Review*, *21*, 21–30.

CHAPTER OUTLINE



CHAPTER 5

Plan Graphics That Direct Attention

Sometimes when viewing a complex visual, it's helpful to have a visual pointer to draw the eye (and the brain) to the parts in the graphic most relevant to the instructional goal. This is especially true with dynamic visuals such as animations when learners cannot control the rate of presentation. Because working memory capacity is limited, any device that helps the learners focus on important elements of the instruction can improve their learning. In addition to focusing attention, you need to avoid split attention that imposes additional mental load. In this chapter, we present research, psychology, and examples to support the following guidelines:

- Use signaling techniques to focus attention when the visual is complex.
- Consider the use of color, contrast, and fast or slow playing speed as cues in dynamic displays.
- Use color to improve job performance in tasks that involve visual search.
- Place text close to the visuals it describes to avoid split attention.
- Avoid distracting visuals.

ATTENTION, LEARNING, AND GRAPHICS

Instructional professionals know intuitively that gaining and sustaining attention during training is a critical prerequisite to learning. Gagné (1985) lists gaining attention as the first of his nine events of learning. We saw in Chapter 4 that human working memory has a limited capacity and is easily overloaded. Attention is the process that helps learners filter out extraneous information in order to select and maintain in working memory the content that is most relevant to the learning goal.

How much emphasis should you give to training methods that support attention? The three factors you must consider are (1) complexity and pacing of the instructional materials, (2) prior knowledge of the learner, and (3) activities performed during learning such as answering questions (Clark, 2008). When studying complex materials that are externally paced (that is, play at a preset rate such as a video), learners who are new to the content need visual pointers. For example, a lesson that includes an animated illustration showing how complex equipment works benefits from visual treatments that draw the learner's eye to the important mechanical components. In contrast, when the learners are familiar with the equipment or when the animation depicts simple processes, less support for attention is needed. And when the visuals are presented as a series of still pictures that can be viewed and reviewed at the learners' own pace, even less support for attention is required.

Focused Versus Divided Attention

Consider two sides of the attentional coin when designing instructional materials: *focused* (referred to as *selective attention* by psychologists) and *divided* (referred to as *split attention* by psychologists). Use visual treatments that focus attention to important elements of a display and avoid visual treatments that split or divide attention.

Focused attention is at work when you are concentrating on one aspect of a busy visual display such as a circled icon on a screen capture. In contrast, divided attention refers to multi-tasking and is at work when you split your mental capacity among several activities at once. In the classroom, attention can be divided when an instructor is presenting a lesson and at the same time passing around samples of items discussed in the lesson. Learners are simultaneously trying to listen to the instructor, examine the sample, and pass it on to the next classmate. During these activities, distracted learners will lose track of the instructor's message. Because working memory is limited, split attention during learning drains resources from the main task and should be minimized.

In this chapter we describe techniques for using graphics and graphic design techniques to focus attention and to avoid divided attention.

Graphics and Focused Attention

Humans are good at selectively attending to specific aspects of the environment. When directed to focus on something, most people can ignore distractions and attend to that thing. Some common focusing techniques in instruction include: incorporating questions into the lesson, adding learning objectives that focus learners on intended outcomes, and using signals and visual organizers in instructional materials (Clark, 2008). Of these three techniques, the use of signals and visual organizers is most relevant to our discussion. Our first four guidelines focus on evidence-based techniques to focus attention.

GUIDELINE 1: USE SIGNALS TO FOCUS ATTENTION

A signal is any technique used to make important elements of the training materials stand out from other elements without adding or changing the content of the materials. Commonly used signals include topic headings, typographic cues such as font, type size, treatment (italics, bold, color, underlined, etc.), white space (indents, bullets, etc.), grouping by proximity or color, and attention-directing graphic elements such as arrows, icons, shading, and animation.

Research shows that, when learning from print materials, signals such as text headers improve learning when the text structure is complex. In contrast, signals have little effect on learning of simple texts (Lorch & Lorch, 1996). Indeed, support for attention is not needed for simple texts. Likewise, signals used to draw attention to visual elements are most helpful in relatively complex content graphics. Animations are good candidates for signals. Animations typically incorporate a great deal of dynamic visual information that imposes mental load in two ways. First the information is transient. To build a coherent understanding, memory must integrate the current state of an animation with previous states just viewed. Also, animations often include many visuals that play at a rate outside of the viewers' control. However, when learners pace themselves through materials where graphics are explained with text, signals are less important. When studying a series of still graphics, the learners can take their time to review and study each visual. Therefore, dynamic visual representations such as video or animations are in greatest need of visual cues.

For example, in Figure 5.1 a discussion of screen real estate presented in print media uses a graphic that can be studied as long as desired. However, in an online

Figure 5.1. A Print Version of a Lesson on Use of Screen Real Estate.

Screen Real Estate Locations

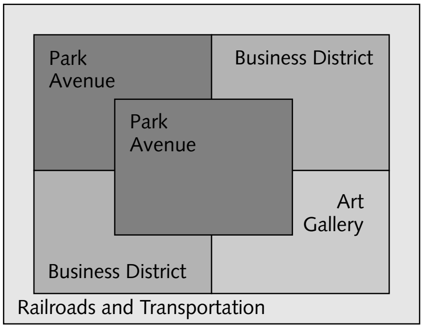
There are many factors that influence where best to put an element, including the relationship among elements on a display. However, in general, remember:

Park Avenue Emphasizes anything places there.

Business District Neither emphasizes or de-emphasizes.

Art Gallery Reduces the emphasis

Railroads Diminishes, making almost completely unobtrusive.



To take advantage of the intrinsic impact that different areas of the screen display have on your instructional content, consider the following guidelines.

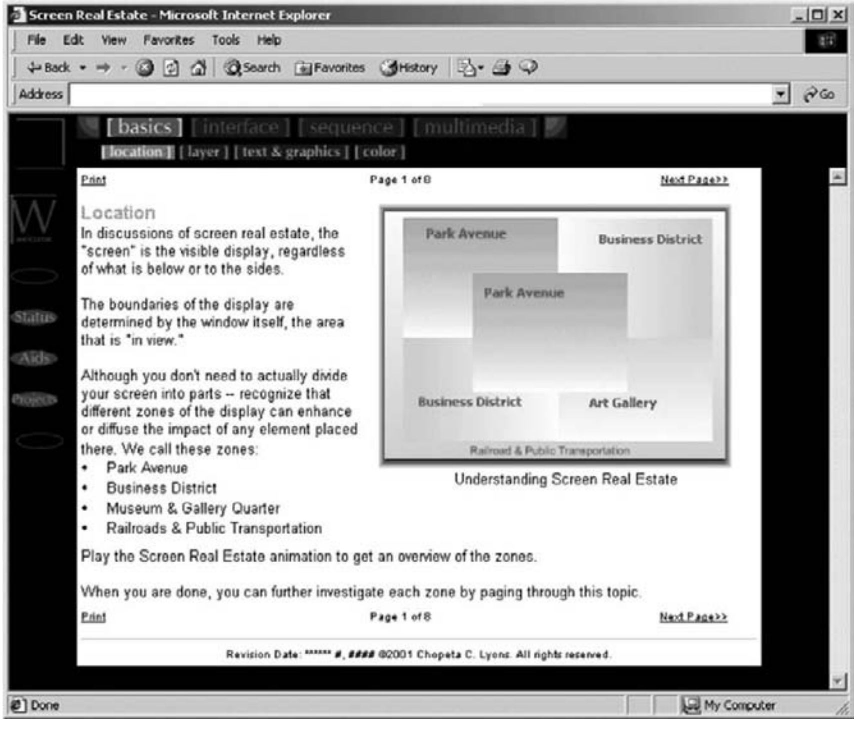
Put this type of content…	…in this screen location
Plain text, "dull" graphics, or other elements that are the key focus of the display	Park Avenue
Striking graphics that are not the sole focal point of the instruction and that visually overwhelm other elements on the screen	Art Gallery
Instruction text or important graphics that need no "diluting" or enhancing	Business District
Elements that need to be ever present, but not visually intrusive such as tools, applications, progress indicators, bread crumbs, or titles that help learners know where they are	Railroads and Transportation

With permission of C. Lyons.

version of the same material shown in Figure 5.2, an animation, which illustrates the points made in the text and can be played at any time, adds each screen locale while the narrator explains it. This overlay technique minimizes the amount of visual search the learner must use. With any online animation, it's a good idea to provide "pause" and "replay" buttons so that the learner can review the animation, just as a reader can study a print graphic.

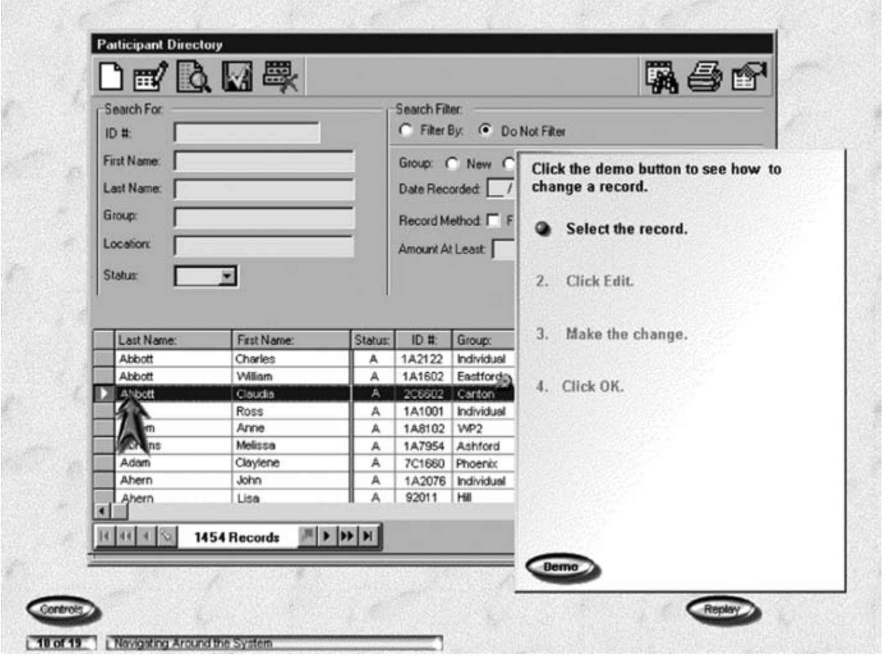
The multimedia course represented in Figure 5.3 provides an animation of a software procedure used to select a client's record. Notice on the example posted on the website that the demonstration begins with a grayed out list of the procedural steps. Once the learner clicks the demo button, each step is highlighted and

Figure 5.2. An Online Version of a Lesson on Use of Screen Real Estate.



With permission of C. Lyons.

Figure 5.3. A Screen from an Online Animated Sequence.



Source: Mark A. Palmer.

a cueing arrow points to the action on the screen. Again, although the animation itself is externally controlled, the learner can replay the demo as many times as needed in order to study the steps.

Research on Graphic Signals

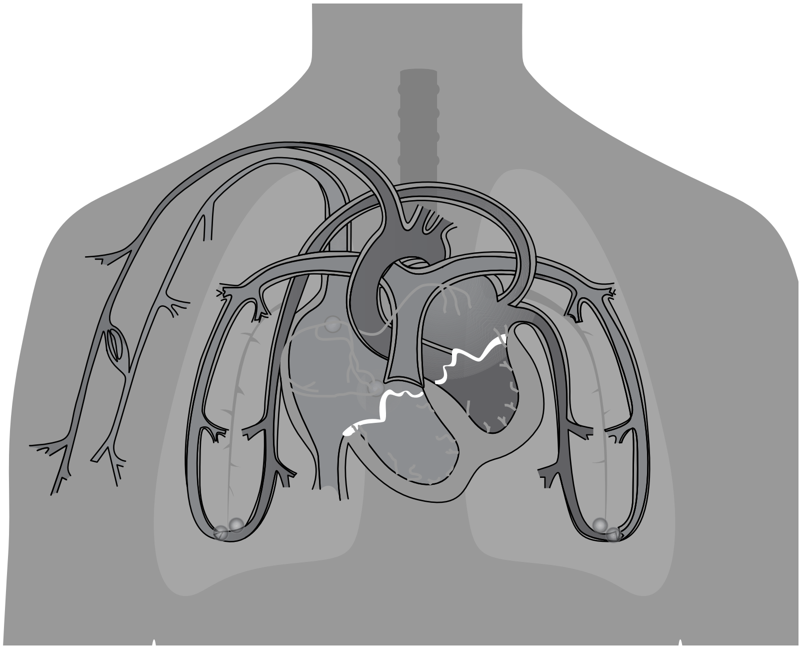
Jeung and his colleagues (1997) found that learning to solve geometry problems that included complex diagrams in a computer-delivered course was better when audio was used to describe the diagrams rather than on-screen text. However, this benefit was only realized when a visual cue helped draw the eye to the parts of the diagram being explained. The authors conclude that "if visual search is likely to be high, then the inclusion of visual indicators such as flashing, color changes, or simple animation is essential for audiovisual instruction to be an effective instructional technique" (p. 352). The research team reported, however, when a graphic was simple and did not require much visual search, signaling did not benefit learning.

Research on Signals in Animations

Recent experiments indicate that the kinds of signals that are effective for still visuals may not work as well for animations (DeKoning, Tabbers, Rikers, & Paas, 2009). After all, an animation is a moving illustration and all movement is inherently attention-demanding. Adding additional visual elements such as arrows may actually be more confusing than helpful. Because arrows are often used to indicate movement in still visuals, using them as a signaling device may confuse learners. DeKoning and his colleagues (2009) summarize thirteen research studies that compared learning from animations with and without signals. Various types of signals were used in different experiments, including brightness contrast (spotlight cue), arrows, and color signals. Only half of the studies revealed a positive effect of signals on learning. The diversity in results may reflect differences in how animations were implemented, such as whether the animations were narrated or "stand-alone," differences in the intensity and types of signals used, such as color or arrows, and differences in learner control over pacing of the animation (learner-paced or played without controls). We will need more research to pinpoint the types of signals that work best as well as the conditions under which to use them.

As an example on one experiment of signals in animations, DeKoning, Tabbers, Rikers, and Paas (2007) evaluated learning from a sixty-second animation that could not be stopped or replayed and did not include words. The animation illustrated five processes involved in the cardiovascular system: the circulatory system, the electrical system, the pulmonary circulation, the systemic circulation, and the valves system. The signaled version shown in Figure 5.4 used a "spotlight" effect in which all elements of the animation were darkened except the valves of the heart. The comparison animation was identical but lacked the spotlight cueing. Learners were tested on all five of the cardiovascular processes. Learning not only of the valves process but of all the other processes was better from the cued animation than the uncued animation with a moderate effect size of around .70. The research team acknowledges the benefits of signaling in this experiment but adds that "it is not clear whether the present results would also apply to animations that are longer, involve narrations, contain more than one cued process, and are played at different speeds"(p. 751).

Figure 5.4. A Signaled Animation of the Cardiovascular System Improved Learning.



From DeKoning, Tabbers, Rikers, and Paas, 2007.

GUIDELINE 2: USE COLOR AND CONTRAST TO FOCUS ATTENTION

In Figure 5.3 the cueing arrow is red. Does color help draw attention? Color has been reported in some studies to direct attention to important information in a lesson. Levie (1973) concluded that color can facilitate learning when it focuses attention on cues that might otherwise not be noticed. As described above, only certain learning conditions—such as complex content graphics presented to learners new to the content—require attention support. In some research studies, lessons with color did not lead to any better learning than lessons in black and white. These research studies used color to direct attention in situations where attention support was unnecessary. Remember that signaling will be most beneficial in situations involving (1) high visual complexity, (2) content presented rapidly and out of learner control, and (3) novice learners.

Color Signals in Animations

Color may have unique value as cues in animations. DeKoning, Tabbers, Rikers, and Paas (2009) and Boucheix and Lowe (2010) suggest that use of colors that synchronize with specific events in the animation might effectively draw attention as a result of a combination of spatial and temporal cues. In other words, a color that spreads in conjunction with particular stages in an animation might be especially effective. In contrast, some types of signals, such as arrows that work well in static visuals, may actually interfere with learning in animations. Boucheix and Lowe (2010) compared learning and eye fixations from three versions of an animation illustrating the mechanics of a piano. The "lesson" was visual only, as the animation had no accompanying words. One version had no signals, a second version used arrows that appeared successively as each mechanical part moved, and a third version used a spreading color cue in which a line of red or blue flowed through the parts. You can contrast the arrows and the color treatments in Figures 5.5 and 5.6

Individuals who studied the version with the spreading color cue showed better comprehension of how the piano worked and made more eye fixations in areas of the diagram that were relevant to understanding but were not as visually

Figure 5.5. Arrows That Appeared Sequentially Were Used to Cue Moving Parts in a Piano.

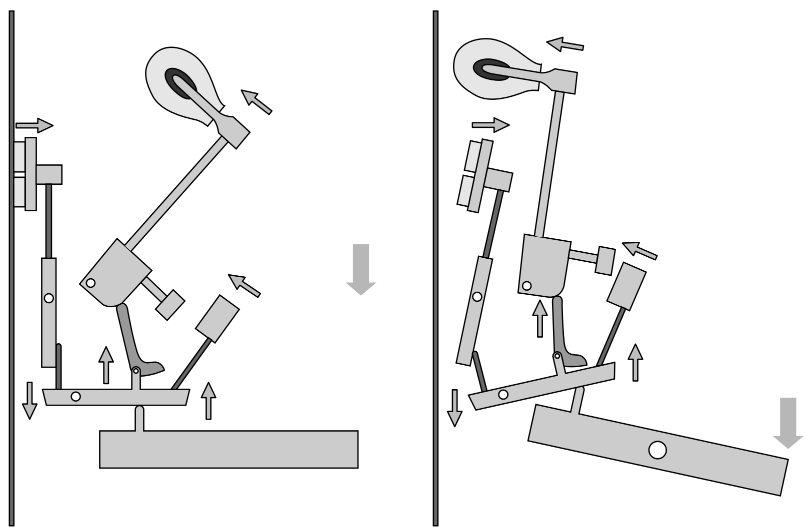
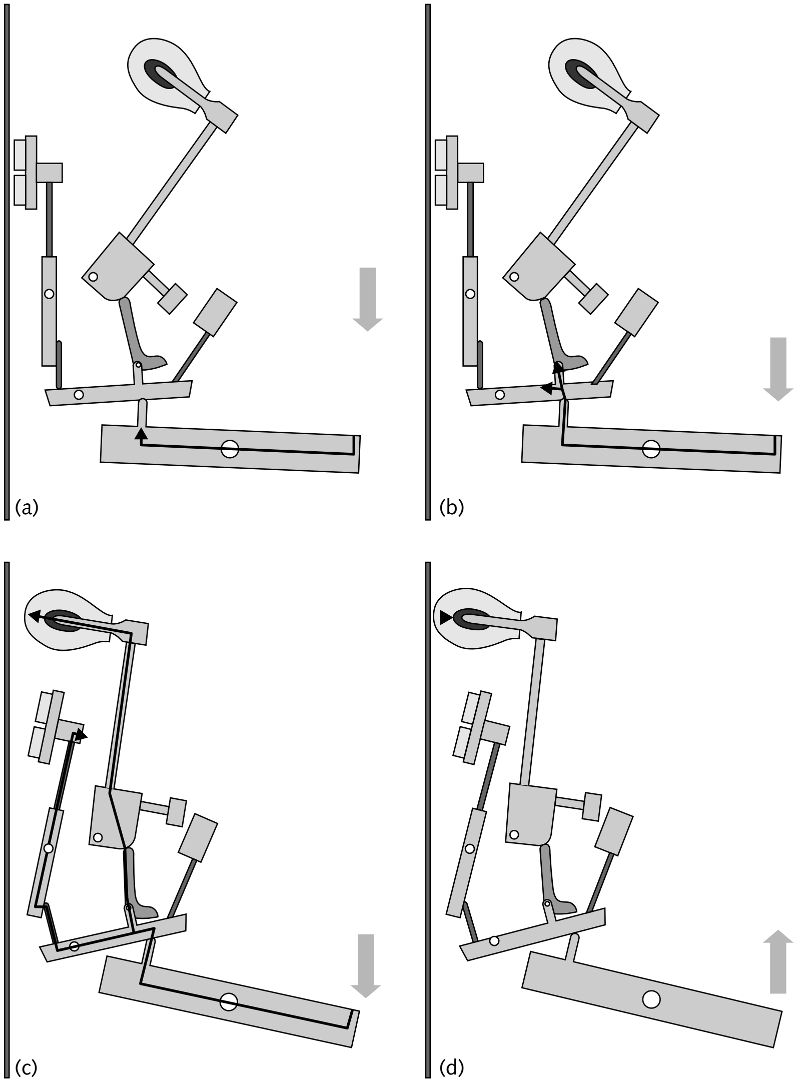


Figure 5.6. Moving Lines of Color (Red and Blue) Were Used to Cue Moving Parts in a Piano.



From Boucheix and Lowe, 2010.

prominent. This experiment and the spotlight effect discussed in the preceding paragraphs suggest the use of contrast and color may be especially applicable for cueing attention in complex animations. Depending on the graphics in the animation, a fine balance lies between the intensity of techniques (shapes, color, movement, proximity) that serve as effective signals or that become distractions.

Obviously, colors that contrast are more useful for drawing attention than neutral or bland colors. For this reason, signaling colors are often highly saturated colors in the red and yellow families. However, the key to effective cues is contrast, so a background of reds might require a black cue arrow. Or if the animation graphic is in neutral tones, a highly saturated color might be too intense and distract. Where color is not an option, other techniques for contrast such as outlining, layering (drop shadows), spotlighting as shown in Figure 5.4, or bold shapes help the signaled elements stand out and catch the learners' attention.

GUIDELINE 3: USE MOTION CUES IN ANIMATIONS

A unique feature of dynamic visuals is the opportunity to play the animation at speeds that are much slower or faster than "real time." In this way, attention can be focused to elements of an event that would not be otherwise perceptually salient. For example, time-lapse photography can illustrate processes such as seed germination or embryonic growth that require hours or days in the natural world. Likewise, slowing down a process can illustrate components that proceed too quickly to be noticed. Fischer and Schwan (in press) found that a fast-speed animation of the components of a pendulum clock drew attention to the clock's weight, which in real time moves too slowly to be noticed. A fast-speed animation resulted in better understanding of the operations of the clock compared to a normal play speed.

GUIDELINE 4: USE COLOR TO IMPROVE JOB PERFORMANCE

Color can be an effective signal in search tasks requiring people to identify information in complex visual displays (Pett & Wilson, 1996). For example, most of us have benefited from the color coding of subway diagrams that are reinforced by color names such as "the green line" and "the yellow line." Other examples are found in color-coded circuit diagrams and troubleshooting guides.

Pett and Wilson (1996) conclude that color is of value when it "emphasizes relevant cues, is used as a coding device, or when it is part of the content to be learned" (p. 27). Therefore, the extra expense of color in print media used for instruction is warranted when it's necessary to (1) draw attention to important elements in complex visual displays, (2) distinguish different elements in a display, or (3) display a representational graphic of an object in which color is a defining feature such as a resistor with colored bands. Additionally, color is useful in performance situations such as the need to interpret a circuit diagram to help workers quickly locate information.

GRAPHICS AND DIVIDED ATTENTION

Recent research on attention lapses when using mobile devices while driving, reinforce the limited capacity of working memory for multiple tasks. While humans are good at focusing attention in the midst of distractions, our capability to attend simultaneously to multiple information sources is limited. Two factors predict a learner's success at multitasking: the modality of the content and the learner's experience. Regarding modality, it is nearly impossible to process two different messages when each one is read simultaneously into a different ear. In contrast, if one message is delivered to the ears and a different message to the eyes, you have greater capability to attend to both. We saw in Chapter 4 that working memory has separate areas for storing and processing visual and auditory information. Therefore, attention can more readily be divided between visual and auditory content.

The second factor that predicts a learner's success at multitasking is the individual's experience with that task. If you are performing a familiar task that is automatic, you can simultaneously perform a secondary task. An automatic task is one that has been performed so many times that it is "hard-wired" into long-term memory and requires no working memory resource. Because the mechanics of automobile driving are automated, we are often lulled into an overestimate of our brain's capacity while driving. As we write this book, there is significant discussion about universal laws banning the use of mobile devices while driving. There are plenty of accidents that stem from these kinds of distractions as well as controlled research demonstrating the distracting effects of cell phone use while driving (Strayer, Crouch, & Drews, 2006).

When designing instructional materials, direct as much of the learners' mental resource as possible to the skills to be learned and avoid distractions that divide the learners' attention. Two ways to avoid divided attention are to integrate text with visual displays and to minimize visual distractions in the learning environment. Guidelines 5 and 6 to follow focus on techniques to minimize divided attention.

GUIDELINE 5: PLACE TEXT CLOSE TO THE VISUAL IT DESCRIBES

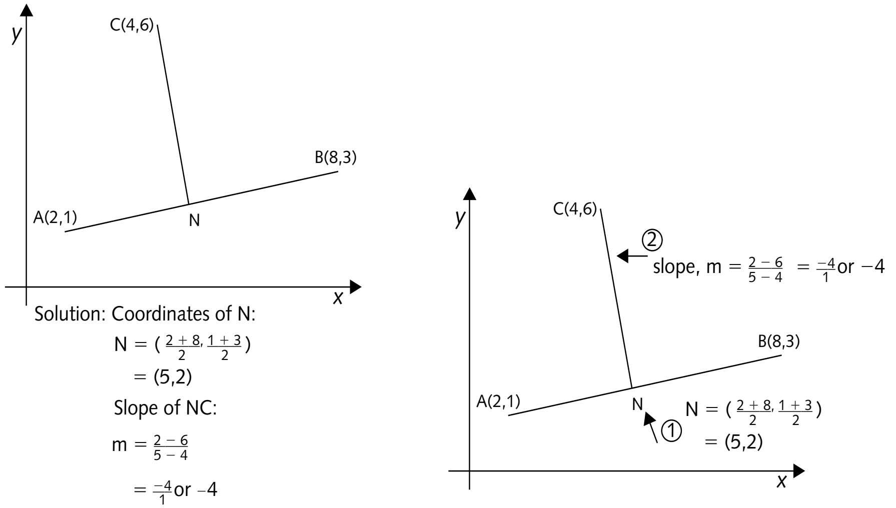
Have you ever been reading a book and find a critical visual located on the back of the page containing the text that describes the visual? To understand the content you need to flip back and forth between the text and the visual. How do you feel? Probably annoyed. That annoyance is your working memory complaining about the extra work required to hold the text in memory while viewing the visual. Split visuals and words have been shown to depress learning compared to integrated pictures and words (Clark & Mayer, 2008: Sweller, van Merrienboer, & Paas, 1990). The *contiguity* principle is based on this research and recommends that related content be placed on pages or screens in an integrated fashion. Think of the concept of contiguity as in *Mexico and the United States are contiguous countries.*

Research on Contiguity

Sweller and his colleagues (1990) compared learning from two versions of a geometry lesson that included graphics. One version (contiguous) integrated the text into the graphic, while the other displayed the text separate from the visual, as shown in Figure 5.7. The integrated (contiguous) version (on the right side) places related text into the diagram, while the traditional version (on the left side) places the related text underneath the diagram. The traditional version caused divided attention and resulted in poorer learning. The learner must use limited working memory resources to look at the diagram, then look at the text, and finally mentally integrate them. In contrast, the integrated version eliminates this extra mental work so that all working memory resources can be devoted to learning.

Similar results were reported by Mayer (2009) for lessons presented on paper and in multimedia. In five different experiments involving lessons on lightning

Figure 5.7. A Separated and Contiguous Placement of Text.



Text Is Separate from Diagram

Text Is Integrated into Diagram

From Sweller, Chandler, Tierney, and Cooper, 1990.

formation and how cars' braking systems work, learners received materials that either applied or violated the contiguity principle. Although both groups were exposed to identical text and illustrations, in five out of five studies, the integrated materials yielded better learning. The median effect size for these studies is 1.12—a high degree of practical payoff.

Eye tracking of individuals reviewing print pages with visuals separate from (Figure 5.8, Version A) and integrated into (Figure 5.8, Version B) the text illustrates the differences in attention allocation during reading (Holsanova, Holmberg, & Holmqvist, 2009). In 5.8, Version A, most readers direct their attention to the graphics immediately after reviewing the headline. They treat the visuals and text as two independent units of information. In contrast, in the integrated text and visual version, readers review the visuals and the text together.

Altogether, the various research studies provide consistent and ample evidence that instructors can improve learning by minimizing split attention between text and graphics during learning. The learning benefits of integrated text and visuals are most pronounced when (1) learners are novice to the materials, (2) the

Figure 5.8. Eye-Tracking Data Shows Different Patterns of Attention Allocation.

With permission from Holsanova, Holmberg, and Holmqvist, 2009.

diagram is not meaningful on its own, and (3) the content is complex (Ayres & Sweller, 2005).

Applying the Contiguity Principle

Apply the contiguity principle to graphics presented in print, on slides, and in multimedia. In print, it is best to place words close to the graphics they describe. In a book with many graphics such as this one, it is often impossible to efficiently place all the visuals near the text they describe. To apply the contiguity principle in print documents, consider using a two-column format shown in Figure 5.9. This layout allows explanatory text to run along the side the graphic. Another technique is to use callouts to label and explain components of the graphic.

In online applications, the contiguity principle is frequently violated by paging conventions where the text explaining a graphic is carried over to a second “page” or by inappropriate use of scrolling screens. Text that appears above or

Figure 5.9. A Two-Column Layout in Print.

Color Combinations

A woman who wears green to make her eyes more blue knows that colors are not absolute.

Colors change depending on the hues next to which they are placed. For example, in Figure 3.1. the two beige squares are the same size and hue.

Yet, the square on the purple background appears more tan than the square against the yellow background. The "color" of an object depends on the other colors surrounding it.

Also, color combinations can affect the appearance of the shape of the object These two squares are exactly the same size and hue. Still, the square on the purple background appears larger and closer.

The square on the yellow background appears slightly smaller and receded.

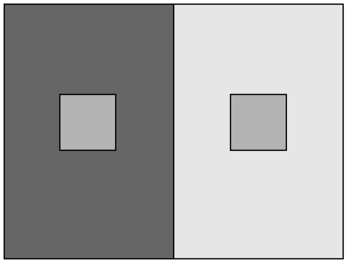


Figure 3.1. Josef Albers Color Contrast.

As you design graphics, consider your color selections in relation to the entire design, not in isolation.

- Use colors combinations with high contrast to separate items that need to be considered uniquely, as on a different layer or as part of different theme.
- Use color families and color combinations with little contrast to visually link separate items on the same layer or to join items thematically.

below a visual that it describes violates this principle when the components cannot be viewed together and the learner must scroll up and down to see both. There are a number of ways to resolve this problem. In Figure 5.3, the explanatory text is placed in a drop-shadowed rectangle distinguishable from the screen capture graphic being discussed. Figure 5.10 places text next to a reduced graphic on a scrolling screen. You can also use rollovers or pop-ups in which text callouts appear when the user clicks on or mouses over various parts of the graphic. Another approach is to use a series of fixed screens rather than scrolling screens such as shown in Figure 5.3. In this approach, the learner sees a series of pages, each with the relevant portion of the graphic highlighted (or even enlarged) with the pertinent explanatory text. Finally, Figure 5.11 shows how, just as with print, a

Figure 5.10. A Scrolling Screen Integrates Visuals and Text with Reduced Graphics.

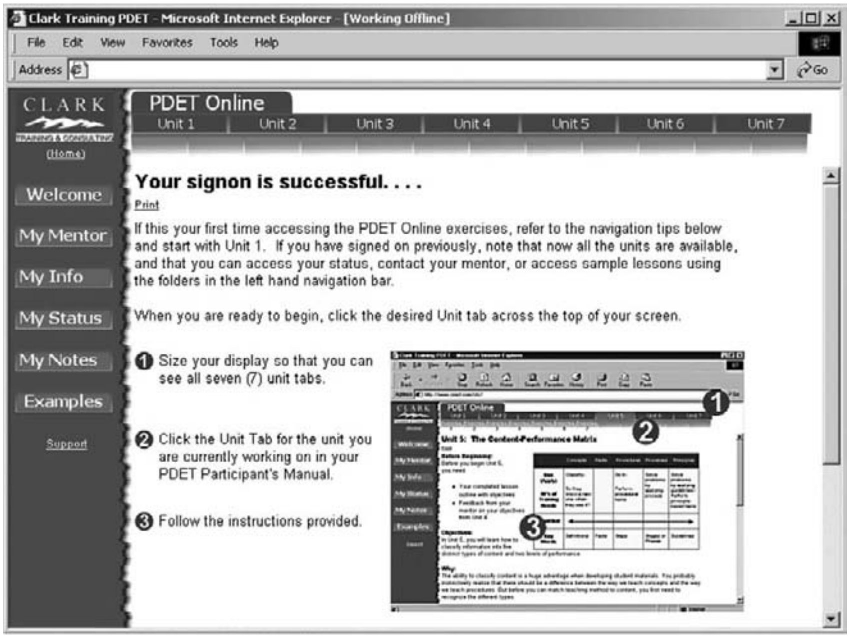
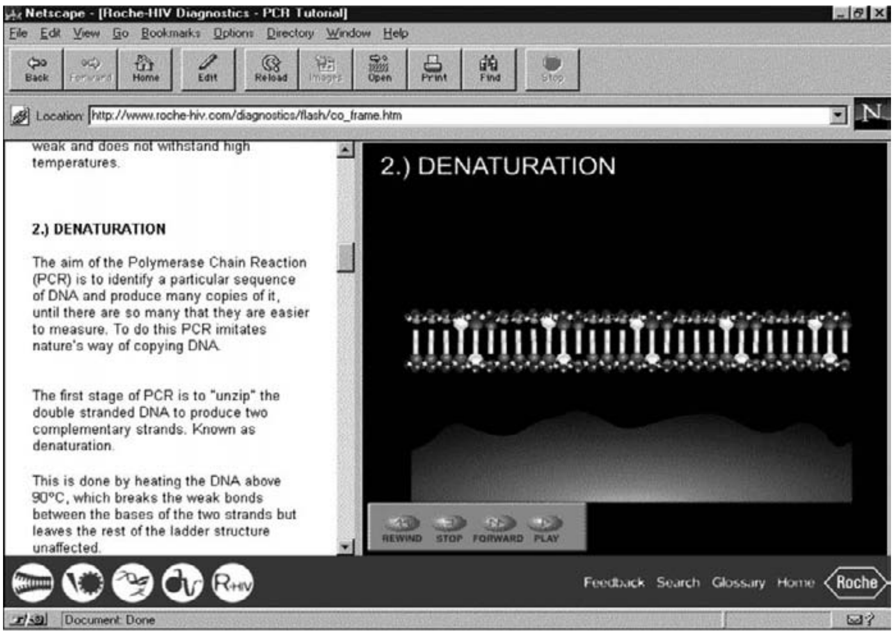


Figure 5.11. Two Vertical Frames Used in an Online Course to Integrate Text with Graphics.



Used with permission from Roche Pharmaceuticals.

"side-by-side" approach, or two-frame format, supports simultaneous viewing of visual and adjacent explanatory text. Because the text scrolls, the learner can see the graphic while reading all the relevant text.

GUIDELINE 6: AVOID DISTRACTING VISUALS

Research shows that all of the visual categories listed in our communication taxonomy (Table 1.3) promote learning except for decorative graphics. While decorative visuals can be appropriate to add aesthetic and marketing value to a lesson, we recommend that you use them sparingly since they can divide attention and create undesirable and often unanticipated psychological associations that we will discuss in the next chapter.

Animations are one popular source of distraction. The MTV influence often drives designers to misuse animation. Consider a flashy animation for a fairly simple process. In the name of art, the animation swaps graphics in and out, streamlines movement indicators by eliminating their explanatory labels, and backs up the narrator's voice-over explanation with throbbing high-tech music. Chances are the learners will enjoy the animation immensely, but not be able to answer the most basic questions about the simple process the animation describes.

THE BOTTOM LINE

In this chapter we presented research and examples that recommend the use of typographic signals such as font, type size, treatment (italics, bold, color, underlined, etc.), white space (indents, bullets, etc.), as well as attention-directing visual cues such as arrows, shading, and color. We summarized recent research indicating that some cues such as arrows that work well in static visuals may not be as effective in animations. Animations offer unique opportunities to focus attention, including spreading color and changes in playing speed. Use these signals to focus attention to important elements of complex content. Signals are especially important when complex content is explained with audio narration and thus is presented under instructional, not learner, control of pacing. We also summarized ways to minimize divided attention, including placing text near visuals and minimizing distracting visuals and visual effects such as animations.

COMING NEXT

Learning requires an integration of new information into prior knowledge stored in long-term memory. Therefore, activation of prior knowledge is a critical event of learning that must be supported early in the lesson. The existing prior knowledge in long-term memory must be "brought into" working memory, which is where the integration takes place. Graphics can help activate prior knowledge. In some situations learners will lack much in the way of relevant prior knowledge. In those cases, the instruction can provide a high-level overview of the content to serve as a framework for attaching the new content details in the lesson. Graphic overviews can often be useful to provide this framework.

For More Information

Ayres, P., & Sweller, J. (2005). The split attention principle in multimedia learning. In R.E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 135–156). New York: Cambridge University Press.

DeKoning, B.B., Tabbers, H.K., Rikers, R.M.J.P., & Paas, F. (2009). Towards a framework for attention cueing in instructional animations: Guidelines for research and design. *Educational Psychological Review, 21*, 113–150.

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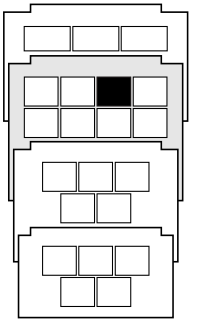
CHAPTER OUTLINE



Prior Knowledge, Learning, and Graphics

Activating or Building Relevant Prior Knowledge

Instructional Methods and Prior Knowledge

What Are Advance Organizers?

Comparative vs. Expository Organizers

Guideline 1: Use Comparative Advance Organizers

Guideline 2: Use Expository Advance Organizers

Guideline 3: Avoid Seductive Details in Lesson Introductions

What Are Seductive Visuals?

Liking vs. Learning

CHAPTER 6

Plan Graphics That Leverage Prior Knowledge

Learning requires integration. Content from the instructional environment must integrate with related knowledge stored in long-term memory. The result is an expanded or more accurate mental model. For this integration to occur, relevant prior knowledge must transfer from long-term memory into working memory. This process is called *activation of prior knowledge.* Activation of relevant prior knowledge is an essential instructional event that must occur early in the learning cycle.

In some situations, learners lack relevant prior knowledge. In these cases a high-level overview of the lesson content improves learning by providing a structure on which to "hang" new content.

Some attempts to gain learner attention and interest by adding extraneous dramatic visuals or stories actually depress learning because they both distract learners and activate irrelevant prior knowledge. In this chapter we present research, psychology, and examples to support the following guidelines:

- Use concrete graphics to activate relevant prior knowledge.
- Use visual summaries of lesson content to supplement relevant prior knowledge.
- Avoid starting a lesson with a dramatic but extraneous visual that will activate inappropriate prior knowledge.

PRIOR KNOWLEDGE, LEARNING, AND GRAPHICS

The well-known learning psychologist Robert Gagné (1985) proposed several key events of learning. Event number three is *activate prior knowledge.* Since then, research continues to support the benefits of activating prior knowledge as a prerequisite to learning. As described in Chapter 4, learning requires the integration of new lesson content with prior knowledge already stored in long-term memory. This integration occurs in working memory. Therefore, relevant prior knowledge must be activated or retrieved from long-term memory to make it available in working memory for learning. For successful integration, relevant prior knowledge must be brought into working memory before the meat of the lesson is delivered.

Activating or Building Relevant Prior Knowledge

In many situations learners will have relevant prior knowledge stored in long-term memory as a result of their job experience or of their previous learning. For these learners, schedule some introductory activity that will engage or activate that knowledge. However, in other circumstances, your learners may have minimal prior knowledge relevant to the new knowledge and skills of the lesson. In these situations, you need to build a knowledge base appropriate to the new lesson content. In either case, you need to avoid introductory content that activates prior knowledge that is not related to the instructional goal. Research we will discuss demonstrates the damaging effects of irrelevant visuals that activate inappropriate prior knowledge.

Instructional Methods and Prior Knowledge

Clark (2008) has recently summarized a variety of instructional methods that are effective because they either activate or build prior knowledge. These include starting a lesson with a group discussion of a relevant problem, answering questions prior to learning new content, and designing an advance organizer. Because in this chapter we focus on how graphics can be used to activate or build relevant prior knowledge, we look at advance organizers that incorporate visuals.

WHAT ARE ADVANCE ORGANIZERS?

If you have ever tried a blindfolded trust walk, you know how unsettling it feels to be moving but not know where you are going! We can avoid making our materials instructional trust walks by using advance organizers. *Advance* *organizers* were defined by Ausubel in 1968 as instructional presentations appearing early in a lesson that "provide ideational scaffolding for the stable incorporation and retention of more detailed and differentiated material that follows" (p. 148). In everyday language, the advance organizer presents a bird's eye view of the key ideas to be presented in detail in the lesson. For example, in Chapter 4 we used an interpretive graphic, shown in Figure 4.3. as an overview of human psychological learning processes.

Comparative vs. Expository Organizers

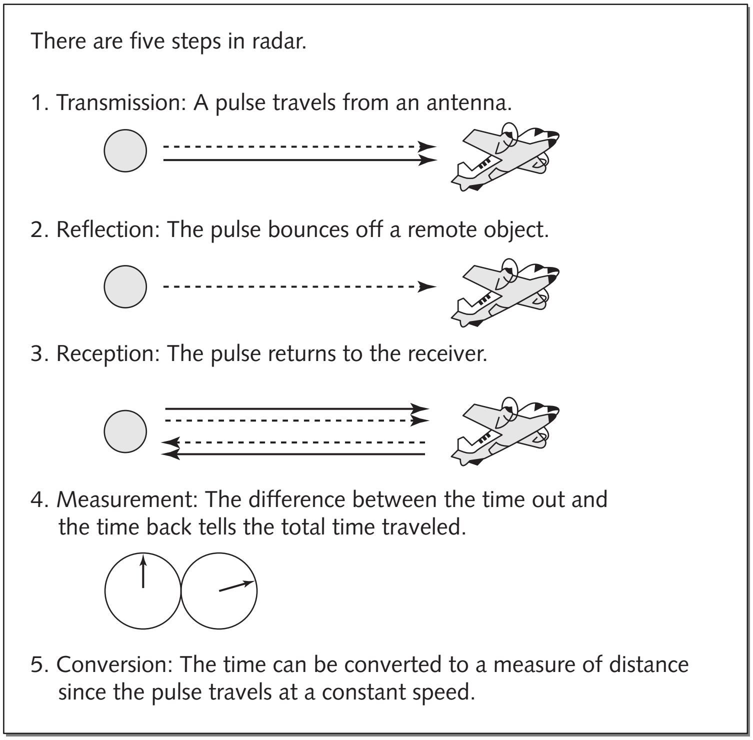
There are two types of organizers you can use, depending on the prior knowledge of your learners: comparative or expository. The *comparative organizer* is most appropriate when your learners have relevant prior knowledge in long-term memory that should be activated. The *expository organizer* is most appropriate when your learners lack relevant prior knowledge and will benefit from a knowledge supplement.

GUIDELINE 1: USE COMPARATIVE ADVANCE ORGANIZERS

For learners who do have prior knowledge related to your lesson content, use a comparative organizer. An effective comparative organizer incorporates information familiar to the learner and links that familiar information to new lesson content. In this way the comparative organizer serves as an analogy that links new content to existing prior knowledge. In a classic experiment, Ausubel provided students with a brief introductory comparison of the relationships between Christianity and Buddhism prior to a lengthy reading on Buddhism. Students who read the comparison were better able to recall more of the content about Buddhism than students who read an unrelated text (Ausubel & Youssef, 1963).

To be effective, a good organizer should be concrete—and that is where a relevant visual can help. To help learners recall and apply basic principles of how radar works, Mayer started the lesson with the diagram shown in Figure 6.1. Note that the diagram provides a high-level text and visual summary of the principle of radar using familiar concrete imagery. The image and text draw upon learners' prior familiarity with how a ball bounces off an object. In research that compared learning of groups who studied the radar lesson with and without the

Figure 6.1. A Comparative Advance Organizer.

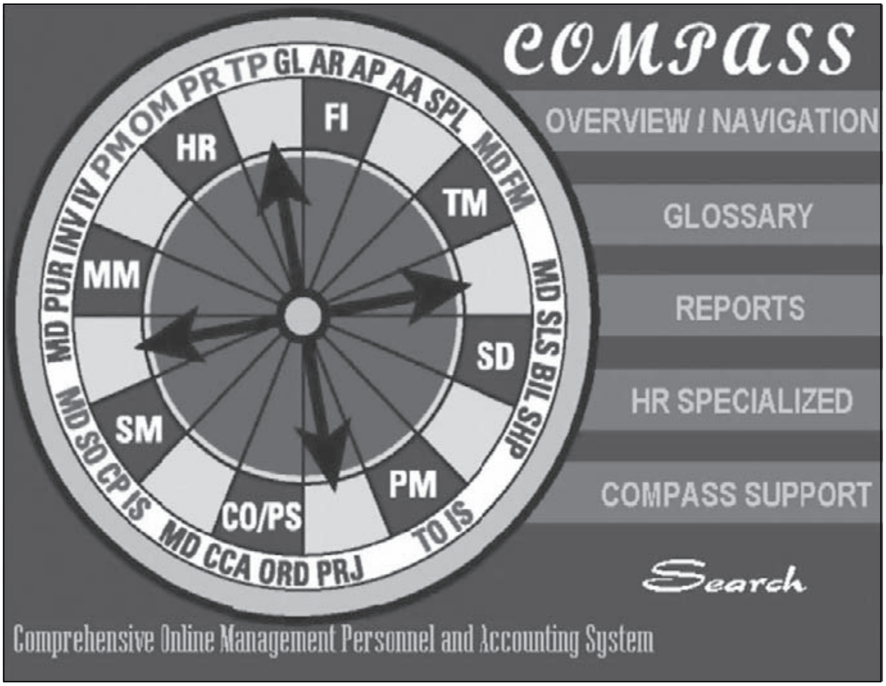


Adapted from Mayer, 1983.

diagram, the recall and application scores of the diagram group were much higher (Mayer, 1983).

The success of the comparative organizer will depend on the extent to which learners make a good connection between the familiar information such as the ball in the radar lesson and the important new content in the lesson. Kloster and Winne (1989) showed that advance organizers only promoted learning among students who successfully linked the organizer to the new content of the lesson. For example, the organizer in Figure 6.2 attempts to provide a link between a compass and the components of a new software system. However, the high

Figure 6.2. A Confusing Comparative Advance Organizer.



number of what to new users are meaningless acronyms placed around the visual renders it more confusing than helpful. In contrast, the visual organizer in Figure 6.3 uses a familiar water pressure concept to introduce the concept of electrical resistance.

Mautone and Mayer (2007) used a comparative advance organizer to help learners interpret a complex graph called a Hjulstrom curve. A Hjulstrom curve summarizes the quantitative relationships among erosion, transportation, and deposition in rivers as a function of particle size and water velocity. Prior to viewing the graph, learners in the test group were presented several slides illustrating erosion and deposition as well as showing smaller and larger particles such as silt and gravel. The goal of these slides was to help learners make connections between the relationships shown in the graph

Figure 6.3. A Helpful Comparative Advance Organizer.

In this lesson you will see that adding resistance affects current flow in the same way as stepping on a hose affects the flow of water.

Please continue.

and their own prior knowledge. Participants who viewed the organizer slides prior to the graph made 57 percent more statements that reflected a deeper understanding of the graph compared to those who viewed the graph alone.

GUIDELINE 2: USE EXPOSITORY ADVANCE ORGANIZERS

An expository organizer provides a context for learning of new lesson content. The expository organizer is best used for learners who do not have related prior knowledge and who will benefit from a bird's eye view of the content contained in the lesson. Expository organizers may be presented with both text and graphics. However, because of their ability to efficiently represent a large amount of information, a graphic either alone or accompanied by text makes a good candidate for an expository organizer.

To experience the benefits of an expository organizer, read the text following this sentence and rate your understanding of its meaning from a low of 0 to a high of 7.

> If the balloons popped, the sound would not be able to carry since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying since most buildings

> tend to be well insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course, the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. Then there would be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face-to-face contact, the least number of things could go wrong.

After completing your rating, look at Figure 6.4. Now reread the text and rate your understanding a second time. Compare your ratings with the actual experimental results shown in Table 6.1.

Bransford and Johnson (1972) read the balloon passage to three groups as follows:

- Group 1 never saw the serenade visual. You fall into this group if you did not "peek" before reading.
- Group 2 saw the serenade visual *after they heard the passage*. You also fall into this group if you viewed the visual after reading.
- Group 3 saw the visual *before they heard the passage*.

Table 6.1 summarizes the participant comprehension ratings. Note that the understanding of the passage among those who saw the visual *after hearing the story* was about the same as those who never saw the visual. Did you notice a similar pattern in your ratings? The results are dramatic evidence for the power that a visual can provide as a context for understanding content. However, any visual intended to serve as an advance organizer is only effective when it is presented *prior to the content*. The expository organizer promotes learning because it provides a structure for the learner to hang the details and manage mental load. Working memory has a place to put each piece of new content it absorbs without having to juggle what, without the organizer, would appear to be random pieces of data.

A successful expository organizer provides a high-level "skeleton" of the content to be presented in the instruction. Too much detail in the organizer will overload the learner. Insufficient or meaningless detail will not provide the learner with an effective content preview. Figure 5.2 shows a graphic

Figure 6.4. The Serenade Visual, an Expository Advance Organizer.

Adapted from Bransford and Johnson, 1972. Credit: Robert Deupree.

Table 6.1. Comprehension Ratings for the Balloon Passage

	No Context	Context After	Context Before	Maximum Score
Comprehension Ratings:	2.3	3.3	6.1	7.0

Data from Bransford and Johnson, 1972.

expository advance organizer that overviews four main real estate areas of a screen. This organizer is followed by detailed information on each of the four screen areas.

GUIDELINE 3: AVOID SEDUCTIVE DETAILS IN LESSON INTRODUCTIONS

In the first half of this chapter, we looked at using graphics either in the form of comparative organizers to activate relevant prior knowledge or in the form of expository organizers to present a context for the learning of new content. In this section we will look at the damaging effects of seductive visuals placed early in a course or lesson.

What Are Seductive Visuals?

Garner, Gillingham, and White (1989) were the first to document the harmful effects of textual details that were related to the topic but not directly relevant to the goal of the instruction. They called such additions *seductive details*. Harp and Mayer (1998) documented the negative effects of seductive text and seductive video inserted into science lessons. They inserted either text or video clips into a basic multimedia lesson on lightning formation. The inserts illustrated extraneous information such as what happened when people or airplanes were struck by lightning. You can review the two lesson versions (with and without inserts) in Figures 4.1 and 4.2. Readers enjoyed the inserts. They rated them as interesting and entertaining. However, in comparisons of learning from materials with and without the seductive details, learning was significantly better *when the details were omitted*. In six different experiments, lesson versions that *omitted* interesting but irrelevant words and pictures improved learning for a median effect size of 1.66, which is extremely high! Mayer (2009) concludes that "adding interesting but irrelevant pictures and words had a strong negative effect on people's understanding of the explanation presented in the lesson" (p. 97). Mayer terms the negative effects of emotionally arousing materials a *coherence effect* (Clark & Mayer, 2008; Mayer, 2009).

Because, when compared to instructor-led classes, self-paced e-lessons are especially susceptible to high learner dropout rates, designers are often tempted to use seductive visuals and words to spice up the training. For example, the screen shown in Figure 6.5 is an example of the type of fantasy themes sometimes used to

Figure 6.5. A Fantasy Treatment Used in a Technical Course Introduction.

Source: Mark A Palmer.

liven up dry technical content. These kinds of edutainment visuals are designed to make the training engaging and exciting. However, the fantasy treatment is not related to the lesson objective. Chances are that learners remember more of the graphic treatment than any content presented in the text.

Levasseru and Sawyer (2006) report similar negative effects of PowerPoint slides embellished with foofaraw compared to slides using simple designs. They conclude that "adding more elements to computer-generated slides did not result in more learning. In fact, results in two studies revealed that more elaborate slide constructions can actually result in less learning" (p. 115).

Liking vs. Learning

Your intuition that people like materials with visuals more than materials with text alone is backed up by research (Christie & Coller, 2005; Sambrook, 2001).

Furthermore, ubiquitous access to online graphic libraries makes it easy to add visuals to training materials. Do positive learner ratings translate into improved learning outcomes? In other words, if a lesson is rated higher, is learning also better? What do you think?

Actually, there is almost no relationship between student ratings of classes and measures of student learning from that class. Sitzmann, Brown, Casper, Ely, and Zimmerman (2008) correlated the class ratings of thousands of students reported in multiple research studies with the learning of those students in those classes. They found a very small positive relationship—a correlation too small to allow us to use lesson satisfaction ratings as indicators of learning.

We recommend that you go for a winning combination of liking AND learning by using graphics that support rather than defeat learning processes. Adding visuals—relevant or irrelevant—will make your materials more appealing. So why not get double benefit from visuals that will add appeal *and* contribute to learning?

THE BOTTOM LINE

In this chapter we have summarized three guidelines related to the use of graphics to activate prior knowledge. Visuals can be used as comparative advance organizers to activate related prior knowledge stored in long-term memory. Visuals can also be used as expository advance organizers to adumbrate the content of the lesson. Finally, decorative visuals should be avoided early in a lesson, as they are likely to activate inappropriate prior knowledge.

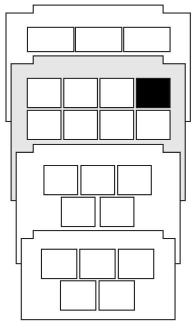
COMING NEXT

In the next chapter we summarize what we know about use of graphics to manage mental load in working memory. Working memory is the brain's center of active processing that results in learning. However, its capacity is very limited. Therefore, a critical function of instruction is to manage mental load in ways that conserve working memory resources for learning. Graphics and graphic treatments are one important tool you can use to manage load.

For More Information

Mautone, P.D., & Mayer, R.E. (2007). Cognitive aids for guiding graph comprehension. *Journal of Educational Psychology*, *99*, 640–652.

CHAPTER OUTLINE



What Is Mental Load?

Learner Prior Knowledge

Content Complexity

Guideline 1: Use Graphics Rather Than Text for Spatial Content

Evidence for Visuals to Present Procedural Content

Guideline 2: Use Simple Graphics for Deeper Learning

1. Line Drawings Better Than 3D Drawings
2. Simple Schematic Animations Better Than Video
3. A Series of Still Visuals Better Than Animations

Guideline 3: Use Animations to Teach Hands-On Skills

The Mirror Neuron System

Provide User Controls in Dynamic Displays

Combine Dynamic and Static Visuals

Guideline 4: Explain Complex Graphics with Words in Audio

The Modality Principle

How the Modality Principle Works

Guideline 5: Use Words or Graphics Alone When Information Is Self-Explanatory

Guideline 6: Use Previews and Overlays with Complex Visuals

Use Previews to Present Components of a Visual Display

Use Overlays and Visual Signals to Present Complex Visual Information Gradually

CHAPTER 7

Plan Graphics That Minimize Irrelevant Mental Load

When content is complex, learners are novices, or the rate of presentation of instructional material is not controlled by the learner, learning can be improved by using visuals in ways that reduce irrelevant mental load. Mental load, which is the amount of work required of working memory, is productive when it leads to learning. In contrast, irrelevant mental load impedes learning and performance. Irrelevant mental load can be reduced by replacing text with visuals, by visual design and sequencing techniques, and by explaining complex visuals with audio rather than text. In this chapter we present research, psychology, and examples to support the following guidelines:

- Use graphics in place of text for efficient communication of content.
- Use simple graphics for deeper understanding.
- Use animations to teach motor skills.
- Explain complex graphics with words presented in audio.
- Use words or graphics alone when information is self-explanatory.
- Use previews and overlays with complex visuals.

WHAT IS MENTAL LOAD?

Mental load is the amount of work imposed on working memory. Some forms of load foster learning. Instructional psychologists call this type of mental load germane or generative load. Relevant visuals as well as practice exercises are two instructional methods that can impose germane load. Other forms of mental load impede learning. Instructional psychologists refer to this type of load as extraneous because it uses working memory capacity in ways that slow down or depress learning. Extraneous load arises from ineffective design of training or reference materials. Effective training materials use techniques that minimize extraneous mental load and maximize germane load. In this chapter we will focus primarily on minimizing extraneous mental load through effective design and explanations of visuals.

Two main factors determine the amount of load present in a training situation: learner prior knowledge and content complexity.

Learner Prior Knowledge

In Chapter 4 we summarized the research showing that chess experts were able to learn a mid-play chessboard much faster than chess novices. However, when the pieces were placed on the board randomly, making the board meaningless in terms of an actual chess game, the experts actually did worse than the novices. The knowledge experts already have stored in long-term memory allows them to process larger chunks in their working memory. Although all of us are limited by the 7 +/− 2 chunk capacity of working memory, chunk size varies according to your prior knowledge. A mid-play chessboard containing twenty-four pieces might include eight or nine chunks for an expert and twenty-four chunks for a novice. Expertise brings with it the advantage of greater working memory virtual capacity!

Therefore, the more relevant background your learners have related to the lesson content, the less you have to be concerned with mental overload in your training materials. Our guidelines for using visuals to reduce irrelevant load apply primarily to novice learners. Research summarized by Kalyuga (2005) shows that instructional methods used to reduce load can either have no effect on more experienced learners or, in some cases, actually depress their learning!

Content Complexity

We define complexity as the amount of interdependency among elements of the content. For example, when learning a new foreign language, vocabulary is relatively low in complexity because each word can be learned independently. In contrast, learning to compose sentences with those words is more complex because the placement and syntax of each word must be considered in relation to the other words. When learning how to use a new computer application, learning the parts of the interface is of relatively low complexity. However, learning how to apply a series of steps to complete an online task will impose much greater mental load.

The challenge for instructional professionals is to minimize irrelevant mental load when learners are novices and for complex content. According to John Sweller, the researcher who defined the concept of cognitive load, "any instructional design that flouts or merely ignores working memory limitations inevitably is deficient" (Sweller, van Merrienboer, & Paas, 1998, p. 253).

In this chapter we will look at proven methods to design and explain visuals in ways that minimize irrelevant mental load. Since our first edition, there has been a great deal of research on dynamic visuals, including video and computer-generated animations. Because dynamic displays include a lot of visual information and also because the displays are transient, they have greater potential to impose more mental load than simpler visuals such as still graphics. We will consider when to use animations and when to stick with simpler formats. We will also review ways to manage load when you do use animations.

GUIDELINE 1: USE GRAPHICS RATHER THAN TEXT FOR SPATIAL CONTENT

Illustrations and diagrams can reduce irrelevant mental load. Information, especially spatial information, can be presented in a diagram more concisely than in text. For example, Figures 7.1 and 7.2 show the same information presented in text and in diagram format. Although the text in Figure 7.1 is accompanied by a graphic of an actual check, processing the information presented on the screen is still difficult. On the other hand, in Figure 7.2, the representation of an account number that relies more on a diagram and less on text is more easily comprehended, without overloading memory.

Figure 7.1. Content Presented Primarily with Words.

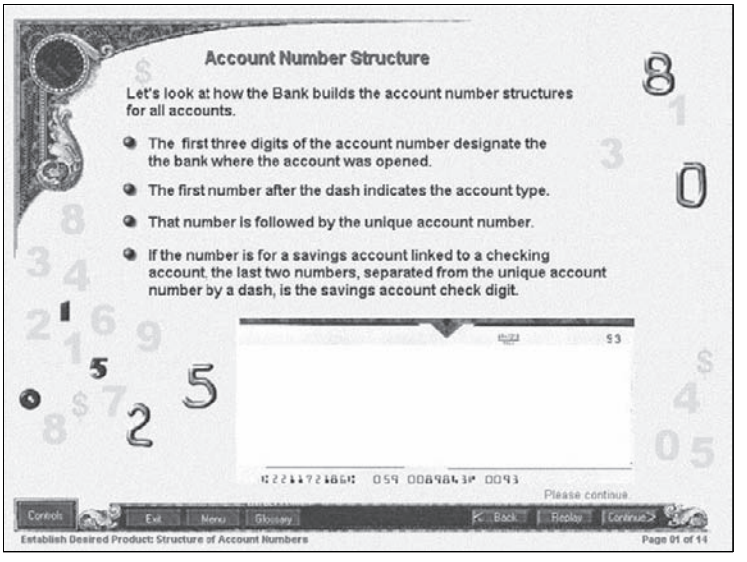
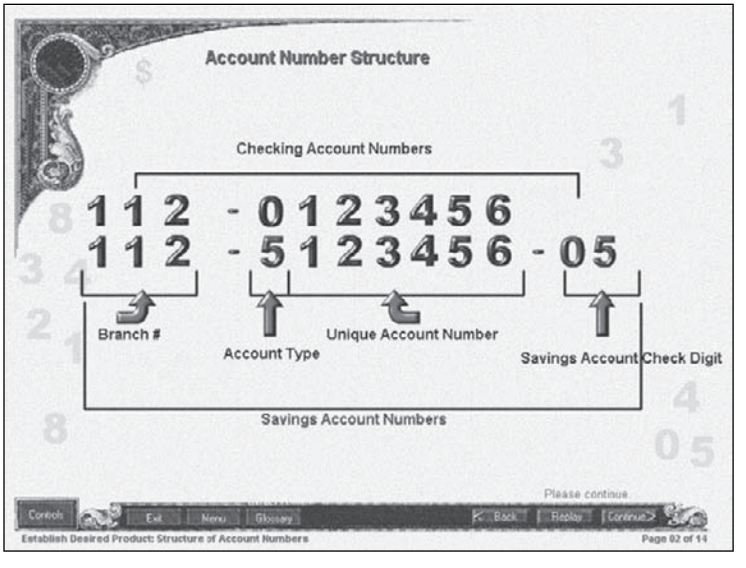


Figure 7.2. Same Content Presented Primarily with Graphics.



Evidence for Visuals to Present Procedural Content

Think of the last time you faced a home assembly task such as putting together your child's new bicycle. Procedures with several steps involving equipment can be performed more easily with directions presented with diagrams rather than with text. Marcus, Cooper, and Sweller (1996) compared the time it took learners to connect resistors in both simple and in complex configurations from instructions presented in text to the time it took learners to connect the resistors from instructions presented in diagrams. See Figure 4.6 to compare the text and diagram instructions.

People using visual directions completed tasks faster for all resistor connections with the greatest improvements in speed noted in the more complex parallel combinations (Marcus, Cooper, & Sweller, 1996). Therefore, when directions are presented visually, mental load becomes equivalent for easier and more complex tasks since the diagram simplifies the complex procedure. In other words, diagrams serve as a mental equalizer!

Watson, Butterfield, Curran, and Craig (2009) reported similar benefits of visual versus text reference materials for an assembly task. The research team compared the time required to complete a thirty-three-step mechanical assembly task once a day for five days while referencing instructions presented with (1) text only, (2) still diagrams, or (3) animated instructions. Neither the still diagrams nor the animated instructions included any words, and the animated guides allowed learners to pause, rewind, or fast forward. Similar to the resistor experiment, they found the graphic reference materials led to much faster assembly at least at first. First-day assembly times for those using animated guides were 56 percent faster than for those using text and 28 percent faster than for those using still graphics. Both the animated and the still graphic instructions led to faster assembly the first and second days. However, for the remaining days, assembly times were the same for all three formats. No doubt, after gaining familiarity with the task, there was less reliance on external guidance.

From a practical perspective, the evidence suggests that, for novel one-time assembly tasks, graphic instructions will lead to faster performance than text instructions. However, in situations in which the same individuals will perform the same assembly task repeatedly, the advantage of visuals disappears as performers learn the steps involved.

GUIDELINE 2: USE SIMPLE GRAPHICS FOR DEEPER LEARNING

When using visuals, reduce mental load by applying a consistent graphical style with less "visual" noise. Line drawings are less complex than photographs that have many details competing for the viewer's attention. Gradations of color or shading in photographs often make it hard to discriminate details such as switches, slots, and outlets in equipment. Line art emphasizes the key aspects by eliminating the visual noise. For this reason technical publications often use line art so that the learner can clearly discriminate among all parts; see the comparison in Figures 7.3 and 7.4.

Several experiments found better comprehension learning from a simpler visual than from a more complex format. We summarize three of these in the following paragraphs.

1. Line Drawings Better Than 3D Drawings

Butcher (2006) compared understanding of heart circulation presented in three formats: text, text plus simple line drawing, or text plus more accurate 3D drawing.

Figure 7.3. A Photograph of Headlight Housing in Car Engine Area.

Figure 7.4. A Line Drawing of Headlight Housing in Car Engine Area.

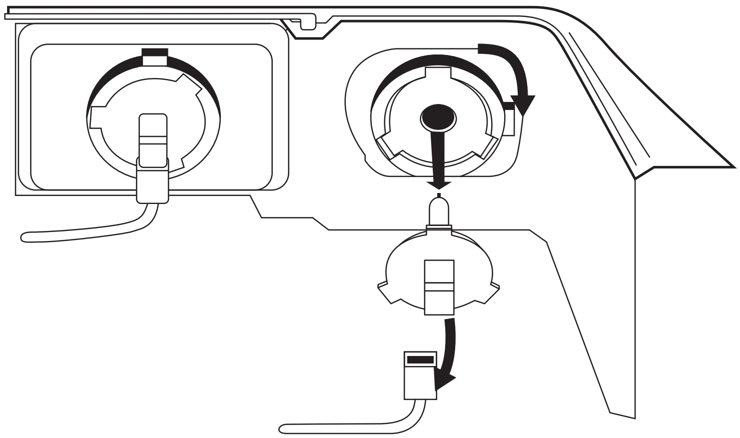
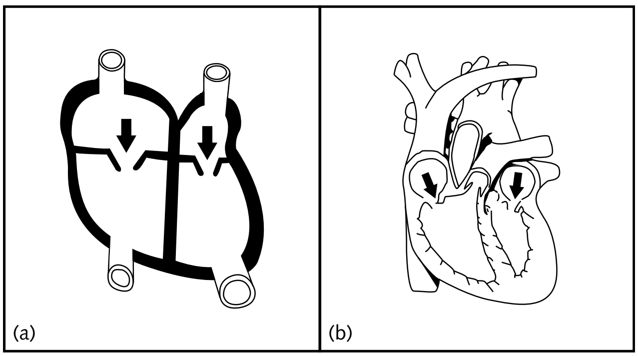


Figure 7.5. Simple Line Drawing Versus 3D Drawing of Heart Circulation.



From Butcher, 2006.

See Figure 7.5 to compare the simple and complex graphic versions. Both visual formats led to more learning than text alone. However, the simpler line drawing was more effective than the 3D version, especially for low knowledge learners.

2. Simple Schematic Animations Better Than Video

Scheiter, Gerjets, Huk, Imhof, and Kammerer (2008) compared conceptual understanding of cell mitosis from dynamic visuals that were simple or complex.

The simple visuals were dynamic computer-generated narrated drawings that illustrated the stages of mitosis. The complex dynamic visual was a narrated video of actual stages of cellular mitosis filmed through a microscope. They found better learning both on multiple-choice tests and visual identification tests among learners who reviewed the simpler animations.

3. A Series of Still Visuals Better Than Animations

In several experiments summarized by Mayer, Hegarty, Mayer, and Campbell (2005), lessons on how lightning, ocean waves, brakes, and toilet tanks worked were compared among learners who studied a series of static visuals explained with text with learners who studied an animated version explained with audio. The animated versions played without controls. In other words, there was no opportunity for learners to pause or replay them. In all cases the static visuals resulted in learning that was better than or equal to the animated versions. Because the animations conveyed a great deal of information in a transitory manner, they likely overloaded working memory. The still visuals, in contrast, allowed learners to review and absorb information at their own pace.

In summary, when your goal is conceptual understanding of a process such as how the heart works, a simpler visual may impose less mental load and free up working memory for deeper learning. Yet, as we will see in the next section, for goals that involve learning hands-on skills, animations are more effective. Therefore, we recommend that you plan graphics at the lowest level of complexity that will support the instructional goal. When deeper understanding is the goal, less is usually more.

GUIDELINE 3: USE ANIMATIONS TO TEACH HANDS-ON SKILLS

Over the last decade, experiments that compared learning from dynamic visuals such as video with learning from still graphics such as a series of line drawings resulted in conflicting results. Sometimes, the animations led to better learning and other times the stills were more effective. As instructional researchers looked more closely, they noticed that the learning goals varied in the different experiments. As discussed in the previous section, for understanding how things work, a simpler visual display was more effective. In contrast, when the goal was learning a hands-on skill, dynamic visuals were more effective. What might explain this anomaly?

The Mirror Neuron System

The mirror neuron system was discovered by accident in research using brain probes to trace neural activity in monkeys. Researchers noticed that the same brain activation pattern that occurred when monkeys grasped an object was also activated when the monkey saw the researcher grasp an object. The specific brain area involved was named the *mirror neuron system*. Learning psychologists believe that these neuroscience findings may be the basis for the effectiveness of dynamic visuals for observational learning (Van Gog, Paas, Marcus, Ayres, & Sweller, 2009).

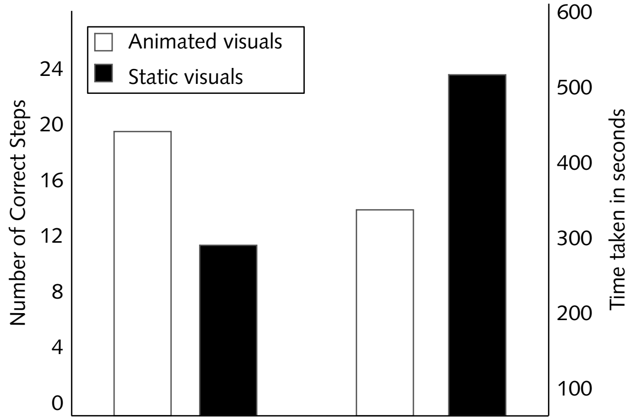
As we mentioned above, dynamic visuals can impose irrelevant cognitive load because they incorporate so much visual information in a transient manner. Perhaps the mirror neuron system is an evolutionary adaptation that permits animated demonstrations to bypass working memory and therefore avoid mental overload.

Two recent experiments reported better learning of hands-on skills from dynamic visuals than from a series of still visuals. Ayres, Marcus, Chan, and Qian (2009) recorded videos with no sound to illustrate how to tie three knots. The video played without stopping. From the video they prepared a second version consisting of forty-two static visuals showing the critical steps. Each group had two 210-second opportunities to observe either the dynamic or static visuals and learn to tie the three knots. After the observation period, participants were given materials and asked to construct three knots. In Figure 7.6 we compare the number of correct steps and time needed to tie the knots in the dynamic and static groups. As you can see, learning was better and faster among individuals viewing dynamic visuals. Similar results were reported by Wong, Marcus, Ayres, Smith, Cooper, Paas, and Sweller (2009) comparing dynamic versus static visuals demonstrating origami paper-folding tasks.

Provide User Controls in Dynamic Displays

Learning hands-on skills is much more efficient when learners can stop, replay, reverse, and change speed of video illustrations. Schwan and Riempp (2004) compared video that could be controlled with non-interactive video. There

Figure 7.6. The Number of Correct Steps and Time to Tie Knots After Studying Dynamic and Static Visuals.



Based on data from Ayers, Marcus, Chan, and Qian, 2009.

was no audio in the videos, which illustrated how to tie four different nautical knots. During the learning phase, individuals could view the videos for as long as they wished until they felt they had learned the knots. They could practice during the learning phase, but only when the video was stopped. The non-interactive video had to be watched in its entirety, while the interactive version could be stopped, paused, repeated, etc. After the learning phase, the participants completed the test phase by tying the four knots. All of the participants learned to tie all four knots. However, learning was much faster when participants could control the video. The average learning time for all four knots for the non-interactive group was 105 minutes compared to 60 minutes for the controllable versions.

Combine Dynamic and Static Visuals

Arguel and Jamet (2009) taught recall and comprehension of first aid skills from three lesson treatments. One version used video. A second version took snapshots from the video to create a series of still visuals. A third version combined the video and the stills. As the video played, key still frames would display under the video window as each step was shown in the video. All three versions included audio narrations. The combined static and dynamic displays resulted in much better learning with a very high effect size of 2.78. The research team suggests that periodically adding still frames to a dynamic visual helps compensate for the transience of animations.

GUIDELINE 4: EXPLAIN COMPLEX GRAPHICS WITH WORDS IN AUDIO

Is it better to explain a visual with words in a text format or with audio narration? We have strong evidence that mental load is affected not only by features of the illustration, but also the modality of the explanatory words.

Many experiments show that, when presenting complex visual information such as detailed static illustrations or dynamic visuals, learning is maximized when the illustrations are explained by words presented with audio rather than with text. In seventeen different experiments involving lessons that explained how lightning or brakes work, as well as an online botany game, Mayer (2009) found better learning when visuals were explained by audio narration than when they were explained by text. The median effect size is about 1, which is large.

The Modality Principle

These findings support the *modality principle;* learning is deeper when new visual information is explained with audio rather than text. The modality principle is most applicable when lesson mental load is high, such as when the content is complex, the presentation is fast-paced, and the learner is novice. The modality principle is applied often in software training, where graphic demonstrations of procedural, step-by-step tasks are accompanied by narration explanations.

How the Modality Principle Works

There are two explanations for the modality effect. As shown in Figure 4.5, working memory has two subcomponents: one for visual information and a second for auditory data. When audio is used to explain a visual, the content is divided between the two centers. In contrast, when written text is used to explain a visual, the visual center is overloaded (Clark & Mayer, 2008).

Recent research using eye-tracking technology offers a second explanation for the modality effect. Consistent with the modality principle, Schmidt-Weigand, Kohnert, and Glowalla (2009) found better retention and transfer learning from a lesson explaining lightning formation that used audio compared to the same lesson that used text for the explanations. As the learners reviewed the lesson, eye tracking defined the areas of visual focus during learning. In lessons using text to explain visuals, learners tended to focus more on the text rather than the animation. In lessons using audio, all attention was focused on the animation as there was no other visual present. The research team suggests that during an audio narration of a complex visual, learners simply receive more benefit from the visual because they can inspect it throughout the explanation. In contrast, when visual attention is focused on reading text, much less opportunity is available to review the visual.

Taken together, the research evidence to date suggests that, when deeper understanding is your goal and you are using a complex visual to illustrate lesson content, you need to maximize learners' opportunities to review and benefit from the visual. To do so, you could use audio narration to explain the visual. Alternatively, you could display explanatory text (for example, use a two-column approach with text on one side and a video player on the other) and then allow the learner to launch an animation after reading.

GUIDELINE 5: USE WORDS OR GRAPHICS ALONE WHEN INFORMATION IS SELF-EXPLANATORY

Although it is usually best to describe complex visuals with words in audio rather than in text, sometimes it's better to leave out the words altogether and simply rely on the visuals to carry the instructional message. And in other situations it might be better to simply use text and not add an illustration.

Presenting multiple sources of information—each of which can be understood in isolation—can overload working memory and depress learning. This effect is known as the *redundancy principle* (Sweller, Van Merrienboer, & Paas, 1998). In some situations, words alone are sufficient for learning; adding a redundant illustration does not improve outcomes. Levin says that "concrete, easy-to-follow, highly memorable prose passages do not require the addition of pictures" (Levin, Anglin, & Carney, 1986, p. 74). In other cases, an illustration alone is sufficient; adding words does not improve outcomes and can actually depress learning (Bobis, Sweller, & Cooper, 1993).

Pociask and Morrison (2008) improved a five-page physical therapy print lesson by eliminating repetitive information that appeared among text passages and diagrams and/or diagram captions. In addition, they integrated the remaining text and visuals to maximize contiguity. Learning was measured by a multiple-choice knowledge test as well as hands-on performance test requiring a mock patient assessment. Both knowledge and performance scores were better among those who studied the improved lesson version than among those who studied the original version. For example, in Figure 7.7 the illustration is sufficient to convey the instructional message. Adding words to this simple graphic representation, as we did in Figure 7.8, would likely slow down the learning process.

Figure 7.7. Content Presented Primarily with Graphics.

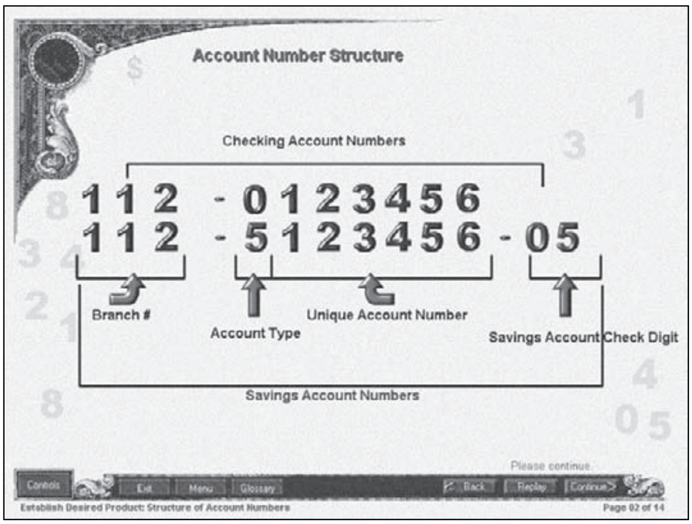
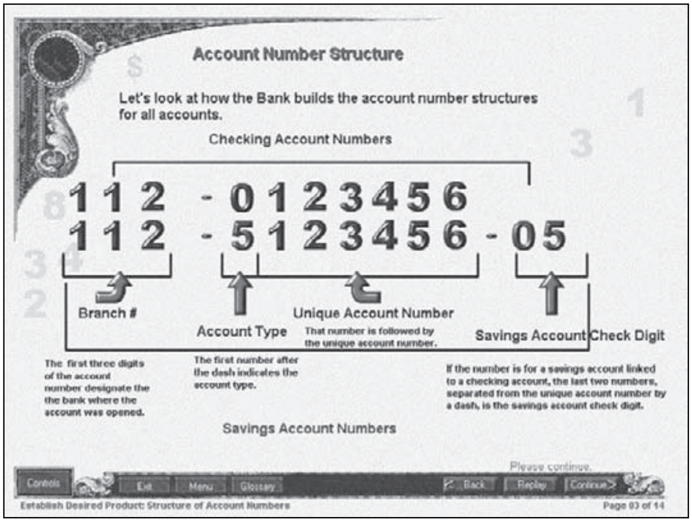


Figure 7.8. Same Content Presented with Graphics and Words. Adding redundant textual information to a self-explanatory graphic can add extraneous mental load and slow down learning.



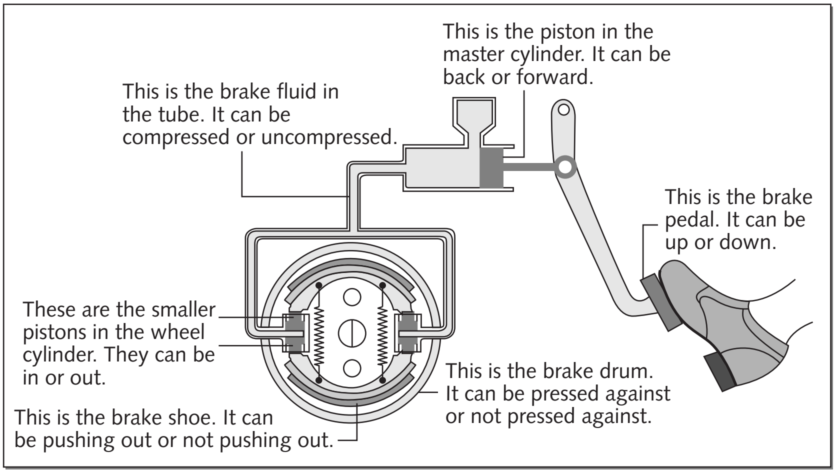
GUIDELINE 6: USE PREVIEWS AND OVERLAYS WITH COMPLEX VISUALS

Chunking and sequencing information is the bread and butter activity of instructional specialists. After the content is defined, instructional specialists break and sequence it into logical lesson chunks. Irrelevant mental load is reduced by designing lessons that present content in smaller bites building gradually in complexity. When your content involves complex visuals, use previews and overlays to control the amount of information presented at one time.

Use Previews to Present Components of a Visual Display

Mayer, Mathias, and Wetzell (2002) produced preview lesson segments both in paper and in multimedia formats. The previews used graphics and text to explain how individual components involved in a complex mechanical process worked. Figure 7.9 shows a print version of the lesson preview. The training consisted of a short, narrated, animated multimedia lesson on how hydraulic brakes work. After reviewing the lesson, participants answered test questions such as “Suppose

Figure 7.9. A Preview Presented on Paper.



From Mayer, Mathias, and Wetzell, 2002.

you press on the brake pedal in your car but the brakes don't work. What could have gone wrong?" Learning was compared between groups that received the previews before the training and groups that received the training without previews. Previews, whether provided on paper or in multimedia, resulted in significantly better learning.

The authors recommend: "Before presenting a multimedia explanation, make sure learners visually recognize each major component, can name each component, and can describe the major state changes of each component. In short, make sure learners build component models before presenting a cause-and-effect explanation of how a system works" (p. 154).

Use Overlays and Visual Signals to Present Complex Visual Information Gradually

A technique similar in intention to previews involves "building" a complex graphic allowing the learner to gradually assimilate the pieces that make up the whole.

Mautone and Mayer (2007) found improved comprehension of a complex graph that was presented in a layered fashion beginning with the x and y axis and using colored lines, arrows, and shading to gradually present key components of the graph.

THE BOTTOM LINE

In this chapter we have reviewed instructional methods involving graphics and explanations of graphics designed to minimize irrelevant mental load. In particular we recommend using visuals to present spatial content, sticking with simpler visual formats, explaining visuals with audio rather than with words, and avoiding redundant explanations that use visuals and words when either the visual or the words alone would suffice.

COMING NEXT

With reduced mental load, the learner can allocate limited working memory capacity for the processing that results in new mental models in long-term memory. In the next chapter we will look at the role visuals can play to help learners build new mental models.

For More Information

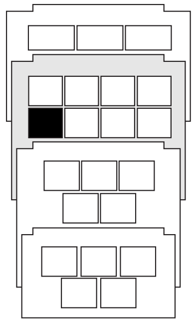
Mayer, R.E. (2009). *Multimedia learning* (2nd ed.). New York: Cambridge University Press. (See Chapters 4 through 8.)

Schmidt-Weigand, F., Kohnert, A., & Glowalla, U. (2010). Explaining the modality and contiguity effects: New insights from investigating students' viewing behavior. *Applied Cognitive Psychology*, *24*(2), 226–237.

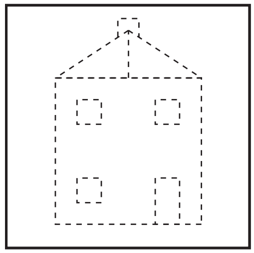
Van Gog, T., Paas, F., Marcus, N., Ayers, P., & Sweller, J. (2009). The mirror neuron system and observation learning: Implications for the effectiveness of dynamic visualizations. *Educational Psychological Review*, *21*, 21–30.

Wouters, P., Paas, F., & van Merrienboer, J.J.G. (2008). How to optimize learning from animated models: A review of guidelines based on cognitive load. *Review of Educational Research*, *78*, 645–675.

CHAPTER OUTLINE



CHAPTER 8



Plan Graphics to Help Learners Build Mental Models

Learners construct new mental models by integrating lesson content with activated prior knowledge. A mental model is a memory stored in long-term memory that is the basis for understanding and problem solving. Visuals that depict relationships are more effective to help learners build mental models than are visuals that simply represent content.

We call these relationship-building visuals *explanatory graphics*. In this chapter we present research, psychology, and examples to support the following guidelines:

- Use *organizational visuals* to show qualitative relationships among lesson content.
- Select and design *relational visuals* to most effectively display quantitative relationships.
- Use *transformational visuals* that illustrate change over time or space to build cause and effect mental models.
- Use *interpretive visuals* to illustrate laws and principles.
- Use *online agents* to model mental processes associated with problem solving.

MENTAL MODELS, LEARNING, AND GRAPHICS

One of the most important contributions of modern instructional psychology is the *rediscovery* that learning requires an active construction of knowledge by the learner. We say rediscovery because in 1916 John Dewey noted: "That education is not an affair of 'telling' and being told, but an active constructive process, is a principle almost as generally violated in practice as conceded in theory" (p. 38). Almost one hundred years later, Dewey's assessment still applies. Modern learning models emphasize the active nature of learning. Learners must integrate new content from the instructional environment with prior knowledge activated from long-term memory. And yet in the 21st Century all too often teaching is still equated with telling.

In the previous chapter we focused on instructional methods to reduce extraneous mental load. In this chapter we look at how graphics can impose germane mental load by helping learners build mental models. In particular we focus on visuals that communicate relationships and consequently help learners build conceptual and cause-and-effect mental models. We call these types of visuals *explanatory graphics.* Explanatory graphics include the communication functions of organizational, relational, transformational, and interpretive visuals as summarized in Table 8.1.

What Are Mental Models?

Mental models are memory structures (called *schemas* by instructional psychologists) that are stored in long-term memory and support thinking. Useful mental models enable learners to discriminate new concepts, to solve problems, to make predictions, and to interpret data from the environment.

For example, when diagnosing engine failures, an experienced automotive technician draws on knowledge of the structure and function of the engine, the testing methods, data interpretation, and troubleshooting guidelines. The serenade visual included in Chapter 6 (Figure 6.4) provides an analogy for how mental models work. Recall from Chapter 6 that readers who viewed the serenade graphic *before reading* the text rated the passage more understandable than those who viewed the graphic *after reading* the text. The serenade visual provided a context to interpret the text. In a similar way, mental models provide a framework to interpret information. For example, an experienced chess player is able to interpret a mid-play chess board and plan a next move based on her mental models of common chess

Table 8.1. Explanatory Graphics

Graphic Type	Description	Example	Used to Build
Organizational	A visual consisting of shapes and text that display qualitative relationships among topics	A graphic organizer such as a flow chart or a tree chart	Mental models of the relationships among facts and concepts
Relational	A visual that communicates quantitative relationships	Bar chart Pie chart	Mental models involving relative quantitative data
Transformational	A visual that shows change over time and space	An animation of how a toilet tank works A video of how to change oil in equipment	"How it works" mental models "How to do it" mental models
Interpretive	A visual that illustrates theoretical or abstract relationships among intangible elements	A simulation of molecular movement	Cause-and-effect mental models

plays. An individual who knows nothing about chess has no relevant mental models and is unable to interpret the chess board.

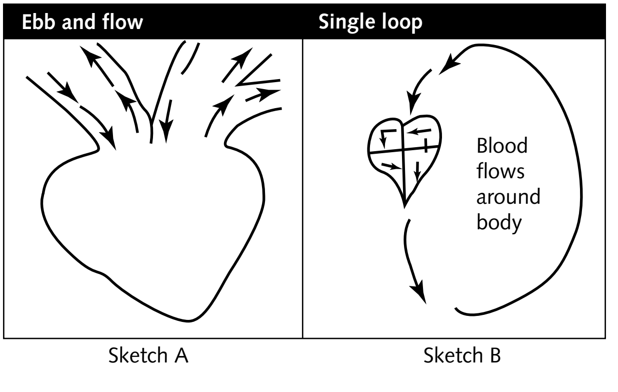
How Can We Measure Mental Models?

Tests that require recall or recognition of lesson content measure a different type of learning than inference tests that require learners to apply new knowledge to solve problems. For example, in an aviation tutorial, a memory test asks learners to identify the different parts of the airplane. A sample question might show a picture of the airplane with spaces for learners to fill in the names of the parts. In contrast, an inference test asks the learner to predict the effects of a position change of each part of the airplane on flight parameters. A sample inference question might ask the learner to select from several visuals the correct airplane orientation that would result from increasing the angle of the elevator. Let's consider how two research studies measured participant mental models.

Butcher (2006) measured heart circulation mental models by asking university students to draw pictures and write descriptions of blood flow. Many of the drawings and descriptions reflected flawed mental models. For example, Sketch A in Figure 8.1 illustrates blood flowing into and out of the heart but with no specific mechanism for doing so. Butcher labeled this type of mental model as "ebb and flow." Another flawed mental model, Sketch B in Figure 8.1, is labeled "single loop." This mental model accounts for blood flowing into and out of the heart through blood vessels but omits the lungs.

Mayer (2009) measured mental models of how lightning or equipment works by posing problems and asking participants to solve them. For example, following a lesson on how lightning forms he asks the following questions: "What could you do to decrease the intensity of lightning? Suppose you see clouds in the sky, but no lightning. Why not?" These kinds of questions require learners to apply a deep understanding of the process of lightning formation to situations not presented in the lesson.

Figure 8.1. Two Sketches of Blood Circulation Reflecting Flawed Mental Models.



From Butcher, 2006.

HOW GRAPHICS HELP LEARNERS BUILD MENTAL MODELS

Researchers have two theories for the beneficial effects of visuals on learning. Dual encoding states that when information is provided in both text and visual formats, two memory traces are formed. A double representation increases the probability of encoding new knowledge into long-term memory.

A second theory suggests that visuals can communicate relationships among content objects more efficiently than can be communicated by words alone. In this chapter on visuals for building mental models we focus on the explanatory visuals that communicate content relationships summarized in Table 8.1.

For example, in Figure 7.5 we showed two explanatory graphics illustrating how blood flows through the heart. Butcher compared mental model improvement among learners who studied one of three lesson versions on blood circulation through the heart. One version used text alone. The other versions used the same text with either a simple line drawing or a more anatomically accurate 3D drawing shown in Figure 7.5. A pre- and post-test requiring learners to sketch and describe heart circulation measured learning. Both lesson versions with graphics improved understanding better than lessons with text alone. However, the simpler line drawing was more effective than the realistic 3D drawing. As we discussed in Chapter 7, often a simpler visual is more effective to build deeper understanding. In the next sections, we review the best ways to use organizational, relational, transformational, and interpretive visuals to build effective mental models.

GUIDELINE 1: USE ORGANIZATIONAL GRAPHICS TO SHOW QUALITATIVE RELATIONSHIPS

An organizational visual is a knowledge representation that uses shapes and text to illustrate various types of qualitative relationships among the content. Organizational visuals are sometimes called graphic organizers and can be presented as a tree diagram, concept map, or a matrix. Table 8.2 summarizes four common types of graphic organizers. Typically, graphic organizers are presented in conjunction with words and result in increased learning of relationships among lesson ideas.

Table 8.2. Some Common Graphic Organizers

Type	Designed to Depict
Tree Diagram	Hierarchical and coordinate relationships
Causal Diagram	Causal relationships
Matrix (Table)	Compare and contrast relationships
Knowledge or Concept Map	Multiple relationships among concepts

Do Graphic Organizers Benefit Learning?

As with all graphics, the benefits of graphic organizers will depend on the learning goal, the type and design of the organizer, and the complexity of the instructional material. Most research on graphic organizers compared learning from text alone with learning from text plus a graphic organizer. Other experiments compared learning from text alone with learning from text plus graphic organizer or text plus an outline or list of topics. After studying their assigned lesson version, learners were tested for understanding of the relationships in the text.

Nesbit and Adesope (2006) report a meta-analysis on learning with concept maps added to text. Overall they found modest learning benefits for studying concept maps compared to outlines or lists, especially for lower ability learners. They conclude: "Pre-constructed maps are particularly useful as a communication medium for students with lower verbal proficiency and may offer little or no advantage to those with high verbal proficiency" (p. 434).

McCrudden, Schraw, and Lehman (2009) compared learning of processes such as kidney stone formation among students who read a 484-word text followed by (1) studying a causal diagram summarizing stages in the process, (2) studying an outline of process stages, or (3) rereading the text. They found that both the causal diagram and the outline led to better learning than rereading the text, but there was no real advantage of the diagram over the outline.

The benefits of a graphic organizer may depend in part on the complexity of the text material. Bera and Robinson (2004) found that graphic organizers led to better learning than outlines when the text was long (6,500 words) and several organizers were included. In contrast, for shorter texts, an outline was more effective.

They believe that the graphic organizers helped reduce excessive load in longer texts but were not needed as guides for briefer materials.

When to Use Organizers

Although research shows that graphic organizers do benefit learning, the evidence does not strongly or consistently support organizers as more effective than an outline. For now, we recommend providing outlines for shorter texts and considering more elaborate graphic organizers for materials that impose greater mental load such as longer lessons or a series of lessons. Select a graphic organizer that best supports the type of relationships described in the text, such as a matrix for compare and contrast or a tree diagram for coordinate and subordinate relationships.

In line with the research evidence, we have used a "tab" graphic organizer at the start of our book and with each section introduction to illustrate relationships among sections and chapters. At the chapter level, however, we are using an outline. In online courses, organizers created as navigation aids also provide learners with a mental model of how the specifics of one lesson relate to the bigger picture.

GUIDELINE 2: USE CHARTS AND GRAPHS TO COMMUNICATE QUANTITATIVE RELATIONSHIPS

In newspapers, PowerPoint presentations, and on cereal boxes, graphs such as pie and bar charts are ubiquitous. Graphs are so popular because they make quantitative relationships easy to understand. Furthermore, displaying numerical data in a visual format supports the discovery of relationships that cannot be readily noticed otherwise. The classic example is John Snow's 1854 cholera epidemic scatter plot of eighty-three disease deaths confirming the water pump handle as the source (previous water tests had failed to prove the water itself was contaminated).

The best chart or graph to use depends primarily on the mental model that you wish to build or the task the user needs to accomplish with the graph. In Table 8.3 we summarize recommended uses of the most common types of graphs. However, the effectiveness of any graph will depend on (1) the background familiarity of the viewer with the format, (2) the intended interpretations of the graph, and (3) the design of the graph itself. Next we will provide a brief

Table 8.3. Evidence-Based Guidelines for Use of Graphs

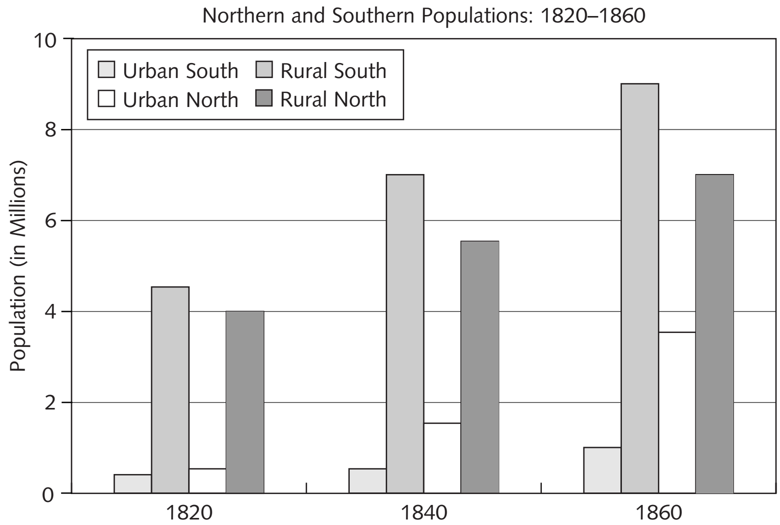
Use This Graph Type	For This Purpose
Line graphs	To display trends. To build highly integrative mental models. To display continuous data (Kosslyn, 2006; Shah, Mayer, & Hegarty, 1999)
Bar graphs	To show differences among categories; To display data from two or more variables on the same outcome (less biasing than line graphs) (Shah & Hoeffner, 2002)
Divided bar graphs	To communicate absolute values as well as proportions; When using a series of graphs to show relative proportions of the same size (Hollands & Spence, 2001; Kosslyn, 2006)
Pie charts	To help viewers make whole-part judgments when only showing one graph or when the wholes are of unequal size (Hollands & Spence, 2001)
Scatter plots	To communicate distribution of data; its variation
Tables	To display accurate single values. Provides least integrative information. Use when goal is to communicate multiple precise values

summary of each of these factors. For detailed evidence-based guidelines on design and use of graphs, we recommend the 2006 book *Graph Design for the Eye and Mind* by Kosslyn.

1. Construct Graphs Most Appropriate to Illustrate Intended Relationships

The bar graph in Figure 8.2 from a U.S. history textbook illustrates events leading to the Civil War. How would you interpret the information? The accompanying text discussion in the book presents the idea that before the war, the North was becoming more urban while the South remained largely rural. In other

Figure 8.2. A Bar Graph from a History Text.

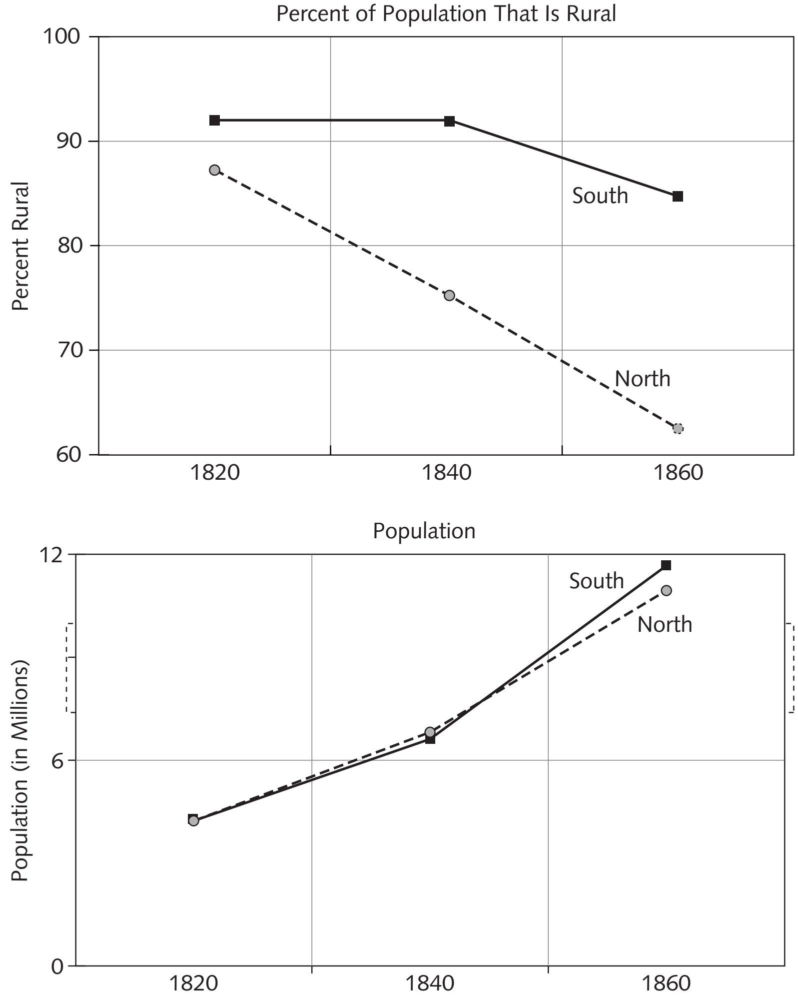


From Shah, Mayer, and Hegarty, 1999.

words, the text was communicating trend data. Most viewers of the bar graph, however, do not draw the conclusion stated in the text. Instead they focus on the relationship among the categories in the bar graph. Although the bar graph is technically correct, it is not the best way to communicate the relationships the history text describes. Better comprehension results when the data is displayed in a way that makes trends obvious and requires minimal mental work on the part of the learner.

To clarify the author's intention, the bar graph in Figure 8.2 was recast into two line graphs, shown in Figures 8.3 and 8.4. These revisions implemented three design techniques: (1) the data is organized to reflect trends across years (line graphs versus bar graphs), (2) the Y axis in Figure 8.2 is changed from absolute population figures to a percentage scale to reduce the mental work required for interpretation, and (3) one frame with twelve data points is converted into two frames with six data points to reduce complexity. Viewers of the line graphs gained an understanding consistent with the text description (Shah, Mayer, & Hegarty, 1999).

Figures 8.3 and 8.4. Revisions of the Display of Data in Figure 8.2.



From Shah, Mayer, and Hegarty, 1999.

2. Use a Graph Format Familiar to Your Viewers

Fischer, Dewaulf, and Hill (2005) compared time to interpret bar graphs oriented horizontally to time to interpret bar graphs oriented vertically. They found that the vertical graphs led to faster interpretation. The research team believes that vertical graphs are more effective due to the "prevalence of vertical over horizontal bar graphs, thus making vertical bar graphs more familiar to our viewers" (p. 959).

Bottom line. As with all instructional representations, your audience background makes a big difference. If you are dealing with a novice group or a mixed group, stick with most standard graph types such as bar graphs, line graphs, or pie charts that best convey your message.

3. Design Graphs to Support Attention and Manage Load

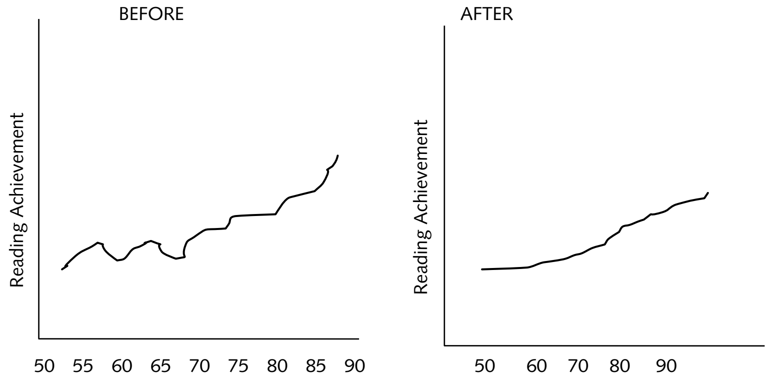
Kosslyn (2006) offers many evidence-based guidelines for the selection and design of graphs. Here we summarize a few tips that manage mental load:

A. *Avoid Split Attention with Graph Labels.* The closer you can physically place labels into the shapes on a graph, the better. For example, when developing a pie graph, label the segments with text placed into or next to each segment rather than a legend that appears on the side or bottom of the page. As we discussed in Chapter 5, when text appears on one page and a critical visual appears on the back of that page, irrelevant mental load is imposed because the reader has to hold information in memory to integrate the text and visual. A similar discontiguity burden is imposed when the viewer has to integrate a legend at the bottom or side of a pie graph with the visual. Placing text into or nearby the graph will reduce split attention.

B. *Keep It Simple.* The example shown in Figures 8.2, 8.3, and 8.4 illustrated the benefits of breaking a complex bar graph with many data points into two simpler line graphs. Along similar lines, limit the amount of extraneous detail in a graph based on your intended interpretation of the data. Compare the line graphs A and B in Figure 8.5. Likewise, a comparison of 3D bar graphs with 2D versions favored the simpler 2D format (Fischer, 2000).

C. *Write a Meaningful Title.* Rather than a single word title such as "Population" use three to five words that guide the viewers' interpretation. For example, "Changes in Global Population 1900 to 2000" will better promote understanding. Depending on your goal, you may want to use the title to direct attention to specific data relationships congruent with the text. For example, "Increased Rate of Population Growth in Third-World Countries."

Figure 8.5. A Graph with (Before) and Without (After) Extraneous Detail.



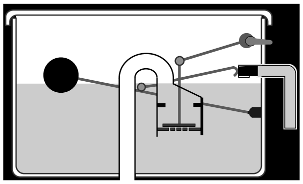
GUIDELINE 3: USE TRANSFORMATIONAL VISUALS TO COMMUNICATE CHANGES IN TIME OR SPACE

Transformational visuals illustrate changes over time or through space. They are very useful to build mental models of how things work. One common example is a cycle diagram showing stages of an internal business process such as following the path of an order from the time it enters the organization until the customer receives the product. Following distribution paths, summarizing science flows, or even illustrating how mechanical systems work are all processes that benefit from transformational visuals.

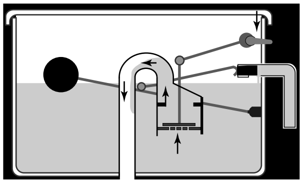
Graphic Design of Transformational Visuals: Dynamic vs. Static Visuals

Suppose you wanted to teach a mechanical process such as how a toilet or a brake works? Would it be better to use dynamic visuals such as an animation or a series of static visuals such as the two shown in Figure 8.6? While a dynamic visual such as an animation might seem to be the best way to communicate movement, there are some practical and psychological reasons to use simpler visuals such as line drawings with movement indicators. Also, on the practical side, animations cannot be easily delivered on as wide a variety of media as line drawings. For all

Figure 8.6. Two of a Series of Static Visuals to Teach How a Toilet Tank Works.



How a Toilet Tank Works



When the handle is pressed down, the connecting rod is pulled up, causing the lower disk to rise and press against the upper disk, pushing it up. Water is forced to the top of the siphon pipe and down into the toilet bowl.

From Mayer, Hegarty, Mayer, and Campbell, 2005.

intents and purposes, animations require media such as video or computers that support dynamic visuals. When delivered on the Internet, the more complex animations require more bandwidth than still drawings. Also, process animations are generally more costly to produce compared to static drawings. Finally, from the learner's psychological perspective, animations may impose greater mental work because animations display a great deal of visual information that typically plays outside of learner control. That is, the pacing of the animated sequence is at a predetermined speed. Therefore, the amount of transient visual information may overload working memory capacity.

Research on Static vs. Dynamic Graphics to Build Mental Models

Mayer, Hegarty, Mayer, and Campbell (2005) compared learning from narrated animations with learning from a series of static visuals described by text such as the example shown in Figure 8.6. Their experimental lessons focused on four different topics: how a toilet tank works, how brakes work, how lightening forms, and how waves form. In all experiments, the static visuals led to learning that was as good as or better than the dynamic visuals. The effect sizes were in the medium to high range. In these experiments, the learner had no control over the animation. In other words, they could not pause or replay it.

Boucheix and Schneider (2009) evaluated learning of a three-pulley mechanical system from lessons that used various formats for static visuals as well as animations. They found that a series of static visuals shown together on a page led to better understanding than a single static frame, a series of static visuals shown one at a time, or an animated display. An important lesson from this experiment is the benefit of placing static visuals together on a page or screen. When shown one at a time (with the previous visual disappearing when a new one appears), the learner must hold the previous images in memory while viewing the newer image, thus imposing additional mental load. In a second experiment, Boucheix and Schneider (2009) allowed learner control over the animation but did not find any positive effects on learning compared to animations that played without control.

We are still learning when and how to best render transformational graphics. Based on evidence to date, we recommend relying on a simpler representation consisting of a series of static visuals explained with text that the learners can view at their own rate. Be sure to keep each stage in view on the same page or screen to avoid split attention.

GUIDELINE 4: USE INTERPRETIVE VISUALS TO COMMUNICATE ABSTRACT CAUSE-AND-EFFECT RELATIONSHIPS

Interpretive visuals are representations of relationships designed to build a cause-and-effect mental model. They often depict abstract concepts, principles, or laws involving interactions among phenomena that are invisible such as molecular motion or genetic inheritance.

Gyselinck and Tardieu (1999) compared the effects of (1) text alone, (2) text accompanied by visuals that only represented elements of the text, and (3) text accompanied by visuals that illustrated the relationships described in the text on understanding of Boyle's Law. You can compare the representational and interpretive versions of these visuals in Figure 4.7. The researchers found that all illustrations resulted in better learning than text alone for both recognition and problem-solving questions. However, the visuals that showed the relationships were more beneficial than those that only displayed elements of the text.

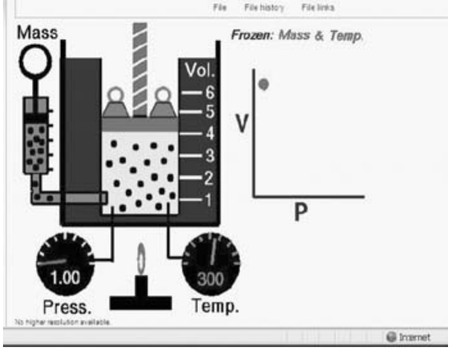
These positive effects of illustrations were noted immediately after reading and on a delayed test a day later. Gyselinck and Tardieu conclude that "The results reported indicate that pictures that highlight the relationships between the objects being described in the text are the most beneficial for readers, allowing them to build connections in order to draw inferences" (pp. 214–215).

Manage Mental Load in Interpretive Graphics

Take a look at the visuals in Figure 8.7, which is a capture from an animated graphic representation of Boyle's Law (the relationship between gas volume and gas pressure). This animation is a more scientific representation of Boyle's Law than the graphic illustrated in Figure 4.7. How do you compare the two depictions of Boyle's Law? For what goals and learners might each be more appropriate?

Notice that the animation in Figure 8.7 uses both symbolic and realistic representations of pressure with the gauges and weights. Note also this visual integrates a relational visual (line graph on the right) and an interpretive visual (tank schematic on the left) to illustrate Boyle's Law. Lee, Plass, and Homer (2006) compared the effects of several graphic representations on students' understanding of Boyle's Law. All versions were simulations that allowed students to

Figure 8.7. A Screen Capture from an Animated Interpretive Visual on Boyle's Law.

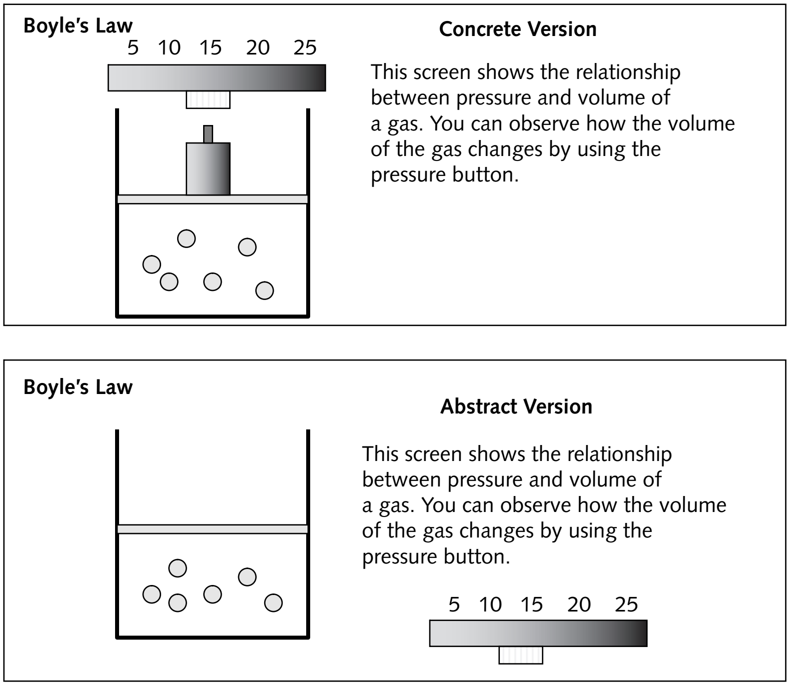


From Wikipedia, September 2009.

manipulate the pressure and see the effects on the volume. As shown in Figure 8.8, a concrete simulation used a weight as a realistic representation of pressure, while a more abstract version used a slider bar only. Students with minimal background in science benefited from the concrete version. In contrast, high prior knowledge students learned equally well from the concrete and abstract representations.

In our opinion, the familiar images of a balloon and mountain shown in Figure 4.7 will impose less mental load than the animated version shown in Figure 8.7 and would be more effective for younger or novice learners. However, for a more experienced learner familiar with graphs and the gas laws, the more complex interface in Figure 8.7 might guide a deeper understanding.

Figure 8.8. A Concrete Simulation Interface (Top) Led to Better Learning Among Novices and Younger Learners Than the Abstract Interface (Bottom)

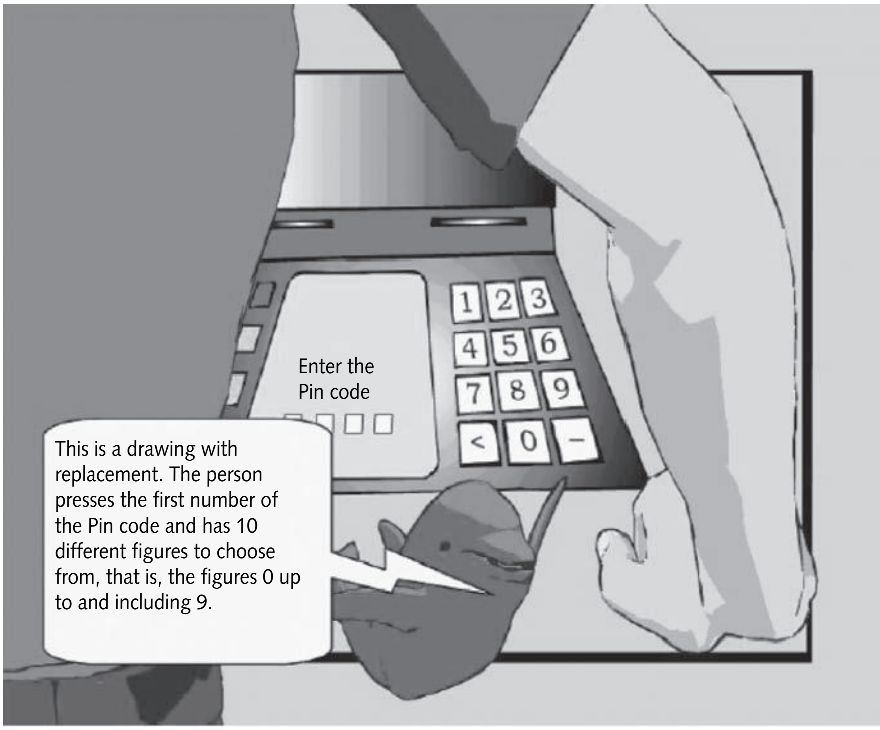


Adapted from Lee, Plass, and Hormer, 2006.

GUIDELINE 5: USE ANIMATED ONLINE AGENTS TO MODEL THINKING PROCESSES

An online agent is a graphic character included in an asynchronous e-learning lesson to serve as a social model. Agents may assume a human, animal, or even inanimate persona. They typically appear on most screens in the lesson and may serve various purposes, including giving explanations, offering hints, providing feedback, or directing attention to important on-screen visual elements. Figure 8.9 shows a screen from a probability lesson using the pin code on an ATM machine to illustrate the concepts of probability calculations when drawing from

Figure 8.9. An Online Agent Explains the Probability Concept of Drawing with Replacement.



From Wouters, Paas, and van Merroenboer (2008).

a pool of items with and without replacement. On this screen the dolphin agent directs attention and explains the concept of drawing with replacement.

Moreno, Mayer, Spires, and Lester (2001) found better learning in a botany lesson in the presence of an agent than from the same lesson with the same content but lacking an agent. Other experiments, however, have not found agents to improve learning. As with many instructional methods, to be effective a learning agent must support the psychological processes we review in this section. An agent placed simply for entertainment purposes may be distracting and impede learning.

Wouters, Paas, and van Merrienboer (2008) review and summarize evidence supporting best-practice guidelines for use of animated agents to promote learning of concepts and far-transfer tasks through cognitive modeling. In cognitive modeling, the agent provides explanations in which the tacit knowledge of an expert is made explicit as a sample problem is demonstrated. They recommend the use of agents to (1) engage learners by asking a question before giving an explanation, (2) present simpler real-world problem explanations before more complex problems, (3) present examples and problems that vary, (4) use spoken rather than written explanations, and (5) segment explanations with pauses between them to avoid mental overload.

THE BOTTOM LINE

Cause-and-effect mental models are stimulated by visuals that depict relationships among lesson concepts. We have seen evidence that simpler explanatory visuals are usually more effective than text alone or complex graphics—especially for learners who are new to the subject. Specifically, we recommend use of:

- Outlines as graphic organizers for simple texts
- Two-dimensional graphic organizers for more complex text
- Static line drawings to illustrate “how it works” content
- Familiar graphs such as bar charts to communicate quantitative relationships
- Use of concrete rather than abstract representations of state changes for novice learners
- Online agents to model thinking processes

COMING NEXT

Transfer of learning is the outcome of effective instruction. In some situations the behaviors learned during training are to be applied more or less the same way on the job. In other situations, a deeper understanding is required to enable workers to adapt knowledge to new and unanticipated work situations. In the next chapter, we discuss what we know about transfer of learning and consider how best to select or design visuals to promote positive transfer.

For More Information

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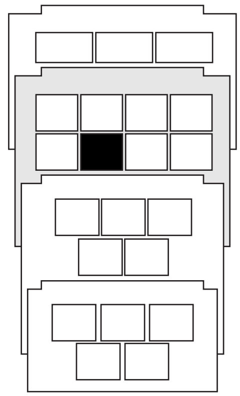
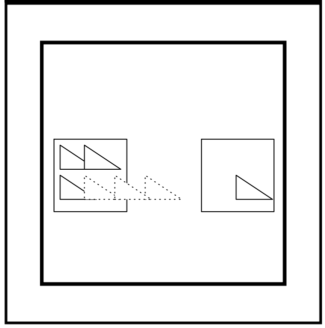


CHAPTER OUTLINE

CHAPTER 9



Plan Graphics That Support Transfer of Learning

Transfer is the bridge from skills learned in the training setting to skills applied in the workplace. When learning transfers, individuals apply new knowledge and skills acquired during training to their work roles. Without transfer, there is no return on the training investment. In spite of its importance, transfer failure is common. Merging workplace and instructional contexts and building mental models are two fundamental paths to learning transfer. Ways to use visuals to promote transfer differ for near- and far-transfer learning. In this chapter we present research, psychology, and examples to support the following transfer guidelines:

- For near-transfer skills, use dynamic visuals that reflect workplace context.
- Design 3D training worlds that incorporate the workplace context.
- For far-transfer skills, build mental models by using:
  - Interpretive and transformational static visuals to explain processes
  - Dynamic visuals to illustrate interpersonal skills
  - Varied context visuals to build more transferrable mental models
  - Visual interfaces that promote immersive learning

TRANSFER AND WORK PERFORMANCE

Without transfer of learning, there is no payoff to training. And, unfortunately, transfer failure is more often the rule than the exception. The previous chapters in this section have summarized ways to use graphics to direct attention, activate prior knowledge, manage mental load, and help learners build new mental models in memory. Even if your instruction successfully supports all these processes, without transfer of learning the effort is mostly wasted. Transfer is the bridge between learning in the training setting and performance improvement in the work setting. Without that bridge there will be no return on the training investment.

The Cost of Transfer Failure

Transfer failure is a common result of formal training programs. Your learners get an A on your test in class but, back in the workplace, they do not do anything differently than before they attended training. This means that learning occurred but job performance did not improve. In an extensive review of transfer of learning, Haskell (2001) concludes that "most of the research on employee training clearly shows that, although millions of dollars are spent on training in the public sector, there is little empirical evidence linking training to improved job behavior or employee attitudes" (p. 5).

In this chapter we will consider ways visuals interact with the psychological processes that underlie transfer of learning. Of course, transfer is influenced by multiple factors other than visuals. We believe that most of us have unrealistic expectations of isolated training events. To effect lasting change, a more inclusive and sustained effort on performance improvement is essential. For a broader discussion of transfer refer to Clark (2008) and Haskell (2001).

Transfer and Retrieval

Transfer of learning relies on a psychological process called *retrieval*. Since all thinking occurs in working memory, new mental models built in long-term memory (LTM) during learning must be brought back into working memory when needed in the workplace. The transfer of new mental models from LTM into working memory is called *retrieval*. Successful retrieval requires the right "hooks" embedded in the new mental models that can be triggered by the job environment. For example, newly learned procedures of how to use a software system will be retrieved when the learner sees the same screens in the work setting as those used during the training. Viewing these screens on the job should activate the new skills.

The retrieval hooks must be embedded at the time of learning—when the new mental models are first formed. If the software training did not use the same screens and steps that the learner will use on the job, the retrieval hooks may not be adequate to ensure transfer. In this chapter we will look at what kinds of graphics can provide the best hooks for transfer. We start by distinguishing between two types of transfer: near and far.

NEAR- VERSUS FAR-TRANSFER TASKS

Some work activities are performed the same way each time. For example, accessing e-mail typically involves the same steps applied in the same sequence. We call these types of routine tasks *near transfer*. Most procedures are considered near-transfer tasks. Procedures are typically trained by demonstrating how to perform the procedure followed by practice on equipment or problems similar or identical to those used on the job. Because the actions learned in training are very similar to the actions needed on the job, procedures are near transfer. There is only a small psychological distance between what is learned in training and what is required on the job. The majority of software training involves building near-transfer skills.

In contrast, *far-transfer* tasks do not have one single correct approach. Successful accomplishment of far-transfer tasks requires the workers to adapt what they have learned to each unique situation. For example, an effective salesperson uses a different approach depending on the product, the client's needs, and the relationship he or she has with that client. These non-routine tasks require judgment to adapt newly learned skills to each unique job situation. Therefore, the gap from the learning environment to the performance environment is considered far. In the next sections, we summarize the best ways to use visuals to promote near and far transfer.

CONTEXT IS KING FOR NEAR-TRANSFER SKILLS

In 1901 the famous American educational psychologist Robert Thorndike proposed that successful transfer requires new skills to be learned in exactly the same context in which they will be applied. He called his transfer principle *identical elements*. According to identical elements, transfer will be better when newly trained tasks incorporate most of the same features of tasks performed on the job.

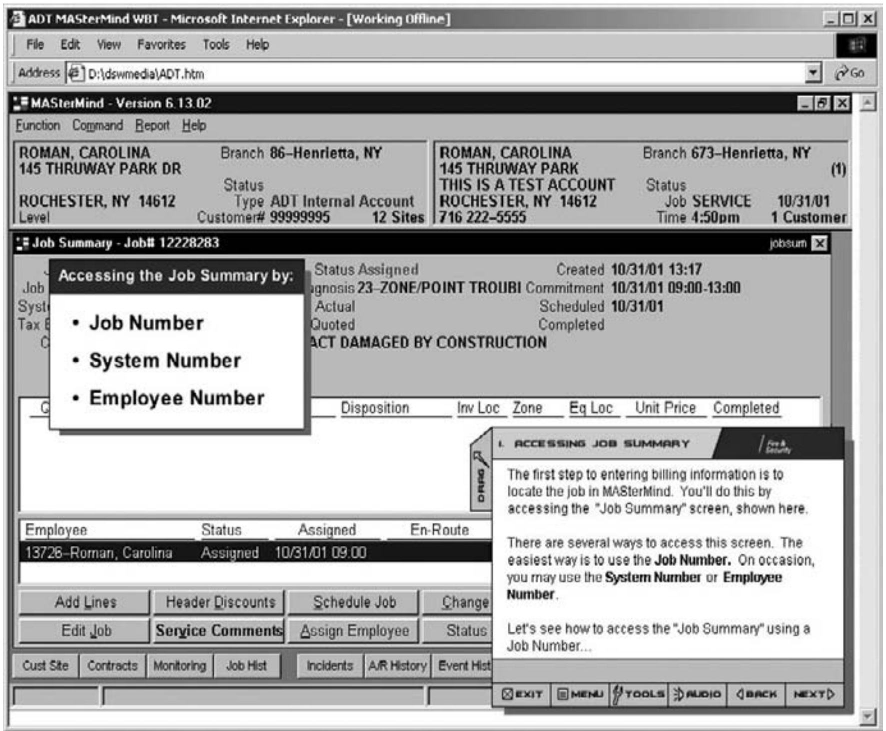
For example, years ago when the Windows operating system was first introduced, those who had previously worked on a Macintosh were able to make a smooth transition with little training. The elements in the Windows and the Macintosh systems overlapped sufficiently to support a positive learning transfer from one to the other. Both use a mouse and require drag-and-drop types of interactions. However, the Windows environment had few common elements for DOS users, who were used to typing in commands. As a result many DOS users needed training on Windows.

You can easily apply the identical elements principle to near-transfer tasks because they are performed more or less the same way and in the same context each time. Once you define the job context, you need to duplicate it during training. For example, if teaching a new software system, the instruction should provide demonstrations and practice using the same screens and interactions that will be used on the job. The benefits of incorporating job context into training is one reason job analysis is such an important prerequisite activity of course development.

GUIDELINE 1: USE DYNAMIC VISUALS THAT REFLECT WORKPLACE CONTEXT FOR PROCEDURES

Demonstrations are one of the most powerful instructional methods for teaching procedures. A demonstration illustrates the steps to complete a procedural task. Recent research comparing static with dynamic visuals for procedural demonstrations favors dynamic representations. Ayres, Marcus, Chan, and Qian (2009) found that a video showing how to tie a complex knot resulted in better and faster learning than a series of still shots taken from the video. Wong, Marcus, Ayres, Smith, Cooper, Paas, and Sweller (2009) found a similar advantage of computer animation to demonstrate origami paper folding. This recent evidence recommends use of computer animation or video for demonstration of hands-on skills such as equipment assembly, computer software use, or first aid techniques. For optimal transfer, that dynamic visual should incorporate the relevant sights and sounds of the workplace. For example, Figure 9.1 from an online software training course uses a screen capture from the new system to demonstrate the procedure and to provide practice.

Figure 9.1. One Screen from New Software Training.

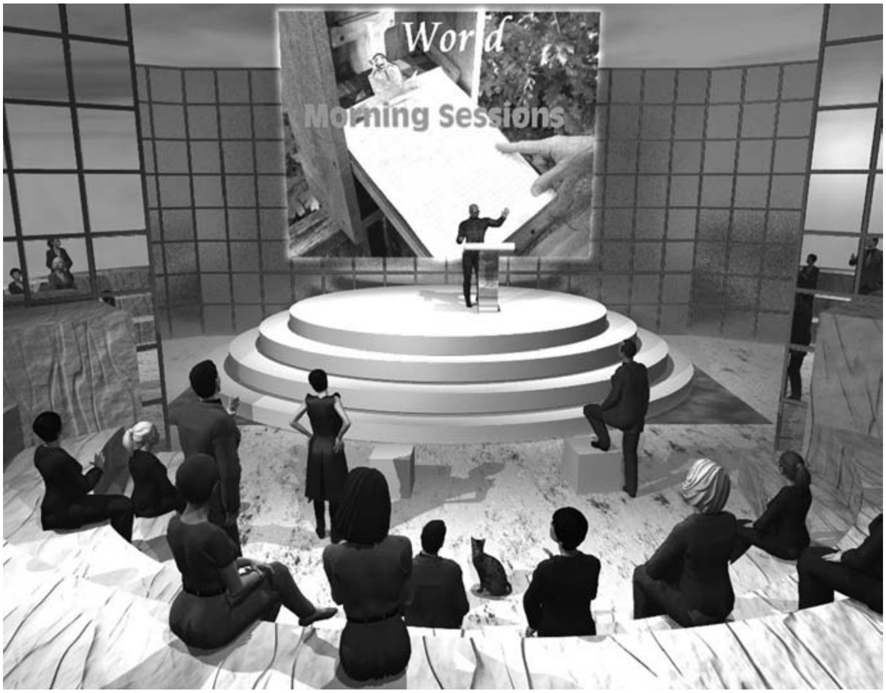


With permission from MicroTraining Associates.

GUIDELINE 2: INCORPORATE WORKPLACE CONTEXT IN 3D WORLDS

Three-dimensional "islands" or worlds are springing up throughout the learning landscape. Recent technology makes it increasingly easy to create and immerse learners in three-dimensional virtual worlds for training purposes. Some organizations have used these technologies to create virtual classrooms in which avatars sit in virtual chairs and watch a virtual PowerPoint presentation. Figure 9.2 illustrates a typical example. However, to most effectively leverage the identical elements principle, interfaces should mirror the workplace environment. For example, Figure 9.3 shows a 3D panoramic interface of a warehouse to illustrate a pharmaceutical

Figure 9.2. A Virtual World Classroom.



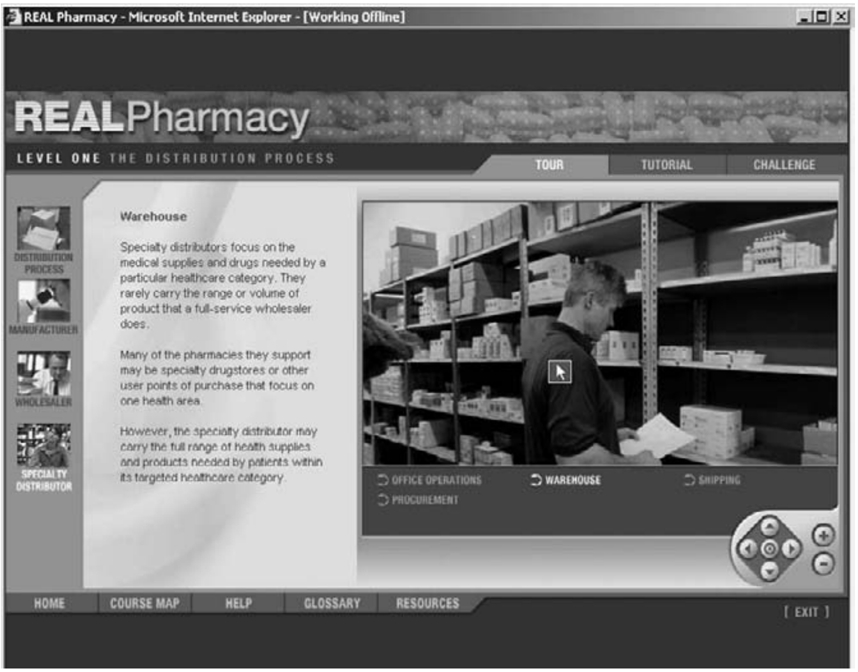
Credit: Mark A. Palmer.

distribution environment. Virtual environments that replicate a classroom setting such as the one shown in Figure 9.2 may be counterproductive. Part of the problem with many real school settings is that they are both physically and psychologically removed from work environments and therefore fail to support transfer. For that reason, using a school metaphor for an online course designed to teach job-relevant skills and knowledge is often a step backward. Later in the chapter we will revisit the use of immersive environments to promote learning transfer.

MENTAL MODELS ARE KING IN FAR-TRANSFER LEARNING

Because the context for near-transfer work will be more or less the same each time, it is easy to leverage the identical elements principle by using representational visuals. However, this approach won't work as well for far-transfer tasks. That's because the context of far-transfer tasks will be different each time they are performed. For

Figure 9.3. A Screen Shot from a Virtual Tour of a Pharmaceutical Distribution Warehouse.



With permission from Total Learning Concepts.

example, when a supervisor is discussing a performance problem with an employee, her approach to the task will vary depending on the specific performance problem, the employee, and the work setting. Therefore, showing a single example of how to handle a performance problem is insufficient to help the learner build a skill base flexible enough to adapt to her own diverse situations. Transfer success requires the instructional environment to extend beyond the identical elements principle. Successful transfer for far-transfer tasks will require the learners to build a mental model of sufficient complexity to adapt their skills to ever-changing situations.

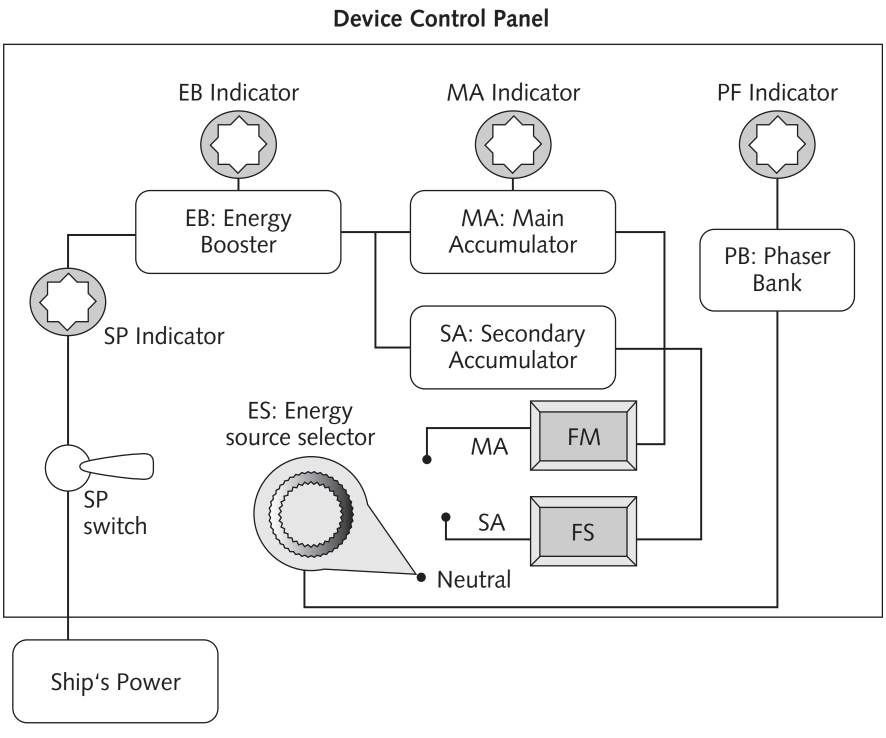
We will discuss four graphic approaches to help learners build deeper mental models: (1) transformational and interpretive static graphics to build cause-and-effect process knowledge, (2) dynamic visuals to illustrate interpersonal skills, (3) varied context visuals to illustrate concepts and principles, and (4) immersive visual environments for experiential learning.

GUIDELINE 3: USE STATIC VISUALS TO ILLUSTRATE HOW THINGS WORK

Process mental models are the basis for understanding how things work. The things in question may be mechanical, scientific, or business work flows. Some sample processes include how the heart works, how electrical components affect equipment operation, or how your tax return is processed. As we saw in Chapter 8, both transformational and interpretive visuals can help build process mental models. We also described evidence in Chapter 8 that a series of still visuals is just as or more effective than an animation to illustrate how things work (Mayer, Hegarty, Mayer, & Campbell, 2005).

Interpretive visuals such as the control panel schematic shown in Figure 9.4 also communicate how things work. Learners who studied this schematic to build

Figure 9.4. A Schematic Diagram of a Control Panel.



Adapted from Kieras and Bovair, 1984.

an understanding of how the equipment works were able to use the equipment more efficiently and resolve equipment failures more effectively than learners who were trained only in the operational procedure (Kieras & Bovair, 1984). The deeper understanding arising from training that went beyond step-by-step procedural training paid off in improved job performance.

GUIDELINE 4: USE DYNAMIC VISUALS FOR INTERPERSONAL SKILLS

Previously in this chapter we saw that video or animations were effective to teach procedural skills. Dynamic visuals in the form of video or animations are also more effective than text alone to promote learning of skills that involve social situations such as supervisory and management training, sales training, teacher training, or allied health education.

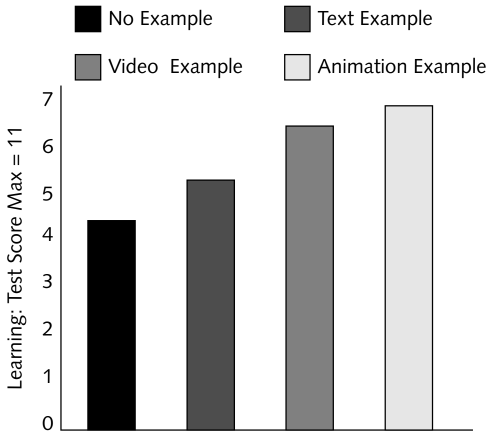
Text vs. Video vs. Animated Examples in Teacher Training

Moreno and Ortegano-Layne (2008) compared learning from three lesson versions that varied the format of examples illustrating application of teaching principles in the classroom. First, a group of student teachers viewed a didactic explanation of the teaching principles. Next participants were randomly assigned to review examples showing how the principles were applied by an experienced teacher in the classroom. The examples were displayed in different formats. The baseline group did not view any examples and served as a comparison group. One example version was presented in the form of narrative text that described the teacher and the class interactions. A second version included a video example and a third used computer animation. All examples used the same words, regardless of mode. The video and animation example used similar visuals except the animation eliminated the extraneous visual classroom activity that was captured in the video version. The researchers compared application learning among the different versions. Figure 9.5 shows the results. As you can see, the text narrative examples were minimally effective. In contrast, both the video and the computer animation examples led to better learning.

Why Dynamic Visuals May Be Better

In a classroom scenario demonstration, no doubt both video and animation can communicate complex visual and auditory information more faithfully than

Figure 9.5. Learning from Teaching Examples Using Text, Video, or Computer Animation.



Adapted from Moreno and Ortegano-Layne, 2008, Table 2.

text narratives. Along the same lines, Kamin, O'Sullivan, Deterding, and Younger (2003) reported that medical students had much richer discussions of a patient case after viewing a video presentation of the case than after reading a text narrative of the case. The medical students viewing the video reported that they felt as if they were responding to a real patient. When visual and auditory cues are important elements of an example, either video or computer animation can provide more complete information. In addition, the increased realism of the visual scenarios may prompt deeper learner engagement.

Video vs. Computer Animations

Moreno and Ortegano-Layne (2008) found that the animation examples were as effective as video examples for learning purposes and both received positive student ratings. In fact, the research team felt the animations might be *more effective* than video because much of the irrelevant classroom activity displayed in the video version was eliminated in the animation. From a production perspective, animations can often be updated easily and may be more cost-effective to produce than video.

Moreno and Ortegano-Layne (2008) found that dynamic classroom examples in video or animation format were more effective than text narratives. However, they did not test the effects of static visual examples. It is possible that a series of static visuals with audio would be as effective as the dynamic formats. We will need more research to define the learning benefits and production tradeoffs of photographic static versus video or computer animated visuals for helping learners build interpersonal skills.

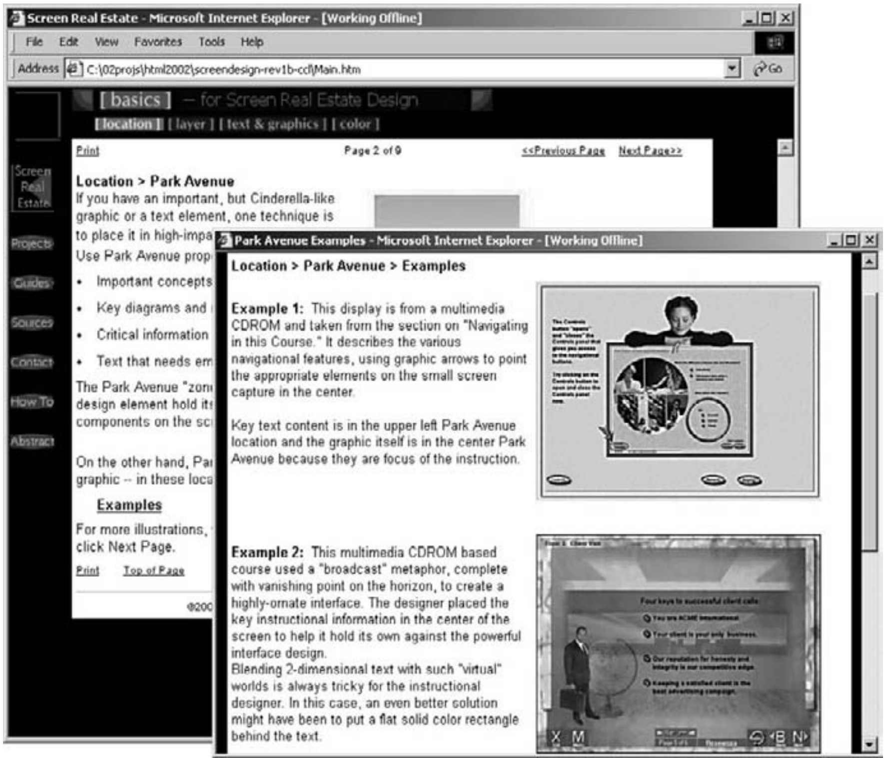
GUIDELINE 5: USE VARIED CONTEXT VISUAL EXAMPLES FOR DEEPER UNDERSTANDING

When teaching procedures, a single demonstration of how to perform the procedure is sufficient as long as the learner can stop, reverse, and replay it and it is followed by an opportunity to practice. However, far-transfer tasks are learned more effectively from several diverse examples. For example, if you want to teach children when to use a multiplication operation to solve a word problem, it is best to use several different word problems that all require a multiplication solution. One problem might involve determining the total cost for twenty-three soccer balls each priced at $15. A second example might focus on determining the amount of paint needed to cover several yards based on half a pint to cover one square yard. Transfer success relies on examples that vary on the surface, for example, cost of items and amount of paint, but are the same regarding their solution principles, that is, multiplication. A varied context approach also applies to examples that involve visuals. For example, Figure 9.6 shows a screen with two graphic examples used to illustrate guidelines for screen layout.

Research on Varied Context Visuals

Most of the research on varied context examples has used mathematical content involving algebraic or statistics word problems in which visuals played a limited role. However, one recent study used varied context visuals in a simulation learning environment. Goldstone and Son (2005) compared transfer learning from a conceptual simulation that used either realistic or abstract visuals in the interface. To help learners induce principles of competitive specialization, the concrete simulation version used graphics of ants and food similar to the one

Figure 9.6. Multiple Diverse Examples of Screen Design.



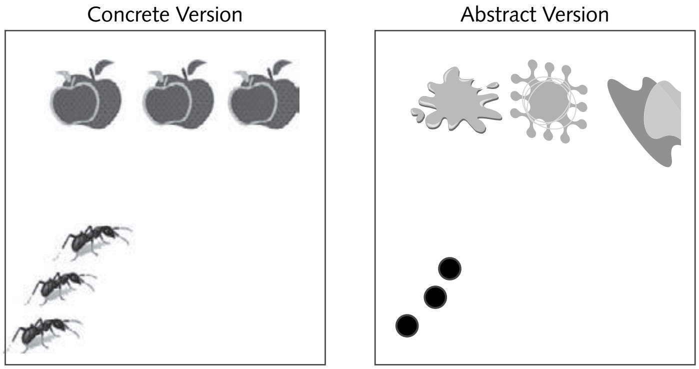
With permission of C. Lyons.

shown in Figure 9.7. The abstract version replaced ants with dots and food with blobs. Both the concrete and the abstract simulations operated according to the rules of competitive specialization.

Four simulation combinations were tested:

1. Two working sessions with the concrete version using the ants and food visuals
2. Two working sessions with the abstract version using the dots and blobs
3. A third combination in which learners first worked with the concrete ant interface followed by the abstract interface
4. A fourth combination in which learners worked first with the abstract interface followed by the concrete interface

Figure 9.7. A Concrete and an Abstract Version of a Simulation.



Adapted from Goldstone and Son, 2005.

After working on their assigned simulation versions for twenty minutes, participants completed a multiple-choice quiz and then were timed as they worked through a second test simulation that used a different interface but operated under the same rules of competitive specialization. Group 3, which started with a concrete interface (ants and food) and then used the abstract interface (dots and blobs), achieved best learning on the multiple-choice quiz as well as best transfer to the test simulation. Consistent with previous research, Goldstone and Son (2005) recommend presenting simulation materials with varied rather than consistent visuals. Secondly, they recommend starting with a concrete representation and evolving to a more abstract representation. The concrete representation reduces mental load during initial learning, while the abstract representation helps learners extend the principles to a more generalized context.

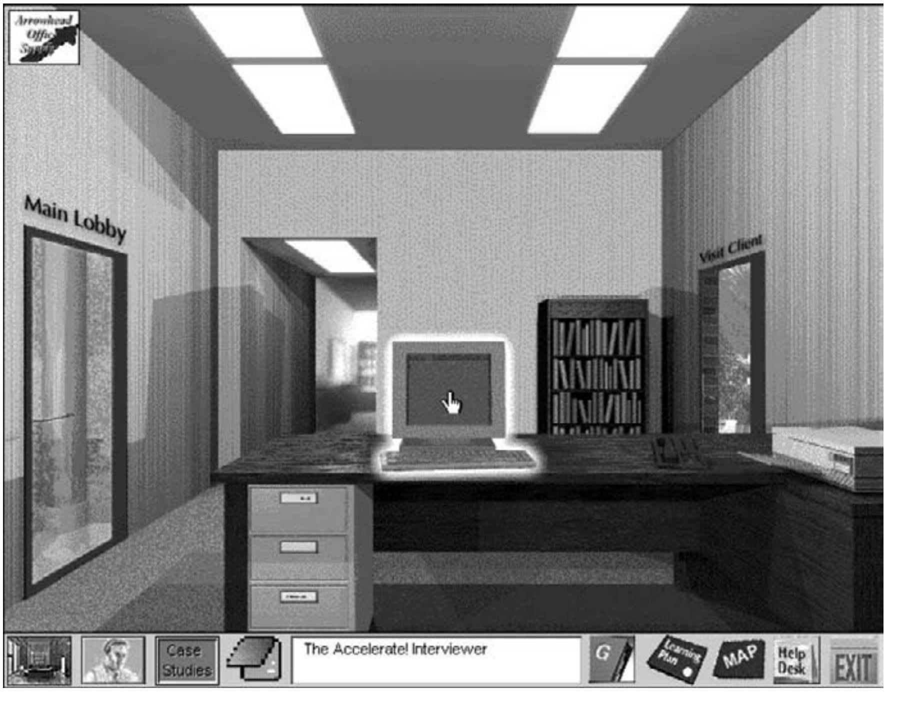
In summary, when teaching far-transfer tasks such as how to handle a performance problem, provide several video or computer animation examples that use different contexts. One animation could show a performance problem discussion involving an employee who did not know the correct procedure and needed information and training. Another scenario could show a different performance problem involving repeated unexplained absence from work. Studying the diverse examples helps learners to build a flexible mental model they can adapt to their own unique work situations.

To transition from concrete to abstract interfaces, consider ways to decontextualize concrete interfaces to more idealized or abstract representations. For example, when teaching ideal gas laws, we saw in Chapter 8 that beginners benefitted from a concrete simulation that used weights to illustrate pressure and a flame to illustrate heat. However, after working with a concrete version, switching to a more abstract interface using slider bars and gauges may improve transfer.

GUIDELINE 6: USE WORKPLACE CONTEXT VISUALS FOR IMMERSIVE LEARNING ENVIRONMENTS

When it comes to context, immersive learning environments have the potential to provide a realistic learning interface. Immersive learning environments typically assign the learner a role—often a problem to solve—and allow them freedom within the learning environment to gather data and try different solutions. For example, in Figure 9.8 an office interface serves as a portal for gathering data

Figure 9.8. An Office Graphical Interface for an Immersive Learning Environment.



Source: Moody's Analytics.

relevant to an assigned case through the virtual computer, telephone, bookshelf, and fax.

Virtual worlds represent a recent technological interface for immersive learning. In a virtual world, the learner assumes an identity through an avatar and can explore and act on the interface. One of the key ingredients in immersive learning environments is graphics. The immersive learning environments use a series of visual interfaces that reflect the context of the scenario. How effective are immersive environments for learning? When does it make sense to use an immersive environment compared to a traditional "rule-example-practice" approach?

Text vs. Virtual Worlds

Barab and her colleagues (2009) compared learning of water ecology concepts from expository text, story-line text, and virtual world lessons. They found better learning from the virtual 3D world in which pairs of learners assumed an avatar persona and were assigned a problem regarding a decline in fish population in a park. In this experiment, there were several differences among the tested lessons, including the amount and type of visuals , the amount and type of learner interactivity, as well as the novelty of the virtual world interface. The research team suggests that the virtual world benefits learning transfer compared to traditional lessons because it is by "understanding the relations of content to a particular context, one in which the learner has had experience in changing, that one is better able to see its meaning elsewhere" (p. 317). Virtual worlds are in their infancy and we will need much more research on how, when, and for whom to make best use of them.

THE BOTTOM LINE

In this chapter we have focused on transfer of learning. For either near- or far-transfer goals, context is a key principle that should drive your selection of graphics. Remember that the retrieval hooks must be planted at the time of learning. For learning of procedures, graphics should emulate the performance environment. However, for learning of more far-transfer skills, consider graphic illustrations that build mental models, use varied context, transition from concrete to abstract, and provide a work context for immersive learning environments.

COMING NEXT

Learning is hard work and requires effort. Motivation to initiate a learning task and to persist in the face of difficulty is the driving force behind learner effort. Interesting instructional materials can influence motivation. However, decorative graphics are often used and misused to add interest to instructional materials. In the next chapter, we look at how to use visuals to make screens and pages more interesting in ways that do not disrupt learning.

For More Information

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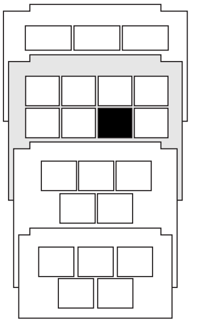
CHAPTER OUTLINE



CHAPTER 10

Plan Graphics for Motivation and Learning

Experience and research evidence tell us that lessons with graphics are more interesting than lessons with text alone. It's common to see graphics liberally added to slides, workbooks, and multimedia screens to enhance the motivational quality of the materials. However, not all visuals added for motivation are compatible with learning. In this chapter we will review evidence on motivation and learning to support the following guidelines:

- Use work-context visuals for examples or case scenarios.
- Leverage social presence through learning agents in asynchronous multimedia lessons.
- For learners low in individual interest, use relevant trigger visuals to spark initial motivation.
- Minimize graphics used solely as eye candy.

MOTIVATION AND LEARNING

Think of a learning event that you initiated in the last year. It might have been a formal educational program such as starting an MBA. Or it might have been learning a skill of personal interest such as a ski class or a self-study Italian language series. What factors prompted you to initiate that learning event and what did you achieve? How did your motivation play a role in selecting a learning goal, investing effort, and /or dropping out? How did the instructional materials influence your interest and commitment to your goal?

Motivation is the fuel that prompts us to select a learning opportunity, invest effort in the learning process, and persist to complete a learning goal. Whether as a student or as an instructor, all of us have experienced motivation or the lack thereof when it comes to training. In fact, some researchers estimate that motivation alone accounts for close to 50 percent of achievement during learning (Means, Jonassen, & Dwyer, 1997). Coaches and expert performers consider desire to succeed as the most important factor for success in any given domain (Zimmerman, 2006).

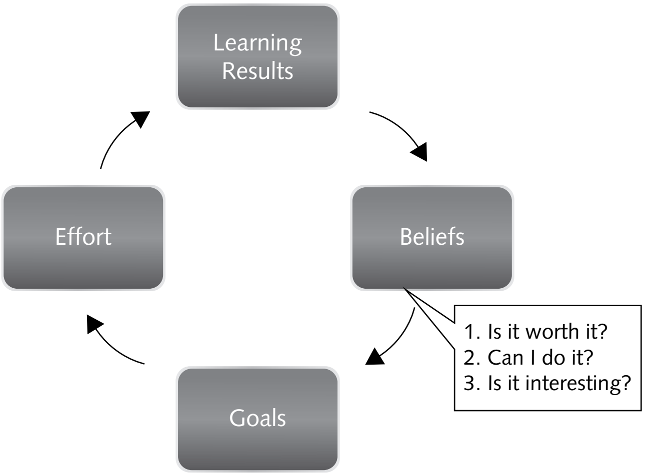
Although motivation has been a research focus for many years, only recently have instructional researchers incorporated motivational measures and models into their experiments and theories of learning. Researchers in cognitive load recently acknowledge that "instructional manipulations to optimize the cognitive load have little effect unless learners are motivated and actually invest mental effort in processing the instructions" (Paas, Tuovinen, van Merrienboer, & Darabi, 2005, p. 26). Moreno (2005) proposes a "cognitive-affective theory of learning with media" that explains the mediating effects of motivation on learning through a greater investment of attention and consequent deeper mental engagement in a lesson.

Goals, Beliefs, and Motivation

Motivation grows from several sources—sources internal to the learner as well as embedded in the instructional environment. As summarized in Figure 10.1, motivation is mediated by goals to succeed that drive focused attention and mental effort. Goals, in turn, are shaped by several internal beliefs. The three most important beliefs influencing goals are value, confidence, and interest.

- *Value* refers to the familiar trainer's expression: WIIFM (what's in it for me?). In other words, how will a specific learning event promote my goals? An MBA might be useful as a credential that leads to better job opportunities. A class in supervisory skills might hold high value for a newly promoted supervisor. A golf lesson might offer inherent satisfaction in improving one's game.
- *Confidence* refers to the learner's belief in his or her capability to achieve a learning goal. When we lack confidence, we will tend to not set goals or to set low bar goals that won't drive maximum effort.

Figure 10.1. The Cycle of Motivation.



- Finally, *interest* is an important belief in setting productive learning goals. When interest is high, motivation and consequent effort will also be high.

At the start of this chapter, we asked about a recent learning event you initiated. What were the driving beliefs behind your training effort? Did you feel that the knowledge and skills learned would provide you *value*? Were you *confident* that, with effort, you could acquire the requisite skill level? Were you *interested* in the skill or knowledge to be gained? Naturally there are many factors in addition to graphics that can influence motivation to initiate and persist to achieve a learning goal. While in this chapter we focus on the role of visuals, refer to Clark (2008) for a broader discussion of motivation.

Interest and Motivation

Individual interest is a well-developed and enduring trait that predisposes an individual to invest time and effort in a particular pursuit. Individual interest is usually the driving force behind practice and learning connected with a hobby such as golf or the choice of a college major. In contrast, *situational interest* is a feature of the learning environment itself. Typically, training materials with graphics are rated as more interesting than training materials made up of text only. Adding graphics is one technique to add situational interest to a learning environment.

Table 10.1. Types of Interest

Type	Description	Example
Personal or Individual	Interest that arises from the individual learner	Marcie is taking a self-study Italian course because she plans to spend six months in Italy.
Situational	Interest that is generated from the training materials	Although she is not interested in science, Gina watches a colorful video documentary on the geology of the Hawaiian Islands.
Situational—Triggered	Attention-getting techniques used in introductory learning phrases to hook learners lacking personal interest	The documentary on the geology of the Hawaiian Islands starts with dramatic visuals of volcanoes and tsunamis.
Situational—Maintained	Interest in an instructional environment that is sustained and may lead to personal interest	After reviewing several documentaries on the geology of the Hawaiian Islands, Gina decides to visit Volcanoes National Park and searches the Internet for additional scientific papers on volcanoes.

Table 10.1 summarizes several types of interest, including *individual* (also called personal) and *situational.*

There are two main types of situational interest: *triggered* and *maintained.* *Triggered* situational interest refers to lesson additions that catch the learners' attention with features that stimulate emotional arousal such as color, graphics, and stories. *Maintained* situational interest comes from learning environments that project meaningfulness and value.

How do situational and individual interest relate to one another? For someone new to a skill domain lacking individual interest, triggered situational interest can be an important hook to draw him or her in. The hope is that gradually the motivation spurred by triggered situational interest can evolve to maintained situational interest which, if continued, builds individual interest (Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Hidi & Renninger, 2006). Consider, for example, a student taking an introductory college class in psychology. Knowing little about the topic, she may not have any defined level of individual interest. This student, however, may be initially hooked by a learning environment that embeds features such as graphics, color, interesting stories, and other types of engagement. Gradually, if the lectures, readings, and activities reflect value and personal meaningfulness, maintained situational interest holds the learner, culminating in enduring individual interest.

In the guidelines to follow, we recommend using graphics that help learners see relevance and value in the training and that trigger interest for learners who lack personal interest. Here it's especially important to rely on your analysis of the learner profile, the learning environment, and the work environment. We caution against over-reliance on eye-candy visuals that generate interest but run the risk of distracting attention and depressing learning. Instead, we recommend the use of graphics that support learning processes.

GUIDELINE 1: USE DYNAMIC VISUALS THAT DISPLAY WORK CONTEXT

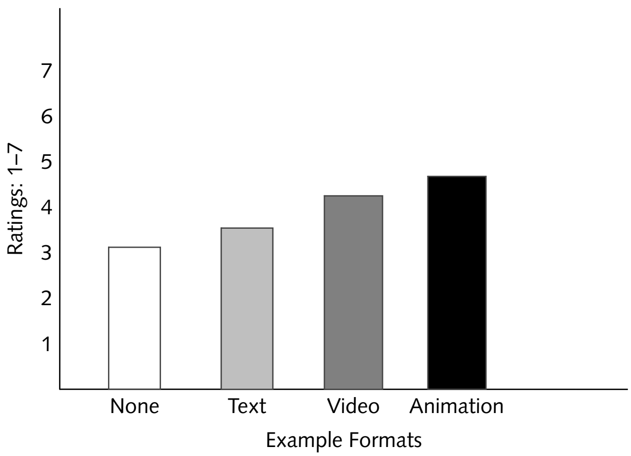
Suppose you are a new supervisor starting a multimedia course on basic supervisory skills. Perhaps the lessons start either with a talking head or a series of slides with text describing some common employee problems that new supervisors must resolve. Alternatively, you view a short video showing a supervisor approaching a problem employee, for example, someone who is habitually late to work. Which would be more motivational—lead-off scenarios presented with text or lead-off scenarios presented in video? Where possible, consider dynamic visuals that project relevance in the form of illustrative examples or case-study scenarios.

Evidence on Visuals, Motivation, and Learning

Moreno and Valdez (2007) and Moreno and Ortegano-Layne (2008) compared learning and motivation among student teachers after viewing classroom teaching case examples presented in text, in video, or in computer animation. After viewing information on effective teaching practices, student teachers viewed case examples of how to apply those practices in the classroom. The case examples were presented as text narratives or as dynamic visuals with sound. The dynamic visuals used either video or computer animations to illustrate the interactions between the model teacher and the class. In Chapter 9 we saw that the video and animated versions led to better learning. Here we turn to participant ratings of the lesson versions summarized in Figure 10.2.

As you can see, the video and computer animation case examples led to higher ratings than the text examples did. The research team concludes that presenting dynamic examples of classroom teaching scenarios "may also promote learning by increasing students' motivation and, in turn, attention" (p. 462). Kamin, O'Sullivan, Deterding, and Younger (2003) offer further evidence that a work-context case-study video can prompt deeper mental processing then text alone. They found that discussions among medical students who viewed a video patient case reflected more critical thinking than discussions among medical students who read a text narrative version of the same case. In domains such as supervision, allied health, cultural awareness, teaching, and sales that involve complex visual and auditory cues associated with interpersonal communications, dynamic visuals such as video or animation can reveal relevant information that is qualitatively different from information in a text narrative. In addition, the realism of these dynamic

Figure 10.2. Student Ratings of Examples in Text, Video, and Animations.



Based on data from Moreno and Ortegano-Layne, 2008, Experiment 2.

visuals may lead to greater engagement due to an increased perception of work relevance and hence value. For example, the medical students viewing the video case reported that they felt as if they were diagnosing a real patient.

How to Use Work-Context Visuals in Scenarios

There are several ways you can incorporate relevant visuals into your lessons. Here we consider three possibilities: (1) examples, (2) culminating cases, and (3) contexts for scenario-based learning. Whether you are teaching in a classroom or via multimedia, video or animated demonstrations make excellent examples of principles involving interpersonal skills. Following a presentation on key guidelines, show several dynamic examples that illustrate how to apply those guidelines in different settings. And to maximize benefit from the examples, make them interactive. For example, ask learners to identify places in the video where the principles are displayed. Alternatively, pause the video and ask learners to consider how they would respond to the situation at that point. The second way you can use video or graphical scenarios is as the basis for case studies. For example, Figure 10.3 on the next page includes a screen capture of the interface for an automotive troubleshooting case study. This case uses animations of a car and shop testing tools as the context for applying all the troubleshooting guidelines that had been taught in previous lessons. While case studies such as this one can serve as an end-of-lesson practice event, instructional designs called *scenario-based learning* use them early in a lesson to provide a learning context. In scenario-based learning the lesson starts with the case and embeds supporting elements including case data, virtual experts, and standard tutorials to help participants to resolve the case (Clark, 2009a, 2010). We discuss these immersive visual environments in Chapters 9 and 16.

GUIDELINE 2: LEVERAGE SOCIAL PRESENCE THROUGH LEARNING AGENTS

What lesson features lead to interest and motivation? In a meta-analysis of student ratings of classroom courses, Sitzmann, Brown, Casper, Ely, and Zimmerman (2008) found that positive ratings were highly associated with social presence in the classroom. Classes in which the instructor was psychologically available

Figure 10.3. A Realistic Automotive Shop Interface. Visual interfaces like this one make the learning value immediately salient.

With permission from Raytheon Professional Services.

(rather than distant) and classes that incorporated overt communication both with the instructor and among the students were correlated with higher ratings. Mayer (2009) recommends application of his personalization principle, which states that learning is better when multimedia lessons use conversational language that includes first-person (I, we) and second-person (you) pronouns and use a friendly human voice for audio.

When learners feel a social connection, they are more likely to engage in deeper mental processing than when social presence is lacking. One way to promote social presence in self-study instructional materials (typically lacking real-time interactions with others) is to add a learning agent that assumes a useful instructional role. For example, the agent may point to important elements of the screen, offer hints to complete exercises, or give explanatory feedback to learner responses.

Figure 10.4. The learning agent in the lower-left corner offers feedback to learner responses to the customer.

With permission from Vcom3D.

Figure 10.4 shows the learning agent who provides explanatory feedback in the lower-left corner. In this branched scenario lesson that teaches customer service skills, the learner selects the best statement to make to the customer, hears and sees the customer response (in the upper-right corner) and then listens to feedback from the learning agent.

We are still researching how to best use on-screen learning agents. Mayer (2009) as well as Moreno (2009) found that the voice rather than the image of the agent is most important to its effectiveness. Lusk and Atkinson (2007) report that an agent in the form of a parrot was more effective when it used gestures and gaze to draw attention to relevant parts of the screen compared to a static on-screen agent or to no agent. Recent research is also considering different roles agents can assume to promote learning. Craig, Sullings, Witherspoon, and Gholson (2006) found that learning of basic computer literacy concepts was better when learners observed a question-answer dialog between two agents than when the learners made active responses to questions in the program.

For now, we recommend that you use agents to add social presence to asynchronous e-learning and give them a useful instructional role such as signaling important content, providing feedback, or giving advice. Be careful, however, that your agent does not lead to divided attention or redundancy—both sources of irrelevant mental load. For example, if your main instructional graphic is a complex visual, it might be best to use audio narration alone by playing the voice but omitting the image of the agent.

GUIDELINE 3: CONSIDER USING RELEVANT TRIGGER VISUALS TO CATCH INITIAL INTEREST

Compare Figures 10.5, 10.6, and 10.7. All three screens are designed to teach retail professionals how to apply dual control when transferring product from the vault to the sales counter. Which of the screens are of greater interest? Which of the screens do you think will lead to better learning?

As we discussed in our introduction, learners lacking interest in a particular training topic can be drawn in by lesson elements such as color, graphics, or dramatic stories that trigger situational interest. A number of research studies tell

Figure 10.5. A Text Explanation of Dual Control.

From Clark, 2009b.

Figure 10.6. A Text and Graphic Explanation of Dual Control Version 1.

From Clark, 2009b.

Figure 10.7. A Text and Graphic Explanation of Dual Control Version 2.

From Clark, 2009b.

us that lessons with graphics are rated as more interesting than lessons that rely on text alone (Harp & Mayer, 1998; Moreno & Ortegano-Layne, 2008; Moreno & Valdez, 2007; Park & Lim, 2007).

Durik and Harackiewicz (2007) compared the effects of math workbooks that added color and graphics to trigger situational interest with workbooks lacking such treatments. The researchers compared learner task interest and task involvement in the two lessons between learners with high and low initial individual interest in math. They found that the versions with greater visual interest (color and graphics) led to deeper task involvement among individuals with low initial math interest. Interestingly, however, the more colorful graphic materials actually undermined interest and involvement of those who started with a high initial interest. The researchers suggest that the added colors and graphics "were distracting for individuals with high initial interest in math because they may have wanted to receive the learning material in the most straightforward way possible without being bothered by visual complexity inherent in the layout of the instructional materials" (p. 606). Learners with more expertise are often "annoyed" by graphics they find "patronizing" or redundant of their own knowledge.

Means, Jonassen, and Dwyer (1977) reported similar findings when comparing lessons on heart structure and function. They created two lesson versions: low and high situational interest. The low situational interest version used a traditional textbook approach that simply presented the facts about the heart. The high situational interest version used human-interest stories, concrete language, visuals, and analogies. Two groups of learners studied the two versions. One group consisted of physiology students who had higher individual initial interest in this topic. A second group was drawn from statistics students whose individual interest was lower. Individuals who were already interested in the topic did not benefit from the embellished lessons. In contrast, the higher situational interest lessons promoted learning among learners lacking individual interest.

In summary, we suggest that you use visuals and visual effects such as color to add interest, especially when the learner population is lacking individual interest in the training topics. Compliance courses are a good candidate for such treatments. Course attendance is usually required—often the same course year after year. Therefore, many learners do not see value nor do they have much interest in these courses. Motivation for learning is low. Using scenarios, visuals, and other emotional adjuncts may be helpful in these situations. However, as you will see in our next guideline, over-reliance on visuals for the purpose of arousal can be a slippery slope.

GUIDELINE 4: MINIMIZE GRAPHICS USED SOLELY AS EYE CANDY

Graphics designed to trigger situational interest through emotional appeal or arousal have been shown to increase engagement among learners lacking their own individual interest in a topic. However, Mayer (2009) found that adding interesting words and pictures that were related to a lesson topic but irrelevant to the learning objective had a strong negative effect on learning. Mayer and his colleagues tested six lessons on the topic of how lightning forms. The basic versions used visuals and words to provide a straight forward explanation of how lightning forms, as illustrated in Figure 4.1. The spiced-up versions added emotional-appeal visuals and text that discussed the effects of lightning on airplanes, statistics about swimmers killed by lightning, and so forth. Although related to the lesson topic, these added visuals and text were not relevant to the lesson goal to learn how lightning forms. In fact, the research found that these additional stories and visuals were distracting and depressed learning.

We have much to learn about how to use visuals that both stimulate interest and promote learning. For now, we recommend that you use graphics to portray relevance and value and to clarify meaning, especially for learners who are lacking in interest. Let's reconsider Figures 10.5, 10.6, and 10.7. The versions in Figures 10.6 and 10.7 include visuals and would likely be rated as more interesting than the text-only version. However, the photograph in Figure 10.6 is eye candy and does not contribute to learning. Instead, we recommend the graphic shown in Figure 10.7. This visual adds interest and, at the same time, clarifies the meaning of the text, and in so doing, will support learning.

THE BOTTOM LINE

Visuals are an important tool as lesson motivators. Use visuals that reflect work context to make the relevance and value of the lesson salient. Make online lessons more personable through the use of learning agents. Visuals to add interest as introductory hooks are especially helpful for individuals lacking personal interest in the learning goals or content. Finally, avoid visuals that serve only as eye candy in lieu of graphics that support understanding.

COMING NEXT

In this section of the book we have concentrated on how visuals and visual effects can promote essential psychological learning events such as attention, management of mental load, and building of mental models. However, do all individuals process visuals alike? We've alluded to differences between expert and novice learners. However, what about learning styles or spatial ability? Do some learners profit more from visuals while others benefit from audio?, The next chapter addresses individual differences in learners proven to affect the processing of graphics.

For More Information

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Harackiewicz, J.M., Durik, A.M., Barron, K.E., Linnenbrink-Garcia, L., & Tauer, J.M. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. J*ournal of Educational Psychology, 100*, 105–122.

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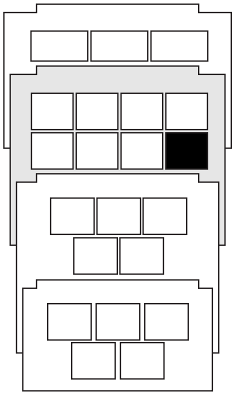
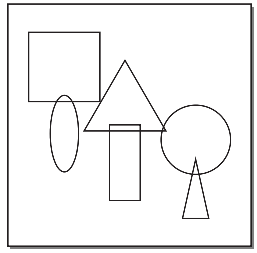
Woo, H.L. (2009). Designing multimedia learning environments using animated pedagogical agents: Factors and issues. *Journal of Computer Assisted Learning, 25*, 203–218.

CHAPTER OUTLINE



CHAPTER 11



Plan Graphics to Leverage Individual Differences

That some people benefit more from graphics than others is a pandemic belief in the training community. Unfortunately, the focus on visual and verbal learning styles is a misconception that distracts us from individual differences that really do matter. In this chapter we will review evidence regarding which differences among individuals do influence learning from visuals. We will consider differences regarding learning styles, spatial ability, and prior knowledge. Evidence on how individual differences affect learning from graphics supports the following guidelines:

- Drop the myth of visual learning styles.
- Emphasize visuals for beginners.
- Provide "just-in-time" training to help learners interpret visuals.
- Encourage all learners to process visuals effectively.

DIFFERENT STROKES FOR DIFFERENT FOLKS?

"I'm a visual learner."

"We use text and audio to accommodate learning styles."

Statements such as these are common and reflect prevalent ideas about significant individual differences among learners. Learning style theories come in different flavors. In fact, a bevy of "learning style" tests that categorize individuals as visual learners, global learners, intuitive learners, analytic learners, and so forth are common tools in many training organizations. However, most relevant to our discussion is the concept of visual learning styles. Individuals with a visual learning style are believed to benefit from materials with graphics; individuals with verbal learning styles benefit more from words.

Yet, for the amount of resources invested in learning styles, there is no compelling evidence of their validity. We have not seen any body of valid research showing reliable guidelines to improve learning based on learning styles. In fact, there is no evidence that true learning styles that influence learning processes even exist. Instead, we recommend that you focus on an individual difference that research shows does matter: prior knowledge. In truth, when we're novices, we're all visual learners.

Even though there are aptitudes known as spatial ability that differentiate learners, for most training practitioners, it's not practical to measure differences in your learners' spatial ability. And even if you can define higher and lower spatial ability, we don't know that much about how to tailor learning environments to them in productive ways.

GUIDELINE 1: DROP THE MYTH OF VISUAL LEARNING STYLES

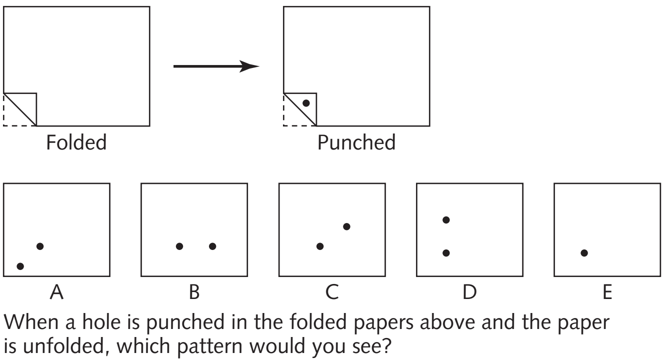
Although it's popular to discuss visual and verbal learning styles, there is little evidence to support their relevance. In fact, we can point to recent evidence that discounts them altogether. Kratzig and Arbuthnott (2006) asked sixty-five university students to complete three tasks. First, each student reported his or her learning style as either visual, auditory, or kinesthetic. Second, each student completed the Barsch Learning Style Inventory that scored him or her on three learning modalities of visual, auditory, and kinesthetic. Third, each participant completed three memory tests: (1) visual memory requiring drawing a visual image from memory, (2) auditory memory requiring recall of a story read aloud, and (3) kinesthetic memory involving placing puzzle pieces into their correct place on a board while blindfolded. If the concept of a learning style is valid, there should be some correspondence among these measures for any given individual. For example, if you state that you are a visual learner, you should score higher on the visual scale of the learning style inventory, and you should do better on a visual memory test than on auditory or kinesthetic tests.

In fact, no relationships were found among the three measures. For example, a participant might have rated him- or herself as a "visual learner." However, the Barsch Learning Style Inventory actually scored the person as an auditory learner. Furthermore, scores on the various tests did not favor any one of the three different modalities. In other words, there were no correspondences among any of the three indicators of learning styles. The authors conclude that their results raise serious doubts about specific learning styles. Instead, they suggest that learning benefits from a combination of visual, auditory, and kinesthetic learning experiences. "When one learns what a rose is, one does not truly understand this concept unless one can see the flower and its vibrant colors, feel the prick of its thorns or the silkiness of its petals, smell its distinctive odor, and hear its name" (p. 242).

Visual Learning Styles vs. Spatial Aptitude

In contrast to controversial learning styles, there are truly significant individual differences regarding spatial aptitude. Individuals with high spatial aptitude are able to mentally rotate and envision changes in two- and three-dimensional objects. Career fields such as engineering, architecture, radiology, and aviation include tasks that benefit from high spatial visualization skills. There are a number of tests that can measure spatial aptitude. For example, Figure 11.1 shows a sample question from a spatial aptitude test. Mayer and Massa (2003) compared scores on several spatial aptitude tests to learners' self-assessments of visual or verbal

Figure 11.1. One Question from a Spatial Aptitude Test.



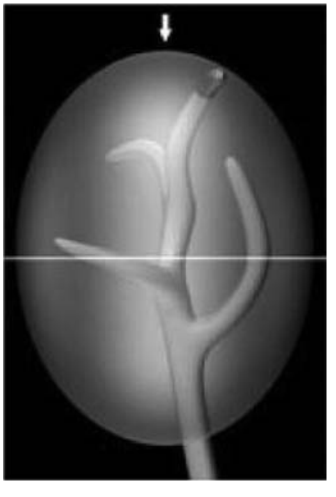
Source: Paper folding test from Ekstrom, French, and Harman, 1976.

preference. The scores on the various spatial aptitude tests correlated with one another but there was NO relationship between visual or verbal styles and spatial aptitude. In fact, individuals who indicated a high visual preference were equally divided between high and low spatial aptitude scores. Additionally, most individuals who indicated a high verbal style preference scored in the average range on spatial aptitude.

Unfortunately we don't yet have clear guidelines on how to adjust visuals for individuals with high and low spatial aptitude. A recent meta-analysis including twenty-seven studies found that learners with lower spatial aptitude benefited from 3D graphics and animations more than learners with higher spatial aptitude did (Hoffler, in press). Hoffler's analysis suggests that more complex visuals such as 3D and animations can compensate for poorer spatial ability.

Cohen and Hegarty (2007) compared performance of high and low spatial aptitude students on a spatial task that required the participant to draw a cross-section of a three-dimension object such as the one shown in Figure 11.2. Participants could rotate the object 360 degrees to view it from diverse angles, including the perspective of the cross-section. Individuals with low spatial apti-

Figure 11.2. An Imaginary 3D Object as Basis for Cross-Sectional Drawing.



From Cohen and Hegarty, 2007.

tude did not make use of the external rotation visualization aid. Apparently, it led to disorientation and hindered their performance. The most successful drawings came from high spatial ability participants who also used the visualization aid. Based on this evidence, spatial visualization aids may be most effective to guide the performance of visual tasks by individuals with high spatial ability such as engineers or radiologists.

We will need additional evidence to define what kinds of learning goals benefit from different graphic representation and representation aids among learners of low and high spatial ability.

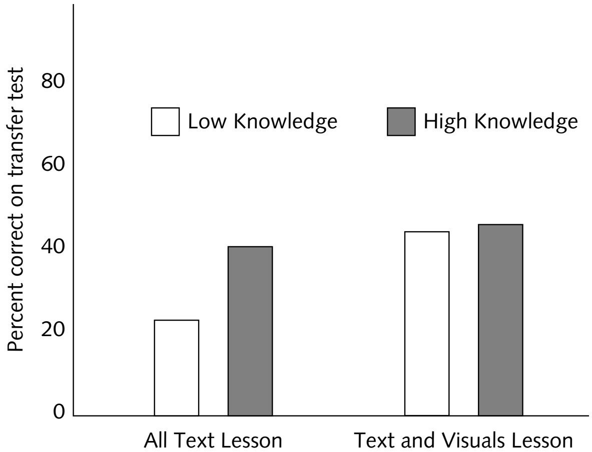
GUIDELINE 2: EMPHASIZE VISUALS FOR BEGINNERS

Starting with Chapter 1, we have presented evidence for the learning benefits of relevant visuals. For example, understanding the process of lightning formation was much better among individuals who viewed a lesson that included visuals similar to that shown in Figure 4.1 than among learners who viewed words alone. However, these experiments did not consider individual differences among learners. How might visuals affect learners who are new to a topic versus learners with some relevant background?

Mayer (2009) summarizes several experiments in which he compared learning from lessons with and without visuals among learners high and low in prior knowledge. Based on the number of correct responses to questions, Mayer classified learners as high or low in prior knowledge of weather. Then the high and low knowledge learners completed lesson versions on lighting formation with text only or with text and relevant visuals. Figure 11.3 shows data from one of these experiments. As you can see, adding relevant visuals improved learning among low knowledge learners but had no measurable effect on individuals with higher knowledge. No doubt individuals with higher prior knowledge can form their own mental images as they read the text, whereas the images help learners lacking background. Mayer (2009) cites his individual differences principle—that some design principles such as addition of visuals "may help low-experience learners but not help high-experience learners" (p. 272).

Based on consistent evidence, we recommend that you invest resources in explanatory visuals to augment text for learners who are relatively new to the lesson content.

Figure 11.3. Learning of High and Low Knowledge Learners from Lessons with Text Only Versus Lessons with Text and Graphics.



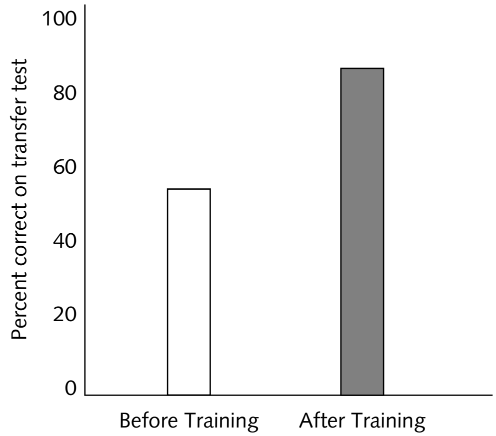
Adapted from Mayer, 2009.

GUIDELINE 3: PROVIDE JUST-IN-TIME TRAINING TO HELP LEARNERS INTERPRET COMPLEX VISUALS

In some situations a complex graphic requires some basic domain knowledge for meaningful interpretation of that graphic. In these situations, you can actually build appropriate prior knowledge as part of your learning environment. For example, when your goal is to train novice learners how to interpret a complex visual such as a weather map, a mini-lesson on weather icons and concepts presented just prior to the map can provide the relevant background to guide learning from the visual.

Canham and Hegarty (2010) asked learners to interpret wind direction from a weather map that displayed surface pressure indicators. Novice learners made predictions about wind direction while their eye fixations were tracked to assess how they directed their visual attention. Following the first round of predictions, which served as a pre-test, learners completed a ten-minute self-paced PowerPoint tutorial on key concepts relevant to wind and surface pressure followed by three examples of interpreting weather maps. After this training, participants were then asked to predict wind direction from a new set of maps while their eye movements

Figure 11.4. Proportion of Correct Predictions from a Weather Map Before and After Training.

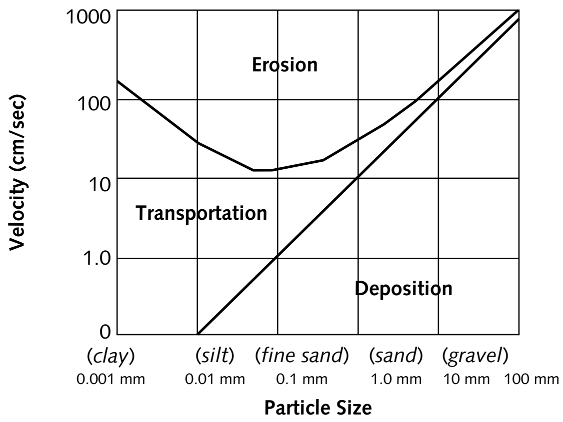


Adapted from data in Canham and Hegarty, 2010.

were tracked. As you can see in Figure 11.4, map interpretation improved greatly after the brief training. Attention measured by eye movements focused more on map elements most relevant to the task after training. Before instruction, 22 percent of the viewing time focused on relevant areas on the map compared to 66 percent after instruction.

Mautone and Mayer (2007) tested several learning aids to help individuals interpret complex graphs such as the Hjulstrom curve shown in Figure 11.5. The Hjulstrom curve shows the relationships among movement, erosion, and deposition of particles of different size in a riverbed. Participants were asked to view the graph and then write a summary of the main information they gained from the graph. The summaries were scored according to the number of statements that included relationships or causality. An example statement is "The heavier the particle, the slower the velocity needed to erode it, up to a midpoint, at which point the heavier it is, the greater the velocity required." Half the participants viewed the graph without any additional support. The other half were provided brief training using slides to provide domain knowledge. The first slide included illustrations of an underwater section of a river showing sediment undergoing erosion, movement, and deposition. The next slide showed various sediment types such as

Figure 11.5. A Hjulstrom Curve. Interpretation of this complex graph was improved by brief training provided just before studying the graph as well as a segmented presentation of the graph.



From Mautone and Mayer, 2007.

sand and gravel. Next the graph itself was presented in a series of builds that used color and shading to illustrate dynamics, starting with the smallest particle sizes and building to the larger sizes. This just-in-time training increased relational statements by 62 percent and causal statements by 44 percent.

Taken together, these two studies point to the benefits that brief, just-in-time training can offer when learners must interpret complex visual displays that are unfamiliar.

GUIDELINE 4: ENCOURAGE ALL LEARNERS TO PROCESS VISUALS EFFECTIVELY

Clearly, a visual ignored won't help learning. Learners who invest effort in studying a visual and correlate it with the text will gain more from it. *Visual literacy* is the term we use to refer to an individual's ability to learn from graphics. Specifically, visual literacy indicates a learner's inclination and ability to attend to and to process graphic information. In Chapter 4, we introduced the concept of metacognitive skill as the ability to set learning goals, select the best techniques to achieve those goals, monitor progress, and adjust as needed. Visual literacy is one expression of good metacognitive skills.

A number of studies have shown that learners may fail to make use of illustrations unless they are prompted to do so (Levie & Lentz, 1982; Schnotz, Picard, & Hron, 1993). In comparing successful and unsuccessful learners who studied a lesson that included a moderately complex visual along with explanatory text, Schnotz, Picard, and Hron (1993) found quantitative and qualitative differences between the two groups. The successful learners not only used the visual more intensively but concentrated on those aspects of the visual and the text most relevant to construction of a mental model. Likewise, Gyselinck and Tardieu (1999) report that the beneficial effect of lesson illustrations on inference test questions was limited to those individuals who invested more time to study the visuals.

Encourage Visual Literacy

There are several reasons why learners may either ignore visuals or process them in a shallow manner. In some cases, learners may have low spatial aptitude. In other cases, they may have a preference for verbal information or consider visuals as fluff that won't contribute to their understanding. In still other situations, learners with poor metacognitive skills may just not have acquired good study habits. How can you prompt your learners to maximize value from graphics?

A comparison of the study behaviors of high- and low-scoring physics students found the better learners processed problem examples deeply. In other words, better learners invested time and effort in explaining a demonstration problem to themselves. In contrast, poorer students either skipped examples completely or gave them cursory attention (Chi, DeLeeuw, Chiu, & LaVancher, 1994). One technique proven to improve learning from step-by-step problem demonstrations involves providing learners with a self-explanation question (Atkinson, Renkl, & Merrill, 2003). For example, a multiple-choice question is sequenced with a sample problem. The question asks the learner to identify the principles applied in a particular step in the sample problem. We believe a similar technique could be applied to visuals. Next to an important visual, insert a question that prompts the learner to carefully study the visual. As an example, in conjunction with the Hjulstrom curve shown in Figure 11.5, ask a question such as: "Which particles will erode most at lowest rate of water velocity? A. Very fine–smallest; B. Fine–small; C. Coarse–moderate; D. Very coarse–large." Questions such as this one should encourage learners first to attend to the graph and then, second, to derive an accurate interpretation. In Section Three on visualization of specific content types, we offer additional suggestions for ways to encourage learner engagement with visuals.

THE BOTTOM LINE

Some individuals may claim they are visual learners, while others express a preference for words. As novices we are all visual learners who can benefit from the appropriate use of both words and visuals. As we gain more domain-specific knowledge, the benefits of explanatory visuals diminish. Although claims for visual and verbal learning styles lack validity, there are truly important individual differences in spatial aptitude and prior knowledge. Based on the current state of research, we recommend that you attend most to prior knowledge to guide your use of visuals:

- First, invest most effort in explanatory visuals for low prior knowledge learners.
- Second, when your goal is to teach interpretation of a complex visual such as a weather map, provide brief just-in-time training. A mini-lesson to build domain-specific knowledge related to the relationships expressed in the visual will greatly improve learners' ability to interpret it.
- Third, to encourage deep processing of an important visual, make it interactive by asking questions that require the learner to attend and to interpret the visual.

COMING NEXT

This chapter concludes Section Two on ways to use visuals to promote the basic psychological events of learning. In Section Three we focus on how to best use visuals to teach specific lesson content. In each chapter we offer guidelines and examples on how to best visualize each of the five most common content types found in training materials: procedures, concepts, facts, processes, and principles.

For More Information

Hoffler, T.N. (in press). Spatial ability: Its influence on learning with visualizations—a meta-analytic review. *Educational Psychology Review*.

Kratzig, G.P., & Arbuthnott, K.D. (2006). Perceptual learning style and learning proficiency: A test of the hypothesis. *Journal of Educational Psychology*, *98*, 238–246.

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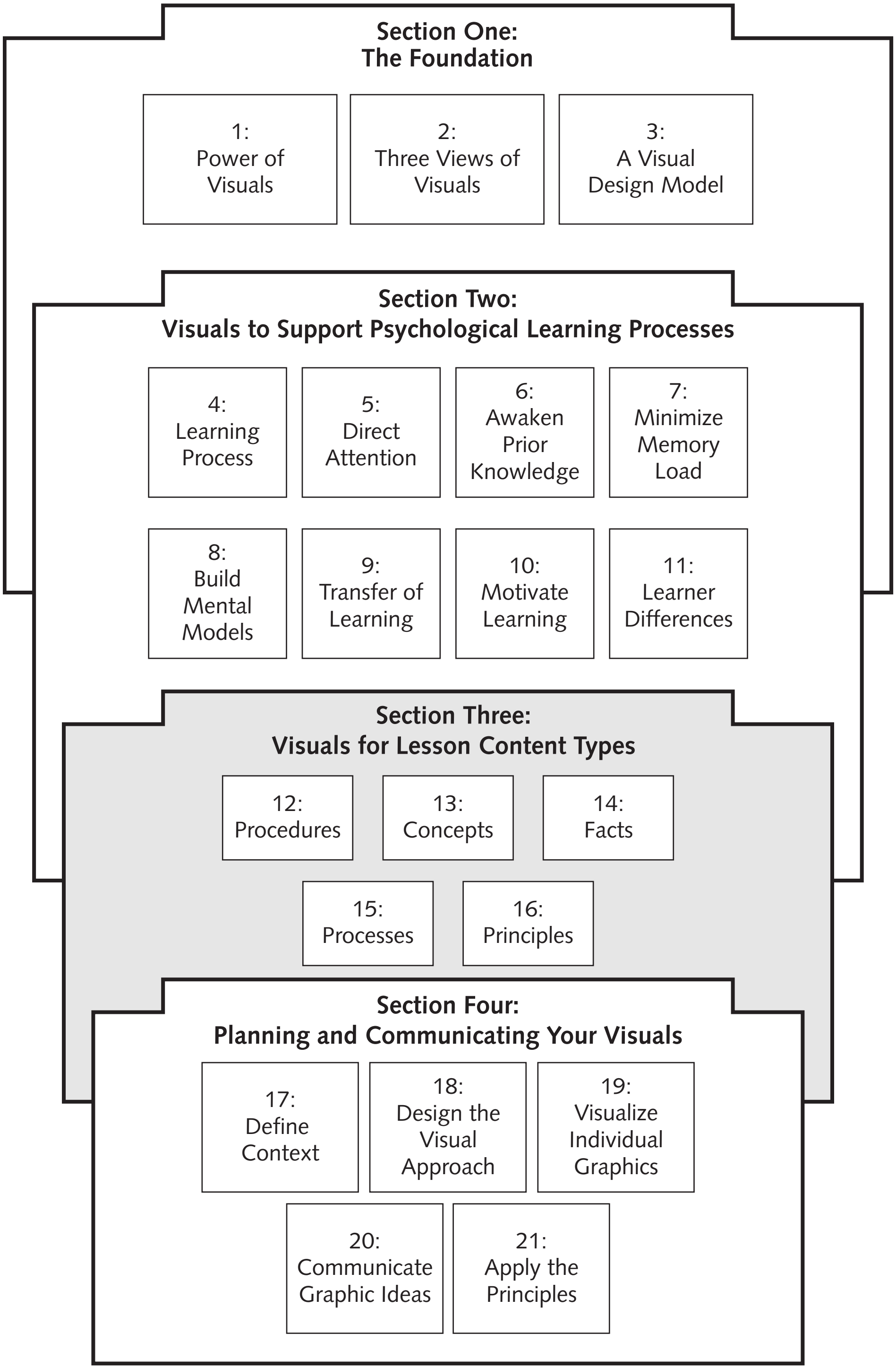

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Introduction to Section Three: How to Visualize Lesson Content

In Section Two, we looked at evidence-based guidelines for ways to plan and design visuals that support the psychological processes leading to learning. In this section we shift our focus to your lesson content. We will review best ways to visualize the following main content types: procedures, concepts, facts, processes, and principles.

HOW DO YOU IDENTIFY LESSON CONTENT TYPES?

As discussed in Chapter 3, when you apply a systematic graphics design model, one of your first activities is to define the instructional goals. Most lessons have one or two of the following goals: to inform, to help workers perform procedural (near transfer) tasks, and to help workers apply guidelines to perform principle-based (far transfer) tasks. Lessons developed to build job skills usually fall into one of the last two categories. Thus, procedural lessons will teach steps to perform routine tasks, while principle-based lessons will teach guidelines. To apply procedures or guidelines, the worker must understand related facts and concepts. In addition, any workers involved in repairing, managing, or optimizing systems will profit from process knowledge.

For example, if you are developing training on how to use a software package to create web pages, the core of your instruction will be procedures to illustrate how to implement the steps to accomplish tasks. Along the way, various concepts and facts will be needed. For instance, if you are learning to use the software to set page properties, you will need to know what page properties are and which page properties to use for specific purposes.

You will define the specific content types for your lessons during your job analysis. Through interviews and observations of experienced workers, you identify the tasks and the associated knowledge needed to perform those tasks. Once you define your content, you can consider how to visualize them in the context of the full instructional landscape. For more information on how to derive the content types during the job analysis process, see Clark (2008).

PROMOTE ENGAGEMENT WITH CONTENT VISUALS

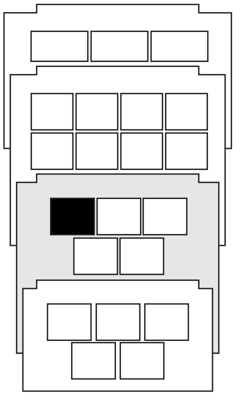
Even the best illustration for a given content type will do little good if it is ignored. Research has proven that learners who take the time to study and process visuals profit from them (Gyselinck & Tardieu, 1999; Schnotz, Picard, & Hron, 1993). It is important that you go beyond providing the best visuals for each content type to also promoting learner engagement with your visuals. Therefore, each chapter includes not only the best visuals to display specific content but also ways to promote engagement with those visuals.

USE VISUALS FOR PERFORMANCE SUPPORT

After training (or sometimes in lieu of training), workers will need memory support on the job. Commonly known as performance aids or job aids, performance help can also benefit from visuals. We discuss design of performance aids in this section.

Although this section treats each content type individually, you will see in Section Four how all the diverse content types that make up a lesson are visualized and integrated into a unified instructional product.

CHAPTER OUTLINE



CHAPTER 12

How to Visualize Procedures

Procedure content dominates training courses and job aids that help workers perform routine tasks. Procedural skills are effectively trained with demonstrations and practice using equipment and interfaces similar to those used on the job. We present research, psychology, and examples to support the following guidelines for visualizing procedures:

- Provide demonstrations that combine transformational and representational visuals.
- Demonstrate procedures with dynamic visuals.
- Manage mental load.
- Use visuals to draw attention to warnings.
- Design online procedure practice exercises effectively.

WHAT ARE PROCEDURES?

Procedures, also called near-transfer tasks, are routine tasks in which workers follow the same step-by-step action sequences each time. Common work procedures include activities such as accessing email, completing a routine customer order, changing copy machine cartridges, and measuring the electrical resistance of equipment during troubleshooting. Some procedures can be quite complex and/or have safety consequences, such as landing an aircraft or administering CPR.

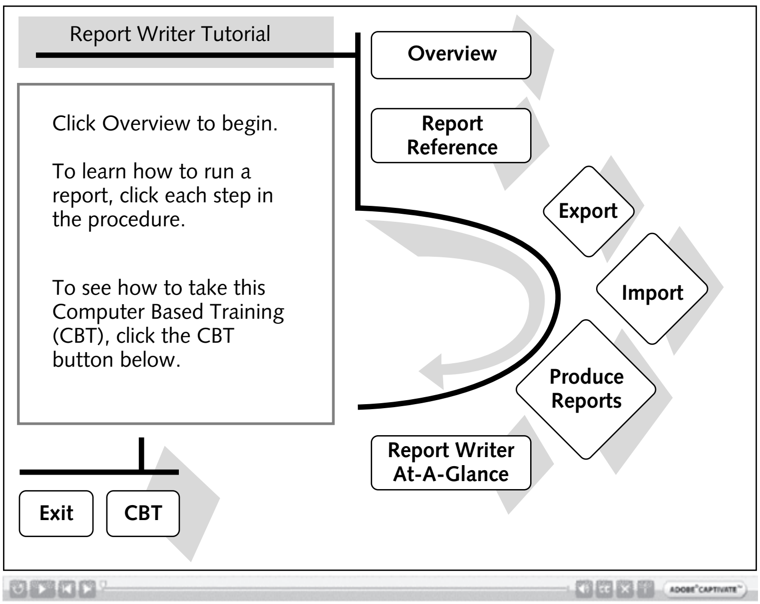
Procedures may include decisions as well as actions. Decisions in procedural tasks are clear-cut regarding specific conditions that lead to actions. Often such decisions are phrased in an *if . . . then* format. For example, routine troubleshooting procedures interlace decisions with actions such as *if the heat warning indicator flashes, check the water level in the radiator.*

TEACHING PROCEDURES

Three main techniques to teach procedures include (1) providing a high-level overview, (2) demonstrating the steps of the procedure, and (3) offering hands-on practice with job aids and feedback to support learning (Clark, 2008b, 2010).

Introduce near-transfer tasks by orienting the learner to the job context in which the procedure is used as well as how the specific procedure might fit into other job tasks. An organizational visual is one good way to orient learners to the flow of procedures involved in a series of tasks. For example, Figure 12.1 shows an online course menu that summarizes the events in the entire procedure. Organizers such as this online overview give the learner a bird's eye view of how detailed procedures for producing a report fit into an overall software process.

Figure 12.1. An Online Course Menu.



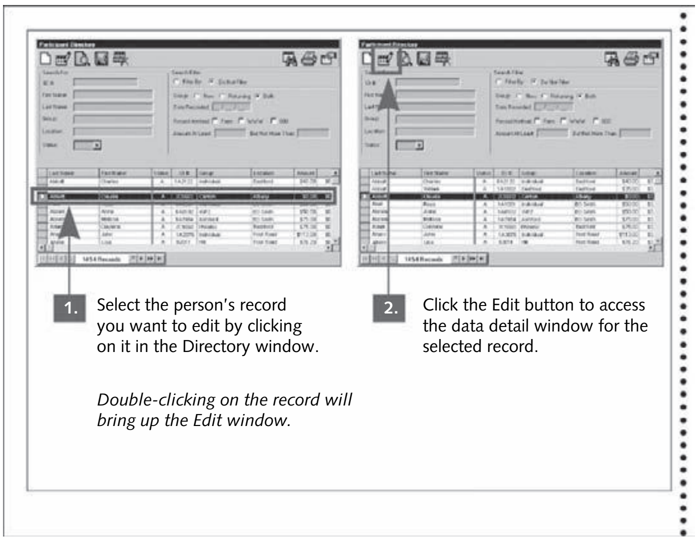
Demonstrate the procedure's steps using the same tools or components as the ones used on the job. Following a demonstration, assign practice in which learners perform the procedure using the same or similar environment as the one that will be used on the job. During practice sessions, provide feedback that lets learners know how to correct errors or complete steps more effectively. Design job aids that summarize the procedural steps in order to provide memory support during and after training.

Finally, teach learners to avoid wrong turns by way of warnings. In some cases, a wrong turn can have serious consequences—some even safety related. In other cases, a warning provided just at the moment a step is to be taken will prevent a wrong turn that could result in wasted time and frustrated users.

Performance Aids for Bypassing Training

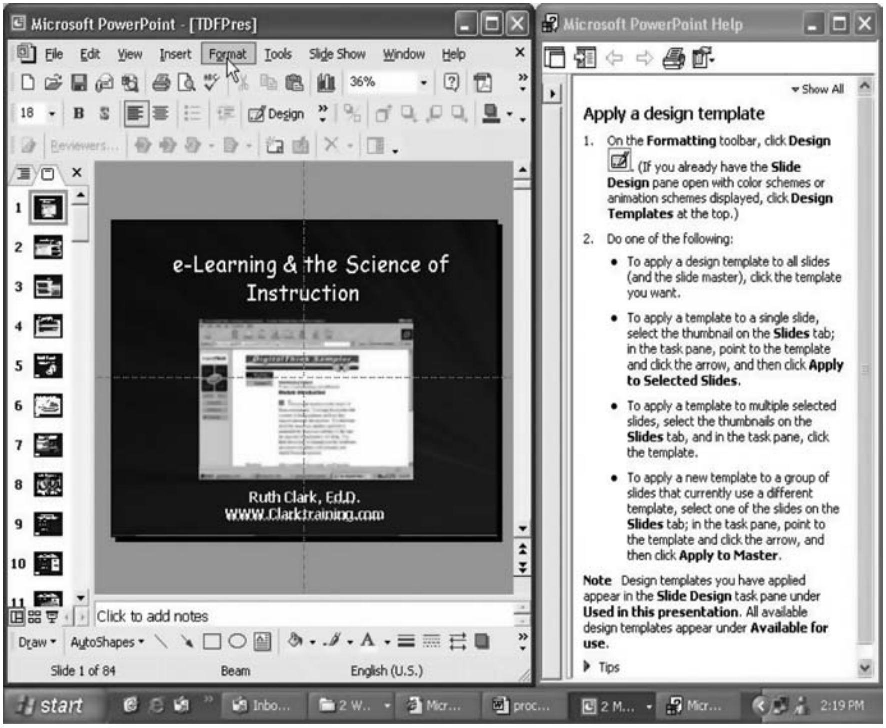
Sometimes training is not needed or feasible and the worker must perform the procedure by following directions on a performance aid. A common example is the assembly instruction sheet accompanying a new toy (beware the note, "some assembly required") or the installation directions on the copy machine toner cartridge. Performance aids can be displayed on computer screens, cards, on equipment, or in manuals. For example, Figure 12.2 shows a print job aid for a

Figure 12.2. A Procedure Job Aid.



Credit: Mark A. Palmer.

Figure 12.3. A PowerPoint Help Screen.



With permission from Microsoft Corporation.

computer procedure and Figure 12.3 shows a step-by-step guide as part of a software help system. Since performance aids must stand on their own, the clarity of the instructions is critical. Likewise, inserting appropriate warnings into performance aids is also important since the workers are usually on their own to resolve any glitches they encounter along the way.

When training is necessary, work aids such as the one shown in Figure 12.2 can be used as memory support for performance back on the job. These aids are especially important for procedures that are performed relatively infrequently. Because training programs cannot usually afford to provide explicit demonstrations and practice on every possible procedure that might be needed, effective design and display of performance aids is critical to support work outcomes.

In this chapter we summarize several guidelines for designing visuals that will help learners build procedural skills.

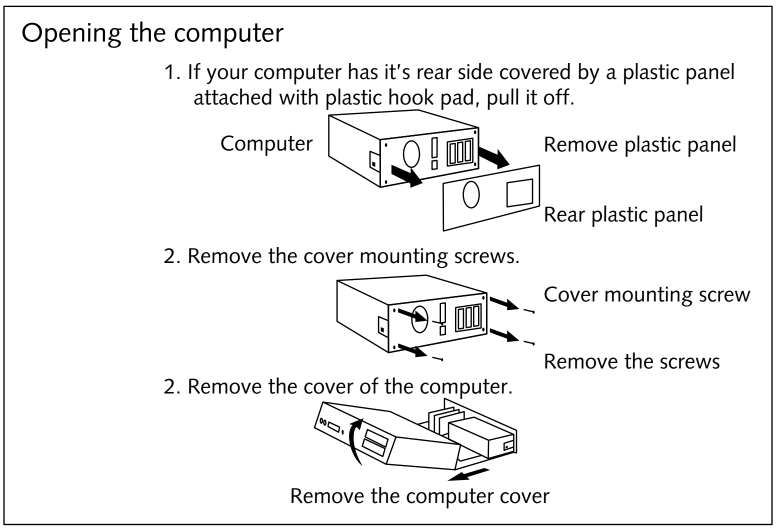
GUIDELINE 1: COMBINE REPRESENTATIONAL AND TRANSFORMATIONAL VISUALS IN DEMONSTRATIONS

Help your learners acquire new procedural skills by demonstrating them in the same context as they will be performed in the work setting. Visuals that depict the equipment, screens, or relevant physical components used on the job promote transfer of learning. Thus, a transformational visual that incorporates representational visuals of the actual equipment or computer interface should serve as the main graphic element of any demonstration or performance guide. For example, in demonstrations of computer procedures, use graphics of the screens involved in the procedure as shown previously in Figure 5.3. In directions for equipment assembly or use, use visuals of the equipment as shown in Figure 12.4.

Evidence for Benefits of Visuals to Guide Procedures

Van der Meij, Blijleven, and Jansen (2003) report significant learning benefits from including full-screen captures in software manuals rather than relying on text alone or on parts of screens. The use of full-screen shots sequenced in a left-to-right layout such as shown in Figure 12.2 resulted in learning completion times that were 25 percent faster with 60 percent better retention of skills.

Figure 12.4. Directions for Equipment Procedure.



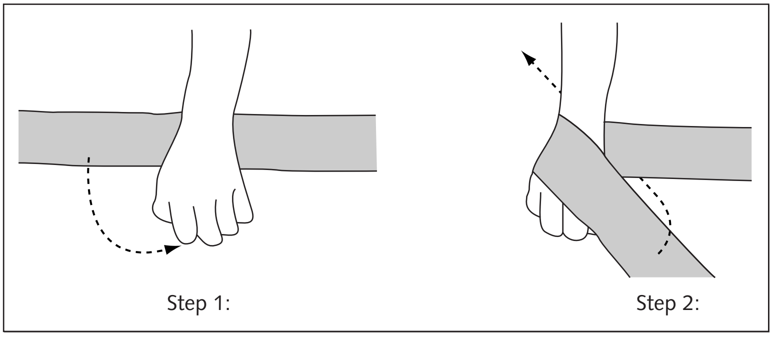
Source: van der Meij, Blijleven, and Jansen, 2003.

Marcus, Cooper, and Sweller (1996) reported increased efficiency when they used diagrams only compared to text only to present directions for connecting resistors in moderate to complex configurations. In some experiments, those using diagrams completed the task five times faster. Watson, Butterfield, Curran, and Craig (2009) found that a thirty-three-step assembly task was completed 56 percent faster from visual displays than from text descriptions. The degree of learning or performance efficiency improvement seen in these studies suggests that incorporating visuals in procedural training or working aids will generate a return on investment in the production costs of the visuals and the use of display real estate to show them.

GUIDELINE 2: DEMONSTRATE PROCEDURES WITH DYNAMIC VISUALS

You can render a transformational visual as a series of static images, as shown in Figure 12.5, or as a dynamic image via video or computer animation of the steps involved. Which is more effective for demonstrating procedures? Research that has emerged since our first edition suggests that a dynamic visual is best. Ayres, Marcus, Chan, and Qian (2009) assigned high school students to three-minute lessons demonstrating how to tie three different complex knots using either video or a series of static images from the video recording. No words were included in either lesson version. After viewing the visuals, learners were asked to complete all three knots without reference and were scored based on the number of correct steps completed. Figure 7.6. shows the results indicating that the dynamic versions resulted in much better learning as well as faster performance on the test. Wong and her associates

Figure 12.5. Static Visuals with Arrows Used to Illustrate Steps.



(2009) found similar learning advantages of animated demonstrations of how to perform origami paper folds compared to static images using arrows to illustrate the folds. Watson, Butterfield, Curran, and Craig (2009) reported animated working aids illustrating a thirty-three-step assembly task resulted in task completion that was 56 percent faster than text directions, while static diagrams resulted in task completions that were 28 percent faster than text directions.

Monkey See, Monkey do

Although animations offer a great deal of visual information, research on monkeys described in Chapters 4 and 7 suggests that a *mirror neuron* has evolved in the primate brain to absorb and learn from motion demonstrations without overloading working memory. Based on current evidence, we recommend you use a dynamic visual to demonstrate procedures. Naturally, when working in a print medium, you will need to stick with a series of static visuals that use arrows and other motion indicators.

Show Actions in Context

Whether displaying procedures with animated or still visuals, show the steps in job context from the performer's perspective. Using an over-the-shoulder video shot or three-dimensional perspective in a drawing gives the learner an accurate frame of reference.

For example, Figure 12.6 shows a graphic designed to show novices how to replace the car headlight bulb. Note, in the before version, there is no indication whether you are viewing the left or right headlight assembly, so a novice could

Figure 12.6. An Equipment Procedure Shown Out of (Before) and in (After) Context.

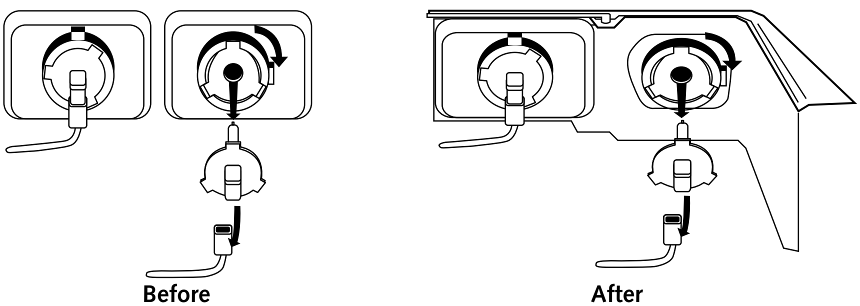


Figure 12.7. A Drop-Down Menu Shown in Whole-Screen Context.

Source: Marily Jones, Micro Training Associates.

easily be confused and replace the high beam bulb instead. Note that the corrected drawing (after), includes the side of the car, so that the novice user can identify which bulb is being replaced. Similarly, computer demonstrations should demonstrate steps in context of the full-screen application as in Figure 12.7.

Use Transformational Visuals in Print Media That Show Action Flows

Van der Meij, Blijleven, and Jansen (2003) found that a large number of visuals (80 percent in software manuals and 48 percent in hardware manuals) used only flat pictures. Flat pictures are representational rather than transformational. The authors note that "In software manuals the most striking finding for picture type used is the overwhelming presence of flat pictures. These pictures are all screen captures of which the majority are positioned within the action steps. The absence of any labeling or flow probably means a missed opportunity" (p. 171).

Instead of isolated flat pictures, visuals should be labeled and show flow such as in Figures 12.2 and 12.5. For the computer procedure in Figure 12.2, the visual uses a horizontal left-to-right alignment, visible numbers, and integrated action steps to show the sequence of actions and outcomes. For equipment procedures, flows can be shown with three-dimensional line drawings supported by arrows, as shown in Figure 12.4.

GUIDELINE 3: MANAGE MENTAL LOAD

Overload can readily occur when novice learners view a complex interface such as a video or computer-animated demonstration. Recent research points to a number of techniques you can use to manage load when using dynamic visuals to demonstrate procedures.

1. Use Visual Cues to Direct Attention

For a representational visual that is complex or a transformational visual that is an animation (with or without audio narration), use visual cues to direct attention. Jeung, Chandler, and Sweller (1997) report that narrating a demonstration is only helpful when a visual cue draws the eye to the visual elements being described. Visual search requirements are much higher when explanations "play" at an external rate of pacing, such as an animation with audio narration. Note, for example, that the demonstration represented by a screen capture in Figure 5.3 uses a combination of animation and narration to demonstrate a procedure. Visual cueing (arrows and highlighting) draws the eye to the relevant part of the screen. Figure 12.2 is a paper version of the same procedure. The lines and circles connect the text steps to the relevant portion of the screen and are colored in red to further cue the viewer.

2. Use Audio to Explain Animated Demonstrations

When you explain a demonstration in audio, you effectively use the visual and auditory centers of working memory and thus maximize the limited capacity of working memory. Thus, the learner can observe the actions and at the same time hear a coordinated description of the actions. As mentioned above, because narration typically runs at a pace outside the control of the observer, it's important to use visual cues to help the learner focus quickly on the parts of the equipment or interface being described. Such animation sequences should be short and involve no more than four or five steps (7 +/− 2). One successful technique is to provide a summary of all steps in a procedure in text on the screen throughout the animation. As each one is explained, the relevant text is highlighted with some cueing device. This technique provides the learner the overall picture, highlights how the individual step fits into that picture, and elaborates on the specifics of each step. Always provide a replay button allowing the learner to review both the visuals and the words describing the visuals.

3. Provide Memory Support for Use During and After Training

As mentioned previously, training often does not provide sufficient practice opportunities for learners to build automatic performance. Therefore, learners need some form of memory support during practice exercises and when they return to the job. Memory support can take the form of brief text that summarizes the steps illustrated in a transformational visual or short text bullets that remain on the screen during a narrated sequence, as shown in Figure 5.3. The bullets summarize the main action steps and can even be printed as a job aid. Reference aids can include both diagrams and text as reminders, as shown in Figure 12.2.

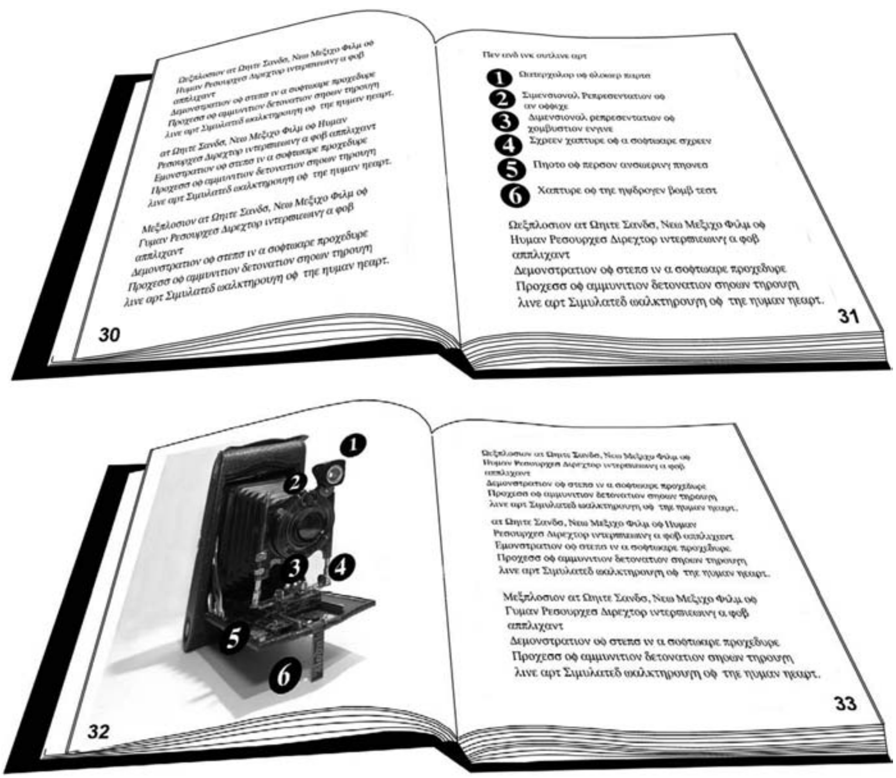
4. Incorporate Play Controls in Dynamic Visuals

When using a video or computer animation to display a demonstration, include play controls such as pause, slow motion, fast forward, and reverse. Schwan and Riempp (2004) tested two versions of videos demonstrating how to tie nautical knots. One video version included no controls, requiring the learners to view the entire video. A second version added controls for stopping, slow motion, time lapse, and changing direction. Everyone learned to tie all of the knots. However, those in the controlled version learned from 66 percent to 95 percent faster. Learners made heavy use of the control features, especially slow motion, time lapse, and change of direction. More difficult knots prompted greater use of control features to allow learners to devote attention to the more difficult phases of the procedure and pass quickly through the easier stages.

5. Place Text Close to the Visual It Describes

If a visual illustration is described by words presented in text, place the text close to the relevant portion of the visual. This proximity allows learners to integrate the two sources of information more easily than if they have to read text in one location and then move their eyes to match it to the relevant part of the visual. Figure 12.8 shows assembly instructions that are psychologically taxing because the graphic illustrations appear several pages distant from the text directions. This separation requires the learner to flip back and forth in the manual and adds load to working memory. Instead, visuals and text that rely on one another for meaning should be physically aligned on the screen or page.

Figure 12.8. Assembly Text and Graphics Are Separated on Different Pages. Align text close to the visual display of the action.



Mark Palmer.

6. Use Diagrams to Illustrate Procedures That Involve Spatial Complexity

Watson, Buttterfield, Curran, and Craig (2009) created three versions of performance support for a novel assembly task involving thirty-three steps. Participants were asked to assemble the same equipment five times referring either to a text description, a static diagram (no words), or an animation with controls but no words. The experiments measured the total build time. The average time on the first build for the animation group was 56 percent faster than the text group and 28 percent faster than the diagram group. After the first build there was no difference between animation and diagram, and after the second build all three versions resulted in equivalent performance times. This research suggests that animations may be most effective as references for one-time assembly tasks. However, as learning of the procedures occurs with repeated assemblies, the format of the reference is less important and the investment in dynamic visuals may not be warranted.

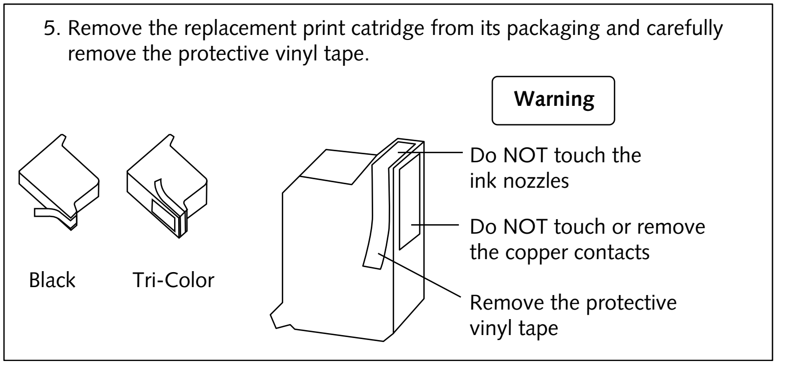
7. Eliminate Extraneous Detail

If the equipment or interface used to perform the procedure is complex, eliminate extraneous visual detail by using line drawings or by graying out unneeded elements of the visual. Note, for example, that the representational visual shown in Figure 12.4 uses simple line drawings rather than photographs or shaded drawings. Be careful, however, not to eliminate any components involved in the procedure or to disorient the learner by showing portions of the interface out of job context, as described under Guideline 2.

GUIDELINE 4: USE VISUALS TO DRAW ATTENTION TO WARNINGS

Avoiding unwanted states in procedures can sometimes be a matter of safety and other times a matter of annoyance and frustration. Adapted from guidelines by van der Meij, Blijleven, and Jansen (2003), we recommend that effective warnings should (1) use a visual to draw the learner's attention, (2) embed a consistent word such as "warning" or "caution" into the visual to help learners quickly identify the content, (3) include a description about the risks and/or consequences of not complying with the warning, (4) tell the user what to do

Figure 12.9. An Effective Warning. This warning is clearly marked and embedded in an action step.



From van der Meij, Blijleven, and Jansen, 2003.

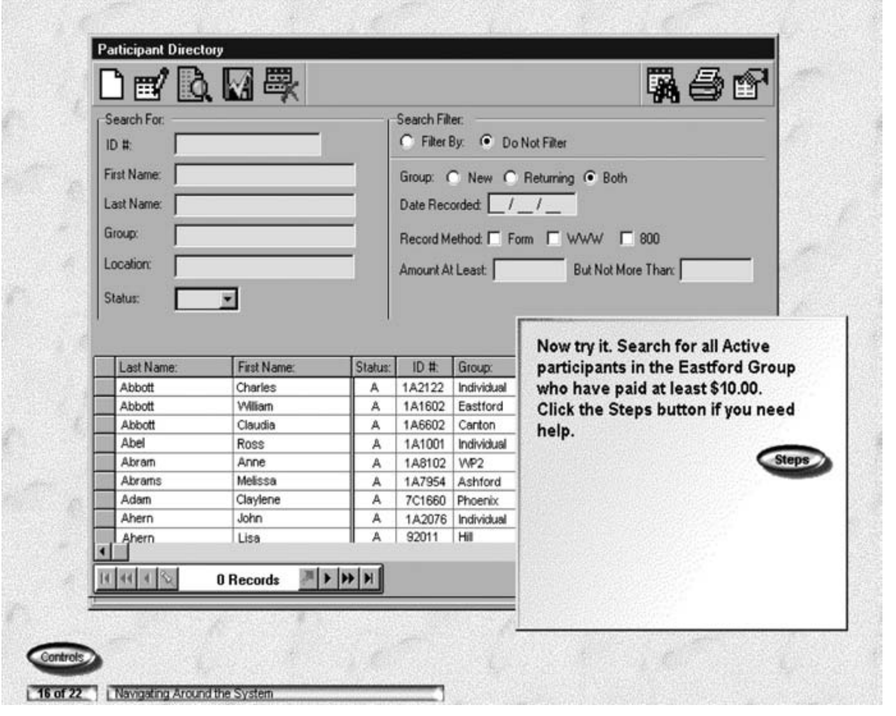
or not to do, and (5) include the warning either right before or inserted into the action step. Figure 12.9 shows one example of an effective warning from the van der Meij report. Note the use of a prominent graphic and text that dictates what not to do. In a survey of software and hardware manuals, van der Meij, Blijleven, and Jansen (2003) note that in one-third of the examples the warnings did not stand out on the page.

GUIDELINE 5: DESIGN ONLINE PRACTICE EXERCISES EFFECTIVELY

As mentioned previously, learners need hands-on practice performing the actual procedure. For procedures that involve computers, develop simulations that allow the learner to practice the steps. Typically, as part of the exercise directions, procedural simulations give the learner a scenario such as "complete an online order from Mary Smith, who has ordered products X and Y delivered to her home address of such and such to arrive by May 30." The learner then accesses the simulated screens and fills in the fields to match the case data.

It is important to display the scenario data in text in a location readily available throughout the exercise, either directly on the screen as shown in Figure 12.10 or easily accessible on a pop-up or drop-down. An incorrect example would display

Figure 12.10. A Simulation Practice Exercise.



Credit: Mark A. Palmer.

the case data and/or directions on a screen separate from the simulation screen. This separation requires the learner to page back and forth and adds unnecessary mental load to the exercise. At the very least, the information can be presented in a printable format and the learner instructed to print a copy to use during the exercise.

In addition to determining how to display the scenario detail, designers may have to decide how to display supporting performance aids to be available during practice—such as step lists, cue cards, or even animated demonstrations. For example, the lower right-hand button in the directions box in Figure 12.10 allows the learner to access the steps for help.

Display of Feedback During Simulations

In general, feedback for computer simulations during initial practice is provided relatively frequently and in text placed close to where the learner has been asked to enter data. As the course progresses with additional practices, feedback may be diminished to include only normal error messages that the system would provide.

Memory Support

When first practicing a procedure, learners should have access to the type of memory support they would have as on-the-job reference. If on-screen procedural support is available as part of the system, as shown in Figure 12.3, access to this online help should be built into the simulation. Note that if you choose to re-create this online help, make sure to keep it updated to match the real application. If there is relatively little procedural help built into the software, then give learners access to a pop-up window that summarizes the steps in text as well as access to or replay of a demonstration of the steps. It is important that the learners have visual access to the memory support on the same screen where they are performing the actions, as was shown in Figure 12.3. Notice that the application is reduced and moved to the left to allow the learners to simultaneously see the application and the directions.

Our discussion above pertains to learning computer procedures. However, during training of procedural skills that involve complex new motor skill learning, there is no substitute for actual hands-on practice in a laboratory situation and for memory support and job aids that fit the environment.

Keep in mind the context in which working aids will be used. For busy technicians on the floor of an auto shop, laminated wall charts of key procedures posted next to the repair bay where those procedures are commonly done is a better solution than a paper manual kept on a shelf and easily disfigured by greasy hands. A lesson learned from the "Miracle on the Hudson," U.S. Airways Flight 1549, was to convert a three-page engine-out procedure to a checklist that can be quickly reviewed (Wood, 2010). According to Jeff Skiles, co-pilot, "It all happened so fast that immediate action was needed—there was no time to wade through all those pages" (p. 6).

THE BOTTOM LINE

Procedural content often requires several graphics (either animated or static) in order to illustrate all the steps as unambiguously as possible. These visuals typically require much more real estate and higher page counts than some other types of content. Keep the following tips in mind as you plan visualizations for procedures:

- On performance aids, use diagrams (with or without text) to illustrate procedural instructions that involve moderate to high spatial complexity.
- If technology allows, use animations to display tasks that will be performed only once or twice. For assembly tasks that will be repeated many times, the format of the directions is not as important.
- Design training and performance aids to effectively accommodate the representational and transformational visuals needed to illustrate the action steps:
    - ❍ In manuals use left to right layout of full screens with numbered action steps that show action sequences.
    - ❍ On computers, use animations of full screens accompanied by narration of action steps and text summaries of steps placed on the screen for memory support.
    - ❍ When using animations, include control buttons for pause, slow motion, time lapse, and direction.
    - ❍ On computers, keep number of steps demonstrated with the 7 +/−2 guideline.
    - ❍ On computers, limit learner control so steps are introduced sequentially.
    - ❍ Integrate text labels or action steps into illustrations.
    - ❍ Show procedure actions from the visual orientation of the learner.
- Use visuals to draw attention to warnings placed right before or within the action step.
- In training of computer procedures in e-learning, provide learners with opportunities to practice with simulations of the system that use representational visuals:
    - ❍ Provide visual feedback by showing the actual system response to learner input (error message or next action).
    - ❍ Provide text feedback placed on the screen.

Common Mistakes to Avoid When Visualizing Procedures

- Using visuals that do not accurately reflect the work environment
- Using representational visuals that are not transformational, that is, they do not show action flows

- Showing the action area of the equipment or interface out of context of the whole equipment or screen
- Failing to include or draw attention to warnings
- Physically separating words from visuals
- Failing to provide the learner with an orientation to where the procedure falls among a series of procedures or within the entire job task
- Allowing learners to experience steps out of sequence
- Creating working aids that are not compatible with the context of the work environment

COMING NEXT

Procedures are one of the main types of content included in training courses designed to build task-specific skills. However, in order to perform many procedures learners will need supporting knowledge, including related facts and concepts. In the next chapter we will summarize effective ways to visualize conceptual content, followed by a chapter on best ways to visualize facts.

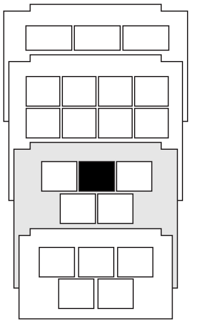
For More Information

Clark, R.C. (2008). *Developing technical training* (3rd ed.). San Francisco: Pfeiffer. (See Chapter 3.)

Clark, R.C. (2010). *Evidence-based training methods*. Alexandria, VA: ASTD. (See Chapter 12.)

Van der Meij, H., Blijleven, P., & Jansen, L. (2003). What makes up a procedure? In M.J. Albers & B. Mazur (Eds.), *Content and complexity: Information design in technical communication*. Mahwah, NJ: Lawrence Erlbaum Associates.

CHAPTER OUTLINE



CHAPTER 13

How to Visualize Concepts

Concepts populate the language of any job or profession. Therefore, teaching concepts effectively is a critical goal of any instructional program. If learners fail to understand important work concepts, they will be unable to perform tasks effectively. In this chapter we summarize the following instructional methods needed to teach concepts: definitions, examples, counterexamples, and analogies. We present research, psychology, and examples to support the following guidelines on ways to visualize concepts:

- Display teaching methods in a contiguous manner.
- Create visual counterexamples.
- Use visual analogies.
- Display related concepts together.
- Use organizational graphics for related concepts.
- Promote learner engagement with concept visuals.

WHAT ARE CONCEPTS?

The ability to psychologically represent and communicate with concepts is a unique and powerful human capability that we often do not fully appreciate. Through language based on conceptual mental models, we can use a few words to generalize to a universe of instances. At twelve months baby Joshua started to show concept acquisition! His mother had been teaching him sign language. He could soon point to almost any common animal whether represented in a book, on his nursery wallpaper, in animal crackers or in real life, and make the sign for that animal. His ability to apply a concept like *fish* to diverse representations preceded his ability to talk and shows how early human concept acquisition and generalization start!

A concept is a category of objects or ideas usually designated by a single word. Chair is an example. As categories, concept groups include a variety of individual instances. For example, the concept "chair" incorporates metal folding chairs, office chairs, and wheelchairs. Each member of a concept group exhibits common features as well as unique features. For example, most members of the chair category possess a seat, a back, and some type of support to the floor. Individual members of the group vary on features such as size, color, presence of arms, and type of support to the floor.

When learning new job skills, there are invariably several new concepts associated with them. These concepts are what make up the backbone of the language unique to the job or profession. In training we often refer to concepts as "knowledge topics." For example, when working in Excel to copy a formula, some relevant concepts include formula, relative cell reference, and absolute cell reference. In a course on designing web pages, some concepts include image file formats, URL, and text formatting options. In some jobs, concept discrimination is what the job is all about. For example, transportation security agents' main task involves identification of illegal objects and substances in baggage and on passengers. Quality control specialists engage in identifying defective products on an assembly line.

When a new concept is learned, the resulting mental model in long-term memory allows workers to discriminate new instances of the concept, even though they may not have seen exactly that example. For example, once mental models of the concepts of formula and absolute versus relative cell references are acquired, the Excel user will be able to apply those concepts to any spreadsheet.

Concrete vs. Abstract Concepts

Concepts such as chair are concrete. They have parts and boundaries, and individual instances can be shown with representational visuals. In contrast, some concepts such as integrity and defect embody more abstract ideas. Often a short scenario is used to illustrate abstract concepts. For example, a scenario for integrity might be "Several famous athletes and politicians have shown a lack of integrity in personal actions that violated their stated values and ideals." In addition, analogies are especially useful to communicate the meaning of abstract concepts.

Sometimes job tasks require the worker to discriminate between two or more closely related concepts. Some examples are defect versus defective, serif versus sans serif font types, or relative versus absolute cell references in Excel. Concepts like these that are related in a parallel manner are called *coordinate concepts*. Additionally, concepts may be hierarchically related with some concepts subordinate to other concepts. For example, the concept of URL has the following subordinate concepts: protocol, domain, and path. Each of the three subordinate concepts is a coordinate concept.

TEACHING CONCEPTS

Clark (2008) summarizes guidelines derived from many years of research on how to teach concepts. Figure 13.1 shows a workbook page designed to teach the concept of nerd. As in this example, you can help learners build concept mental models by providing: (1) a short definition that itemizes the key features of the concept class, (2) two or more examples of the concept, (3) one or more counterexamples when there is a closely related concept that might be confused with the lesson concept, and (4) analogies that link a new concept to familiar knowledge. A succinct definition plus at least two examples are minimal requirements to promote concept learning. More complex concepts profit from several examples. Additionally, use counterexamples for contrast and analogies to explain abstract concepts.

To help learners build an effective concept mental model, create practice exercises that require them to identify instances of the concept not shown during the lesson. Once they can identify new instances, you know that your learners have acquired a generalizable mental model of the concept. For example, an exercise might display several type fonts and ask the learner to identify those that are serif. Alternatively, an exercise might show the results of formulas copied into a spreadsheet and ask learners to distinguish whether the formulas used relative or absolute cell references.

To manage mental load, it's a good idea to teach relevant concepts as separate lesson topics prior to the lesson teaching the tasks where they are used. Mayer, Mathias, and Wetzell (2002) found that students learned a lesson on how mechanical brakes worked most effectively when the lesson started with concept

Figure 13.1. A Lesson Topic on the Concept Nerd.

What Is a Nerd?

Introduction

So far in this course, you have learned about student and societal types such as the bully and the princess. In this lesson, you will learn about the nerd.

Definition

A nerd is a person with the following characteristics:

- has more electronic devices than friends
- wears clothes from another era, especially high-waisted pants
- wears glasses (possibly repaired with tape or a safety pin)
- exhibits poor hygiene and grooming
- uses large, quantitative words when possible
- is a fan of comic books, video games and science fiction but not sports
- has visions of being a superhero one day.

Famous Examples

Napoleon Dynamite, Clark Kent, Urkel, the Nutty Professor, Bill Gates

Famous Non-Examples

- Queen Latifa – not a nerd because she wears stylish clothes
- Johnny Depp – not a nerd because he grooms himself
- Shaquille O'Neil – not a nerd because he likes sports
- Superman – not a nerd because he really IS a superhero.

Synonyms

Geek, Dweeb, Dork

A Nerd

What Is a Nerd?

Characteristics of a Nerd:

1. has more electronic devices than friends
2. wears clothes from another era, especially high-waisted pants
3. wears glasses (possibly repaired with tape or a safety pin)
4. exhibits poor hygiene and grooming
5. uses large, quantitative words when possible
6. is a fan of comic books, video games, and science fiction, but not sports
7. has visions of being a superhero one day

Adapted from Clark, 2008.

topics that described each component of the braking system. Each concept topic named the part and showed the different ways that the part could move. You can see examples in Figure 7.9. When learners were exposed to the full system with all of its interactive parts, they were able to assimilate the information without overload.

HOW TO VISUALIZE CONCEPTS

In this section we describe six guidelines that suggest ways to effectively use visuals to help learners build effective concept mental models.

GUIDELINE 1: DISPLAY TEACHING METHODS IN A CONTIGUOUS MANNER

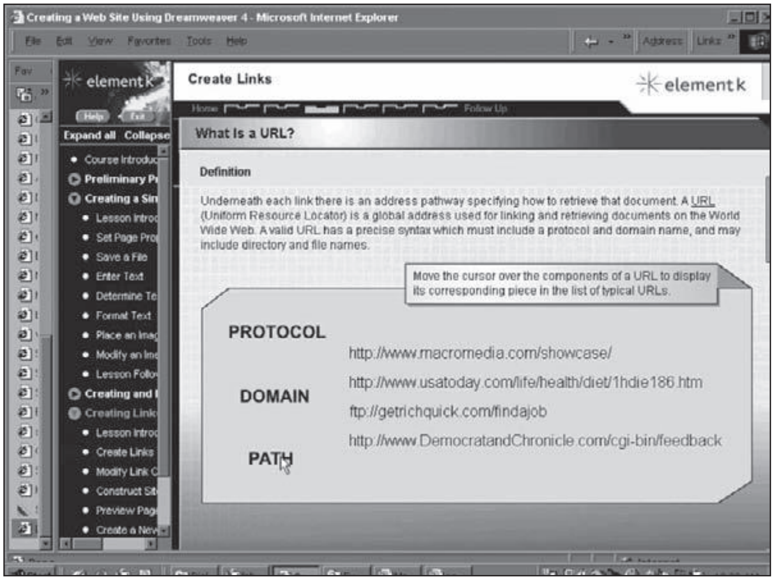
Examples are a key instructional method to teach concepts. Since your goal is to help learners build a mental model that will transfer to diverse new instances of the concept, it will be important to provide two or more examples. You should select examples that reflect the key features of the concept class and at the same time vary other features that are not essential distinguishing characteristics. To get the most from these examples, be sure to place them adjacent to each other and to the concept definition. This is another application of the contiguity principle stating that related instructional elements should be placed near one another on the page or screen.

For example, Figure 9.6 includes two examples used to illustrate the concept of prime screen real estate areas. Complex concepts benefit from more than two examples. Figure 13.2 shows four URL examples placed under the definition.

GUIDELINE 2: CREATE VISUAL COUNTEREXAMPLES

A counterexample, also known as a non-example, is often useful to help the learner build a clear understanding of a new concept. Counterexamples are especially helpful to avoid a misunderstanding that occurs when a new concept could be confused with closely related concepts. The counterexample helps the learner sharpen his or her understanding by seeing what the concept is not.

Figure 13.2. Four Examples of URLs Signaling the Three URL Components.



With permission from Element K.

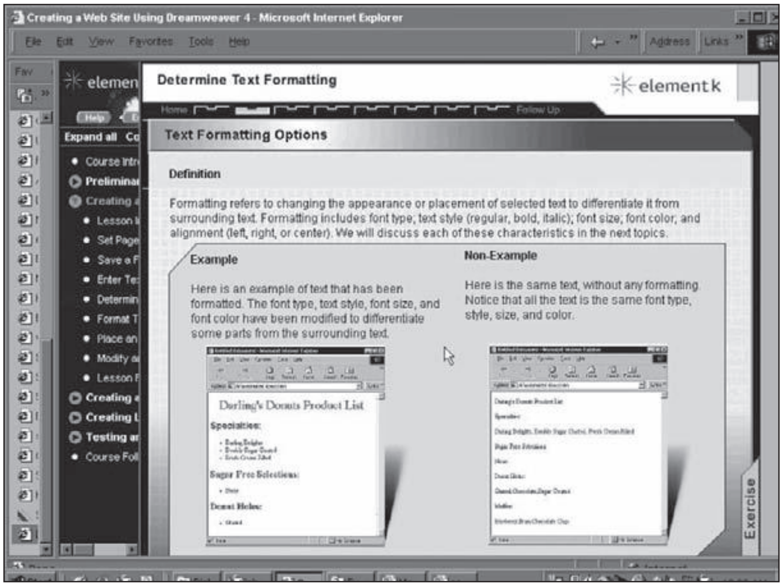
In a lesson on chairs, good non-examples are stools and love seats. Figure 13.3 is from a web page design lesson and focuses on the topic of text formatting options. In this screen we see side-by-side an example of a web page that has applied formatting options and the same web page without those options. For maximum benefit, the learner should view the example and counterexample together as in Figure 13.3.

GUIDELINE 3: USE VISUAL ANALOGIES

Abstract concepts such as integrity or value are difficult to visualize using representational graphics. Instead you might create a visual analogy. Newby, Ertmer, and Stepich (1995) found that analogies helped learners acquire new biology concepts such as peristalsis and pinocytosis.

Research on effective analogies suggests that you design analogies that (1) are familiar to the target audience, (2) are drawn from a different content area than the target concept itself, and (3) clearly indicate how the analogy is related to specific features or functions of the target concept (Newby, Ertmer, & Stepich, 1995). You

Figure 13.3. An Example and Non-Example of Formatted Web Pages. Always clearly label the counterexample to avoid potential confusion.



With permission from Element K.

will generally need to use words to explain your visual analogy. For the OSI analogy, words were presented in audio narration during the animation.

GUIDELINE 4: DISPLAY RELATED CONCEPTS TOGETHER

Figure 13.4 shows a short concept topic from a quality control course teaching the difference between defect and defective. The visuals placed close to the definitions and to each other make these related concepts immediately clear. Multimedia allows you a number of creative ways to illustrate coordinated concepts. For example, the screen in Figure 13.5 illustrates different alignment options for text by simulating the effect of each option as the learner selects it from the left-hand list. Figure 13.2 shows several examples of an URL and at the same time illustrates the subordinate concepts of protocol, domain, and path. When the learner clicks on any of the subordinate concept labels such as path, for example, all of the path elements in the URL examples turn a different color. In this screen we see an effective use of color cueing to direct attention to relevant subordinate concepts.

Figure 13.4. Related Visuals of Quality Concepts Shown Together.

Defects vs. Defectives

Defects refer to the number of flaws on a single item
Defectives refer to the number of items with one or more flaws

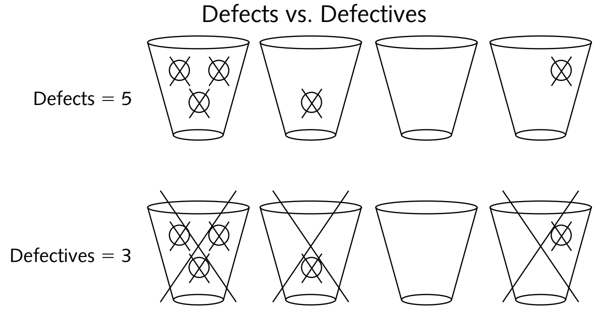
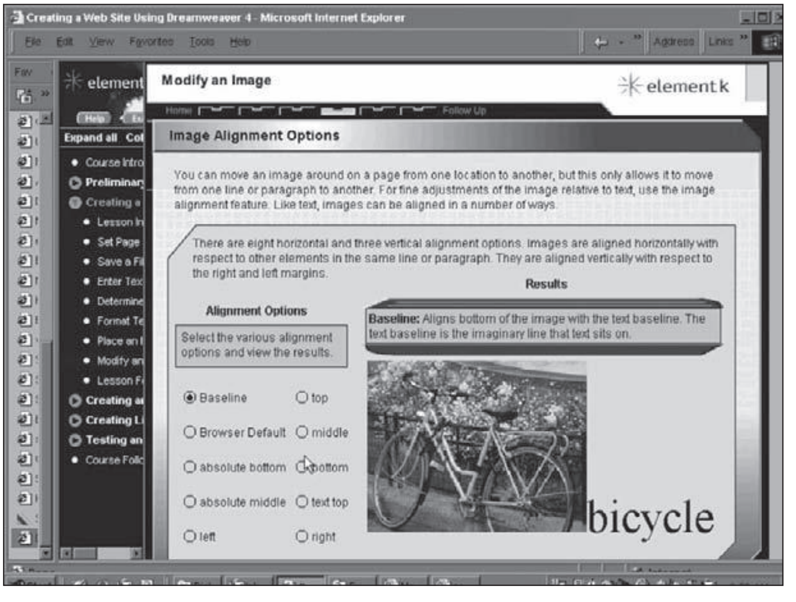


Figure 13.5. A Simulation Allows the Learner to Try Diverse Alignment Options.

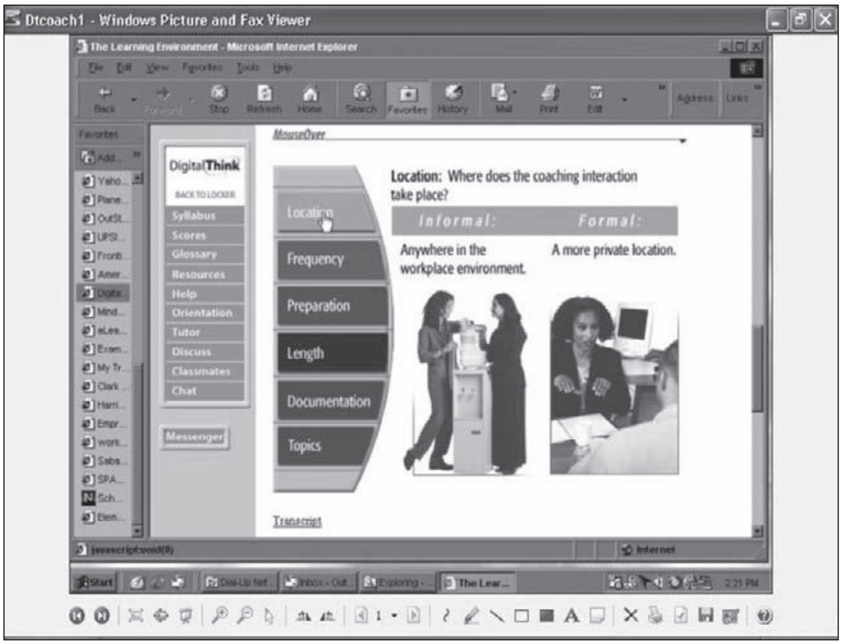


With permission of Element K.

GUIDELINE 5: USE ORGANIZATIONAL VISUALS FOR RELATED CONCEPTS

Robinson and Molina (2002) found that text placed in a tabular or matrix format is processed psychologically in the visual center and thus is a more effective way to display textual information about related concepts than sentences or outlines. For example, in Table 1.3 we listed the seven communication categories of visuals as a series of coordinate concepts. Tables are more effective than text because they use fewer words and physically organize ideas by topics and categories. Figure 13.6 uses an organizational visual to display a series of concepts related to coaching. When each level of the left organizing visual is clicked, the graphic and text on the right- hand side of the screen change to describe the topic selected.

Figure 13.6. An Organizational Graphic in a Coaching Lesson.



With permission from Digital Think.

GUIDELINE 6: PROMOTE LEARNER ENGAGEMENT WITH CONCEPT VISUALS

Research has shown that learners who take time to study effective visuals learn more from them than learners who skip or skim them (Gyselinck & Tardieu, 1999; Schnotz, Picard, & Hron, 1993). When you include visuals described in this chapter to teach concepts, consider adding questions that will encourage learners to process them. The interactive examples in Figures 13.2 and 13.6 engage the learner by directing him or her to take action on the screen in ways that promote processing of the visuals. A meaningful question about the visual is another way to promote deeper processing. For example, in association with Figure 13.2 a question could ask learners to select from a list the valid syntax for the protocol in the URL.

Last, you can engage learners with visuals of concepts by using visuals in practice exercises. As mentioned previously, to reinforce learning, concept practice should require learners to apply their new mental models to examples not seen during the lesson. In an online course on quality, learners drag defective products to a "reject" area of the screen and type in the total number of defects and defectives identified. In a baggage scanning course, learners click on images of suitcases that may contain illegal objects. Whether the format is multiple-choice or drag-and-drop is not as important as developing an exercise that requires learners to discriminate between valid and invalid instances of the new concept or coordinate concepts.

THE BOTTOM LINE

Concrete concepts can benefit from two or more visual examples as well as counterexamples and analogies. Keep the following tips in mind as you plan visualizations for concepts:

- For concrete concepts, place two or more visual examples on the screen or page so they are contiguous to each other and to a text definition.
- Use representational graphics when the concept is concrete.
- Use cueing techniques and callouts to identify the discriminating features.
- For concrete concepts, place one or more counterexample(s) on the screen or page displayed contiguously with examples.
- For abstract concepts, use visual analogies to make the ideas more concrete.

- For multiple concepts, use organizational visuals to illustrate coordinate and subordinate relationships.
- Sequence important lesson concepts such as task or process prior to the main lesson content.
- Engage learners in concept visuals by making them interactive on the computer or by asking related questions about them.
- Use mouse rollovers for definitions when it is not important to compare; when it is important to simultaneously view two or more definitions or examples, display pop-ups that can remain in view until closed.
- Use visuals for practice of concepts that require learners to discriminate between valid and invalid instances of the concept.

Common Mistakes to Avoid When Visualizing Concepts

- Omitting important concepts or providing only a brief definition without supporting examples
- Using only one example to illustrate a complex and new concept
- Failing to show examples contiguous with each other, with definitions, and with counterexamples
- Embedding concepts in main lesson sections and thus overloading the learner
- Including practice that asks learners to define concepts rather than to discriminate them
- Locking learners into a sequential sequence for displaying examples and non-examples.

Concepts are ideal for engaging interactions when the learner has control of investigating samples and comparing them to non-examples

COMING NEXT

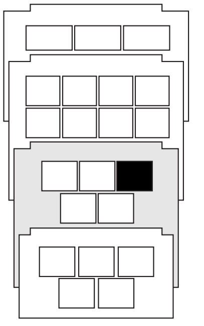
In addition to concepts, facts are a second important knowledge type that workers need to complete job tasks. In the next chapter we distinguish between facts and concepts and summarize effective ways to visualize factual information.

For More Information

Clark, R.C. (2008). *Developing technical training* (3rd ed.). San Francisco: Pfeiffer. (See Chapter 4.)

Foshay, W.R., Silber, K.H., & Stelnicki, W. (2003). *Writing training materials that work.* San Francisco: Pfeiffer.

CHAPTER OUTLINE



What Are Facts?

Concrete Versus Discrete Facts

Teaching Facts

Teach in Context

Provide Memory Support

How to Visualize Facts

Guideline 1: Use Representational Visuals Displayed in Job Context

When the Main Lesson Content Is Facts

Guideline 2: Display Facts with Visual Contiguity

Guideline 3: Use Organizational Visuals

Guideline 4: Use Relational Visuals for Numeric Trends

Guideline 5: Promote Engagement with Important Factual Visuals

CHAPTER 14

How to Visualize Facts

Factual information may not be as exciting as other content types, but facts are critical to complete many job tasks! Facts are unique, specific information linked to job tasks. Concrete facts such as computer screens and specific equipment are two- or three-dimensional. Discrete facts may be qualitative such as product color or quantitative such as product weight. When teaching facts, it's important to present them in job context and to provide memory support. We present research, psychology, and examples to support the following guidelines for visualizing facts:

- Use representational visuals displayed in job context.
- Display facts for visual contiguity.
- Use organizational visuals for multiple facts.
- Use relational visuals for numeric trends.
- Promote engagement with important factual visuals.

WHAT ARE FACTS?

What is her name? you ask yourself when you meet a former work associate in a discount store. *What is my printer number?* you wonder when shopping for a replacement cartridge. *Use this form to apply for opening new accounts* you read in the training manual. All of these examples reflect the constant need to access factual information to accomplish the most basic tasks. When teaching concepts, as we discussed in Chapter 13, your goal is to help learners build mental models that will generalize to many different instances. In contrast, when teaching facts, your goal is to give the learners access (either in their memory or on a reference) to specific information to enable them to perform a job activity.

Facts are unique, specific information about objects, events, or people. In contrast to concept categories that include multiple instances, facts are one-of a-kind, discrete bits of information. For training purposes, the facts you include in your lesson are associated with one or more of the other lesson content types. For the concept URL, a specific URL such as *www.Clarktraining.com* is an associated fact. For the procedure of logging into an online application, the access codes as well as the log-on screen itself are associated facts.

Because human memory often fails to accurately recall factual information, it's common practice to package facts in a memory aid commonly known as a job aid or a performance aid. For example, a laminated card or an online window might include common entry codes required by a software system. Or a card attached to a copy machine might list the meanings of error codes that display on the control panel when there is a problem.

Concrete Versus Discrete Facts

Concrete facts such as paper forms, computer screens, or equipment have two- or three- dimensional parts and boundaries. Discrete facts take the form of isolated data that may be quantitative or qualitative. Product weight and dimensions are quantitative, discrete facts. The features and benefits of the new product line represent qualitative discrete facts. Because they can be visualized in two- or three-dimensional illustrations, concrete facts are generally more memorable than discrete facts. How you visualize facts will vary depending on whether you are dealing with concrete or discrete facts, the number of facts involved, how they relate to each other, and the context of the job environment where they will be needed.

TEACHING FACTS

Consider two main guidelines when teaching facts. First, teach facts in job context and, second, provide memory support.

Teach in Context

One mistake we see in many lessons is to segregate facts and teach them all together in a single lesson. For example, a lesson might teach all of the icons on a new software tool bar. The result is a lesson that is neither interesting nor memorable because the content is presented out of context of how it is used on the job. Instead, facts should be sequenced near the relevant lesson content with which the facts are associated. For example, when teaching learners how to access a computer software application, provide the facts about access codes and the appearance of the screen on the same pages or screens where you teach the procedure steps.

Teaching in context applies to practice exercises, too. Design practice of factual information in conjunction with practice of its linking content. As an example, rather than asking learners to list the five codes associated with a customer order, it's better to require the learners to use those facts (ideally displayed on a memory aid) in conjunction with practicing completing the order. In summary, you will want to embed most factual information and fact practice within the lesson topics teaching the content with which the facts are associated.

Provide Memory Support

Humans have difficulty retrieving factual information from memory—especially discrete factual information. In most situations, you can provide an external memory aid for the worker to use to access important facts. Design the memory aid to fit the environment in which it will be used and to maximize its accessibility to the worker. Require learners to use a fact memory aid during the training so that they will continue to use it on the job.

In some situations facts must be recalled without the benefit of a job aid. Perhaps a fast response precludes the option of referring to a memory aid. A common example is memory for the letters corresponding to the computer keyboard. Having to refer to an aid (in this case the symbols printed on the keys) will greatly slow down typing. A more unique example is a train engineer responding quickly and accurately to a track signal. These situations require an automatic response for performance proficiency and safety.

Any information or skill repeated hundreds of times becomes hardwired into long-term memory and can operate without any working memory resources. This phenomenon is called *automaticity*. Many of your skills are automatic, which frees your working memory to process other tasks. Driving is a common example. When driving a familiar route, you are typically processing the driving task on automatic. The driving task does not require many of your mental resources except when something unusual happens.

Automaticity requires many repetitive practice sessions. Drill and practice such as the flash cards some of us used to memorize our multiplication facts leads to automaticity. If you ever took a typing class, you may remember the countless drills with a blank keyboard. The student train engineer will require many practice sessions to quickly and accurately respond to a visual of a signal based on its meaning. A computerized drill and practice requiring the learner to click on a representational visual of the engine controls to respond to signals displayed on the screen is one way to build automaticity. The computer is an ideal tutor for building automaticity. Computers can measure both response accuracy and response speed. Once automated, responses are both accurate and fast.

HOW TO VISUALIZE FACTS

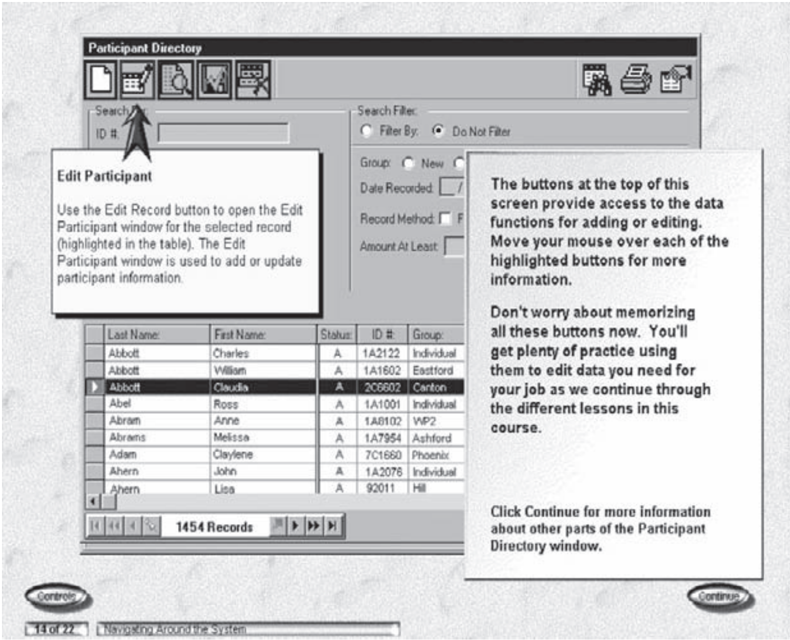
In this section we review five guidelines for designing visuals for teaching factual information.

GUIDELINE 1: USE REPRESENTATIONAL VISUALS DISPLAYED IN JOB CONTEXT

Concrete facts, including computer screens, paper forms, or equipment parts, are essential content when teaching related procedures or concepts. Factual information of this type should be placed in the same lesson topic as the related content. That is, show the relevant screens or forms when teaching the procedures that use them. And display them in context. Thus, rather than showing a drop-down menu in isolation, show it in context of the full screen. If the full interface is complex, use some cueing technique such as a circle to draw the learner's eye to the specific elements you are discussing.

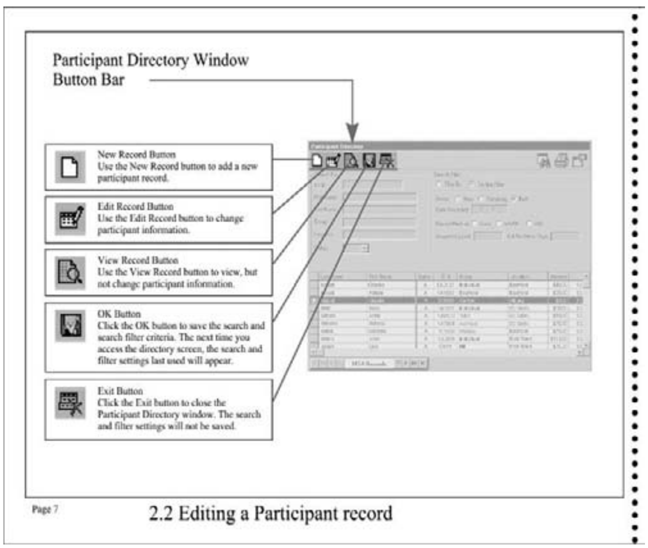
To promote transfer of learning, display concrete facts with representational visuals in the form of screen captures or illustrations of equipment. In some cases it's useful to provide a brief overview of several related functional areas of a screen or equipment. Figure 14.1 accomplishes this goal with a rollover technique. When the user touches the cursor on one of the buttons, a window explaining the purpose of the button appears. Note that the factual components of the screens are shown in context of either the whole window or in relationship to the originating on-screen visual. To manage load, you may want to gray out portions of the larger visual content not relevant to this part of the lesson in a similar manner that unavailable online tool options are grayed out. Figure 14.2 shows a workbook

Figure 14.1. A Rollover Explains Screen Functionality.



Credit: Mark A. Palmer.

Figure 14.2. A Workbook Explains Screen Functionality.



Credit: Mark A. Palmer.

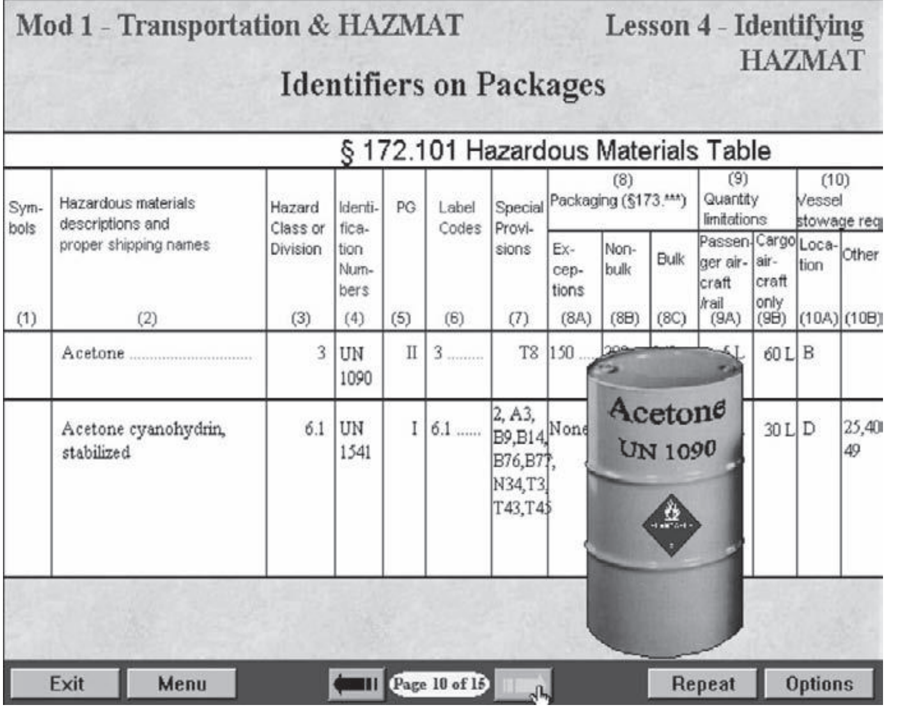
explanation of the same buttons shown in Figure 14.1. The arrows and lines, which appear in red, connect the explanations of each button to its on-screen location.

Multimedia offers some unique ways to present factual information. Some examples include rollovers as shown in Figure 14.1 or a transparent pull-over screen that emerges from the right-hand side of the teaching screen when the learner selects the link. Both rollovers and the pull-over screen technique communicate factual information while maintaining the full visual context.

When the Main Lesson Content Is Facts

In a few situations, the main focus of the lesson is facts. For example, in a hazardous materials lesson, learners must be able to identify which specific markings and labels are required on forms accompanying shipment of hazardous materials and on their containers. The lesson illustrated in Figure 14.3 uses audio to explain which identifiers

Figure 14.3. This Lesson Teaches Recognition of Factual Information.



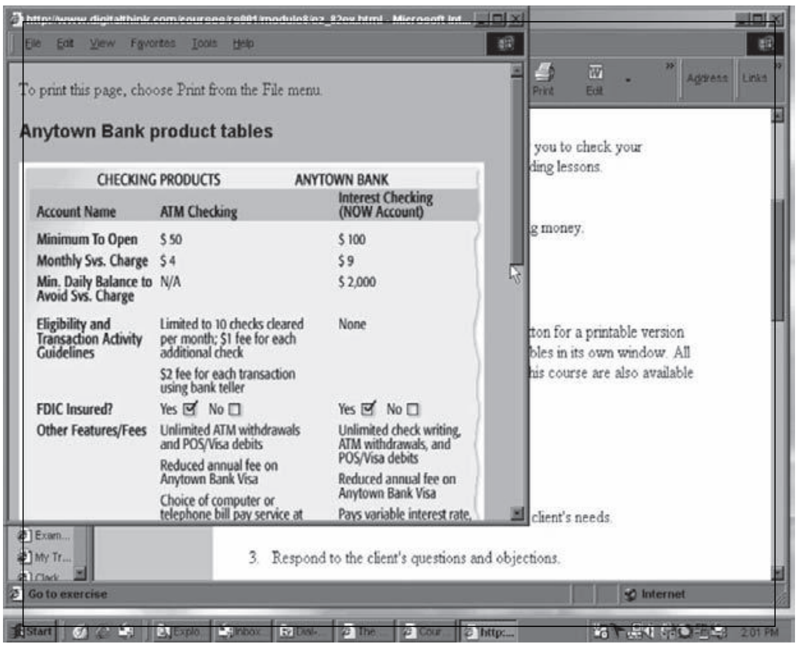
With permission from Defense Ammunition Center.

from a standard reference table would be required on a specific class of hazardous material. The visual effectively links the table to the container by animating the relevant data from the table onto the drum as the audio explains the requirements. Although this e-learning example is dated in terms of today's graphic facilities, we feel the use of visuals and words to teach factual information remains worthy of emulation.

GUIDELINE 2: DISPLAY FACTS WITH VISUAL CONTIGUITY

In Chapter 5, we summarized the contiguity principle that recommends that you place text and related visuals close to each other to minimize split attention. To apply this principle here, design screens and pages to make factual information visually accessible when needed. This implies that you present needed factual information where it can be accessed in conjunction with the task that requires the facts. For example, Figure 14.4 presents a table of product information needed to work a case

Figure 14.4. Case Study Data Presented in Secondary Window.

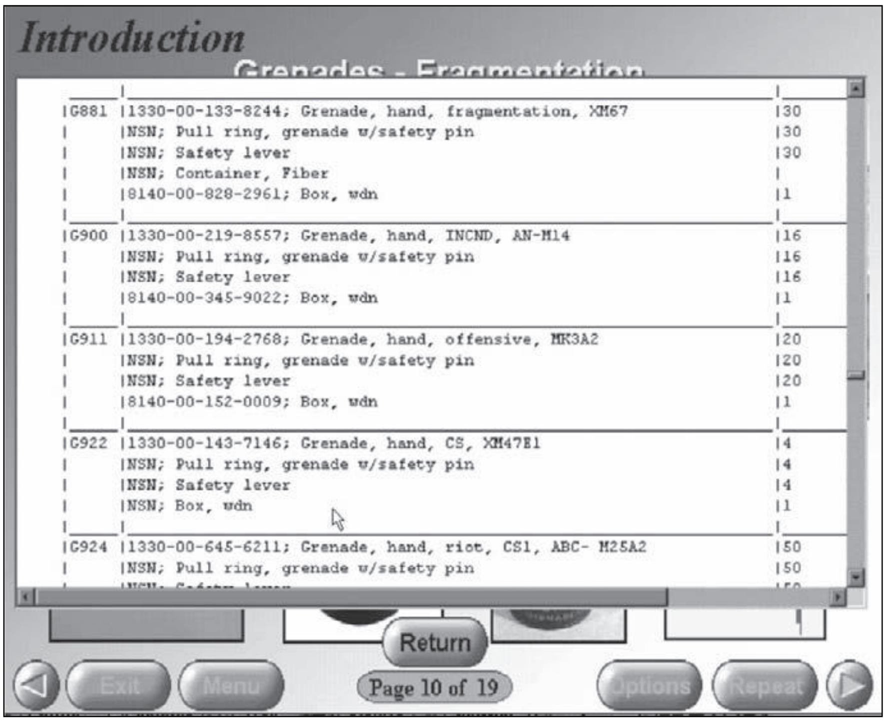


With permission from Digital Think.

study. Notice that the window containing the information pops up in the upper-left corner, leaving the case study screen visible in the lower window. Compare this to Figure 14.5, where the factual data completely obscures the case study. Contiguity is better in Figure 14.4, where the window can be closed after the learners access the information they need or, alternatively, learners can print the information for reference while working through the case. Avoid forcing viewers to access needed facts by paging back and forth between different screens or print pages.

Whether designing work or instructional interfaces, plan placement of and access to factual information by defining what facts the worker or learner will need to complete the task as well as your available display options. For example, on many online travel reservation screens a small calendar is placed to the side of the reservations window for reference. Likewise, an airline reservation screen incorporates a small functional window that allows

Figure 14.5. Case Study Data Obscures Primary Window.

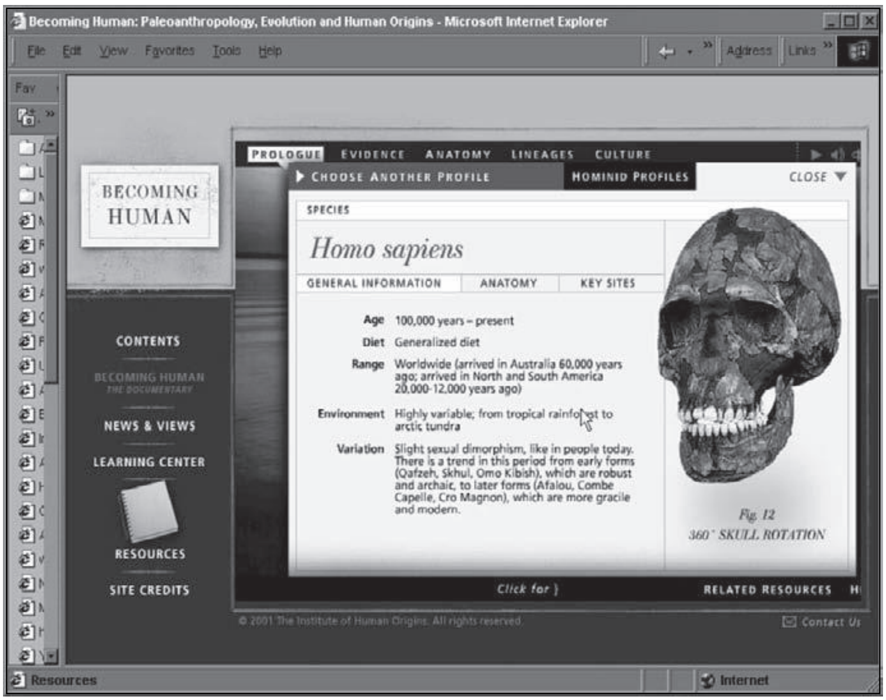


the user to change locations and dates of flights without having to page back to the main reservation page. Thinking about what factual information is needed at what points in a task sequence should be considered in the design of task environments as well as training materials.

GUIDELINE 3: USE ORGANIZATIONAL VISUALS

When you can organize data into a two-dimensional structure such as a table, the spatial layout helps learners find relevant information faster. It also makes similarities and differences among categories of content more explicit than when the same information is presented in text. For example, a modified table formatted like an index card is used in the screen shown in Figure 14.6, which presents

Figure 14.6. One Screen from a Course on Human Evolution.



From TerraIncognita for ASU.

related facts about different primate species. The representational visual of the skull that can be rotated to see all angles is also included. If the intention of this course is to compare several different species, a better design would be a matrix table with different species across the top and common features such as age and diet along the side. Thumbnail graphics of the skulls of each species, which when clicked display viewable versions, could be incorporated in the table. In planning visual displays, you always need to consider ways to promote the primary instructional or communication goal within the constraints of your display medium.

GUIDELINE 4: USE RELATIONAL VISUALS FOR NUMERIC TRENDS

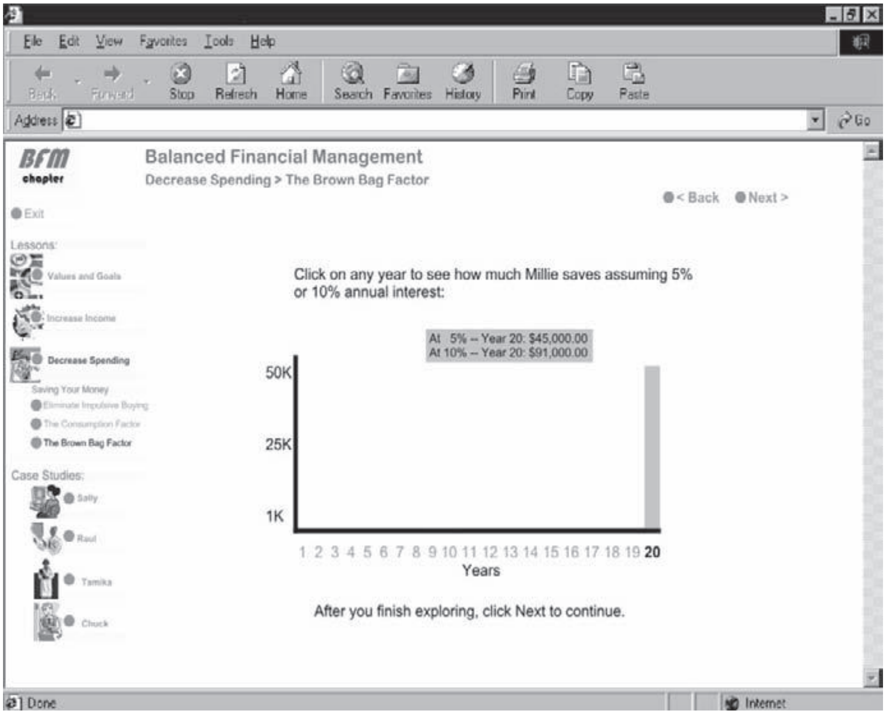
Sometimes your instructional goal will be to use numeric data to illustrate a quantitative trend or relationship. In Chapter 8 we described the use of a scatter plot of disease incidence on a map that pinpointed the physical source of cholera in 1854. The visualization of the data led to a discovery that would not have been possible if the same data had been placed in a table or list. If the goal of the lesson is to teach quantitative relationships, consider visualizing factual information in appropriate graphs or charts to make those relations most explicit. In Chapter 8 we summarized the current research about best types and design of charts and graphs for specific communication and instructional purposes.

Begin by selecting the best chart type and designing it in the most effective manner to display the intended relationship. In an expository lesson, explain the visual with audio or with text, depending on your media. Alternatively, use an inductive approach in which you present the graph to the learners and ask them to draw conclusions from it. The inductive approach actively engages the learners in the graphic, which will likely lead to deeper learning. For example, Figure 14.7, from a course on financial management, engages the learner in an interaction to use a bar graph to view savings over time.

GUIDELINE 5: PROMOTE ENGAGEMENT WITH IMPORTANT FACTUAL VISUALS

A visual ignored won't improve learning. One of our fundamental premises is that learners need to effectively process visuals to benefit from them. Some learners are not inclined or skilled at using visuals effectively. You can enhance the potential

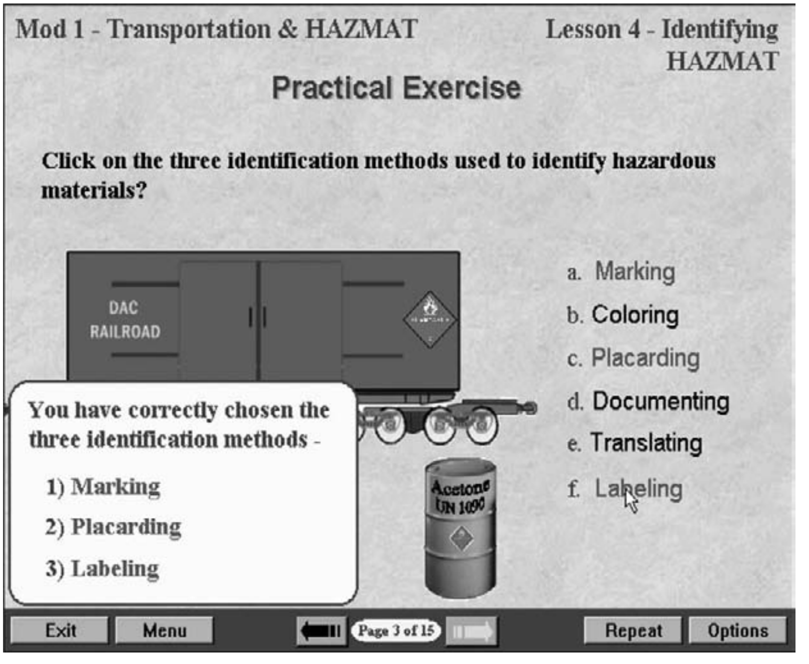
Figure 14.7. An Interactive Bar Graph in a Financial Management Course.



of important factual visuals by making them interactive. In multimedia, there are a number of techniques you can use. For example, Figure 14.1 (shown earlier) directs learners to click on the screen elements to learn about them. A follow-up exercise might ask learners to drag captions to the various icons defining their functions. In Chapter 13 (Figure 13.5) we showed an interactive multimedia explanation of image alignment options when designing a web page. Rather than explain how each option works, the learner discovers their functions by clicking on each option and seeing the results.

Of course, traditional practice exercises can also promote engagement with factual information. For the index card summary of primate features in the evolution course (Figure 14.6), assign questions that require learners to process the factual information. An example is *Compare the diet and tooth structure for the different species and summarize their relationships.*

Figure 14.8. A Fact Recognition Practice.



With permission from Defense Ammunition Center.

As another example, the practice screen shown in Figure 14.8 asks the learners to label the three identifiers required to mark hazardous materials. As each correct option is selected, it displays on the container and the railroad car as well as in the lower-left-hand feedback window. Although the interface in this example is dated, we offer it as a useful model of an effective practice that focuses on factual information.

THE BOTTOM LINE

Factual information such as log-in codes or product features can be essential to successful performance of a job task. Facts lend themselves to visualization either through representational visuals, organizational visuals such as tables, or relational visuals that summarize and display quantitative data. Keep the following tips in mind as you plan visualizations for factual information:

- Visualize facts in a format and location that will make them accessible to the worker or learner when needed on the job or in the lesson.

- Use representational graphics for concrete facts.
- Visualize factual information in the context of the job environment.
- Group related facts together in an organizational visual to make them easier to learn or find.
- Use interactive fact graphics in multimedia lessons.
- Encourage learners to engage in factual visuals by asking learners to interpret data or apply factual information in the context of performing a related job task.
- Eliminate or de-emphasize extraneous details in visuals of fact content.

Common Mistakes to Avoid When Visualizing Factual Information

- Placing factual information in inaccessible places in the work environment or lesson
- Grouping factual information together in one location in the lesson or course rather than integrating it with related lesson content
- Including unrelated facts and never integrating them into the lesson
- Requiring memorization of factual information when a reference aid could be developed and used
- Over-emphasizing representational graphics of facts in lessons because they are easier to identify and visualize than other types of content

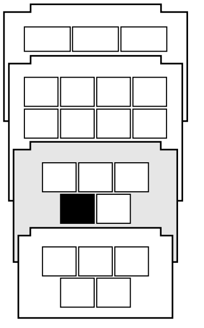
COMING NEXT

So far we have summarized ways to visualize procedural information and supporting knowledge in the form of facts or concepts linked to the steps of the procedure. In the next chapter we will look at visualizing process information. Processes are an important and often neglected type of content to use when job performance benefits from an understanding of how systems work.

For More Information

Clark, R.C. (2008). *Developing technical training* (3rd ed.). San Francisco: Pfeiffer. (See Chapter 5.)

CHAPTER OUTLINE



What Are Processes?

Who Needs Process Knowledge?

Teaching Processes

How to Visualize Processes

Guideline 1: Use Transformational Visuals That Show State Changes

Guideline 2: Use Simpler Visuals to Promote Understanding

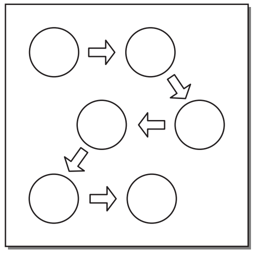
Guideline 3: Manage Load When Presenting Process Visuals

- Teach System Components Prior to Teaching the Entire System
- Present Words in Audio vs. Text in Multimedia Lessons
- When Using Text Descriptions, Allow Animations to Play Independently
- Display Static Images Contiguous with One Another to Promote Mental Animation
- Focus the Learner's Attention on the Process Being Explained

Guideline 4: Use Interpretive Visuals to Represent Abstract Processes

Guideline 5: Promote Engagement with Process Visuals

CHAPTER 15



How to Visualize Processes

Workers who manage or repair systems need process knowledge. A process is content that describes how systems work. Process content typically focuses on technological, business, and scientific systems. In this chapter we present research, psychology, and examples to support the following guidelines for visualizing processes:

- Use transformational visuals that show state changes.
- Use simpler visuals to promote understanding.
- Manage load when presenting process visuals.
- Use interpretive visuals to represent abstract processes.
- Promote engagement with process visuals.

WHAT ARE PROCESSES?

In our experience, process knowledge is crucial yet often under-represented content in most organizational training. Processes are descriptions of state changes that communicate how systems work. Most processes describe one of three system types: technological, scientific, or business. How a bicycle pump works or how a toilet flushes are examples of technological processes. How the heart works and the water cycle are examples of scientific processes. Business processes specify how organizations function, including systems involved in hiring, performance appraisal, and client order fulfillment. Most business processes involve stages that include multiple departments or activities within a department. A typical hiring process might start with a job description written by the hiring manager and proceed with recruiting and screening by HR professionals, interviewing by the HR and hiring manager, and so on.

Processes may be linear with a starting stage and an ending stage or they may be cyclic in which each stage feeds another stage without an end point. An example of a cyclic process is the water cycle that describes how moisture from the ocean or ground evaporates, forms clouds, and condenses to result in rain, which replenishes ground water. The manufacture of computer chips in which a series of stages yield a completed product is an example of a linear process.

WHO NEEDS PROCESS KNOWLEDGE?

Process knowledge is most needed by individuals who will work with systems to manage them or to repair them. A common example includes workers involved in diagnosis and resolution of problems, including equipment troubleshooters, medical professionals, and computer support professionals. Kieras and Bovair (1984) showed that learning how equipment worked in conjunction with learning equipment operational procedures resulted in faster learning, better retention after learning, and more flexible workers who could optimize procedures. In addition, workers involved in one or more stages of a process often benefit from understanding the entire process. For example, the customer service representative handling a refund request needs to know the refund process in order to answer customer questions.

We don't mean, however, that all training should incorporate process knowledge. In order to use a telephone effectively, one does not need an in-depth understanding of how the telephone works. We know of one client who devoted three weeks to teaching staff details of a work process associated with their internal customer. The goal was to help staff shape their own products more effectively to serve the needs of their customer. Still, a three-week course is probably overkill in this case. Since adding process content to courses will increase training costs, you will need to determine when and for whom and to what detail teaching process knowledge will give you a sufficient return on investment.

We think one reason for neglect of process content in training programs is that, while procedures are relatively easy to define, experts have stored process content as tacit knowledge in long-term memory and fail to articulate it during job analysis. As a result, process content often fails to surface during the course design stage. In an extensive psychological analysis of troubleshooting expertise based on observations of technicians solving real problems, Gott and Lesgold (2000) defined three major knowledge components underlying expert performance of repair technicians. The three included process (or how-it-works) knowledge; procedure (or what-to-do) knowledge, and strategic (or how-to-decide-what-to-do-and-when) knowledge. Of these three, it is the first—the *how it works* knowledge that we address in this chapter.

TEACHING PROCESSES

Hegarty, Narayanan, and Freitas (2002) designed training on how equipment works based on a psychological model of how people learn these kinds of process. They defined three main learning phases, summarized in Table 15.1. First, learners break a mechanical process down into the component parts of the equipment and

Table 15.1. A Psychological Process for Learning Systems

Stage	Description	Result
Decomposition	Learners break a complex system down into its component parts and learn the names and functions of each part	A static mental model of the system
Causal Model	Learners build a cause-and-effect model of how a system works to include an understanding of how each component affects other components in the system	A causal mental model of the system
Dynamic Model	Learners mentally animate a static model based on their causal model to create a dynamic mental model	A dynamic mental model that allows learners to visualize the entire process and reach a deep understanding of the system.

Based on Hegarty, Narayanan, and Freitas, 2002, and Mayer, Mathias, and Wetzell, 2002.

then form a static model of how each component relates to the others. Second, learners develop an explanation of how the system works based on cause and effect or on logic. Third, learners infer a dynamic mental model of how the entire system functions by way of mental animation.

This learning model suggests that process lessons should first help learners understand the individual components in a process, second the logic or cause-and-effect relationships among the components, and finally the interactions among the components in a model of overall system functions.

Hegarty, Narayanan, and Freitas (2002) developed lessons on how a toilet flushes in multimedia and in print based on this model. They found their lessons to be more effective than award-winning commercial lessons on the same topic. Their process lessons included three main phases. First, learners were provided a view of the entire system along with descriptions of parts of the system. Second, learners answered questions that encouraged them to reason about how the system functioned. This stage was designed to help learners form a causal model of the system as well as to mentally animate the system. Third, learners viewed a fully functioning system via either an animation or a series of static diagrams that were accompanied by descriptions of the process with text or audio.

HOW TO VISUALIZE PROCESSES

Processes such as how a toilet flushes or how the heart works involve tangible components. These components can be readily illustrated with transformational visuals that incorporate representational graphics. In this section we describe four guidelines that suggest ways to effectively use visuals to help learners build process mental models.

GUIDELINE 1: USE TRANSFORMATIONAL VISUALS THAT SHOW STATE CHANGES

Transformational visuals are graphics that show changes over time and/or space. They are most effectively used to communicate procedural and process content. Mayer (2009) summarizes nine studies involving lessons teaching process content, including how pumps, brakes, lightning, and generators work, that compared text alone with text and visuals. Some of the lessons were delivered in a print format and others used on-screen animations. Figures 15.1 and 15.2

Figure 15.1. A Text Description of How a Bicycle Pump Works.

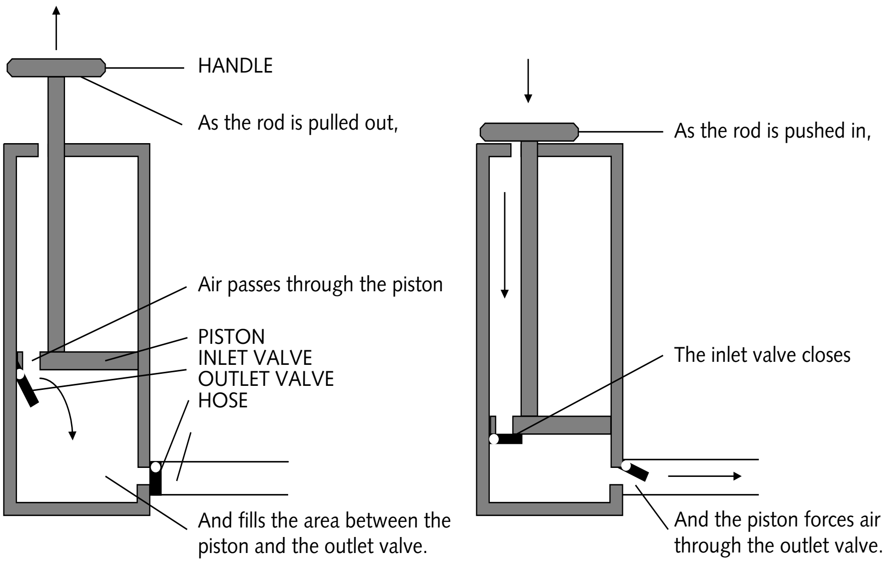
How a Bicycle Pump Works

"As the rod is pulled out, air passes through the piston and fills the area between the piston and the outlet valve.

As the rod is pushed in, the inlet valve closes and the piston forces air through the outlet valve."

From Clark and Mayer, 2008.

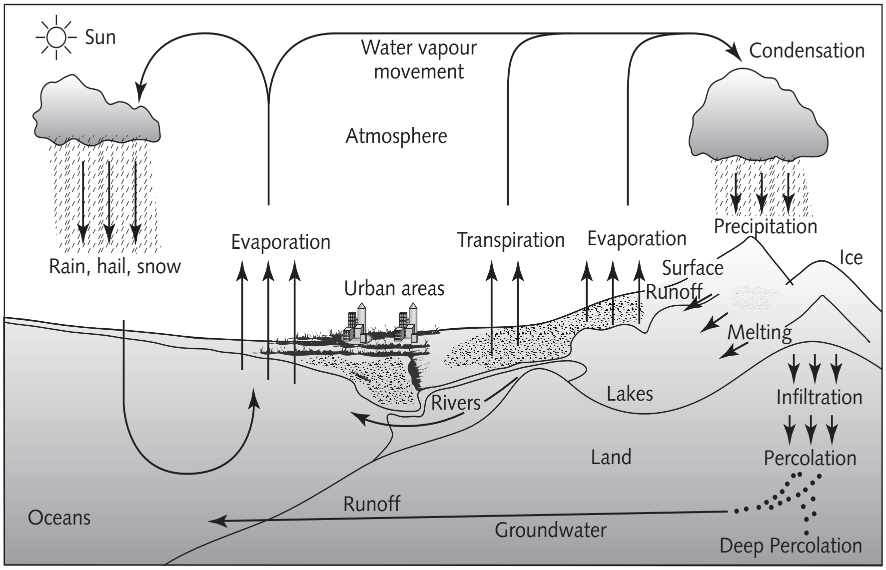
Figure 15.2. A Text-Plus-Graphic Description of How a Bicycle Pump Works.



From Clark and Mayer, 2008.

illustrate a words-only and a words-plus-visual segment from two experimental lessons on how pumps work. In all nine studies, transfer learning was much better among those who studied the lessons that included words and pictures than among those who studied lessons with words alone The median gain was 89 percent, with an effect size of 1.5, indicating a large practical effect.

Figure 15.3. Water Cycle.



From Unsworth, 2001.

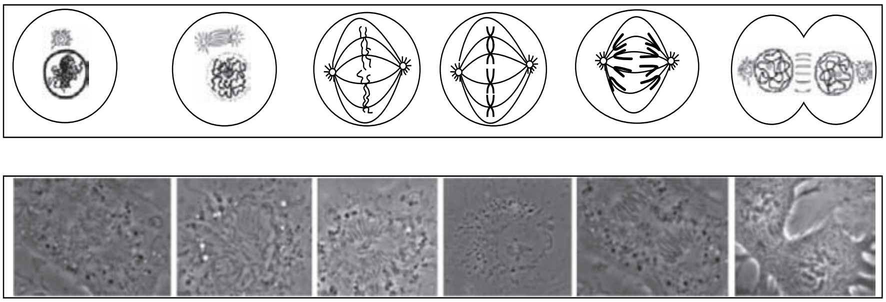
If you are displaying a process on paper, use a cycle chart or flow diagram such as the water cycle illustrated in Figure 15.3.

GUIDELINE 2: USE SIMPLER VISUALS TO PROMOTE UNDERSTANDING

Several studies published since our first edition show that simpler visuals such as static line drawings can promote understanding of a process better than more complex 3D graphics or animations. In Chapter 7 we summarized research by Butcher (2006) evaluating the benefits of three lesson versions on heart circulation: text only, text with simple line drawings, and text with realistic 3D drawings. Figure 7.5 shows the different visuals used. Butcher found that both drawings were more effective than text alone. However, the simpler line drawing led to better learning than the more realistic 3D visual.

Scheiter, Gerjets, Huk, Imhof, and Hammerer (2008) compared learning the stages of cell mitosis from a animated series of schematic visuals compared to a

Figure 15.4. Schematic Versus Realistic Dynamic Visuals of Mitosis.



From Scheiter, Gerjets, Huk, Imhof, and Hammerer, 2008.

video recording of microscopic images, as shown in Figure 15.4. Both versions were accompanied by audio explanations of the process. Learning was measured by multiple-choice tests and visual tests, including detecting errors in schematic diagrams and accurate sorting of static microscopic images. Lessons with the schematic animation resulted in better performance on the multiple-choice test as well as on the error detection test. There was no difference in the sorting of realistic images, even though the schematic group was never exposed to realistic images. The research team concludes: "It seems that learners [in the realistic video group] were overwhelmed with the amount of realistic detail and failed to come to a proper understanding of the process of mitosis" (p. 9).

Mayer, Hegarty, Mayer, and Campbell (2005) summarize four experiments that evaluated process understanding from an animated explanation compared to an explanation illustrated with a series of static visuals. The processes included how a toilet flushes, how brakes work, and how lightning works. Figure 8.6 shows two of the static images used in the toilet tank experiment. In two of the experiments, including the toilet tank lesson, the simpler static visuals were more effective. In the other two experiments, both static and animated visuals were equally effective. Although it seems intuitive that an animation would be more effective, the evidence does not support this idea. Animations provide a great deal of information in a transient manner, requiring the learners to hold early stages in memory as they view later stages. This extra memory burden may depress learning. In contrast, viewing a series of static visuals requires the learners to mentally animate the stages in order to understand state changes. Therefore, a series of static visuals may actually be more engaging than an animation.

In summary, evidence comparing the learning benefits of simpler to more complex visuals weighs in favor of simpler visuals to help learners build process understanding.

GUIDELINE 3: MANAGE LOAD WHEN PRESENTING PROCESS VISUALS

In Chapter 7 we discussed the negative effects of mental load on learning. We noted that load management is especially important for novice learners, complex content, and for dynamic visuals that display without learner controls such as pause and replay. When teaching complex processes, we recommend five research-proven strategies to manage load:

- Teach system components prior to teaching the entire system.
- Present words in audio format rather than in text when using a multimedia platform.
- When using text descriptions, allow animations to be played independently.
- Display still visuals contiguous with one another to promote mental animation.
- Draw the learner's attention to the portion of the process being explained by using cueing visual techniques.

Teach System Components Prior to Teaching the Entire System

Learning is better when system components are presented first. In a lesson on how a car's braking system worked, Mayer, Mathias, and Wetzell (2002) found that transfer learning was significantly better when the full process lesson was preceded by an explanation of the major components of the braking system and how each component could move. Pre-training on system components was effective whether the lesson was presented on paper or in multimedia. Figure 7.9 shows an example from the print version. The research team recommends that "before presenting a multimedia explanation, make sure learners visually recognize each major component, can name each component, and can describe the major state changes of each component" (p. 154).

Present Words in Audio vs. Text in Multimedia Lessons

Mayer (2009) summarizes research showing that, when using animation to illustrate a process, transfer learning is better when stages are explained with audio narration rather than with on-screen text. In four process lessons, a median learning gain of 80 percent was achieved when words were presented in audio. The reason is that an animated visual of a process is quite complex and will absorb all of the working memory visual processing capacity. When an animated visual is explained by words presented in text, learners typically read the text and while doing so miss the visuals. However, if the animation is explained with narration, the learner's attention is not split across two separate visual inputs. See Chapters 4 and 7 for more details on working memory structure and mental load.

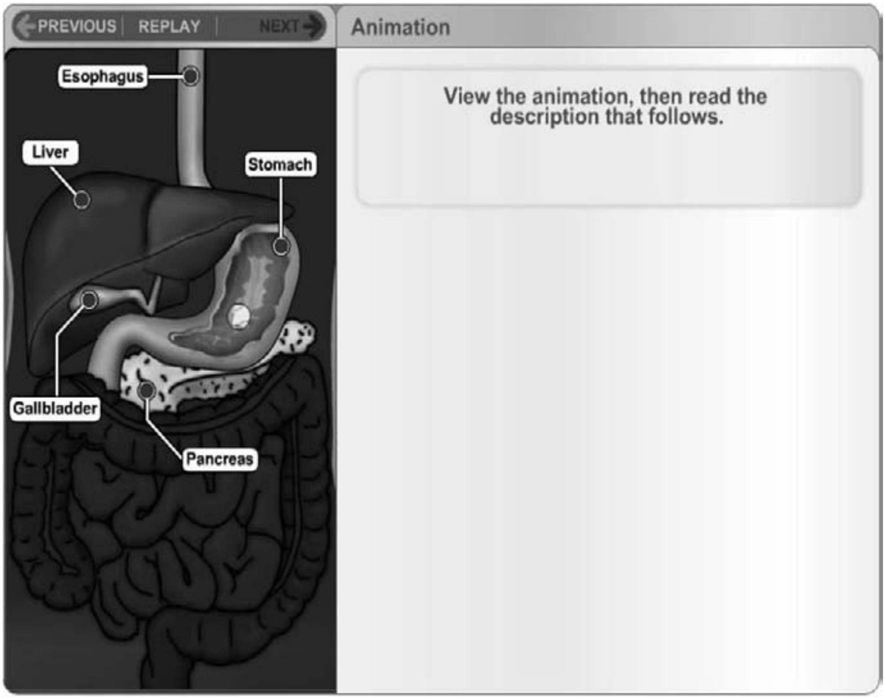
When Using Text Descriptions, Allow Animations to Play Independently

Sometimes it is not practical to use audio to describe an animated illustration of a process. If you use text, allow the learner to read the text independently of the animation. For example, in Figure 15.5, a lesson on the digestive system asks the learner to view the animation and then read a text description. We have seen the opposite arrangement as well in which text appears on the screen along with a static image. The static image plays when the learner clicks on a play control button after reading the text.

Display Static Images Contiguous with One Another to Promote Mental Animation

We've seen that a series of static images showing state changes in processes can be as effective or more effective than an animated display. However, it will be important to maintain visual access to a series of static images to allow the learners to view and review each stage as they mentally animate the changes.

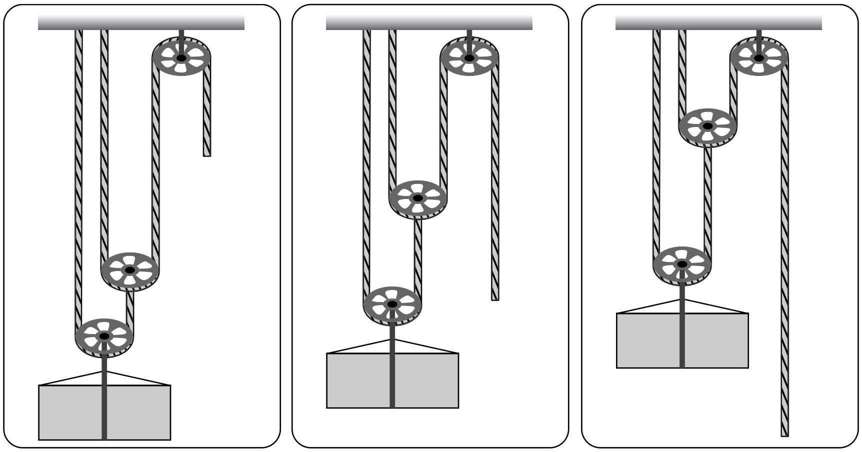
Figure 15.5. A Multimedia Lesson on Digestion.



With permission from the University of Phoenix.

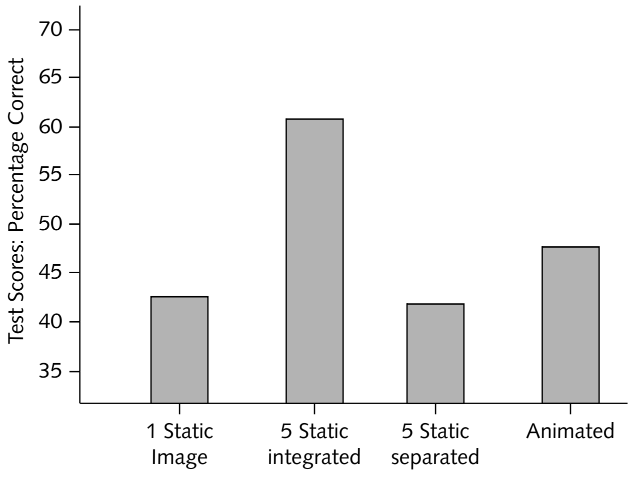
If different stages appear on separate screens or pages, the mental load of having to hold prior states in memory will negate the advantage of still visuals. Boucheix and Schneider (2008) compared learning a three-pulley system from four graphic versions explained by text: (1) single static frame, (2) five independent static frames that could be viewed one at a time on separate screens, (3) five integrated sequential static frames that could be viewed together on one screen, and (4) an animated illustration. Figure 15.6 shows the five integrated sequential static frames illustration. The other versions used the same visuals included in this figure as follows: the single static frame used frame 1, the independent frames showed all five visuals on separate screens, and the animated version provided a moving version of these visuals. As you can see in Figure 15.7, the integrated static frames resulted in much better understanding of the pulley functionality than the same frames presented separately or the animation.

Figure 15.6. Integrated Visuals Used to Explain a Three-Pulley System.



From Boucheix and Schneider, 2008.

Figure 15.7. Learning from Four Visual Representations of a Three-Pulley System.



Based on data from Boucheix and Schneider, 2008.

Focus the Learner's Attention on the Process Being Explained

Use cueing techniques to focus the learner's attention to the phase of the process being discussed. Some effective methods include highlighting the portion of the visual being explained, using spreading color to show movement, or a "reveal" technique in which each stage is added to the diagram gradually until the full illustration is shown. Other techniques include treatments to focus attention to the process stage being described such as (1) magnifying it while other stages remain in the background; (2) intensifying its colors while others retain their original intensity or are grayed out; and (3) playing a process animation at faster or slower than normal speeds to draw attention to elements that would be otherwise difficult to perceive.

GUIDELINE 4: USE INTERPRETIVE VISUALS TO REPRESENT ABSTRACT PROCESSES

Some professions use unique visual notations to represent processes. For example, circuit diagrams and equipment schematics are unique visual displays used in troubleshooting work to represent how equipment is controlled electrically and/or mechanically. In Chapters 8 and 9 we described research by Kieras and Bovair (1984) showing that learners who were taught how a control panel worked using the schematic in Figure 9.4 were more efficient at learning and using the system than were learners who were taught only the steps to use the control panel. Table 15.2 summarizes the results. Participants who were trained in the process of how the equipment worked retained 80 percent of what they learned, compared with 67 percent retention among learners trained only in the procedures. Furthermore, 40 percent of the individuals who learned process content made the procedure more efficient by figuring out shortcuts based on their understanding. In contrast, only 8 percent of those who learned the procedure alone implemented shortcuts.

GUIDELINE 5: PROMOTE ENGAGEMENT WITH PROCESS VISUALS

We know that some learners are better than others at learning from visuals. More successful learners take time to study and process a visual effectively. What are some ways you can promote deeper learning from your process visuals?

Table 15.2. Learning and Performance Based on Process Knowledge

	Training Content		
	Procedure Only	**Process Procedure**	**Improvement**
Training time process		1141	-
Training time procedure	270	194	28 percent
Retention	67 percent	80 percent	19 percent
Shortcuts	8 percent	40 percent	400 percent
Execution time	20.1	16.8	17 percent

From Kieras and Bovair, 1984.

Hegarty Narayanan, and Freitas (2002) found that asking questions that prompted learners to mentally animate a static model of the system before viewing a lesson animation of the system resulted in better learning than for learners who did not answer questions. In their study, one group of learners studied a static diagram of how a toilet flushed and then were asked to explain how the system worked before viewing an animation that illustrated the system. A second group of learners studied the static diagram and then viewed the animation without trying to explain the system. The first group learned more. The authors concluded: "Students learn more from viewing an animation of a mechanical device if they first attempt to mentally animate the device" (p. 379).

Encourage learners to think about process content by asking questions that will promote engagement with a process visual in ways that build job-relevant understanding. Include questions such as: *What would happen if the float in the toilet tank developed a hole? Sketch the path that a rejected prescription might take through the reimbursement process.*

Multimedia presentations provide a number of ways to encourage learners to engage with process graphics. For example, in a multimedia presentation of the digestive system presented in Figure 15.5, learners click on the different organs to learn about their functionality. A display such as this could be followed with questions about the role of the liver and gallbladder in digestion or with "what if" questions requiring the learner to click on the organ responsible for a given digestive problem.

THE BOTTOM LINE

Process visualizations can be real-estate hogs, requiring creative treatments to keep their elements legible and yet still fit within the available space. For print, consider two-page spreads or large page dimensions. For online courses, consider using a process flow graphic as the graphical user interface. In video, consider including a graphic of the process as an organizer that precedes a "zoom in" to investigate each stage. When designing process lessons for any delivery medium, consider the following tips:

- Illustrate individual process components first in system context, followed by transformational illustrations of the entire process.
- Use simpler visuals to help learners build a cause-and-effect mental model.
- Engage learners with process visuals, depending on the medium in which they are displayed.
- Manage mental load by using simpler visuals, explaining animations with audio narration, separating animation play from text descriptions, presenting static visuals contiguous with one another, and using cueing to focus attention to stages as they are explained.

Common Mistakes to Avoid When Visualizing Processes

- Failing to teach the process at all or not using visuals to illustrate the process
- Overemphasizing process content when work performance does not benefit from deeper understanding of how it works
- Overloading learners by illustrating complex processes all at once with animations
- Failing to promote engagement of the learner with the process visuals
- Oversimplifying the process to fit real-estate constraints

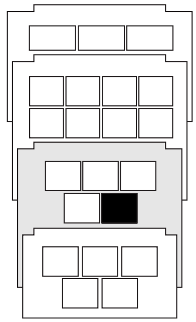
COMING NEXT

Using visuals to teach processes will help learners build a mental model of the systems with which they work. In the next chapter, we turn to another content type that involves mental models—principles. Understanding principles is the basis for far-transfer learning that enables workers to adapt guidelines to unique job situations that cannot be anticipated. In Chapter 16, we will discuss the design of highly visual scenario-based learning environments to promote learning critical thinking skills in work context. We will also describe some ways to teach principles in their more traditional sense as scientific laws or theories.

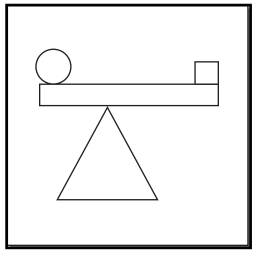
For More Information

Clark, R.C. (2008). *Developing technical training* (3rd ed.). San Francisco: Pfeiffer. (See Chapter 6.)

CHAPTER OUTLINE



CHAPTER 16



How to Visualize Principles

Some of the most important work in organizations is based on principles. In contrast to procedures, tasks based on principles do not have a single correct approach so the worker must rely on judgment to adapt guidelines to changing work situations. In this chapter we focus on three approaches to visualization of principles: problem-centered learning environments, video analysis for building interpersonal skills, and engagement in interpretive visuals for scientific principles.

We present research, psychology, and examples to support the following guidelines:

- Use representational visuals for problem-centered learning components.
- Use multimedia dynamic visuals to display case scenarios.
- Use animated learning agents to model critical thinking skills during problem-solving demonstrations.
- Use graphic design devices to manage mental load during problem-centered learning.
- Analyze video- or audio-recorded work examples.
- Engage learners with explanatory visuals including visual simulations.

WHAT ARE PRINCIPLES?

In this chapter, we discuss two types of principles. First, the more common definition of a principle is “a comprehensive and fundamental law, doctrine, or assumption.” Laws associated with mathematics and the sciences include familiar principles such as the ideal gas law, principles of genetic inheritance, and the law of supply and demand. Second, Clark (2008) defines principle-based tasks as work tasks for which there is no routine approach. Principle-based tasks are also called *far-transfer tasks*. Some examples include making a sale, designing a web page, and coaching employees. In fact, designing graphics to support learning is a far-transfer task! Note that for each of these examples, the different work situations require the worker to apply general guidelines in unique ways. For example, when making a sale, a guideline such as "define the client's needs" must be adapted to each unique client situation depending on the sales setting, the relationship with the client, and the nature of the products or services being sold.

The Transfer Challenge for Far-Transfer Tasks

It's impossible to provide step-by-step directions for far-transfer tasks because the job situations in which they are applied will vary. Instead, the best instructional approach is to help workers build critical thinking skills that are flexible enough to be adapted to different job situations. This is a challenging instructional goal and may be the reason that so much training focuses on procedures or even tries to teach principle-based tasks as if they were procedural. However, procedural skills won't help workers when they face an environment that is significantly different from the one they learned during the course. Your learners are better served by helping them build a deeper understanding that will flex to changing circumstances.

In this chapter we discuss the role that visuals can play in teaching far-transfer work tasks as well as in teaching more traditional scientific principles. We look at ways to use visuals in problem-centered learning environments as well as explanatory graphics that promote complex mental models underlying interpersonal skills and scientific principles.

PROBLEM-CENTERED LEARNING ENVIRONMENTS

Clark (2008, 2010) has described an instructional model called *problem-centered learning* (PCL) or *immersive learning* that is especially applicable to far-transfer learning. Over the past ten years, PCL has been called guided discovery, scenario-based learning, immersive learning, and even whole-task learning. Whatever name you use, the underlying idea is to use real-world work assignments and decisions as the kick-off and context for learning. Whereas traditional lessons may end with a case study assignment, PCL lessons start with one. PCL lessons can be motivating because starting a lesson with a real-world assignment similar to what a worker will encounter on the job generates a "moment of need" for learning.

For example, new bank loan agents may be given a lesson assignment to research and recommend a funding decision for a case loan applicant. The learners have a number of resources in their "virtual office" interface, shown in Figure 9.8. They can use the fax machine to access the credit history of the applicant, the telephone to check references, and even interview the applicant to obtain background information. The goal of the case is to help learners locate and evaluate information in alignment with bank policies regarding loan risk, client privacy, and equal opportunity. These policies, together with an efficient research process, form the underlying content for the lesson.

COMPONENTS OF PROBLEM-CENTERED LEARNING ENVIRONMENTS

Table 16.1 summarizes the main components of PCL learning environments: a trigger event, case data, case resolution, guidance, feedback, and reflection. Here we will describe some alternatives for visualizing each.

Table 16.1. Six Components of a PCL Learning Environment

Component	Description
Trigger Event	How the problem or scenario presents itself to the learner
Case Data	Information about the lesson scenario
Case Resolution	Actions learners must take to solve or complete the case scenario
Guidance	Instructional resources and techniques to keep learners on the right track
Feedback	Information in response to learner actions
Reflection	Opportunities for learners to review their actions or decisions and consider lessons learned

The Trigger Event

Quite often PCL lessons begin with a task assignment such as: *We have a new loan application. Please research and evaluate the application and give us your recommendation.* The assignment could be delivered as an email from a supervisor, a telephone call from a client, a work order, or an iPhone reminder of a scheduled meeting. Alternatively, rather than an assignment, the trigger event could take the form of a Murphy's Law video scenario. As the scene unfolds, everything goes wrong. At the conclusion, the learner has the opportunity to turn back time by making better decisions to resolve the scenario.

Case Data

Most case scenarios will require some background data about the situation. For example, in Figure 16.1 a virtual automotive shop includes test equipment that

Figure 16.1. A Virtual Automotive Shop.

With permission from Raytheon Professional Services.

can be used to diagnose an automotive failure. Clicking on the equipment lets the learner run a specific diagnostic test. To define the case data, consider what sources would be available in the normal work environment. For example, for the bank loan case, a credit report, client references, and client interview are all potential case data sources.

Case Resolution

As you plan the PCL lesson, consider what the workers would normally produce when they complete the task. For example, in the case of a bank loan, the loan officer would make a recommendation to reject or fund the loan supported by a report that summarizes the reasons for the recommendations along with supporting documentation. After identifying the job actions, determine how to represent them in the learning environment. For the bank loan scenario, the learner uses a checkbox to recommend funding or rejecting the loan. In the automotive troubleshooting scenario, a multiple select screen lists twelve different potential causes of the problem. With twelve options, making a guess at the cause of failure won't be that easy.

Guidance

Here you consider how to visualize various sources of instruction and guidance. Some typical resources include virtual experts, online agents, links to traditional tutorials, references, and worksheets with questions for the learners to answer as they progress through the scenario. If the scenario will be used in an instructor-led setting, group discussions and instructor support (either in a face-to-face class or online) offer additional guidance opportunities.

Feedback

There are two routes to feedback in PCL learning environments. First, you can use traditional feedback either through an instructor, peer evaluations, or via online comments on solutions. In addition you can offer *intrinsic* feedback by allowing the learners to experience the results of their actions and reflect on them. For example, in Figure 16.2, we see intrinsic feedback that appears upon selecting an incorrect cause of the vehicle failure. Here the learner sees that the symptom that initiated the problem persists.

Figure 16.2. Response to an Incorrect Diagnosis of an Automotive Failure.

With permission from Raytheon Professional Services.

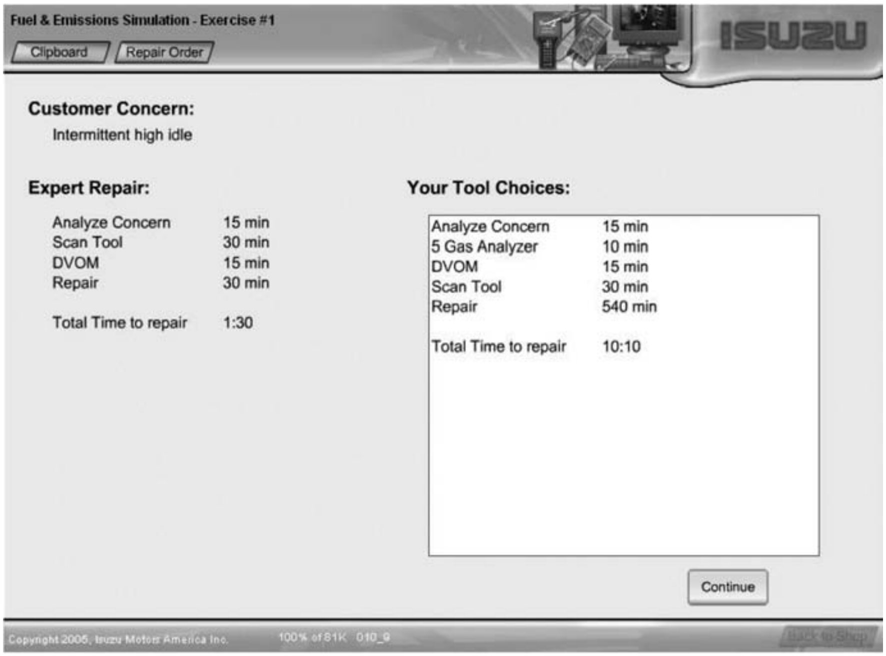
Reflection

Unlike a video game, the goal of PCL is learning. Along with feedback, provide an opportunity for the learner to review his or her actions or decisions and compare them to expert choices. In Figure 16.3 we see displayed on the right of the screen a summary of the tests performed by the learner to resolve the automotive failure as well as how long the tests required. On the left we see the actions and times of an expert. Comparing a visual summary of the case activities with an expert resolution offers a powerful opportunity for reflection.

WHEN TO CONSIDER PROBLEM-CENTERED LEARNING

When does it make sense for you to consider some form of PCL instead of a more traditional "tell-show and do" type of lesson? Three main indicators are (1) learning goals, (2) learner background, and (3) scarcity of on-the-job learning

Figure 16.3. A Comparison of Learner's Actions to Expert's Actions.



With permission from Raytheon Professional Services.

opportunities. PCL makes sense when your goal is to help learners build critical thinking skills applicable to principle-based tasks that involve problem solving. Second, consider PCL for learners with some relevant work experience. For inexperienced staff, we recommend sticking with a more traditional instructional format that ends with a case study practice. Third, consider PCL when the work context offers few opportunities for building skills due to safety or infrequency of initiating events. Troubleshooting is a good example. Certain equipment failures may be rare and unlikely to surface in a logical sequence for learning. Gott and Lesgold (2000) summarized evidence that PCL courses can accelerate expertise by helping learners gain job experience in a compressed time frame. Rather than taking years to build loan decision expertise, by working through a number of simulated cases, this experience can be gained quickly. In addition, there is consistent evidence that learners like PCL lessons because they are highly engaging and job relevant. Refer to Clark (2009a, 2010) for more details on research and features of PCL.

INDUCTIVE LEARNING FROM CASE EXAMPLES

Mayer (2002) distinguishes between *interactive cases* similar to the problem-centered learning model described above and *retrospective cases*. Lessons that use retrospective cases require learners to analyze video- or audio-recorded examples of actual work performance. Retrospective cases have been used most extensively in teacher education. Student teachers work in pairs or small groups to evaluate short video clips from actual classrooms. For example, suppose student teachers are learning techniques to manage disruptive students. They view a number of videos that show successful experienced teachers managing their classrooms in ways that avoid disruptions before they occur or minimize disruptions that do occur. The student teachers are guided in their analysis of the videos. For example, they might be asked to view five video cases and note how teachers minimized disruptions proactively through classroom routines and reactively through physical movement and through verbal comments. The analyses of real teacher behaviors are discussed. In this way, a number of real-world examples provide learners with a source for inducing principles of classroom management.

Moreno (2009) reported better learning when classroom case examples presented in video were elaborated on by a virtual agent. In her study, agent explanations for the actions the teacher would take in the video case were placed periodically throughout the video case just prior to the example. The explanations provided a rationale for the teacher's actions and helped draw learner attention to relevant elements of the video case.

TEACHING PRINCIPLES AS LAWS OR THEORIES

Principles associated with science or mathematics provide a basis for making predictions about natural phenomena. Often such theories or laws are abstract and can be taught through the use of concrete models that show principles in action. Models that can be visualized and made interactive have special potential to help make abstract relationships concrete and to build mental models.

HOW TO VISUALIZE PRINCIPLES

In this section we will focus on guidelines for visualizing problem-centered learning environments as well as ways to use visuals to build mental models in more traditional lesson formats.

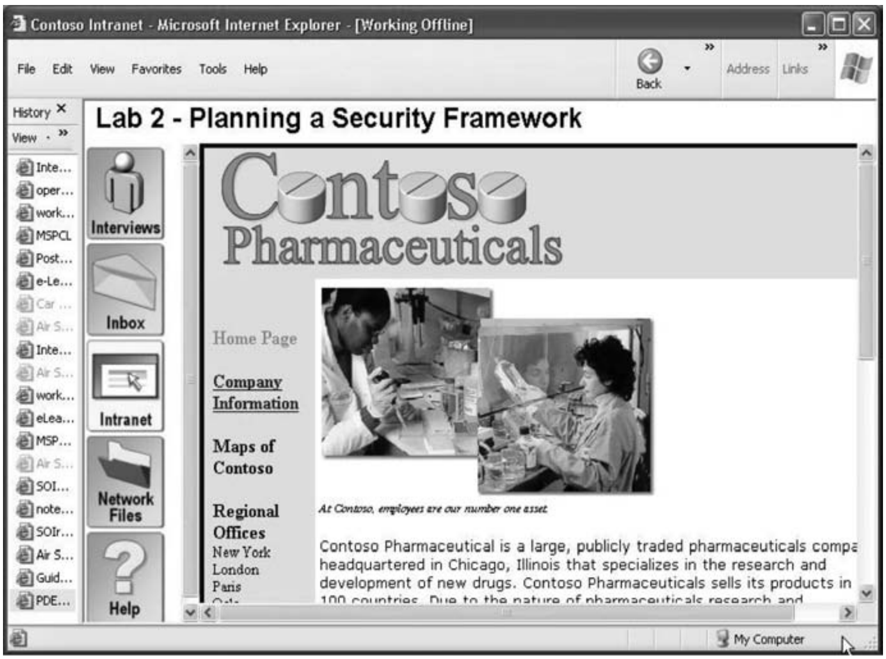
GUIDELINE 1: USE REPRESENTATIONAL VISUALS FOR PROBLEM-CENTERED LEARNING COMPONENTS

As described previously, PCL lessons initiate the learning event with realistic work assignments. The visual interface can contribute to the ambiance of the case by providing realistic representations of the actual work environment, as shown previously in Figures 9.8 and 16.1. In a Microsoft certification networking course, a case study originally presented in text was brought to life through a case company website shown in Figure 16.4 designed to provide background case data to learners.

GUIDELINE 2: USE MULTIMEDIA DYNAMIC VISUALS FOR CASE SCENARIOS

You may wonder whether it's worth the investment to build high-fidelity case visuals such as the Contoso website. Would learning be just as effective from the

Figure 16.4. A Website Created for a Case Company.



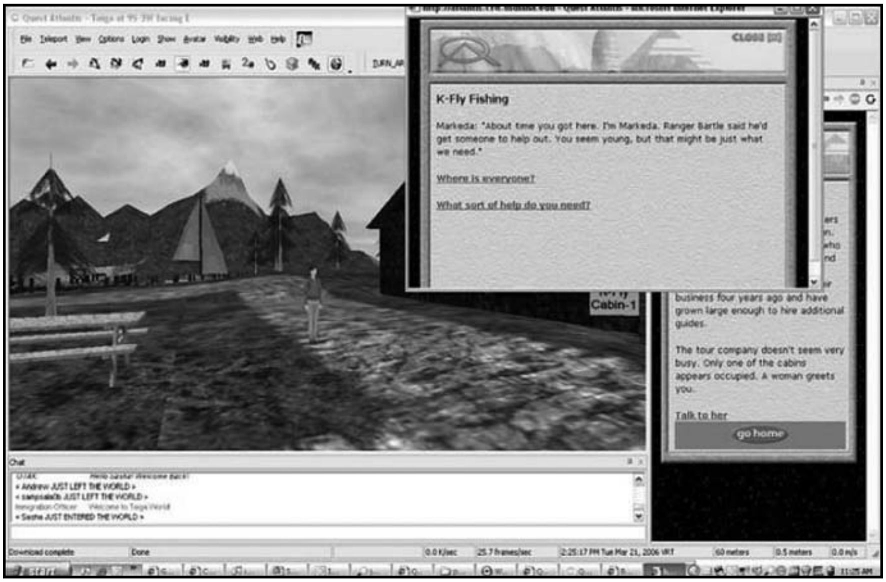
With permission from Microsoft Training and Certification.

same case presented in text? Research published since our first edition suggests that more realistic visual interfaces do increase engagement and learning. Kamin and her associates (2003) compared the depth of discussion among medical students reviewing a case presented in text versus a case presented in video. After reading the case in text or viewing the case in video, the learning teams discussed the case. The discussions among team members who viewed the case in video included a higher proportion of critical thinking compared to teams who read the case in text. The research team comments: "The video information corresponded more closely to what students actually see in cases than did the text case, and the video component seemed to enhance the case discussion" (p. 13). Balslev and others (2009) reported increased numbers of concepts emerging from collaboration among medical students discussing a video case compared to discussions of the same case presented in text. They noted that group discussion began right away while viewing the video, unlike those involved in reading the text version, which was completed in silence. The research team concludes: "Compared to a paper case, a video case is more effective in facilitating the sharing of cognitive processes by learners engaged in team learning" (p. 563).

Moreno and Ortegano-Valdez (2008) compared learning of student teachers who reviewed classroom examples presented with narrative text, with video, or with computer animation. They found better learning from both visual versions (video and animation) compared to the text narratives. Additionally, the research team suggests that animations may be more effective, as they can eliminate much extraneous visual noise captured in a video example. Production of animations may be easier to update and less expensive compared to video. It's useful at any rate to have evidence suggesting that either video or animation can offer effective visualization of complex interpersonal exchanges.

Barab and her colleagues (2009) compared the effectiveness of didactic text, story narrative text, and immersive virtual worlds in learning of water ecology principles. In the virtual world shown in Figure 16.5, the learner's avatar visits several groups in a park to investigate why the fish population is declining. The virtual-world lessons resulted in better learning of lesson-specific concepts as well as transfer to a different water ecology problem. We will need more research to identify what specific elements of the virtual world resulted in better learning. Was it because of the intensive visualization, the level of engagement in learning, additional information available in the virtual environment, the novelty of working in a virtual world, or some combination of those features?

Figure 16.5. A Virtual World Context for Learning Water Ecology Principles.



From Barab, Scott, Siyahhan, Goldstone, Ingram-Goble, Zuiker, and Warren, 2009.

The Future of 3D Learning

While evidence to date suggests benefits of visual presentations over text, greater visual fidelity does not always result in more learning. One study that evaluated learning of botany concepts in a multimedia game-type environment reported that experiencing the game in a virtual reality mode did not result in any greater learning than experiencing it in a two-dimensional graphic format (Moreno & Mayer, 2002). In the botany game, the added reality from virtual-reality motion cues did not contribute to greater learning.

Three-dimensional environments—both interactive and observational—will be driven by the gaming industry, and training applications will be one natural stepchild of that technology. Already several companies have invested in proof-of-concept virtual-world learning environments for new-hire orientation, role play, meetings, and emergency-response scenarios, to mention a few. As with all new technologies, we will initially use 3D interactive worlds to repurpose traditional environments such as virtual-world classrooms complete with PowerPoint presentations, as shown in Figure 2.7. Over time, however, we will learn when, where, and for whom to exploit the affordances offered by virtual worlds. As we mentioned previously, learning from a botany game did not benefit from a 3D treatment. In contrast, goals that benefit from the coordinate of multiple players in a three-dimensional environment may become the killer applications of 3D worlds. We look forward to additional research to pinpoint when more complex visuals such as animation, video, or virtual worlds benefit learning. (For more information, see Kapp and O'Driscoll, 2010.)

GUIDELINE 3: USE ANIMATED AGENTS TO MODEL CRITICAL THINKING SKILLS

One goal of some problem-centered lessons is not only to focus on the best actions to take or decisions to make but also to help learners build critical thinking skills that underpin problem solutions. Consider using an online animated agent to model the cues, hypotheses, or considerations an expert would think about while solving a problem. In the real world this tacit knowledge is typically invisible. However, you can make it salient by using an on-screen agent to model these thinking processes in the context of a problem solution.

In Figure 8.9 we showed an on-screen dolphin agent used by Wouters, Paas, and van Merrienboer (2008) to explain an abstract probability concept—the effects of replacing or not replacing items on the probability of drawing a given item from a pool of items. As another example, imagine including an on-screen animated apprentice technician in the virtual automotive shop illustrated previously in Figure 16.1. The agent could show how she completed a repair by not only illustrating the tests she conducted but at the same time by commenting on her rationale for each test and her interpretation of the results.

GUIDELINE 4: USE GRAPHIC DESIGN DEVICES TO MANAGE MENTAL LOAD DURING PROBLEM-CENTERED LEARNING

We've discussed management of mental load in almost every chapter in this book. However, nowhere is load management more important than when constructing PCL lessons. Mental overload is a common outcome of PCL designs. The combination of learning principle-based guidelines at the same time as working on case assignments can easily exceed mental capacity.

Here we offer four ways to constrain or "scaffold" the learning environment to manage mental load.

Use a Branched Scenario Interface

In contrast to the full-screen objects interface shown earlier in Figures 9.8 and 16.1, you can limit options and manage mental load through a branched scenario interface. In a branched scenario, the learner is presented with a short vignette followed by several choices. Each choice leads to a different result. For example, in Figure 16.6 we show a customer service branched scenario lesson. After hearing the customer's dialog, the learner can select from three choices shown under the customer window. Each choice will lead to a different customer response. In addition, the on-screen agent in the lower left will offer commentary on the choice. Branched scenario designs are applicable to linear cases such as a back and forth dialog in a customer service or sales setting.

Figure 16.6. A Branched Scenario Customer Service Lesson.

With permission from Vcom 3D.

Constrain Options in the Interface

If your learning goals do not lend themselves to a branched design, you can still use the full-screen objects interface shown in Figure 16.1. However, you can limit learners' access to the various on-screen objects. For example, in the automotive shop you might begin with a relatively simple failure that involves only two or three tests. For a simple beginning case, you deactivate all but a few relevant objects in the interface. Should the learner click on an inappropriate test, a small text box can state: *Not relevant to the problem* or some similar message. As learning progresses, scenarios become more complex and more testing options are available.

Provide External Case Data Repositories in the Interface

In many situations, the learners will need to accumulate multiple sources of data relevant to the case assignment. For example, in the bank loan scenario, credit history, references, and client interviews are a few of the case data resources available. As the learners access this information, provide a repository for it, allowing storage and convenient review of the data in one place. In the office graphic used for this scenario (Figure 9.8), you can see the file cabinet in the lower-left corner of the desk. As data is accessed, it is automatically stored there in file folders. In the automotive troubleshooting case, the learners have the option to store test data if they wish. After reviewing the results of a test, clicking a link will paste the results to the clipboard. Since the link is optional, the learner can disregard test results that do not help to resolve the problem.

Offer Worksheets to Guide Choices and Activities

In cases that will require a process to access and interpret data, worksheets can offer guidance regarding what data should be collected at what stage. A worksheet can include questions the learner must answer. In the bank loan case, the online worksheet is accessed by clicking on the virtual office computer.

GUIDELINE 5: ANALYZE VIDEO- OR AUDIO-RECORDED WORK SAMPLES

As we mentioned previously in this chapter, teacher education classes have made wide use of video cases of teaching skills such as classroom management, classroom questioning techniques, and dealing with disruptive learners. Examples of actual teachers working in real classrooms make the samples very relevant. Since a video is a very rich source of visual and auditory data, directing the learners' attention to and engagement with the video will help them derive maximum value. Additionally, making these assignments collaborative—that is, involving two or three learners observing and discussing the video cases—will also add to engagement. A sample assignment is: *Review the five video examples dealing with disruptive learners in the classroom and complete the attached chart by first summarizing the nature of the disruption and then observing the physical actions of the teacher, the verbal responses of the teacher, and finally the results of these actions on the disruption. When you complete the assignment yourself, discuss your observations with your learning team.*

In our experience, the use of real-work recordings as a learning resource is underutilized in corporate and business training. While video cases have long been used, most of these are scripted and acted out scenarios rather than actual work examples. An exception is the common practice of recording call center dialogs, which are often used for training. In the past, the filming process itself made creating actual work samples cumbersome and expensive, but advances in digital and video technology make recording cheaper and easier. Also, obviously, privacy issues and the need to secure releases from the individuals involved may preclude some recording. However, many business tasks based on interpersonal skills such as customer service, coaching, or sales are good candidates for the use of audio or video analysis for training.

GUIDELINE 6: ENGAGE LEARNERS WITH EXPLANATORY VISUALS, INCLUDING VISUAL SIMULATIONS

In some courses, you may need to teach traditional principles as the law of supply and demand, Ohms law, or other science principles. Many science programs use interpretive graphics coupled with computer simulations to help learners build mental models of principles.

For example, the ideal gas laws quantify the relationship between gas volume and temperature and pressure. Lee, Plass, and Homer (2006) evaluated learning from different interfaces for a simulation of the ideal gas laws. The simulation included an interpretive visual showing molecular movement with learner-controlled changes in temperature and pressure. Figure 8.8 shows a screen similar to the one used in the research. The research team compared learning from four different interfaces that manipulated the complexity of the user actions as well as a concrete versus an abstract interface. In Figure 8.8 you see that the concrete interface uses a small weight to represent pressure. Best learning originated from versions that allowed manipulation of only one variable at a time, for example, only temperature or only pressure AND used a concrete interface.

THE BOTTOM LINE

Lessons teaching far-transfer tasks may require several major visual components, including an interface that replicates the job environment, representational graphics that present guidelines applied to tasks in the form of job aids, worksheets, diagnosis tree charts, or other checklists. When designing visuals for principles, consider the following tips:

- Design checklists, job aids, or worksheets to aid learners in PCL.
- Use interpretive graphics and dynamic simulations to model principles in action.
- Keep an eye on virtual world technologies to consider how your far-transfer task training goals may exploit its features.
- Use on-screen animated agents to model critical thinking skills during a problem-solving demonstration.
- Engage learners with simulations to promote critical thinking skills.
- Use questions to engage learners with interpretive visuals.

Common Mistakes to Avoid When Visualizing Principles

- Using procedure or process visuals that imply a fixed sequence of steps
- Failing to promote learner engagement with interpretive visuals
- Using a discovery learning approach that lacks guidance with visual simulations
- Removing details that carry important cues to the appropriate diagnosis or application of principles
- Developing elaborate visual environments such as virtual worlds that obscure the key tasks or do not contribute to the instructional goal

COMING NEXT

In this section we have described research-proven ways to visualize five predominant content types associated with lessons designed to teach work tasks. In the final section of the book, we turn to the practical side of visual production by summarizing the many issues you will need to address in the planning, design, and communication of visual treatments to others.

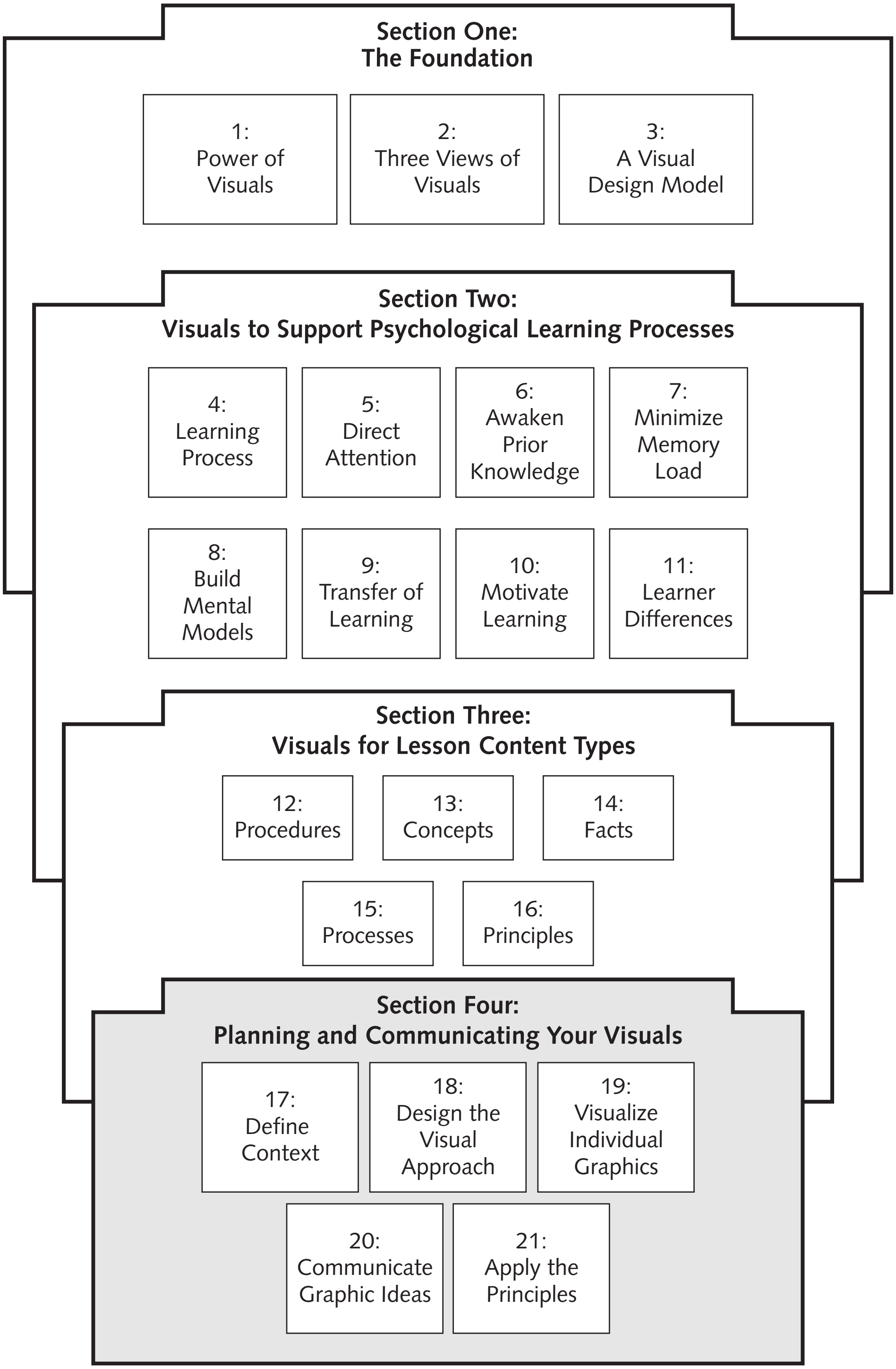
For More Information

Clark, R.C. (2008). *Building expertise* (3rd ed.). San Francisco: Pfeiffer. (See Chapter 7.)

Clark, R.C. (2010) *Evidence-based training methods*. Alexandria, VA: ASTD Press. (See Chapter 13.)

Kapp, K., & O' Driscoll, T. (2010). *Learning in 3D*. San Francisco: Pfeiffer.

Wouters, P., Paas, F., & van Merrienboer, J.J.G (2008). How to optimize learning from animated models: A review of guidelines based on cognitive load. *Review of Educational Research*, *78*, 645–675.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Visuals
2:
Three Views of
Visuals
3:
A Visual
Design Model
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Attention
6:
Awaken
Prior
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Models
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Introduction to Section Four: How to Plan and Communicate Your Visuals

In Sections Two and Three, we focused on how individual instructional graphics should match the lesson content and how treatment should support psychological learning processes. This section focuses on the systematic process of graphic design and production for instructional programs. In Chapter 3 we introduced the three aspects of graphic design: (1) the overall treatment, (2) the individual instructional graphic, and (3) the layout of the instructional graphic within the template. We also introduced a process for designing and integrating these aspects into the final product. In this section, we revisit that design process, adding details that will help you implement many of the guidelines offered in Sections Two and Three. Of course, graphics design and production is a subject worthy of an entire library or curriculum, as indeed it is in art schools and institutes of design such as Chubb, Parsons, Pratt, or the Rhode Island School of Design (RISD).

Our intent here is to focus on just the key elements and what you need to know in order to specify graphics that support learning. Finally, how much control you have over the design and production of any or all aspects of the graphic design of your instructional materials depends on the realities of your workplace. However, no matter how much responsibility for the treatment, individual graphics, and layout you have, understanding the impact of the design process can help you request, select, and communicate your graphic needs so that they are executed successfully. To that end, we provide brief guidelines and examples as well as quick checklists. We also provide resources for additional information.

THE IMPORTANCE OF EXECUTION

With this second edition, we continue to see how good visuals can be undone by poor execution. Even the best-planned graphic, if executed poorly or laid out haphazardly, will fail to realize its potential to enhance learning. Perhaps the ease of the rapid development tools and the emphasis on faster and leaner production contribute to these outcomes. Rankin's research (1989) found that 92 percent of learners' comprehension mistakes about graphics were caused by four reasons:

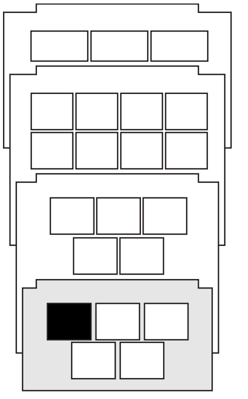
- Layout-related difficulties
- Lack of caption-picture correspondence
- Unfamiliarity of the graphical convention
- Misinterpretation of the graphical layout

Only 7 percent of learner comprehension mistakes were content related.

The first three reasons on Rankin's list relate to components of the package's overall design and the layout of individual pages or screens. In a systematic approach, the graphical conventions, including the parameters for icons, captions, and callouts, are generally standardized throughout a product, providing continuity and a visual vocabulary that the reader quickly learns and relies on. The basic visual approach is also determined early and for the entire product, with variations based on the individual content within each section. But if these are poorly planned, inconsistently executed, or badly distorted during production, the learners' ability to comprehend is compromised. As just one example, in cases where the graphic contains key instructional content, such as a powerful online interactive graphic, insufficient bandwidth can render it useless. If, in production, a figure or table is separated from the text that describes it, the learners' cognitive load is increased unnecessarily. Or if a video portion of a multimedia course runs too slowly or hangs so much as to be distracting, the graphic fails.

AN OVERVIEW OF THE CHAPTERS IN THIS SECTION

We begin in Chapter 17 by outlining the different types of workplace realities that shape your role in the graphics development for an instructional project. We go on to describe the many issues of the context within which the instructional materials will be used, as well as the production and delivery issues that can make or break your graphic's impact. Chapter 18 looks at how to translate the front-end analysis discussed in Chapter 17 into the "display framework" or the overall look and feel of the instructional product. Whether you are designing the templates from scratch or creating content to populate them, this chapter investigates the design implications of the following factors: the dominant medium that carries the storyline and guides the learner through the instruction, the size and orientation of your format, the desired style, and even the navigational elements. Chapter 19 focuses on ideas to jump-start your visualization of individual instructional graphics and provides some tips to help the non-artist translate procedures, concepts, facts, processes, and principles into graphics. Chapter 20 discusses how to communicate and lay out graphic ideas to clients, reviewers, artists, and production team members, including, if applicable, programmers. It highlights what each needs to know in order to complete his or her task in the execution of the finished product, integrating graphic and text, and in e-learning, integrating audio, animations, and video. Chapter 20 also outlines the tools that best provide the information needed and that support the collaborative effort usually involved. Finally, in Chapter 21, we wrap up this section by looking at the life cycle of two small projects as they progress from design inception to finished products.



CHAPTER OUTLINE

The Realities of the Workplace

- Instructional Designer Working in a Production Team
- Instructional Designer Working Alone
- Instructional Designer Collaborating with Graphic Designers

What to Decide and When

Assess the Learning Landscape

- Profile the Learner
- Analyze the Environment in Which the Learning Materials Will Be Used
- Determine the Delivery Medium

Consider Production

- The Equipment
- Formats
- Schedules
- e-Learning Production
- Online Training Technical Guidelines
- Production Personnel

CHAPTER 17

Determine the Context

This chapter visits what you need to determine at project startup to plan for your graphics. We begin by taking a quick look at the "realities of the workplace," which dictate how much control you have over the final execution of your graphic choices. No matter what your situation, you'll need to understand the impact of the factors identified in this chapter on your design.

Here we also discuss assessing the learning environment in which your materials will be used. Especially with the current explosion of applications for mobile devices, considering the environment—the "what, where, when, and how"—takes on renewed importance. Finally, we look at the design decisions that have to be made early in the process because they impact all subsequent graphics design and development. These include decisions about:

- Learner profile
- Learning environment
- Delivery media and platform
- Production issues, including the equipment, formats, and even schedules

THE REALITIES OF THE WORKPLACE

In our work with various companies, organizations, and individuals, we find the instructional designer's control over the visual design ranges from being the sole arbitrator with total control over all phases of development to being just one member of a team with little control or say. A few of the more common workplace situations are described below.

Instructional Designer Working in a Production Team

In some training organizations, the instructional designer/writer is often just one member of a larger team that may include artists and developers who do the actual graphics creation. Large-budget projects that have higher visibility, longer shelf life, or are part of an organization's strategic initiative often use this full-production team structure. In such situations, although the instructional designer may specify his or her own individual graphics, the overall treatment has probably been predetermined and individual graphics must conform to some sort of standards. Sometimes, instructional designers may even be restricted to a set or library of graphics from which to choose.

If you are in this environment, make sure you understand what the restrictions and parameters are with which you have to work. Preview your graphic needs, looking for anything that might conflict with the established templates, and be sure to communicate when you have very specific requirements for an individual page or screen layout. If you are part of a multiple author team—all working on one course, or related courses—communicate with the other designers about their graphic designs. Avoid a compartmentalization mentality, where you focus on just your part and miss opportunities to use visuals and techniques other designers have requested. When there is a perfect balance between instructional and graphic design, this approach often produces a polished, sophisticated meshing of art and content.

Instructional Designer Working Alone

We've found that the solo instructional designer often has a small budget, although occasionally there's unlimited time and money for high-quality production. Usually, however, the instructional materials are highly "disposable," perhaps used for a single presentation or for initiatives that do not have high visibility. Because of this, sometimes the designer uses a "canned" template and concentrates on only the content, the individual graphics, and the layout. Often the designer relies heavily on clip art, commercially available stock photos, or art in the public domain, resulting in graphics that are often merely decorative or representational and only topically related to the content. If you are an instructional designer working solo, push yourself to design explanatory visuals that will help your learner assimilate the content. Your chief challenge is to create a product where the treatment, individual graphics, and layout contribute to an integrated whole. Avoid a haphazard approach that undermines the content.

Instructional Designer Collaborating with Graphic Designers

In other situations, the instructional designer collaborates with a graphic designer from the project's outset. The instructional designer identifies the general instructional goal and idea that must be communicated visually, and the graphic designer helps build a treatment that supports the goal, the individual graphics, and layouts. Scenario-based learning often requires a customized treatment or GUI that reflects the job environment. Additionally, the instructional designer may collaborate with a graphic designer to create transformational or interpretive graphics that convey the basic components for concepts, processes, and principles.

If you have a high percentage of original art to be generated or are developing a job-context treatment for scenario-based learning, a collaborative arrangement often works best. For e-learning projects, the programmer may also be a collaborating member of the team. Such a team structure occurs most frequently in organizations or groups seasoned in the development of instructional materials and for materials projected to have longer shelf life and higher visibility. If you are lucky enough to work collaboratively with a graphic designer, your chief challenge will be communicating your ideas and incorporating your collaborator's feedback.

In the rest of this and the following chapters, we explore the systematic approach to designing the treatment, the content graphics, and the layout of the individual pages or screens. A conscious act of addressing each of these phases can help you overcome the institutional tides that can carry you away from graphics that promote learning.

WHAT TO DECIDE AND WHEN

Understanding the questions to ask at the beginning of a project can help you develop graphics that will work in your learning environment. You'll be able to avoid spending time you don't have on fabulous ideas that haven't a prayer of being executed due to technical or production restraints.

Most instructional design methodologies—including the commonly employed ADDIE (Analyze, Design, Develop, Implement, and Evaluate)—tackle such content and production issues right at startup, during the analysis phase of the project. With graphics, it's especially important to factor in the practical considerations, particularly cost and schedule, which leave you little wiggle room and time.

ASSESS THE LEARNING LANDSCAPE

Along with identifying the goal of the instruction (build awareness or build procedural or principle-based skills), you also need to verify information about the learners themselves, including where and how they will take the instruction.

Profile the Learner

Identify the learner characteristics that might have influence on your graphics. These characteristics include the learners' prior knowledge of the content, visual acuity, nationality, geographic location, first language, and so forth (see Table 17.1). The results of your investigation may have a startling impact on your overall display framework as well as on the individual graphics and layout. For example, as mentioned in Chapter 12, visuals that are congruent with text benefit low-prior-knowledge learners more than they benefit high-prior-knowledge learners. So if your learners are novice, you'll want your overall treatment design to accommodate an individual layout that keeps a graphic visible alongside its explanatory text.

Identifying the cultural background of your learner is also critical. Colors and symbols can inadvertently add connotations that you might not intend. Red in some Asian cultures is associated with prosperity and good luck. Yet in many Western cultures, red is used for alarms, alerts, and danger warnings. Which do you want your learners to think—luck or danger? Symbols, which are essentially metaphors, must also be used carefully. The charitable organization known as the Red Cross in the Western world is known as the Red Crescent in Turkey to avoid the religious connotations of the cross shape. So if your audience is international, scrutinize any visual analogy or metaphor for possible unintended localized meanings. Strive instead for universality. If a high percentage of your learner population

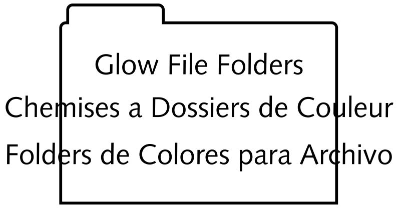
Table 17.1. Key Learner Profile Characteristics to Consider

Characteristics	Examples
Age	12, 22, 32, 52, etc.
Localization	Country, language, culture
Gender	Male/Female
Demographics	Rural or urban
Education	High-school diploma Bachelor's degree Post-graduate degree
Socioeconomic group	British class system Indian caste system American economic quintiles (upper fifth, etc.)
Vocation	Teacher Mechanical engineer Physician
Avocation	Gardening Video games
Key features	Refugee population Military background
Prior knowledge	Low, high, or mixed
Accessibility issues	Limits on sight, hearing, mobility, etc.

is from a culture with which you are not familiar, it pays to get some help with localization issues such as color, symbols, and the space needed for text that will appear in a different language.

If English-language material will be translated, your design may need additional white space to accommodate translation length. As just one example, Figure 17.1 illustrates the additional real estate required when translating English to French or Spanish. Note that the French version requires one-third more space than the English version. Be sure to allow extra space for all elements, including space on graphics for labels, callouts, pop-ups, or captions.

Figure 17.1. Space Needed for English, French, and Spanish.



Source: © 2004 Mark A. Palmer.

The American Institute of Graphics Artists sponsors a forum dedicated to graphic design across cultures. We've also listed a few resources at the end of this chapter if localization is a concern.

Analyze the Environment in Which the Learning Materials Will Be Used

During analysis, identify exactly *where* a learner will use and need to have the instruction available. Perhaps the materials need to be always visible to learners whose hands are anchored to the keyboard entering data and therefore unable to easily leaf through a manual without losing time and efficiency. Sometimes, the instructional material should be displayed *on* the equipment itself. For example, a job aid on how to change the cartridge on a shared printer is best displayed on a job-aid card with the printer, rather than in a manual sitting on someone's desk. Perhaps a graphic is to be used only when an instructor is present, such as in a virtual or classroom presentation. In such a "real-time" situation, there are fewer demands on your graphic designs to be self-contained and comprehensive because the instructor can verbally add information or address questions from the learners. Yet when the delivery is asynchronous, be that through print, video, or e-learning, the graphics need to be as self-explanatory as possible. Ultimately, your investigation of the learning landscape will lead you to decisions about media, size and layout, contrast, and boldness of the design. Table 17.2 provides some questions to start you thinking about the conditions in which the instructional materials will be used.

Table 17.2. Questions to Ask About the Learning Environment

Describe the learning environment in which the instructional material is to be used.

How is the package to be used?

- Group study?
- Self-study?
- Presentation?
- As a job aid?
- Other?

How many people who share space, visually and aurally?

What uniform or dress is required by the job?

Any special equipment that impacts the learning environment?

What is the lighting in room? (Will the room be darkened for a presentation, perhaps making it difficult for the learners to see their individual materials?)

How far away is the furthest learner from the materials?

How much time does the learner have with the materials?

Will the learner be able to control his or her own time looking at the materials?

How much space does the learner have to spread out materials?

In a classroom type setting, what is the typical room layout?

Are there other environmental issues to be considered, such as air circulation, temperature? (Will air movement disturb learning materials while the learner is attempting to perform a procedural task?)

Determine the Delivery Medium

As we noted in Chapter 3, all instructional material is delivered through some sort of medium: book, VCR, computer monitor, wall chart, or job aid. Printed materials are relatively consistent in quality from start to end of a print run. However, computer monitors, mobile device displays, and video or DVD players vary widely in their display capabilities and quality. If you have ever had a critical color in your PowerPoint presentation wash out when projected, you've witnessed the impact of the delivery platform on your graphics. Identifying the delivery media up-front helps you to make conscious choices on the graphic designs that will work in all the intended environments.

Also, identify *all* potential delivery media—book, web, video, or job aid—with their different design and layout requirements. An online graphic that relies on color families to show key context relationships will be difficult to interpret when printed as a black-and-white job aid. Even if you know that the materials are destined solely for one medium, for example, e-learning, are they to be delivered at the desktop in the work environment? Accessed over the Internet from home? Projected on a screen at the front of a classroom? The size of the graphic in this situation needs to accommodate both close viewing and viewing from a distance.

Identifying multiple uses at the onset of the design process allows you to plan effectively to accommodate all the intended delivery media, with the littlest possible compromise to the instructional integrity of your graphics. As just one final example, a common tactic is to stretch a small web graphic when adjusting materials for projection in a classroom, resulting in a blurry or jaggy image. If both the web and the projection delivery medium are known up-front, a different graphic or file format might be chosen, preventing distortion of the graphic or the additional time spent redoing it.

To uncover such potential pitfalls, test a representative sample graphic in its final deliverable(s) and environment. Often, artists who develop graphics on high-end computers may completely miss how distorted and poorly the graphic displays on an average user's monitor. If you use color photographs in materials intended for black-and-white print without testing them, you may miss the flatness and lack of definition of the final printed versions. When you can't test out your designs, you may at least be able to review samples of similar pieces, for example, e-learning courses developed to the same templates or other books by the same publisher.

Use the questions in Table 17.3 to start your assessment. Just the process of going through the questions systematically will jog you into thinking about how your instructional graphics will be displayed.

Finally, if your project is e-learning, you will need another, more specific pass at the technical platform parameters, such as the browser versions that have to be supported, hardware configurations, and any other restrictions from your information technology (IT) department. If you are involved with e-learning or training to be delivered on mobile devices, you have to know at

Table 17.3. Questions to Ask About the Delivery Media

Preliminary Delivery Media Assessment Questions

If projected at the front of a classroom

How far is the furthest learner from the display?

What is the lighting? In dark rooms, display frameworks with light backgrounds help the instruction and graphics stand out (especially if they are done in high-contrast colors). In light-filled rooms, dark display frameworks might work better. (I was once in a training room on the twentieth floor. Three walls were solid windows.)

If appearing in a book or guide

Are there restrictions on the size, use of color, paper stock, or even specialty papers (such as transparent films as are often used for illustrations in human anatomy texts)?

Will the learner need to use the book at a desk, hold in one hand, read from it at a distance?

What is the shelf life of the book? Does it need to be durable or disposable?

If appearing on a flip chart, bulletin board or white board

How far away is the furthest learner from the display?

Are there any bad angles for flip chart stands, white boards, etc.

If displayed on the learner's computer monitor

What is the maximum/minimum display resolution? For example, some companies standardized the desktop configuration to reduce help line calls to tech support. Or, in other situations, the learners may be in environments with limited resolution options, old equipment, or laptops.

What is the color depth? 256? 16 bit (sometimes called high color) or 24 bit (sometimes called true color)? If discriminations are required based on subtle differences between colors seen only in high color, learning for viewers at lower color depths is compromised.

What is the connectivity or speed of access (wireless, local drive, dial up, or broadband)? Elaborate graphics that consequently is a big file may display too slow to be seen simultaneously with the text or audio that explains it. For browser-based courses, you will also want to assess whether the platforms will have or can have (based on corporate standards) plug in software to run animations, audio, or video. Many corporations prohibit plug-ins, so training components dependent on animation or audio delivered through plug-ins will not work.

Table 17.4. Questions to Ask About e-Learning Platforms

If you are building for this . . .	**Use these graphics file formats**	
	Raster or "bit map" files for photos, illustrations	Vector or "draw" files, for diagrams, charts, illustrations, logos
Portable document	.jpg, .gif, .bmp, .png	.ai, .eps, .emf, .wmf
Slide Show	.jpg, .gif, .bmp	.ai, .wmf, .emf
Print	.tif, .jpg, .bmp	.ai, .eps, .emf, .wmf, .dxf, .wpg, .cgm
CD-ROM	.gif, .bmp, .jpg	.ai, .wmf
Web	.gif, .jpg, .png	.swf, .spl, .svg

Legend

Jpg, jpeg	**J**oint **P**hotographic **E**xpert **G**roup
Gif	**G**raphics **I**nterchange **F**ormat
Bmp	**B**it**M**a**P**ped format
Png	**P**ortable **N**etwork **G**raphics
AI	**A**dobe **I**llustrator
Eps	**E**ncapsulated **P**ost**S**cript
Emf	Windows **E**nhanced **M**eta **F**ile
Wmf	**W**indows **M**eta **F**ile
Cgm	**C**omputer **G**raphics **M**etafile
Dxf	**D**ata e**X**change **F**ile
Wpg	**W**ord **P**erfect **G**raphics format
Swf	Flash movie/animation format
Spl	Flash movie/animation format
Svg	**Sc**aleable **V**ector **G**raphic
Tif	**T**agged **I**nformation **F**ormat

least some of the basics about the technical restrictions of your project before you begin to think about color, shape, size, or animation of your graphics (see Table 17.4).

CONSIDER PRODUCTION

In development, the mantra "Start at the end and work backward" applies to more than just the schedule, but to all aspects that can impact how the final product will look. During analysis, identify production issues—such as the budget for art, actual production equipment, format of files required, and the schedule—that may compromise your graphic designs.

The Equipment

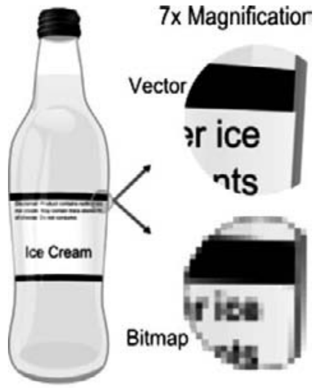
You may find yourself constrained by the realities of production quality. For print, you can see reproduction proofs before the print run, but sometimes you need to know the quality long before the proof stage. One organization, aware of its aging print shop equipment, chose to rely exclusively on line art for their instruction guides, rather than on photographs. It knew the quality of the print runs would not be good enough to support the color depth and detail that photographs would have to convey.

For these reasons, whenever your materials include photographs or elaborate graphics to be reproduced, you'll want to check for crispness, clarity, and contrast. When we sent samples of the graphics for the first edition of this book to our reviewers, we made this same common error—and for some of our e-learning screen captures, all our reviewers could see were smudgy black rectangles, because our low-end copiers could not handle the detail our graphics included. Lesson learned? Even though these were just review drafts, we knew we needed to use different examples for this book.

Formats

These days almost all art for reproduction is delivered in digital format, so most likely you will be working with a digital file, whether it is an Acrobat PDF file or a high-resolution graphics file ready for final print runs. Vector graphics are created by algorithms and are scaleable so that they can be stretched without losing detail. Corporate logos and many "illustrations" are vector graphics. Raster graphics—such as photos or software screen captures—are images created in a grid of pixels. Although they can be stretched, they will lose detail and may become distorted. Some recent formats bridge this gap; for example, the *png* format was designed as a scaleable raster format that reduces the loss of detail.

Figure 17.2. Vector vs. Raster Graphics.



Source: Wikipedia. Credit Ariel Lepor.

The difference between vector and raster graphics is illustrated in Figure 17.2. Other graphic formats (such as tiff or eps) suitable for high-quality print are often huge files too big to load quickly for web delivery.

For example, a rich, high-color, high-resolution graphic that clearly delineates the individual gradations of corrosion on a boiler pipe may lose all such color definition if reduced to a file that has lower color depth (less color information stored). Also, increasing size and resolution can distort graphics. As you enlarge a graphic, you magnify its existing properties and defects, a process that is less forgiving to raster graphics.

Schedules

With deadlines, of course, there are schedules. If you are working with an artist, remember that different types of art have various time requirements. In-house art production may be a faster alternative, but whatever your situation, find out how much lead time is needed. If you don't, you may be caught without enough time to make final but critical changes or be forced to pay "rush" costs.

e-Learning Production

In e-learning, programming or "authoring" is also part of the production effort, which culminates in publishing the materials to the host website, uploading them to a LAN server, or—although much more rare these days—burning them onto CDs. Sometimes, e-learning courses are a part of an organization-wide curriculum or university and must be uploaded to a common portal. The portal itself may be as simple as a single web-page course catalog or as complicated as a full-featured learning management system (LMS). Thus, the programmer may need to design to established technical standards. These technical standards may seem of little concern to you, but they often impact how a course is structured and experienced by the learner, which in turn can impact screen real estate as well as the size and orientation of your graphics.

Online Training Technical Guidelines

Several influential sets of guidelines are currently referenced in the online training industry. Two of them are

- Aviation Industry Computer-Based Training (CBT) Committee's AICC Guidelines and Recommendations
- Advanced Distributed Learning's Sharable Content Object Reference Model (SCORM)

Although in the six years since our first edition, many SCORM and AICC standards have been baked into e-learning authoring tools and learning management systems, they are still worth a brief mention here. AICC compliance applies to any online course, not only those disseminated via the web. CBT and multimedia that are delivered by CD or even a legacy mainframe can be designated "AICC Certified" or "Designed to AICC Guidelines." Note that although the AICC guidelines and recommendations concentrate on technical and interface issues, they also govern the use of icons and instructional chunking.

The SCORM is a collection of specifications based on other guidelines (including the AICC) that provide some standardization for instructional content delivered via the web. Currently, these are technical specifications, but they can have considerable impact on course-wide graphics determination. Central to the SCORM is the delineation of what is a uniquely addressable learning object or the size of the smallest discrete (addressable) component. This standardization is so that a learning management system can keep and track learner progress information. The design of your graphical interface is, in part, driven by total number of levels of granularity within the course. (In other words, the total number of levels in the course's organizational hierarchy—curriculum, module, course, unit, lesson, topic, subtopic, page.) Because SCORM compliance may influence some graphic design, ask whether your course needs to be SCORM compliant at the beginning of your project.

There are also several other international standards for digital images that may affect the technical aspects of the graphics you wish to use or display. The International Organization of Standards (ISO) and the World Wide Web Consortium (W3C) publish technical standards for international symbols, for virtual reality modeling language (VRML) as the basis of 3D content in MPEG-4, and the properties and attributes of computer graphic metafiles (CGM) for the web. The resources at the end of this chapter indicate where you can find out more about AICC, SCORM, and web standards.

Production Personnel

Finally, if you don't know, find out about how the instruction will be produced or programmed. In this era of globalization, it is quite possible that your online instructional materials may be assembled by individuals from another country, with a different first language. If so, you'll need to be very specific in your instructions for your content and graphics, their page layouts, and any issues of sequencing or syncing to audio.

THE BOTTOM LINE

Deciding or finding the answers to these questions at the start of your project will help you avoid unhappy endings, such as graphics that are too big to display or too small to be read, requiring expensive and time-consuming rework. Answering questions about production can prevent you from poor reproduction qualities that diminish the instructionval integrity of your graphic. And, of course, e-learning has its own private cemetery of dead projects for which the designers neglected these considerations. One company designed an elaborate multimedia interface that, because of its size, ended up requiring distribution on a CD rather than through their intranet. So they pressed 15,000 copies only to realize too late that, as a matter of corporate policy, there were no CD drives on the company's computers. The CDs, of course, were unusable.

COMING NEXT

Now that you have defined the context for the instruction, you are ready to plan your visual approach. The next chapter looks at the process of designing the overall look of your instruction. We begin by describing treatment meetings as brainstorming confabs to start ideas percolating. We then discuss how to determine whether the visual approach should be driven by text or by graphics, and overall issues such as size and orientation, style and available real estate and, for e-learning, navigation and functional graphic needs.

For More Information

American Institute of Graphic Artists (AIGA) and the cross-culture forum
164 Fifth Avenue
New York, NY 10010
http://www.aiga.org

Graphic Artists Guild (GAG)
90 John Street, Suite 403
New York, NY 10038
http://www.gag.org

Society of Publications Designers (SPD)
60 E. 42nd Street, Suite 721
New York, NY 10165
http://www.spd.org

Communication Arts
110 Constitution Road
Menlo Park, CA 64025
http://www.commarts.com

Folio
11 Riverbend Drive S.
P.O. Box 4272
Stamford, CT 06907–0272
http://www.inside.com/default.asp?entity=FolioMag

Computer Graphics Organizations

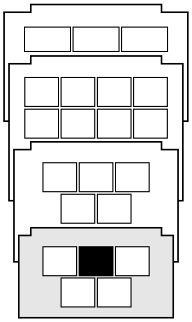
ACM SIGGraph
Association for Computing Machinery, Special Interest Group Graphics
http://www.siggraph.org/

ADL
Advanced Distance Learning and SCORM
http://www.adlnet.org

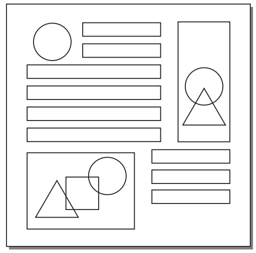
AICC
Aviation Industry CBT Committee
http://www.aicc.org

W3C
World Wide Web Consortium
http://www.w3.org/Graphics

CHAPTER OUTLINE



CHAPTER 18



Design Your Visual Approach

This chapter visits the basic elements to consider as you translate treatment ideas into a cohesive overall design for your instructional piece. Even if you are working to pre-designed formats, such as the requirements of a book publisher or the look and feel of an e-learning template, you need to know the parameters in order to develop a style for your individual graphics and a strategy for their layout. The process of creating the overall visual approach involves:

- Getting the right artist
- Brainstorming what is needed to support the goals of the instruction and the learning landscape
- Deciding dominant medium, size, and orientation, as well as color palette, style, and image
- Constructing a preliminary basic format that accommodates all the content

GETTING THE RIGHT ARTIST

Who does what and when in the development of graphics? At the most basic, someone comes up with the idea, someone creates the art, and someone integrates the art into the final production material. Depending on the size and nature of the project, these functions may be done by one person or by many. Table 18.1 provides descriptions of most roles in the production of commercial art (Graphic Artists Guild, 2007). Small organizations and training departments, however, rarely have

Table 18.1. Roles Involved in Art Production

Role	Responsibility
Instructional Designer	Designs the instruction and identifies what materials need visualization
Writer	Writes the content (may be specialized, as script writers for audio and video)
Art Director	Supervises the quality and character of the visual work; selects talent, purchases visual work. Usually an employee of the advertising agency, publishing house, magazine, or other user of the graphic artist's work, some organizations hire freelance art directors to perform these duties
Graphic Designer	Visual problem solver. A professional artist who works with all graphic elements (typography, illustration, photography, and printing) to create communication materials
Interface Designer	Creates the graphic user interface (GUI) that allows a user to navigate a software application or website. Has additional training in human factors and usability
Art Staff (animators, cartoonists, illustrators, photographers, videographers, CG artist, graphic film artist, etc.)	Create the artwork
Production Coordinator	Makes sure that everything is in order before the work goes into production (under camera)
Production Staff (tweeners, pasteup, inker, color checker, etc.)	Take the art from artists and ready it for production

Adapted from Graphic Artists Guild, 2007.

the luxury or the budget for a full-fledged cast. Sometimes, it's just one creative person who does it all—designs the instruction, writes the content, originates the creative vision, finds, creates or manipulates the art, and rolls out the production, all from his or her own desktop.

On the other hand, in many corporate settings, the instructional designers and writers pass off the graphics development to an artist. Unfortunately, a common mistake is assuming that one artist can do it all, from creating an effective e-learning interface to rendering 3D models for a virtual world. To highlight a few of the differences:

- *Interface designers* study human factors and are ideal for designing the graphic face of a website or software program.
- *Videographers* are skilled in creating dynamic images.
- *Graphic designers* are skilled in visual problem solving.
- *Artists* are often specialized in a particular medium—such as computer, print, film, or animation—and render graphics to detailed specifications.

As Table 18.1 shows, not all artists are graphic designers, just as not all writers are scriptwriters. If you have ever given a rough sketch to an artist hoping for magic and received back merely a cleaned-up version of your original chicken scratching, you've learned the difference between a designer and an artist the hard way. So, if you are designing material for a book, work with someone experienced in technical publications. If you are designing an e-learning interface from scratch, work with an interface designer.

DESIGNING THE VISUAL APPROACH

Chapter 3 introduced the idea of the "display framework," a generic term to refer to all the components that make up the look and feel of the product. In e-learning, the display framework encompasses the graphical user interface (GUI). In print, video, or slideshows, it might be called the theme, format, treatment, or template. No matter what the look and feel is called, if you are working to existing templates and formats, make sure you obtain samples and understand all the requirements. If you are crafting a treatment from scratch, begin with brainstorming, in a treatment meeting.

TREATMENT MEETINGS

Everybody loves treatment meetings. Ideas are popping and there's an adrenaline rush in the collaboration of team members feeding off each other's creativity. Virtual world for teaching diagnostic skills? Detective story for claims adjusters uncovering the causes of an accident? Nothing is "real" yet, so spirits are often high.

Does Your Project Warrant a Treatment Meeting?

Every project needs conscious consideration of its graphic look and feel—even if it is no more than to check off that the project will have the exact same look as the nine other projects that preceded it or to acquaint yourself with the requirements of the established format. For highly restrictive and automated productions, understanding the limitations and parameters is critical to effective design. In such cases, you may not partake in a treatment meeting per se, but treatment should be at least an agenda item of another project startup meeting.

Who Attends?

Few of us work in a high-end full production house where an art director, project manager, content developers, and artists as well as instructional, graphic, and software designers make up the team. Instead, many of us work in corporations where, at best, such teams include the content developer, graphic artist, and project manager. But even if you are a team of just one, hold a session for yourself anyway and perhaps invite a few trusted advisors. Treat yourself to the requisite finger food and beverage . . . and mentally kick around ideas about the look and feel that your instructional piece will have.

What Are the Prerequisites for a Treatment Meeting?

Coming up with relevant treatments, rather than just fanciful ideas, depends on the information you discover or decide about the goals of the piece and the learning landscape. These were introduced in Chapter 3 and further elaborated in Chapter 17.

What Is the Outcome?

The treatment meeting should provide a distinct direction for the overall visual approach; colors; styles, including the look of and access to ancillary materials (glossary, references, help); the typeface (or font) selections; the text, page, slide, or screen numbering conventions; and so forth. When these decisions are firmed up, even if you are working solo, document them. Include samples, standards for placement and functionality, and style guides for color, font, and type. Obviously, if several designers are working on the same project, they need to be working to the same design standards. In media agencies, such documents are known as "design briefs" or "treatment documents." Chapter 20 discusses these in more detail.

WHAT TO CONSIDER

At the treatment meeting or brainstorming session, it's easy to spend much of the time on visual ideas and treatments, colors, characters, and "cool stuff." Still, there are several basic instructional and design issues that should also be considered before committing to a specific visual approach.

Identify "Have to Have" Graphics That Must Be Accommodated

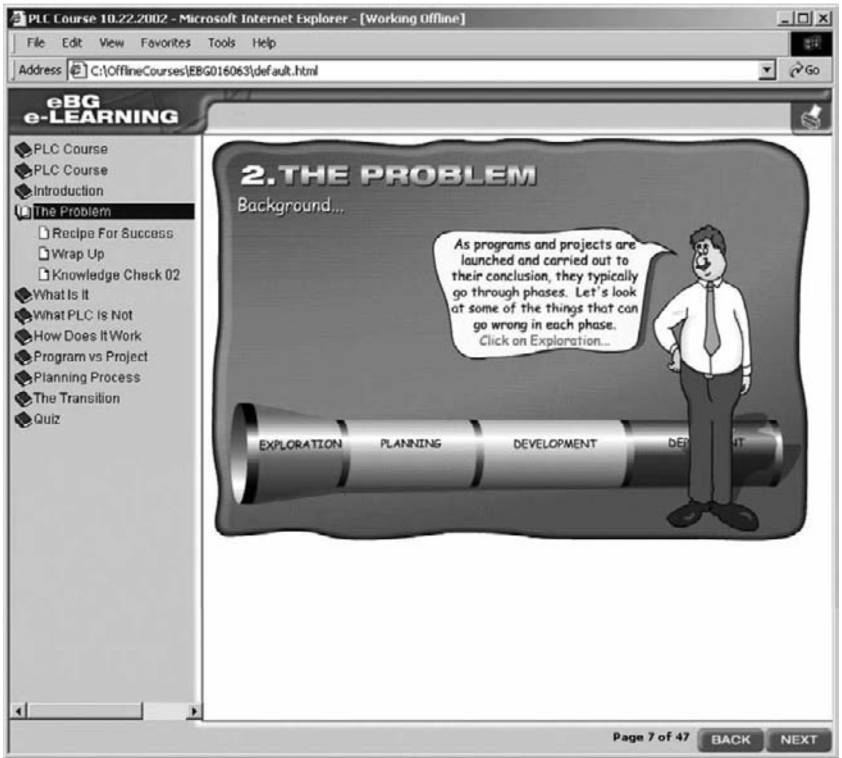
If certain graphics are part and parcel of the content—such as a key schematic or workflow diagram that carries throughout the entire course—their size and space requirements, along with any essential color and style elements, must be factored into the overall design treatment. If you skip this critical step, be prepared for plenty of rework or for compromised learning. In one e-learning project, artists developed a graphical user interface (GUI) that devoted one-fifth of the horizontal space just to navigation elements. Yet, the central content of the course required the simultaneous display of five columns of spreadsheet, which could not be legibly displayed in the GUI. By the time the designers discovered the problem, they were already locked into a programming production model. Learning was sacrificed to expediency.

Decide What Carries the Story Line

In training materials, either words or visuals carry the training story line and dominate the layout. With one medium dominant, as the learners move from page to page, slide to slide, or even link to link, they know whether to watch, listen, or read to follow the story line. As long as the technique remains constant throughout the instructional unit, there is no extra load for the learners trying to figure out what they need to pay attention to first. But if the design is schizophrenic, with competing emphasis for audio, text, graphics, and even animation, the experience is chaotic, unnecessarily overloads working memory, and is not conducive to learning.

As an example of a graphics-dominant display, consider picture books that use graphics to tell the story so that a child can literally decipher what happens from page by page by following the illustrations, even though there may also be text on each page. The graphics have primacy in the visual approach and are dominant. As another example, the e-learning course shown in Figure 18.1 is graphic-dominant. The pictures carry the story line, and the text is subordinate, often appearing only in speech balloons or integrated into the graphic.

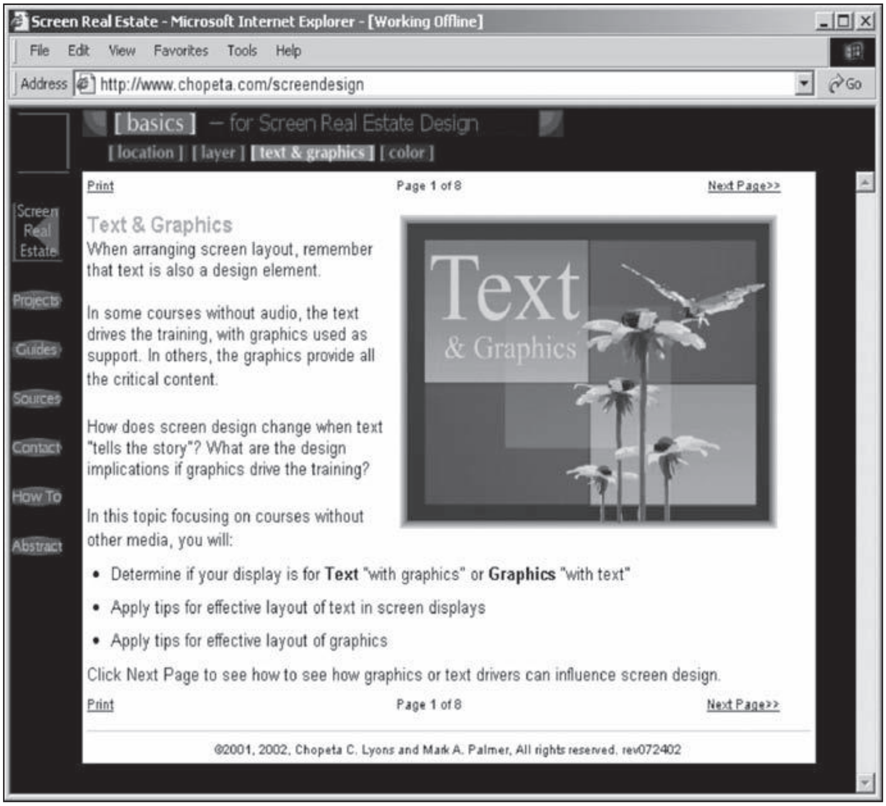
Figure 18.1. A Graphic-Dominant Instructional Screen.



Most manuals and books, however, tend to be text-dominant. It's the text that guides the learner through the materials. In Western cultures, the text often starts in the upper-left-hand corner where the eye is drawn. In text-dominant designs, the text should be the most salient feature, as in Figure 18.2. However, it's worth pointing out that a text-dominant display doesn't mean that the display is a wall of words. It merely means that the learners rely on the text to guide them on where to focus or on what to do next.

As you plan your visual approach, decide what element—audio, text, graphics—guides the learner through the materials. Naturally, you decide based

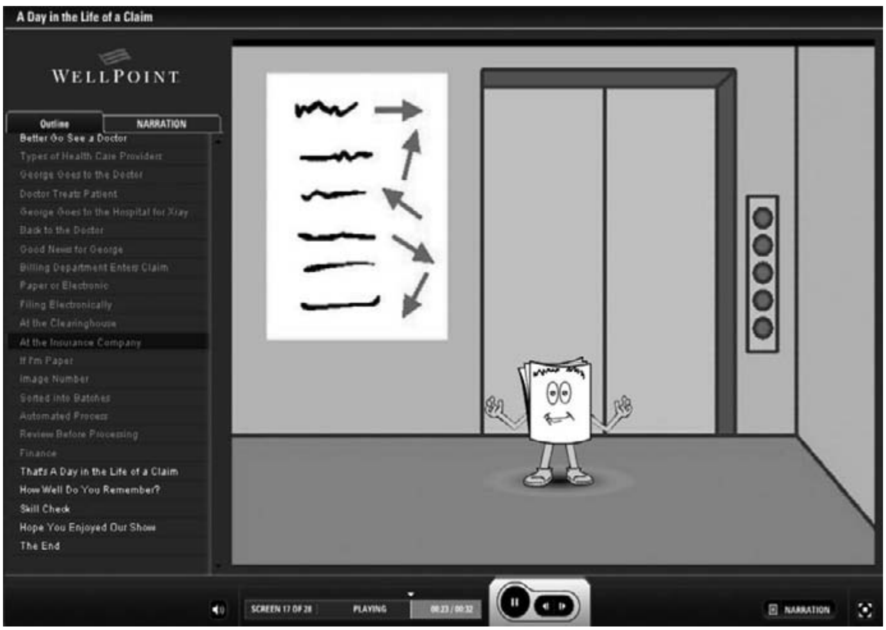
Figure 18.2. A Text-Dominant Instructional Screen.



on the content, the audience, the learning environment, the platform, all those issues you investigated and determined during assessment and analysis. Your decision determines the placement and sequencing of graphics as well as the real estate designated to other components. In text-dominant courses, prime real-estate space is dedicated to text. And in e-learning courses, where audio carries the story line, as in Figure 18.3, learners expect the audio to launch immediately and to cue them to what is important to look at or watch, so more real estate is available for graphics.

With audio and video technologies becoming ubiquitous on computers, cell phones, and now even e-tablets, making conscious decisions about what carries the story line is increasingly crucial to avoiding overloading working memory. To help determine whether your instructional content is a good candidate for a graphics-driven treatment, use the checklist in Table 18.2. If you answer five or six

Figure 18.3. Treatment for Instruction Carried by Audio.



From *A Day in the Life of a Claim*. © 2008 WellPoint.

Table 18.2. Candidate for a Graphics-Driven Layout?
Is the audience novice?
Do the graphics tell the story? (such as discriminating among the appearance of various skin cancer types)
Does the audience include speakers of many different languages?
Is the instructional content relatively straightforward, presenting mostly procedures, facts, and some concepts?
Is the explanatory text less than 20 percent of the total content?
Can the explanatory information be handled almost entirely in rollovers, callouts, or caption text?
Does the information need to be absorbed quickly, while performing the task?
Is the intended delivery platform a mobile device?

of the questions in this checklist with a "yes," your content may be a candidate for a visual approach that lets the picture tell the story.

Decide the Size and Orientation

For both paper-based and e-learning packages, decisions about the size and orientation of product are critical to how well the display framework supports the instruction, especially if "have to have" graphics are central elements of the content.

The size of the final product may also have the most far-reaching impact on the design and selection of other individual graphics. Is the book a standard 8½ by 11? 5 by 4? Landscape? Portrait? In e-learning, should the "page" be fixed to fit completely in the display window or extend beyond it and thus require vertical scrolling? If scrolling is required, how will it impact the comprehension of graphics? Will the graphic be visually separated from its explanation? Usability studies show some minimal vertical scrolling is considered okay; horizontal scrolling is less acceptable; and requiring both puts an extra burden on your learner's working memory (Lyons & Clark, 1999).

Size and orientation should also meet the requirements of the learning environment and the learner profile. Consider step-by-step instructions for clearing a paper jam in the office copier. The product size needs to be small enough to access while attempting to clear the copier, but large enough to accommodate legible illustrations. If designed by the equipment manufacturer, the instructions can be an integral part of the machine, on a control panel display, or even on decals inside the various parts of the machine. But if not, the size and orientation decisions need to take into consideration where the machine is located and how instructional materials can be kept with the machine. As one solution, perhaps you create a 5-by-4-inch landscape booklet that is stored in a pouch affixed to the side of the machine.

ROUGH IT OUT—STYLE AND AVAILABLE REAL ESTATE

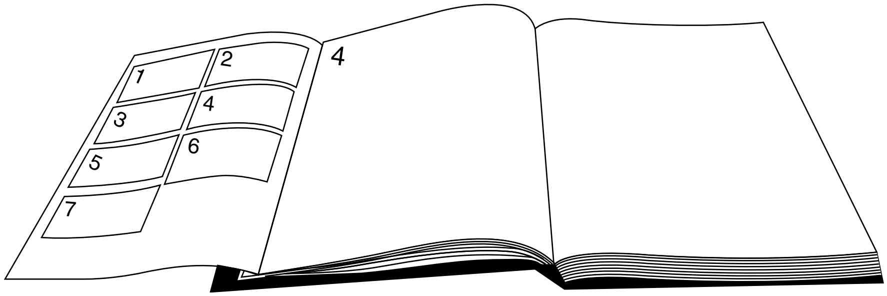
Now you are ready to take out your sketchpad and begin to think about the basic format. If you are fortunate enough to work with interface designers, here's where they bring all their creative expertise to the enterprise. If the product is paper (job aid, fold-out card, brochure), a print graphics designer may create a dummy, a mockup of how the product opens when held in the learner's hands.

For example, a recent coffee-table book, *Earth from Above* (Arthus-Bertrand, 2005), employs a technique that provides visual continuity (see Chapter 5 of this book) for a series of oversized photographs, each photo spread over two pages. Figure 18.4 illustrates how the legends for all the photos in the series are on a single page that folds out to extend outside the book covers, so that the reader can simultaneously see them while flipping through the photos. Obviously, this treatment issue had to be solved early since the development of content (the thumbnail photos, the legend text, and so forth) is dependent on the overall design.

Style

You may not have much latitude over your product's visual style. Perhaps your work is tightly controlled by corporate standards, e-learning tools, the desire to keep costs down by using "one-size-fits-all" templates, or even by restrictive production standards. Or perhaps at other times the style of your instruction is wide open to all the creativity that your design team can bring to the project. No matter

Figure 18.4. Visual Approach/Treatment for a Series of Two-Page Photo Spreads with Legend. With the legend folded out, the reader can page through the photos without having to flip back and forth to read about each one.



whether you are creating from scratch or conforming to standards, remember that every single visual element contributes to the style:

- The typeface/font you use for headers, subheads, and body text can communicate a style that is light and chatty or classic and professional.
- The color palette you choose can add an element of whimsy or of steely technical savvy.
- The amount of white space used in the layout not only aids in readability, but also contributes to the image the materials project. Dense type crowding a few graphics can connote an academic style. Lots of white space in the margins, between lines, around graphics and other page elements is not only more inviting to the average reader, but it can also project a more casual, less pedantic style.
- The type of graphics—illustration, photograph, stock images, or clip art—adds to the overall image. A reliance on over-exposed clip art can contribute to a "bargain basement" look.
- The style of the individual graphics—impressionistic, baroque, pop, rococo, or even cubist—also contributes to an overall style of the instructional material.

If you want to learn more about the "elements of style," investigate the resources listed in the end of this chapter as well as those listed in Chapter 17.

As you develop the overall style of the piece, keep in mind the cognitive principles for directing attention, managing load, and helping learners build mental models, as these may provide guidance on how you use, position, and sequence your elements.

Available Real Estate

Available real estate refers to the amount of space reserved for instructional content, distinct from navigational elements, decorative graphics, and theme treatment in your template. Even though at this point in the process it is too soon to be determining the exact layout of every page, frame, or screen, you are making decisions about the general pattern for the components of your display. Where do the standard graphics go? How should the running organizational graphic or text be handled? Should a book's template be a two-page spread to accommodate a graphics-dominant display?

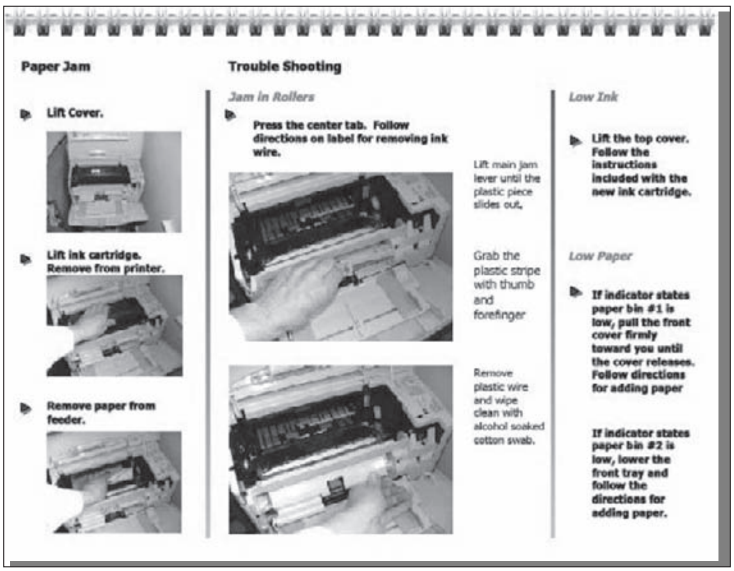
Note that these decisions become key development efficiencies in later phases of design. In e-learning, for example, the graphics and programming teams often develop templates that provide designers and writers guidelines on how much text will fit. In some cases, these guidelines establish the maximum number of characters as well as the maximum number of lines. Some very restrictive e-learning courses allow only small graphics, and these are limited to the upper-right corner of the display. Obviously, instructional materials designed for mobile devices are especially limited.

Sometimes, in attempts to jazz up interest, the tendency is to designate more real estate for seductive graphics, leaving less for what sometimes seems to be dull text or a "boring" chart or table. Although this tendency is especially evident with theme-based courses, the screen capture in Figure 18.5 illustrates that even the most basic courses can make the mistake of dedicating too much prime real-estate space in the templates for gratuitous graphics and thereby relegating the instructional content to a corner.

Designers of paper-based materials sometimes paint themselves into a similar corner. Consider Figure 18.6, a Quick Reference Card created for the paper jams instructions we mentioned earlier. Here, the graphics tell the story, but the three-column visual approach leaves very little space for the series of illustrations, especially for

Figure 18.5. Notice where your eye is drawn.

Figure 18.6. This design would have been better served by line art.



the three in the left-hand column. The available real estate for graphics is too limited. Thus, the illustrations are squeezed down to the smallest size possible. Three sets of instructions in three separate columns are jammed onto one page. Worse yet, the small photographs themselves are crowded with extra visual noise that makes it hard to decipher the steps of procedure. Solution? More pages, bigger illustrations, and line art instead of photographs.

Navigational and Functionality Needs

Navigational elements help learners move through the training. But they also let learners know where they are, where they have been, and where they can go. With print, several hundred years have refined these cueing techniques, so that the navigational purposes of section and chapter indicators, tabs, page number, or header and footer are universally recognized and understood. In e-learning's infancy, each package invented its own strategy, thus adding to learners' cognitive burden as they had to learn new navigation techniques as well as the content. Since our first edition, however, many e-learning tools have standardized navigation elements, reducing the need for designers to create their own. Now, research into navigation design for mobile devices is just beginning, with early work showing that a full GUI helps users perform better (Jacob Nielsen in July 2009 study.)

Generally, the navigational elements of the display framework in e-learning are more elaborate than those used in print, although we are a long way from the early days of e-learning with giant pulsing forward arrows. Learners need to know where to click to go forward or back through an instructional chunk. They need to know how to jump to another segment, access a glossary, and find adjunct samples and research. If the e-learning provides an on-screen agent or coach, the learner needs an icon or visible device to access it. These navigational elements should be readily accessible, require no extra clicks, and recede somewhat visually so as not to distract from the instructional content.

Even with the newer tools, good interface design is a discipline unto itself and beyond the scope of this book. Jakob Nielsen's *Designing Web Usability: The Practice of Simplicity* is a standard, but there are several other key books and seminars on the subject. Suffice it to say here, however, that for every function the designers anticipate the learner performing, space in the display framework needs to be reserved for a button, icon, and navigational identifier to let them do so.

Table 18.3. Are You Working to Existing Templates?

- ❍ Make a date to review the existing templates, formats, display framework, or GUI to make sure you are aware of all the requirements and restrictions that might impact your graphic design decisions.
- ❍ If there are documents dictating styles, formatting standards, and functionality, review them as well. Bib options and colors that may impact your design, selection, or creation of individual visuals.
- ❍ If you have an "essential graphic" need that isn't supported by the existing "display framework," communicate your needs and see if adjustments to the framework can be made.

Finally, what if you are working to templates that already define your navigation and design framework? Use the checklist in Table 18.3 to guide you.

A SEMI-FICTIONAL CASE STUDY

A company decides to put its basic two-day instructor-led seminar on the web. It's their first venture into e-learning, but their business objective is to start a catalog of offerings so that this first effort sets the standards for all the others in the library. They need to get the project up and running under a tight deadline, so they decide to use six instructional designers supported by a team of programmers, graphic designers, and artists. They compress the analysis, design, and development time frame and agree to take the risk associated with concurrent development (such as beginning scripting before the interface has been completely designed and prototyped).

During the analysis phase, the team determines that the content from the two-day seminar will be chunked into twelve modules, each as a stand-alone course accessible through a learning management system. Because the course will be available over the commercial Internet, they plan very limited use of audio and no video at all.

Once the instructional designers have analyzed the content, the programmers have investigated the delivery platform considerations, and the graphic designers have looked at the corporate graphic guidelines, the team meets for a treatment meeting.

During the treatment meeting, the team discusses all the elements the interface must include, such as a learner's online notebook, glossaries, sample data, and real-life examples. They know that the entire library of offerings will be in a 1024 x 768 resolution and use the same colors and branding as the corporate logo and website, so the corporate style guide becomes their bible in terms of "theme colors." The content is complicated, principle-based, and requires significant explanation, so the display framework needs to have significant real estate reserved for the text. The programmers decide to fix the screen size to allow only a little vertical scrolling where absolutely essential. The team agrees that once the interface is finalized, the programmers and artists will provide the instructional designers with maximum line and character counts to provide guidance on how much space they have for words. The instructional and graphic designers hammer out a compromise on the size of the text (the programmers and the artists want it smaller, equivalent to 8-point Arial; the instructional designers want it bigger and bolder at Arial 14 point).

The project manager asks the graphics designer to design a few samples and schedules another meeting when the team will reconvene. He asks the six instructional designers to look over all the content and consider worst-case needs for text, graphics, and interactions to make sure that the interface will accommodate everything the courses must include. They will also divvy up content development assignments when they meet again.

Later, in Chapter 19, we will follow one of the instructional designers as she focuses on the graphics needed for her individual lesson.

THE BOTTOM LINE

No matter whether you are creating the visual approach from scratch or working to tightly constrained restrictions, pay attention to your display framework components and how they impact the instructional content. Make sure you consider what medium is dominant—audio, graphics, or text. Research any "have-to-have" graphics to make sure that they are sufficiently accommodated by the visual approach. Check that elements of font, point size, style of graphics, color, and navigation support the instructional content that will be laid out in the template.

COMING NEXT

Once the backdrop is set, you and the team know the parameters and limitations against which you have to work for your content and any individual graphics your lessons require. In the next chapter, we take a look at how to get the creative juices flowing as you delve into the specifics of planning your individual content graphics. Some of these techniques are good data collection techniques or spring from the content types themselves. Others involve honing a new awareness of visual techniques.

For More Information

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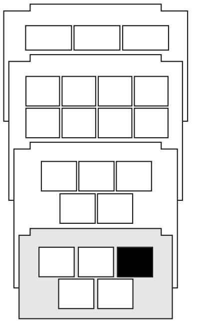
CHAPTER OUTLINE



CHAPTER 19

Visualize Individual Graphics

The past six years have seen an explosion in the availability of quality photographs and graphics easily and inexpensively purchased via websites. Yet, with so many options, it can be overwhelming to find exactly what we need, especially since many of us are not artists, nor have we worked in fields where art production is the norm.

In this chapter we identify key factors that can help you select and plan your individual graphics. We then provide some tips for exercising your visualization muscles, starting the moment you begin to research your content. We talk about collecting different source materials for your graphics based on the content types and suggest ways to activate your imagination and test out your graphic ideas. Finally, this chapter lists some resources you can investigate if you have to actually create original art.

CREATING INDIVIDUAL VISUALS THAT WORK

In the previous sections, we've discussed the communication functions and psychological events that can be aided by judicious use of graphics. We've shown how graphics can help learners absorb content that is

- Unfamiliar to the audience so that they need mental models and organizers
- Overloaded with detail and desperate for:
  - Organization to minimize mental load

  - Cues to focus learners' attention
- Complicated, either causally or temporally, requiring indicators of movement or time

In the two chapters immediately preceding this one, we've also discussed designing a display framework that meets the needs of the learning landscape. Next, how do you, as a training professional, begin to create or acquire the individual visuals that meet these demands? No matter whether you are working solo or as part of a team, the techniques in Table 19.1 can help you avoid the clip art rut.

Table 19.1. Tips for Going Beyond Clip Art

Tip	Examples
Start Thinking Visually from the Onset	• Consciously note graphics used by SMEs and in source materials • Register mentally when you feel the need to "see" the content • Ask resources "How would you draw this?"
Use Tools to Help You Capture Details	• Take photos • Gather charts and diagrams • Keep sketches made by SMEs and other experts
Collect Different Data or Different Content Types	• Be alert for "worst case" visual • Capture elements peculiar to content type
Procedures	• Capture the equipments, objects, or system applications used in the procedure • Capture examples of what the equipment looks like when steps are not followed correctly
Concepts	• Capture several (at least two) different examples of concepts • Include counter- or non-examples • Include items that often lead to confusion

Table 19.1. Tips for Going Beyond Clip Art (Continued)

Tip	Examples
Facts	• Get snapshots of specific items that represent the facts
Processes	• Capture various "stops" along the way for the process • Capture "outside" of object where the process occurs
Principles	• Be alert to the job environment, capture check-lists, resources, any items that the expert uses
Watch Movies	• Take trips to museums, bookstores, libraries, movies, even galleries, to see how others put together art to communicate ideas • Check the competition for how they use graphics for the same content • Pick up design books to help you start thinking in terms of color, layout, type, movement, etc.
Get the Big Picture	• Use treatment blocks in your design documents to force you to think about the graphics • Step back from time to time and look at all the individual graphics you are using. Do they work together?
Work from Visuals, Work from Content	• Graphics-dominant? Start by assembling the graphics • Text dominant? Less important to have all the graphics amassed, but don't let this become a reason to procrastinate about thinking through your graphics
Sketch	• Drawing is an excellent way to move from thinking in words to thinking in pictures
Test It Out	• Test graphics with the content they support • Test graphics with representatives of the target audience as they attempt to assimulate the meaning of the graphic (this technique prevents subjective whirlwinds of opinion by those who don't actually have to learn from the content)

Start Thinking Visually from the Onset

During the research or data collection phase of your project, observe where your sources used visuals to good effect. As you interview subject-matter experts (SMEs) during data collection, be sure to note whenever they resort to sketching out illustrations on a white board, flip chart, notepad, or napkin to explain a point. Even if the SME's "artwork" isn't much to behold, the act of drawing itself represents a need for a visual to communicate. Also, don't be shy about asking your SME for graphics inspiration. For example, ask, "If you had to draw out this concept or relationship for a learner, how would you do it?" The SME may welcome the opportunity.

If you encounter a graphic that promises to illustrate a key concept, but you find it confusing or misleading, consider why the graphic failed. You may be able to rescue it. To find out, test the graphic with representatives of the target audience. Have them explain what did or did not work for them. If it failed, try to isolate whether the graphic was (1) just a bad concept, (2) a good concept poorly executed, or (3) a good concept well executed, but poorly laid out with the other elements on the page or screen.

As you begin your analysis of content, pay attention to your own "visualization" techniques. If content makes you start diagramming, flowcharting, or "mind mapping" relationships among ideas, consider that your learners may also benefit from the same sort of visualization.

Finally, if part of your research involves touring facilities, note what is critical to be seen. Perhaps the physical layout of the facilities is a key visual for your learners.

Use Tools to Help You Capture Details

In the first edition of this book, we recommended investing in digital still and video cameras as "graphic idea collection tools." Today these tools are commonplace. With cameras now included in most cell phones, you can easily take photos of any flip charts, white board, or other non-digital surfaces on which an SME has drawn. Use these as you would any other reference material. Just as artists and designers have "idea books" or collections that stimulate their image-producing subconscious, these charts, lists, graphs, and scrawls can become your own "idea deck."

Take photos of onsite locations, equipment being used, or even areas that can be used for case studies. Note or photograph the types of clothing worn by the people doing the tasks to be taught. Uniforms? Casual attire? Professional garb? These source graphics will help you select appropriate stock photos or help guide illustrations for case studies or scenarios. And, of course, if you need to grab screen shots of software applications, there's a host of good capture tools on the market such as TechSmith's Camtasia and SnagIt or Adobe's Captivate.

Design Key Graphics Early in Your Process

Certain individual graphics, such as organizers and key explanatory visuals, may need to be selected or designed early, as they may be integrated throughout the design of several lessons, impact several other visuals, and perhaps even influence the overall look and feel of your product. Also, story line graphics involving characters, locations, and even equipment for case studies need to be developed early to provide consistency and so that every individual on the team has access to the same graphics. For courses that provide procedural training on filling out completed worksheets or progress charts, design the final state of these graphics early to ensure that the step-by-step graphic components fit together seamlessly.

Collect Different Visual Data, Depending on the Types of Content

Given the type of content you are teaching, focus on collecting different resources for your graphic ideas. Always be on the alert for your "worst case" visual need, such as the largest graphic, the oddest shape, the most complicated animation, or even the most unusual color palette. Its needs may impact your plans for other graphics.

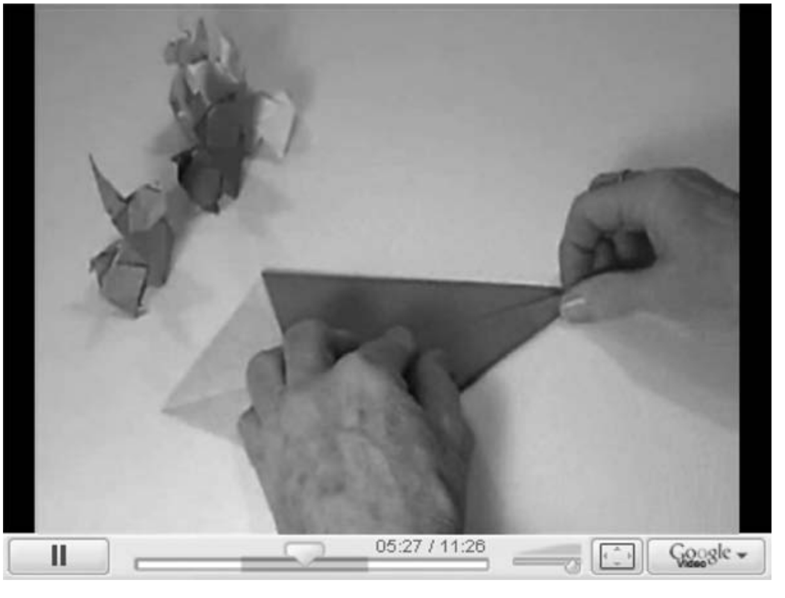
Procedures

For procedures, review the equipment, objects, or system applications used in the procedure to assess their real-estate needs. A piece of equipment that has a horizontal profile, such as the dashboard of a car, may require a different usage of space than a narrow vertical object such as a wiring rack. Get samples of as many of the equipment "states" as possible. In other words, capture how the equipment or screens change with each action step.

Also, rather than get a product-centered orientation, be sure to present a task-centered view of the procedure. If you have ever taught a child to tie his or her shoes, you know to demonstrate the procedure from the child's visual perspective. As simple as this advice sounds, doing so is sometimes difficult. The perspective may have to be from overhead (Figure 19.1) or from behind the back of someone doing the task. For a product that is new and has never been used in the field, ascertaining a task-centered approach is difficult. Perhaps you are designing training for a generic product, the use of which depends solely on the customer. Ask your SMEs for help creating a generic case study that addresses most major users and eliminates distracting industry-specific detail. With enough budget and time, another solution is to create graphics for several case studies, geared to the different industries or user types.

Remember that even abstract organizers need to correlate what the learner is supposed to be doing, responding to, and avoiding at each point along the way. Again, as you do your research, be sure to note the visual cues. Capture samples

Figure 19.1. Overhead View of How to Fold an Origami Rabbit to Provide a Task-Centered Perspective.



Source: Chopeta Lyons.

of what equipment looks like before and after each step is completed correctly. In some cases, it is equally important to capture how the equipment or product looks if the step is performed *incorrectly*, perhaps after a warning or caution has been ignored. Finally, many procedural courses teach computer application skills, which require full screen captures that are legible. You will need to reserve enough real estate for helpful explanations and tutorial information without obscuring critical detail.

Concepts

Do not forget to obtain samples of the counter- or non-examples. Sometimes the non-example provides a key to how to present graphics illustrating what a concept is by helping you visualize what it isn't. When gathering detail, be sure to get images of photos of items commonly misidentified as belonging to the concept class. Ask your SMEs what features or details of the non-example commonly confuse users into misidentifying it. Use this information to help you determine what should be emphasized in your graphic and then design your cueing techniques accordingly.

Facts

Concrete facts are often visualized with a representational graphic. During data collection, a snapshot is your best tool for visualization because it can tell you what needs to be emphasized and whether the fact needs to be rendered as line art to remove irrelevant detail, the "noise" or "chart junk" that merely confuses the learner. If you are dealing with multiple discrete facts such as product features, be sure to capture samples of each in order to create organizational visuals to help learners quickly associate common feature categories.

Processes

Process graphics are generally organizational, transformational, or interpretive. Sometimes, however, individual components of the process visual may be representational graphics illustrating how something looks as it passes through various stages, as in a process diagram of internal combustion in an automotive engine. Part of your task for creating the process graphic is documenting the flow or process itself. The very act of creating a diagram for a new process often surfaces issues or illogical steps in the process itself that need to be resolved.

So be prepared for several rounds of revisions to the process graphic, based on content changes.

It's a good technique to think of a process as a trip through space or time, with stages along the way. As part of your data collection, determine what types of images best represent those stages to your audience. Unlike procedures, processes do not require space for a one-for-one explanation correlating to each action the learner must take. But they do need some explanation of each stage. Process diagrams work best when they include textual cueing within the graphic itself, following the Guideline of Contiguity as described in Chapter 5.

Principles

During the data collection phase, you may find users relying on specific checklists, troubleshooting guides, or hand-made job aids. Principle-based training is best when it is job-based, so collect all the visual detail you can about the work environment, the types of problems the learner will encounter, and perhaps even samples of the tools that the learner uses. You may end up creating graphics that represent the work environment.

Use the Graphics as Your Outline

You may find it necessary to collect all your graphics before you actually begin the content development. Especially if graphics carry the story line, as they might in teaching a procedure, use them to guide you as you write for either text or audio presentation, ensuring that all the steps or phases are addressed.

Identifying all your graphics can also help you assess whether you are missing opportunities to enhance the materials with graphics that explain the content and add cognitive interest. If you have only a few graphics, it might be a tipoff that you are heading toward a rut of producing paragraph after paragraph of text in an unending river of words.

Go Off the Beaten Path

You can also gain inspiration from outside sources. Look at competitors' materials designed for the same content, purpose, and audience. An infusion of new inspiration can also come from even further afield. With an eye toward "borrowings" for your project, watch movies and visit museums, galleries, libraries, and bookstores to get fresh takes on how to present information. Concentrate on how materials are visually organized. Thumb through magazines and periodicals outside of your industry to see how they illustrate key content. For example, the *USAToday* Weather Book is splendid stimulant for visualizing processes. Browse the web for unusual techniques. And, of course, pick up design books to help you start thinking in terms of color, layout, type, movement, and sequence.

Get the Big Picture

Create ticklers in your design documents to make yourself think about graphics. In e-learning, some designers include a graphics specification segment for each topic in the outline (see Figure 19.2), forcing themselves to think about the best ways to communicate the content, verbally and visually, as an integrated whole.

Figure 19.2. Treatment Section from a Detailed Outline for an e-Learning Product. These treatment ideas ultimately became graphics in the course represented in Figure 20.2.

Tour 1: The Retail Pharmacy
Objective: Briefly describe the various locations within the retail pharmacy, the types of items found at each location, and the various roles within the pharmacy.
Content: Brief audio descriptions, with short bulleted highlights, describe each type.

Graphic Treatment: Scrollable 360-degree photographic tour of a typical retail pharmacy. Use a small to medium sized pharmacy. Need to have shots of the front door, inside the front door, aisles of off-the-shelf products (ideally with coupons or other rebates attached); the pharmacy counter, someone in the shelves behind the pharmacy counter; ideally the refrigerator for refrigerated pharmaceuticals, the cash register, etc.
Each of these will translate to hotspots the learner can click on to get more information. The hotspots and explanatory text are listed below.

Hotspot 1: The Pharmacist
The pharmacist is ultimately responsible for everything that goes on in the pharmacy. The pharmacist prepares medications, fills prescriptions, resolves reimbursement issues with physicians and third-party payers, manages the pharmacy staff and inventory, and advises both customers and physicians about issues related to the pharmaceuticals and treatments dispensed.

Source: Barry Galloway for Total Learning Concepts.

Once the outline or high-level design is complete, step back and look at the big picture. Ask yourself whether the graphics for all the topics work together or whether they are disjointed. Are there opportunities for common themes or the reuse of graphics? Consider the graphics together the same way you would look at topics in an outline. Do the graphics flow from one to another? Is there consistency across graphics? Do any of the graphics unduly emphasize minor points to the disadvantage of more important ones?

Sketch

Draw it. This exercise is for you and does not have to be shared with anyone. The process of arranging the various elements of the drawing can help you identify anything you have missed. Also, trying out the individual graphic in a rough of the page or screen will help you adjust the graphic to what can or cannot be done. Even if your drawing skills never progressed beyond coloring books, this exercise will also help you make sure the verbal and visual are integrated.

Use Software to Visualize

Software products are available that can help you visualize your ideas. Simple charting tools such as Visio provide templates for mind-mapping, flowcharting, office furniture arrangement, and so forth. These software products can help you step back and see how all the elements in your graphic can fit together. Also, the drawing tools in word processing and presentation software have become increasingly sophisticated since the first edition of this book. Now more than ever, it is efficient and relatively easy to rough out visuals without having to even own a higher-end graphics package.

Use the Right Skill Set

Since the first edition of this book, the skill sets of graphic artists have shifted so that few artists are exclusively "print" or "web." Still, if you are designing a 3D character as a guide for an e-learning program, hire appropriately or be prepared to be surprised and spend a lot of time asking for revisions. Just as you wouldn't expect a still photographer to be able to create a line art illustration, don't enlist a technical illustrator to provide you with cartoon graphics. Refer back to Table 18.1 for typical roles in art production.

Go Hunting

Even if you are a team of one without any graphic artist, you can still find ample existing art to support your instruction by investigating public domain art from a variety of sources, including the Library of Congress, United States Information Agency (USIA), or even Wikipedia. Graphics or photographs for the U.S. government have been paid for by the American taxpayers and are part of the public domain. The explosion of crowd sourced graphic sites, such as Getty and iStockphoto, also provides ample stock art and photos that are usually royalty free and for a relatively low price. These are often good sources for representational visuals.

Borrow Ideas from the Pros

Many of us do not have an art background or formal training in how to translate an abstract idea into a concrete visual. What shape is best? What colors to use? Will perspective help the learner focus on a key point?

When we are designing individual graphics ourselves, we keep handy three books especially targeting the non-artist: In Robin Williams' *The Non-Designer's Design Book,* she teaches us four basic design principles: *proximity* to show connection; *alignment* to show hierarchy and relationship; *repetition* to illustrate unity; and *contrast* to draw attention, to cue, or to create interest (Williams, 2008). Linda Lohr in her *Creating Graphics for Learning and Performance: Lessons in Visual Literacy* identifies tools, four of which are *space, type, color*, and *shape*, that we can manipulate in order to create a graphic that supports our training goal (Lohr, 2007). Stephen Kosslyn's *Graph Design for the Eye and Mind* (2006) should be the bible for anyone who needs to create charts, tables, or other graphics to provide interpretive graphics that help learners successfully visualize data. Each of these books provides specific, useful information for the non-artist tasked with creating individual graphics.

Honor Intellectual Property Rights

Although most content developers are savvy about copyright and the protection of digital media, many novices still mistakenly believe that anything on the web is free for their use. However, only art within the public domain is truly free for use without payment, but one should still provide proper attribution. Since grabbing

Table 19.2. Artists' Rights

Right	Definition
All Media Rights	Grants the rights to use the art in all media, print, web, video, etc.
Attribution	Artist is credited and acknowledged properly as the creator of the work. Artist retains authorship.
Berne Convention	The 1886 convention in Berne, Switzerland, that established a multinational treaty for the protection of literary and artistic works. The copyright laws of member nations conform to certain minimum standards and cover their citizens. The United States joined the Convention in 1988.
Copyright	The exclusive legal right to reproduce, publish, and sell original works. According to the U.S. Government Copyright Office, "Copyright is a form of protection grounded in the U.S. Constitution and granted by law for original works of authorship . . . Copyright covers both published and unpublished works."
Copyright Registration	Although under the Berne Convention an artist owns copyright from the moment the work is created, should an artist need to sue for copyright violation, registration is necessary.
Fair Use	In circumstances such as news reporting, scholarship, teaching, and research, original works can be used without payment, although proper permission and attribution is still required. The doctrine of fair use is detailed in section 107 of the copyright law.
Public Domain	Works in the public domain are not owned, but are instead public property and available for anyone's use. Works with expired copyrights or created for the U.S. Government and paid for by taxpayer dollars (such as photographs taken for the U.S. Information Agency) are in the public domain.
Royalty-Free	Royalty-free is a designation that indicates that the artist does not get paid per use. Instead, the purchaser has unlimited use of the work.
Work for Hire	Artists who are contracted under "work for hire" agreements—as is often the case with those who are employed as staff artists—do not own their creations, the employer does.

Adapted from the *Graphic Artists Guild Handbook: Pricing and Ethical Guidelines* (12th ed.) and the U.S. Copyright Office (www.copyright.gov).

art for your instructional materials is so easily accomplished by a right click and a save, it's important to recognize what is public domain, work for hire, and copyrighted art. Table 19.2 defines these terms and provides some examples of where you can acquire each type.

Test It Out

Although you can separate somewhat the development of the content and the graphic, have them reviewed or tested together. They are two parts of the whole. If the art and content are reviewed separately, reviewers may "approve" the text/audio content and then separately "approve" the graphic. But when those same reviewers see the final version with the graphics and content integrated, they are sometimes disappointed, confused, or miss an essential concept. They often demand changes to what they previously approved, increasing the cost of the project and delaying its completion.

Most importantly, avoid the trap of changing graphics based on subjective discussions about color, appeal, or even style. Test out the content and graphic combination on representatives of the target audience and see whether they make comprehension mistakes. Do not be side-tracked by subjective comments made by individuals not actually trying to learn from the graphic and the content.

Many of these suggestions apply to anyone tasked with creating individual graphics, but especially if you are working solo, use Table 19.3 to help you start.

Table 19.3. Do You Have Sole Responsibility for Selecting and Creating Your Own Individual Graphics?

- ❍ Assess your own design strengths. Even novices can produce polished looking materials from stock art by following the guidelines introduced here and investing some time in the resources suggested at the end of the chapters.
- ❍ Don't overlook the power of simple but clearly executed charts as explanatory visuals. These are relatively easy to produce in current word processing or slide presentation tools.
- ❍ Once you have collected your visuals, look at them as a comprehensive whole. Do they work together or do you have a hodgepodge collection that screams "thrown together"?

A CASE STUDY CONTINUED: SANJI'S GRAPHIC

As one of the six instructional designers on the team introduced in the previous chapter, Sanji attends a presentation on the subject matter. The presentation is videotaped, and copies are given to all the writers. At its conclusion, to supplement the video, Sanji also takes digital photos of the flip charts on which the presenter drew explanations throughout his talk. From experience, she knows that sometimes the videotape does not capture everything she needs. Finally, she also obtains copies of the slideshow the presenter used as well as all his other supporting documentation.

Next, as Sanji designs the content, she often flips through her digital photos for inspiration and clarification. One photo captured a graph that crystallized the stages within a process that supported the principle-based task her lesson teaches (see Figure 19.3). It becomes a starting point for her design of a dynamic animation to be incorporated in her lesson. She includes her photo in her scripts so her SME can see how she wants to use the graphic with the text.

From reading this book, Sanji knows she needs to engage the learners interactively. She knows she needs to eliminate extraneous data (chart junk) from the graphic, so she will indicate to the artist to drop the bottom curve of the graph that the presenter drew on his graphic on the flip chart. She also needs a technique that allows the learners to see several different pop-up text boxes and the chart at the same time.

To get ideas, she goes surfing through online learning websites and checks her own library to remind herself of techniques that have worked in the past. While she is at the museum with her children, she notices that one of the interactive kiosks lets her daughter chart the population growth of deer by changing the food supply.

Back at work, Sanji designs her chart, employing some of the ideas she has discovered. Her learners can watch the chart develop as they click on the various years, just as her daughter did with the food supply graphic at the museum. From her Internet browsing, she also has some examples of where to place explanatory segments to keep the chart and the text simultaneously visible.

She tests out her sketch with her SME, who likes the idea, but suggests she try it out with someone not as familiar with the process. Sanji does so, getting good feedback, which she incorporates into her sketch. She is ready to communicate the design to the artist for execution. In the next chapter, we will see just how Sanji does that.

Figure 19.3. Digital Photo Included in Script.

<table>
<tr><td colspan="2">Balanced Scorecard/Sky World</td><td>How to Build a Balanced Scorecard Final Draft Script
Course 7: Identifying Targets</td></tr>
<tr><th>Condition</th><th>Text</th><th>Graphic/Photo/Diagram Description
Audio Narration</th></tr>
<tr><td>Learner enters page.</td><td>How the HMO Sets Intermediate Targets

Click each year to see how an HMO set its intermediate targets based on the long-term stretch target of 88% patient satisfaction.
When you are finished investigating, click Next to look at another command's target setting and see if you can recognize their thinking.</td><td>Use cleaned up chart shown in flip chart example. Included in the graphic are percentage points on the vertical axis and years along the horizontal axis.

Below the curve graphic, use the chart on the bottom of the top slide page 55 of the version 2.2. seminar materials. Substitute data below.
<table><tr><td>Measure</td><td>Baseline</td><td>Yr 1</td><td>Yr 2</td><td>Yr 3</td><td>Yr 4</td></tr><tr><td>% patient satisfaction as determined by question #5 on patient survey</td><td>55%</td><td>65%</td><td>80%</td><td>83%</td><td>88%</td></tr></table></td></tr>
<tr><td>User clicks Baseline</td><td>Baseline

55% is the current patient satisfaction score.</td><td>Show baseline point on graphic</td></tr>
<tr><td>User clicks Year 1</td><td>Year 1

65% is the target for patient satisfaction in Year 1. Because there is a plan ready to be put in place, the command feels it can increase satisfaction by ten percentage points quickly.</td><td>Show line being drawn from baseline to year 1.</td></tr>
</table>

Source: Balanced Scorecard and SkyWorld Interactive.

THE BOTTOM LINE

To plan and specify individual graphics to support content, you need to think visually. Instructional designers tend to be verbal and think in terms of words. If you are fortunate enough to collaborate with a graphic designer, you will begin to view the world with a new perspective. But if you are not, in this chapter we have touched on a few of the techniques you can use. As with many skills, the more you do it, the better you will become.

COMING NEXT

The next chapter expands on the brief introduction to communicating your graphic ideas and layout begun here. It identifies what each team member needs to know and introduces the different methods for communicating graphic ideas.

For More Information

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Harris, R. (2000). *Information graphics: A comprehensive illustrated reference.* Atlanta, GA: Management Graphics.

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Malcolm, C. (2002). *Thinking visually: Business applications of 14 core diagrams.* London: Continuum.

Margulies, N., Maal, N., & Wheatley, M.J. (2002). *Mapping inner space: Learning and teaching visual mapping.* Tucson, AZ: Zephyr Press.

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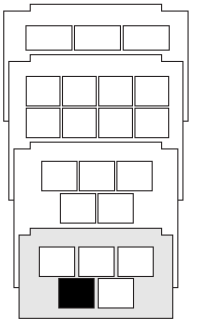
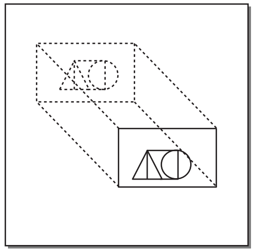
CHAPTER OUTLINE



CHAPTER 20



Communicate and Lay Out Your Graphic Plans

The technological advances since our first edition have made it easy for one person to master all aspects of the production—from design to creation to layout. Many e-learning tools now commonly import or capture PowerPoint files. Word processing software has become so feature-rich that designers can produce materials that rival those of the publishing industry. Yet, at the same time, other forces conspire to eliminate the designer's control over interface, graphic, and individual page layout, especially in work environments where the economies of scale have led to the outsourcing of development. Chances are that at some time in your career you will probably need to communicate your graphic ideas to those who approve the concept, create the art, or produce the final package.

This chapter looks at:

- Who needs to know what and when
- Methods for communicating the overall look and feel
- Methods for communicating plans for individual graphics
- How to communicate layouts that incorporate the individual graphic within the overall look and feel

WHO NEEDS TO KNOW

Even if you do all your own production work, you may need to show a client or stakeholder your ideas to gain approval. You may need a subject-matter expert (SME) to review the graphic idea for technical accuracy. Any artist you work with needs to know what exactly you want in the visuals. And for those of you who work

Table 20.1. Who Needs to Know What

Team Member	What He or She Uses the Graphic Specification for	In Order to . . .
Writer/Instructional Designer	Think through and work out the design specific and stay "honest" to the instruction. The process of specifying the graphic keeps the designer "on hook" to make sure that content (visual and verbal) teaches	Communicate exactly what is specified to SMEs, clients, artists, and programmers
SME, Reviewer, Client	See enough detail to make sure that the graphic will be an accurate reflection of the content; See what the designer is envisioning and how it supports the instruction; Correct any inaccuracies in detail or emphasis; Correct any inaccuracies in approach, image problems, identify any possible graphic connotations that are inappropriate	Approve graphic
Artist	Understand exactly what the designer is specifying, for example, the exact shot the designer needs and the exact animation sequence	Create the art; Shoot the video; Identify and manipulate stock images; Create the animation
Production Personnel	Understand where the graphic is to be placed as well as any special considerations in terms of its being viewed	Program calls (file or library name) Execute any special programming required for animation or video; Make any display adjustments necessary

with a production team, in addition to everything else, they will need file names, location notes, and sequencing specifications to put the final product together. Table 20.1 provides an overview of what you need to communicate to each of these players.

COMMUNICATING THE VISUAL APPROACH

Sometimes the product must conform to a set of corporate guidelines and standards. As Chapter18 indicated, these guidelines may be limited to branding issues of color, font, and logo, or they may include actual graphics, dimensions, and other parameters, particularly if your project is one in a series of related titles. The design tools that define and communicate the look and feel are treatment documents, design briefs, style guides, standards, and templates. When working within already-established parameters, you will want to *review and reference* these documents and tools. Table 20.2 provides a list of these tools with brief explanations.

Table 20.2. Standard Look and Feel Documents

Document	May Be Known As	What It Includes
Style Guides	Website graphics guideline Branding guide Corporate communications guide Corporate logo standards	General company or organization-wide specifications about: font detail (name and point size) for primary- and secondary-level headers, body content, callouts and notes Color for standardized graphics by Pantone number Branding detail, colors, and usage Logo detail, where it must be placed on different documentation and media
Standards Document	Graphics guide Project specifications Functionality specifications	Layout and color requirements for a specific product's look and feel, including operational pages or screens (section opener, summary, exercises, etc.) Placement of graphics Size and format of graphics
Templates	Models Boilerplates	Exact replicas of the layout that designers can use to create their document pages, e-learning designs, or PowerPoint slides

At other times, especially when involved in a first effort of a particular type of instructional product, you actually *create and establish* the guidelines and standards. As discussed in Chapter 18, establishing these guidelines needs to occur early to prevent unnecessary reworking of graphics or content and to communicate the vision with stakeholders, team members, and production groups. Agreement is best and most efficiently reached through a set of samples, and especially for e-learning, a prototype.

Samples

To be truly effective, your samples should approximate the finished product in terms of medium, size and layout. These samples—often called mockups, dummies, roughs, or "comps" (comprehensives)—often do not include actual text, graphics, or audio, but they illustrate exactly how all these elements fit together. You may have seen dummies with the Latin *lorem ipsum* used to fill in where text would be on page or web samples, so that reviewers can focus on the style and font and not be distracted by the meaning of the words.

The sample should be the same size as the final product. If your product is a 4-by-5-inch spiral-bound job aid with tabs, then the samples should have the same dimensions and elements. For a book, approximate as closely as possible the finished product in terms of page size, column width, and gutter (space between columns). Consider also the impact of the number of graphics on the final page count of the product. The more graphics, of course, the more displays or pages.

For e-learning, creating a first-time "look and feel" design sometimes requires two passes, static samples, and then a small functioning prototype. The static sample screens communicate the "look." Once those have been shared with the client, revised, and finally approved, the team creates a fully functional prototype, authored in the final production tool and providing "the feel." Especially for a first-time, highly interactive e-learning, static screens are simply not robust enough to show how the final product and graphics will display and function.

If you are responsible for designing to an existing "look and feel," be sure to focus on any new unique functionality, such as animated organizers or on-screen tutors. For a short electronic slide show presentation or print job aid, you may need to mock up only one or two screens or pages. However, for a robust first-time e-learning program or print-based manual, you may want to mock up or prototype the different types of displays: section introductions, chapter overviews, content sections, case studies, exercises, and so forth:

- *The Major Section Organizers.* Review how the whole product is unified; reference or create samples to show how a look is translated throughout modules, chapters, lessons, topics, and even subtopics.
- *The Content Displays for the Body of the Material.* Review how the body content will appear. Reference or create samples that show generic layouts for graphics and text. You may have several variations to support the different needs of your content. In an e-learning prototype, include the visual handling of pop-up windows, interactions, animations, and video as well as straight content.
- *Exercises and Activities.* If you use a particular type of activity or exercise format throughout the product, include a sample. In an e-learning prototype, include the major types of interactions you expect to use (multiple-choice, multiple-select, dichotomous, or matching). It's important to rough out every component, including such items as the placement of question content and instructions, options, where the learner will answer the question, and feedback.
- *Special Feature Treatments.* If you plan to include any unusual graphics or layout designs for videos, worked examples, terminology, step-by-step charts, demos, or case studies, review or create samples of these for stakeholder approval and to give your production team what they need to make sure your plan can be executed.

COMMUNICATING IDEAS FOR THE DEVELOPMENT OF INDIVIDUAL GRAPHICS

Once you are working with the right artist to develop your individual graphics, schedule a "face-to-face," whether real-world or virtual meeting. Many an idea has been communicated via a sketch on a paper napkin, accompanied by hand gestures and talking. In fact, "voice" is a prime component when collaborating with an artist about graphics. This approach by itself works fine if there is no need for review and approval by others before development or for management and production after. However, art specifications delivered aurally are often too ephemeral. Such informal instructions can't be shared or referenced after the fact, nor can they efficiently be used for multiple audiences. Artists, reviewers, and production people need the graphic specifications at different times and in different contexts.

So, at the very least, sketch your graphical idea and include as much information as possible, such as what points the graphic needs to convey, examples, surface features, and treatment. If text is incorporated into the graphics, be sure to include the exact copy. If the artist is compositing several stock photos, include a description or examples of the type of images needed or, if available, identify the exact photos by file name or identifier. Finally, for a glimpse of what an artist wants to hear from you, see Figure 20.1.

If your design calls for original, professional quality photographs that you can't take yourself, you need to provide the photographers with a list of

Figure 20.1. What Artists Want.

Artists Speak:

If you want more than a cleaned up sketch you need to tell us. We need to know what you want as specifically as possible.

Talk to us. By our very nature. we tend to be visual. We generally don't mentally process text as well as we process sketches or verbal explanations. If you have to communicate what you want in written format, include a sketch or a sample.

Find examples of what you want. Doing so will help take the discussion out of the realm of the subjective and into the realm of the concrete. We'd be rich if we got paid every time someone asked us to make it "flashy."

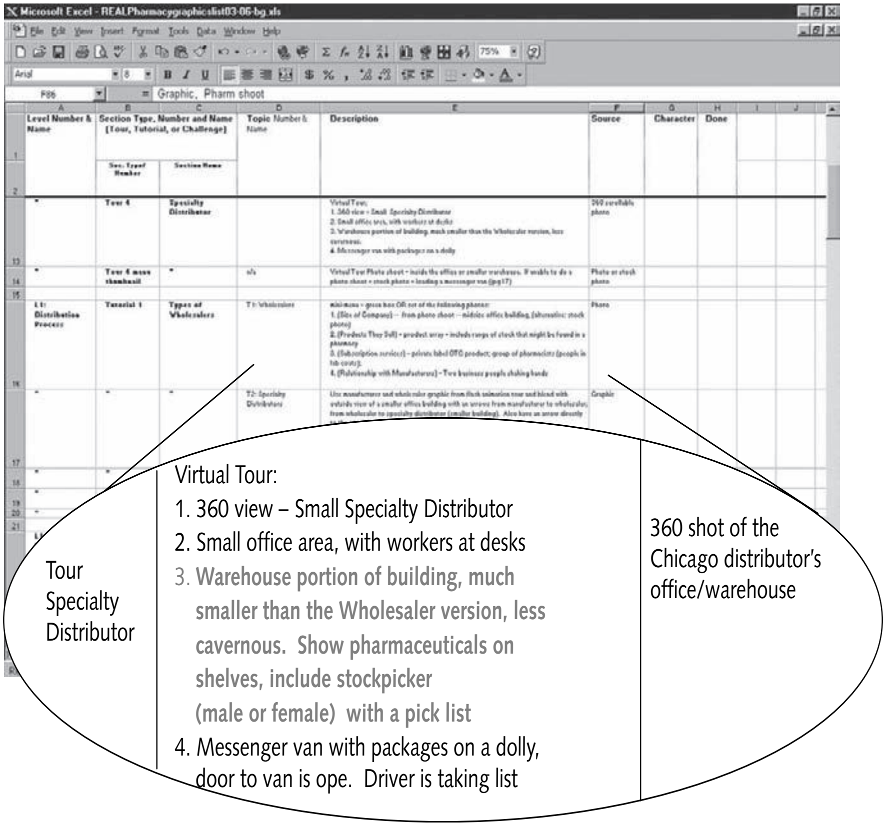
Let us know our role and whether you want us to collaborate. If we are to assist you in visualizing your ideas, tell us. We will do roughs and show them to you, instead of wasting time fine-tuning production quality graphics. We will suggest ideas to you, and we will be more tolerant of revision requests.

Don't expect us to be an expert on your content and audience. Inform us about what point you are trying to make so that we can help you emphasize it.

We can't read minds or tell fortunes.

Credit: Mark A. Palmer.

Figure 20.2. A Sample Shot List.



required shots, especially if you are unable to attend the photo shoot. Shot lists are often simple spreadsheets organized by the physical location, with specific instructions about what is needed in each photo. Sometimes shot lists can be quite elaborate, identifying any storyline characters that may need to appear in the different shots for consistency. Note also that these lists become production management tools later in the process. Figure 20.2 shows part of the shot list that was developed for the e-learning project shown in Figure 20.3 on the next page.

Figure 20.3. A 360-Degree Photograph Based on the Description in Point 3 of the Shot List shown in Figure 20.2.

COMMUNICATING LAYOUT PLANS

What Is Layout?

Even though the templates provide basic strategies, every single screen or page of your instructional materials is still "laid out" individually; that is, the various elements are placed in relationship to each other and to the display framework. In e-learning, screen layout requires thinking about the timing and sequencing where dynamic elements such as an animation, cueing arrows, or bullet points synchronized to audio impact the arrangement of your screens. It's in the individual layout that many of the psychological principles discussed in Section Two of this book apply. Managing load, focusing attention, and motivating learning are often accomplished by how much, where, and when graphics are displayed.

Four Principles of Design

Even with highly templated formats, the layout of individual displays is essentially about relationships among design elements. The learner's interpretation of those relationships relies in large part on how human brains are hard-wired neurologically, but also on how the learner is conditioned culturally. Western culture readers process the display left to right, top to bottom. Eastern culture readers start top right and process the display right to left, top to bottom. As we think about communicating our layout needs, Robin Williams (2008) suggests that we use the four principles to guide us:

- *Proximity* shows that items are related. Proximity can be a matter of color family or special placement.
- *Contrast* focuses attention, whether the contrast is in color, shape, or placement. Contrast is often the strongest and most attention-grabbing element of a display.
- *Repetition* of color, shape, and even graphic suggests organization of elements and is a unifying device both on the individual display and throughout the instructional material.
- *Alignment* of the elements is used to demonstrate hierarchy, relative importance, and chunks of ideas.

Location, Location, Location

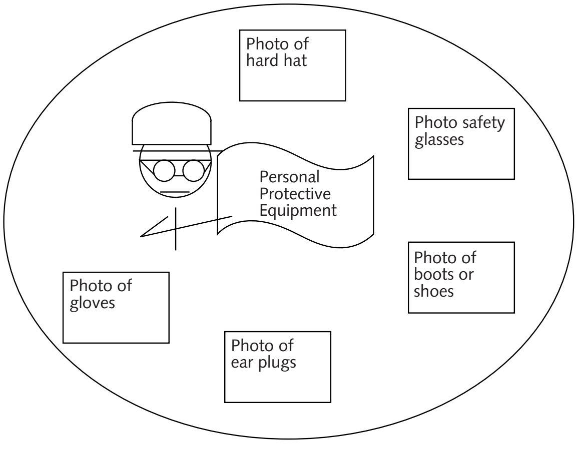
Generally speaking, if you need to draw attention to an element, place it in a high-impact area of the display—the center or in the upper left for Western readers (or upper right for Eastern readers). However, remember that this placement boosts the attention-grabbing abilities of any element so, when placed in the center, an already powerful graphic can potentially overwhelm less strong components such as text, ancillary graphics, and so forth. Since graphics are intrinsically more attention-grabbing than text, if you need to boost the "visibility" of a text element, place it in a power position relevant to the other elements in the display.

Storyboards to Communicate Layout

In e-learning, with its multiple media components competing for screen real estate and sequencing description, you need a communication tool that lets you communicate the graphic in context: how it is laid out on the screen, when it appears,

Figure 20.4. A Sample Layout Storyboard.

Screen ID: t01 s005



Screen ID: t01 s005

Sequence	Required photos/graphisc	Audio/Narration	Wht's happening on screen
1	Colored circle backdrop (same as that used in previous safety programs) Title animation similar to that used in other safety programs but tailored to this topic. (Character marches in from right side of screen holding flag labeled "personal protective equipment". Character is wearing hard hat, safety glasses and gloves.)	(music accompanying title animation. same as that used in previous safety programs.)	Display wavy flag title animation with accompanying intro music.
2	Photo of individual types of personal protective equipment (gloves, ear plugs, boots or shoes, safety glasses, hard hat).	(Sound effect accompanies display of each PPE photo)	When sequence 1 animation is complete, display photos of indivdual types of personal protective equipment one at a time around character with flag. Play "ping" sound effec with each photo.
3		Narrator audio with identifier t01_s005_audio: *"Welcome to the safety training programs on personal protective equipment, or 'PPE,' PPE is one of a number of programs that make up the safety curriculum."*	After sequence 2 photo have finished popping on, play t01_s005-audio as voiceover.
			When narrator audio done, pause 1 second then move automatically to next screen.

Source: Micro Training Associates.

what areas may be clickable, and so forth. The most common tool for designing and communicating the layout is the storyboard.

Storyboarding was first used in film production as a technique to visualize the story line and includes sequencing, the film angle, and shot details. Storyboards relate the narrative of the course through a combination of text and drawings that convey all the necessary information about each screen. When the storyboard is used for review and approval purposes, it contains a visual layout area with the same aspect ratio (vertical to horizontal ratio) as the actual delivery vehicle. The storyboard also communicates the exact words to be displayed on screen or narrated. Usually a page or two of a storyboard represents one page or one screen of the final product (see Figure 20.4). Even if you are working solo, the storyboard may also be the tool you use to figure out your design and finalize your content.

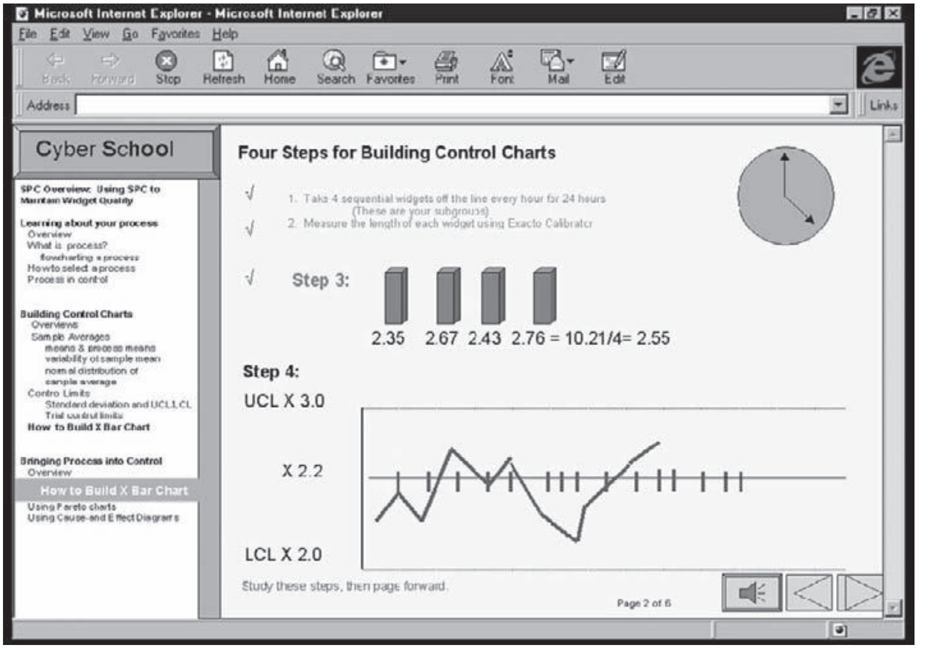
As the "blueprints" of your design and development process, the more detailed, accurate and complete the storyboards are, the fewer the assumptions, questions, delays, confusion, and errors that will occur later during development.

Some instructional designers create storyboards in online tools such as slide-show presentation software where they mock up the online display with actual text and sketches, or even the final graphics. Figure 20.5 on the next page shows such a mockup. The general layout of the content is on the slide itself. In the notes section below the slide, the designer includes audio scripts and programming notes.

Storyboarding in Production Software

Fostered by rapid e-learning, another online storyboarding technique is to use the actual programming tools in order to communicate to reviewers as realistically as possible what the final product will be. In fact, the newest e-learning tools (Articulate, Captivate, Adobe Presenter, and Camtasia, for example), with their ability to input or capture PowerPoint files, make it much easier for instructional designers to efficiently develop storyboards that essentially become part of the final product. This rapid prototyping approach is useful when the development schedule is tight and for clients who have trouble visualizing the finished product. But it is riskier than other approaches, sometimes leading to massive rework or lulling designers into a static, slide-by-slide page-turner instead of designing a dynamic, interactive e-learning product. The technique works best in environments in which development is done in small teams of individuals with high tolerance for chaos or when the content is relatively stable.

Figure 20.5. A Storyboard Developed in PowerPoint.



Audio (plays on page launch):
Male Narrator (L04T02P02.wav)
In the fourth and final step, you plot each average value on the Xbar chart.
Take a moment to study these four steps before continuing to answer a question about them.

Programming Notes:
After audio times out, display the green text:

Study these steps, then page forward.

Graphics:
Note to reviewer, these graphics are approximations. Finalized graphics will be developed for production.

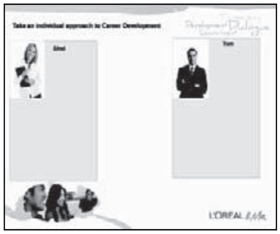
Source: Clark Training and Consulting.

Scripts

Scripts are another adaptation for layout design from the world of film and are often used to communicate the sequencing and actual content of courses that contain both audio and text. Often such scripts are in a three-column format, with

Figure 20.6. A Three-Column Script.

SECTION 3: Best Practices and Case Study

CONTENT–Information display	GRAPHICS	NOTES
<u>**TEXT ON SCREEN:**</u> Take an individual approach to employee development. <u>**AUDIO**</u> It is crucial to take an individual approach to employee development depending on your employees'needs. For example: Shui has been on your team **for three years** and you know her capabilities pretty well. She's had several cross-functional jobs and has had **high exposure to the business**. She's **performed well** in her role and the talent committee has tagged her for the **next people manager role**. <u>**TEXT ON SCREEN:** (*for Shui*)</u> • With team for three years • High exposure to the business • Performs well, no issues • Tagged for next management role <u>**AUDIO**</u> When you are ready compare Shui to Tom, click Next for a question.	**Upon Entry:** Top line of text already visible. Graphics of two employees. Audio plays on entry,  **Sequence:** 1.As narrator introduces Shui, display bullets in sync with audio highlights. 2.Pause for 2 seconds. 3.Play second audio 4.When last audio finishes, display Next button. **Transition to next slide:** Next button	83 words (@ 20 seconds) Shui pronounced like "Shue" Use these photos. Keep bottom of boxes empty. (next display will use the same images) On next display will be the drag and drop question using the lower portions of the screen. PowerPoint file **Appraisal01.ppt**

Source: Victor Dumeige and Mimi Banks © 2009 L'Oreal.

a column for text or audio; another for a description of the sequence, possible layout and the intended graphic(s); and a third for programming and other notes (Figure 20.6). The advantage of column-based scripts is that they force you to think in terms of dynamic sequencing (text, audio, animation) rather than focus on just the static display.

There are tradeoffs to using either a scripting or storyboarding approach to communicate visual ideas. For e-learning projects where the layout is predetermined and highly templated, a script can speed production. Tables 20.3 and 20.4 on the next two pages compare the advantages and disadvantages of storyboards and scripts from the perspective of communicating to artists, reviewers, clients, and production teams.

Table 20.3. Tradeoffs of Using a Storyboard

	Storyboards	
Role	**Advantages**	**Disadvantages**
Writer/Instructional Designer	Separates the tasks of developing the text from laying out the components of the display	Spends more time constructing sketches or creating mockups of graphics
	Is forced to confront real-estate issues in terms of getting content and graphics integrated	May encourage tunnel-vision designer into thinking about a page-by-page presentation, rather than a dynamic flow
Artists	Favors graphic development	May not receive enough guidance on all the specific elements required to create the finished graphic. Other communication tools may be required, such as a graphics meeting with the designer to talk through each graphic to be created
	Gets visual guide for the development of the graphic and sees the context the graphic will be displayed within	
Reviewer	Sees graphic and instructional content in context in order to ensure that the content is accurate.	May see screens as discrete entities instead of as part of a whole
	Has expectations of end product more appropriately set	
Production Team	Gets clear guidance on placement and production specifications	Difficult to update for production and maintenance
		May require separate production control documents

Table 20.4. Tradeoffs of Using a Script

	Scripts	
Role	**Advantages**	**Disadvantages**
Writer/ Instructional Designer	Favors text and audio script development Faster, allows the designer to focus on flow of content Easier to send electronically	Shortcuts thinking about the visuals in context Presents no reality check to ensure that graphics will fit into available real estate
Artists	Encourages understanding of the content the graphic must convey	May not present enough guidance on all the specific elements required to create the finished graphic. May require other communication tools, such as a graphics meeting with the designer to talk through each graphic to be created
SME/Reviewer/ Client	Facilitates ability to communicate revision requests because can add them right into the electronic document, using a revision tracking feature Has expectations of end-product more appropriately set	May be difficult for novice reviewers to visualize the final product, the integration of text and visual Often reviews words to the exclusion of graphic and their relationships May request content that exceeds available real estate
Production Team	Gets text-based guidance on production specifics Easier to update as specifications evolve, materials are developed	Provides no visual key to how the designer envisions the screens looking and working

COMMUNICATING GRAPHICS TO PRODUCTION STAFF

In highly automated projects where much of the work is templated, the task of compiling the final product may fall to administrative staff, production people, or even to offshore developers who speak a different language. These individuals may not be aware of the instructional purpose and relationship of the graphic and the content. Use the checklist in Table 20.5 if you have little or no control over the individual screen or page layout.

Sometimes production staff work from tightly controlled scripts or storyboards and do not have the ability or the responsibility to make decisions outside it. As a simple example, on their own, they cannot or may not change the placement of a graphic in case the text runs over to the next screen. If this is the case in the production of your e-learning project, leave nothing to chance—or be prepared for plenty of rework.

To combat the problem of miscommunication, experienced production teams keep the instructional designer in the loop until the final product release. Unfortunately, we hear of situations in which the instructional designer is only employed through the storyboarding stage. Thus, there is no "check" that the visual designs are executed as intended.

Finally, some of the tools you use to communicate your graphic ideas may end up doing double duty for the production team. Shot lists for the photographer are just one example. These tools tell the production team important details about the graphics, file name, library location, format, and even size of the final product.

Table 20.5. Have No Say Over the Layout of Individual Displays?

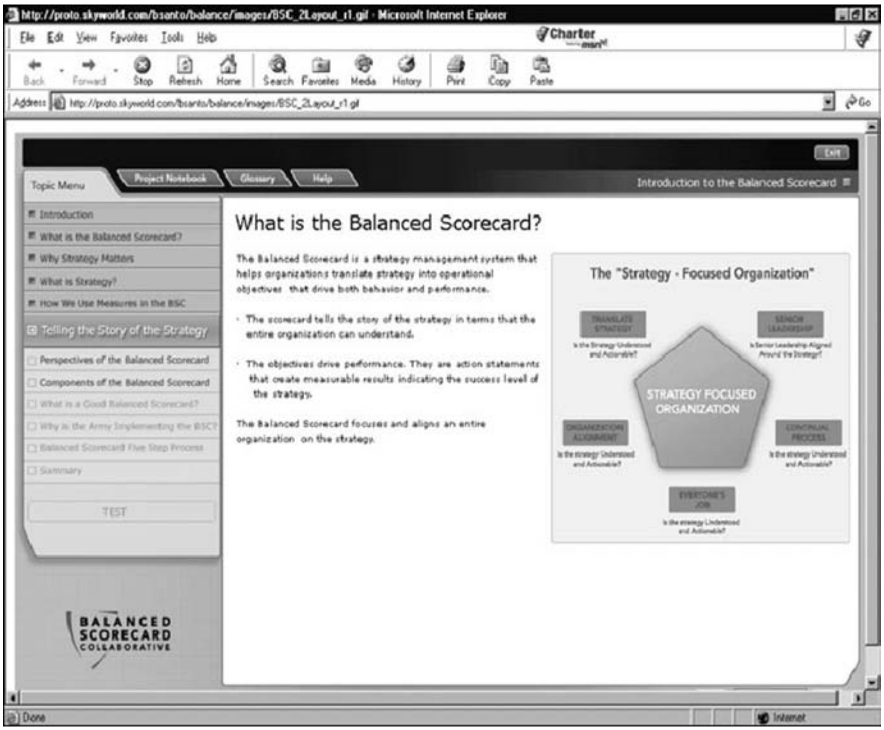
- ❍ Review any samples or existing templates to fully understand the restrictions of real estate and sequencing.
- ❍ Sketch out for yourself how the different design elements might be arranged according to the template, then revise your content if learning isn't supported. Embed in your design content-specific layout notes to the production team.
- ❍ Ask for page proofs, review copies, or other production mockups with your content and visuals to ensure that your plan is effectively executed and learning is supported.

Such tools track status, production responsibility, and where the graphic has been used within the course or materials.

CASE STUDY CONTINUED: SANJI TALKS TO THE ARTIST

While Sanji is working on her content, the graphic interface designer and programmers are fine-tuning the interface through client reviews. After the treatment meeting, the interface designers create three samples that they show the client based on the client's own logo, corporate colors, and web graphics style guide (see Figure 20.7). The client reviews the samples and wants some elements from each, so asks the graphics interface designer to combine them for the final look. From

Figure 20.7. Static Comp-Screen Sample. The sample is a "picture," a static graphic that is completely non-functioning.

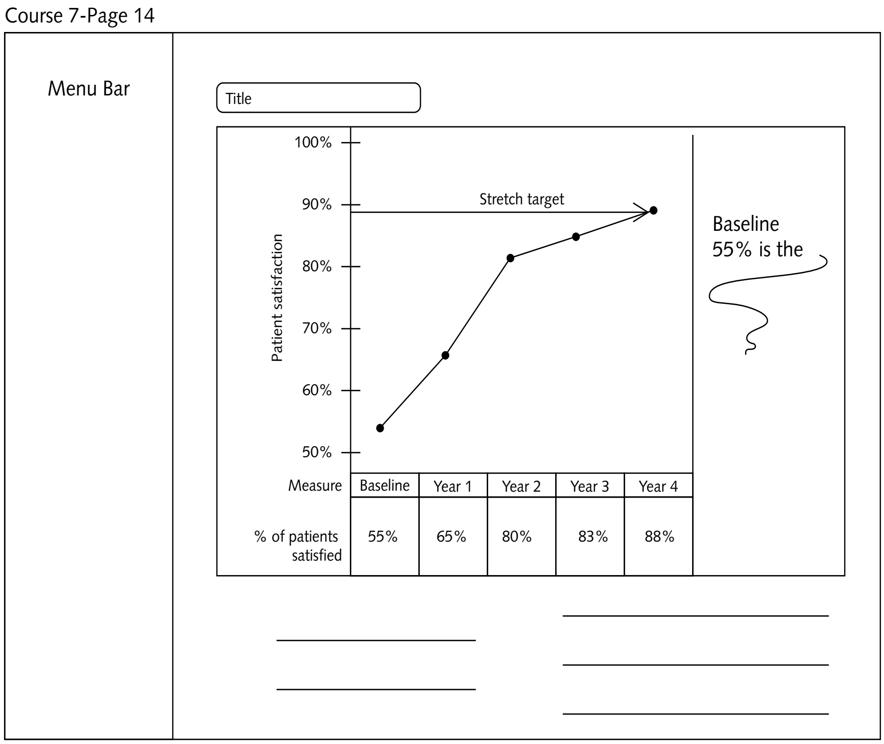


that design, the team creates several templates for quizzes, content, interactions, summaries, and so forth.

While those decisions are being made, Sanji is concurrently working on her own lesson content. As we illustrated in Chapter 19, she communicates her individual graphic ideas to the SME through the draft script (Figure 19.3). Once the templates are finalized, she finds one that allows her to use almost the entire screen for her interactive graphic.

Sanji thinks everything will fit, but she still sketches out the layout for the graphic designers to help communicate placement of pop-up text and dimensions of her chart (see Figure 20.8). In doing so, she finds that she has to prune her text extensively.

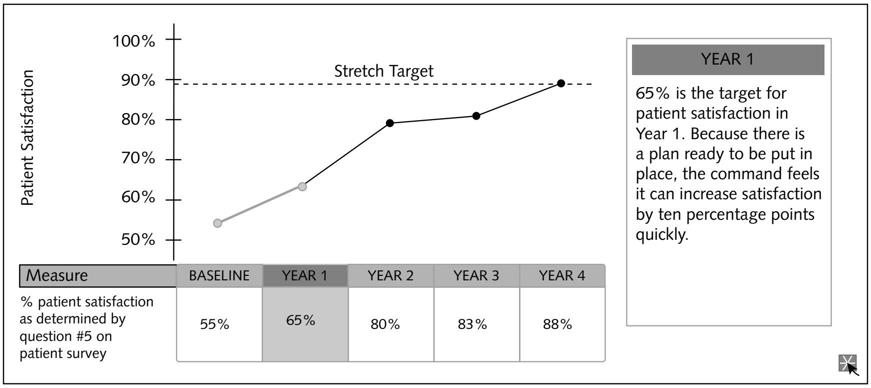
Figure 20.8. Sanji's Pencil Sketch of the Layout in the Full-Screen Graphic.



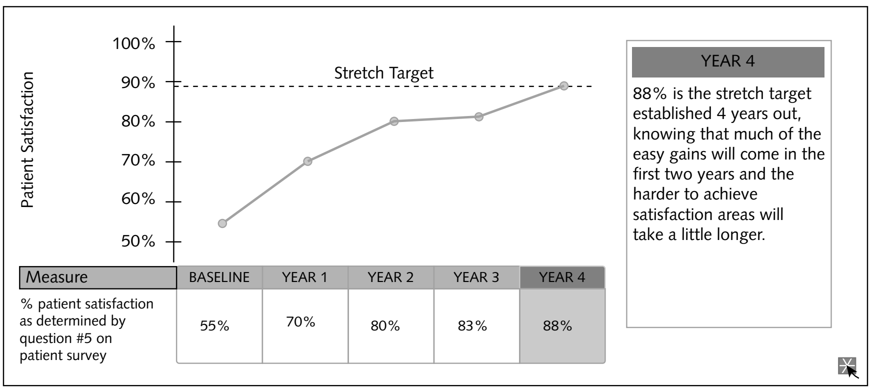
The graphic designer previously reviewed Sanji's script in preparation for his face-to-face meeting with Sanji and understands the content of the course. He is therefore able to visually solve some of Sanji's problems and real-estate issues. He takes the script and her layout sketch and develops the art (see Figure 20.9). He sends it to Sanji for review and, after incorporating her edits, sends it to the client for review and approval.

On review of just the interactive graphic, the client has additional changes based on testing it with representatives of the target audience. One request is to increase the incline of the graph's first segment to more effectively illustrate the

Figure 20.9. The Developed Interactive Art.



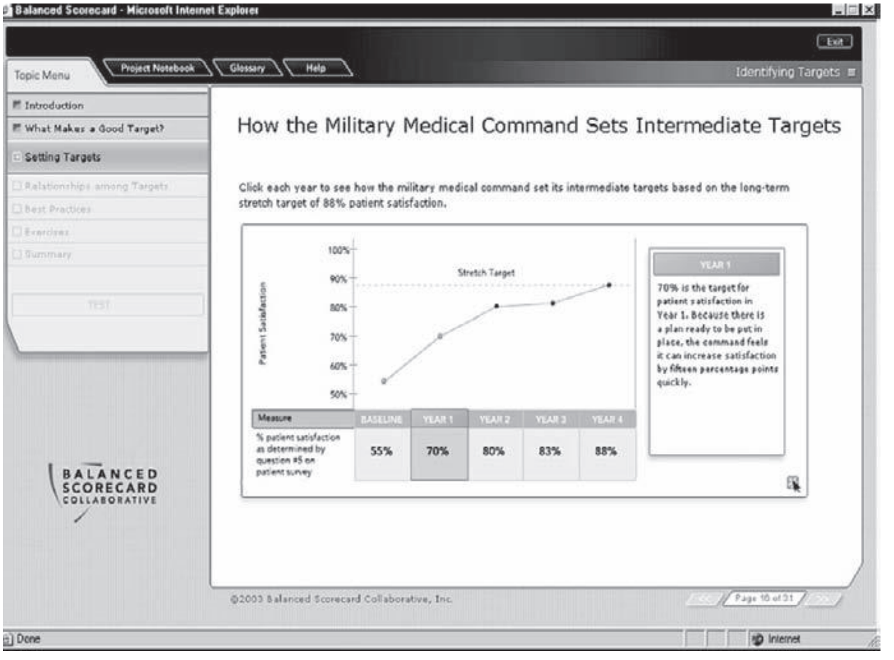
A. First client review



B. Adjusted to create steeper first segment

Source: Andy Riley © 2003 Balanced Scorecard and SkyWorld Interactive.

Figure 20.10. Programmed Version. The final visual encompasses all three facets: treatment, graphic, and layout of individual screen.



rapid results in the first year. After these revisions are incorporated and again reviewed, although the line is still not as steep as Sanji had intended it, the art is ready for final production.

During production, the text and art are brought into the templates that the interface designer and programming team generated. The completed lesson is hooked to the learning management system. The client reviews it online to see the integration of text, graphic, and functionality (see Figure 20.10).

THE BOTTOM LINE

When communicating your graphic needs to stakeholders, reviewers, artists, and even programmers, consider what they need to know in order to execute the design ideas. Use tools appropriate for their roles and abilities and the realities of your work environment.

COMING NEXT

The next chapter follows two different training professionals as they apply the principles discussed throughout the four sections of this book. One instructional designer develops a financial basics e-learning course for his investment club. The other develops procedural materials, in both print and multimedia, for software used in a customer service group.

For More Information

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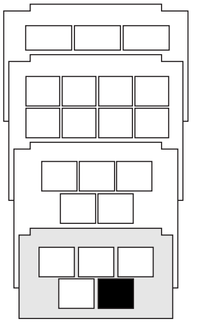
CHAPTER OUTLINE



The End-User System Application Training

- Define the Goal
- Determine the Context
- Design the Visual Approach
- Identify the Communication Function to Match Content Types
- Apply Principles of Psychological Instructional Events to Visual Design Decisions
- Alternative Training Delivery Medium

The Investment Club's Financial Basics Training

- Define Goals
- Determine the Context
- Design Visual Approach
- Identify Communication Function to Match Content Types
- Apply Principles of Psychological Instructional Events to Visual Design Decisions
- Alternative Training Delivery Medium

CHAPTER 21

Apply the Principles

In this chapter, we follow two instructional designers as they apply a systematic approach and the guidelines from the previous sections to visualize their instruction. Although the case studies are fictionalized, they are a composite of details from real projects and designs.

In the first case, Naomi and her team of a programmer and a graphic artist design training for novice users to be delivered in multimedia and in print for a system application in a large corporate setting.

In the second case, George, working alone, creates an e-learning training course for a financial investing club's website. George has some programming and graphics skills, so he feels he can handle almost all of the development, though he may need to contract out a few pieces.

THE END-USER SYSTEM APPLICATION TRAINING

Naomi works in the training department for a corporation that has recently purchased its own custom-developed purchasing and customer loyalty program software. Her boss assigns Naomi the task of developing training for the employees who answer the phones and maintain the loyalty participants' entries. The department already conducts the telephone answering and customer relationship training. Naomi is to develop the training on the systems component. She follows the systematic approach we introduced in Chapter 3 and present again here in Figure 21.1.

Figure 21.1. A Visual Design Model. Applying the design model to projects.

I. Define Goals

Goals are:
- To inform or motivate
- To build near-transfer (procedural) skills and associated knowledge
- To build far-transfer (problem-solving) skills and associated knowledge
  - Can include procedural skills that support far-transfer tasks

II. Determine Context

Context Includes:

LearderProfile	- e.g., novice, advanced, mixed
Learning landscape	- e.g., classroom, self-study computer
Delivery media	- e.g., book, computer (resolution, bandwidth, etc.)
Pragmatic issues	- e.g., budget, style guides, etc.

III. Design Visual Approach

Designing the Visual Approach Includes:
- Determine the image
- Assess general graphic requirements of content
- Design Treatment—includes decisions about:
  - Instructional strategy:
  - Text dominant or visual dominant
  - Layout or Interface for media (style, orientation, real estate)
  - Navigation and functionality (for online learning)
  - Surface features that align with context and goals

IV. Identify Communication Function Needed to Match Content Types

Identify Communication Function for:

Multiple content	—use organizational visuals
Procedures	—use representational, transformational visuals
Concept	—use diverse representational or interpretive visuals
Facts	—use representational and mnemonic visuals
Process	—use transformational visuals
Principles	—use explanatory visuals, such as relational, interpretive, or transformational

V. Apply Principles of Psychological Instructional Events

Apply Principles:

For all instructional goals,
Apply principles to awaken prior knowledge and support transfer

If complex content, novice audience, or runs outside learner control
Then apply attention and cognitive load principles

If building far-transfer skills
Then apply mental model principles

If building near-transfer skills
Then apply transfer principles

If learners low in personal motivation
Then apply motivational visual principles

Define the Goal

Her department conducted a needs assessment before Naomi was even assigned the project, so her first task is to verify their findings about the business need and the instructional goal:

- *Business need:* To provide value-add for loyal customers, call center personnel must ensure participant data is accurate, while smoothly and seamlessly answering calls.
- *Instructional goal:* Call-center employees will, with 99 percent accuracy, search on, filter, add, and edit loyalty participant information.

Once she verifies these, Naomi then identifies the instructional goal: skill building for near-transfer procedural tasks.

Determine the Context

Next, Naomi investigates the context. As she does so, she establishes the following.

Learner Profile

There is high turnover in the call centers, as high as 40 percent in some years. New employees are hired continually, and there is an ever-present need for immediate training just to prepare the new employees to work the phones. Typically, the new employee is young, English-speaking, often female, and does not have prior knowledge of the loyalty program participant database software.

Learning Environment

On the job, the employees work in small cubicles in an open space, wearing headsets so that their hands are free to access the computer. Their call answering equipment keeps them continuously supplied with a steady stream of customer requests, purchases, and complaints. In each call center, there is a separate room with computers set up for small group instruction or self-paced training, either developed by the company or purchased off-the-shelf. Learners can take courses on the company intranet or on CDs there or even at their cubicles, where their computers also are equipped with CD-ROM drives, sound cards, and earphones. The call centers are open seven days a week, with three shifts of workers to accommodate customer calls at any time of the day or night.

Delivery Platform

Because the task is software-based, Naomi determines that, to be job-oriented, the practices need to be simulations or exercises using a live system. In order to prevent data contamination, the learners cannot practice with the "real" database.

But still, for at least part of the training, Naomi decides that computers are a logical delivery platform. The loyalty participant software was designed for 1024 x 768 resolution, which has become the default resolution throughout the call centers. Naomi decides that multimedia is a good match for the learner profile, the need for high fidelity to the real system, and the requirement of anytime access to training. She recognizes that any e-learning her organization develops must be AICC/SCORM compliant. Even though her course is multimedia, she will work with the programmers to make sure her structure supports the organizational standard.

Naomi also knows that the use of audio in the course will have a significant impact on her graphics. Audio gives her more screen real estate, since she won't have to allocate as much space to text. It also will allow her to reduce cognitive load and focus the learner on the key elements of the graphical representations of screens. Based on the proximity to the training room and the presence of earphones and soundcards on each employee's workstation, she decides the tradeoffs favor the use of audio.

Pragmatic Issues

Because the training is supporting a key corporate mission, Naomi has a solid, but not extravagant, budget for artwork. Further, although the training is important, it is not a high-visibility project. Thus, Naomi does not need to obtain approval from anyone outside the training department for her graphics or her content treatment. Finally, since the corporation already produces a number of multimedia courses, her training will use the same style templates and guidelines. She does, however, have a tight and unforgiving schedule because the training must be disseminated nationwide to all call centers two weeks before the new version of the system goes live.

Design the Visual Approach

Naomi knows that learners need to be able to perform flawlessly the first time they are on the system. Whatever training she designs needs to have significant simulations and practices using data that closely approximates what the learner will encounter on the job.

Determine Image the Materials Should Project

Naomi decides the image should be professional, but accessible, since many of the learners will be new hires. She knows that the display framework will need to communicate the importance of the job to the corporation, even though the task itself may seem trivial or insignificant to the uninitiated. She's tempted to use bold and colorful graphics to motivate, but she's afraid that bright shapes and colors will pull focus away from system screens. She decides to use colors judiciously and counts on the audio to help grab and hold the learners' attention.

Preliminary Assessment of the Graphic Requirements of Content

Naomi decides that most graphics will be the system screens or representational graphics of the different types of people behind the phone calls. Her "worst case" graphic is one particularly crowded system screen used for multiple tasks. She also knows she probably needs separate graphics to explain the individual sections of the screen, but there isn't enough real estate. She knows she'll need help solving this design problem.

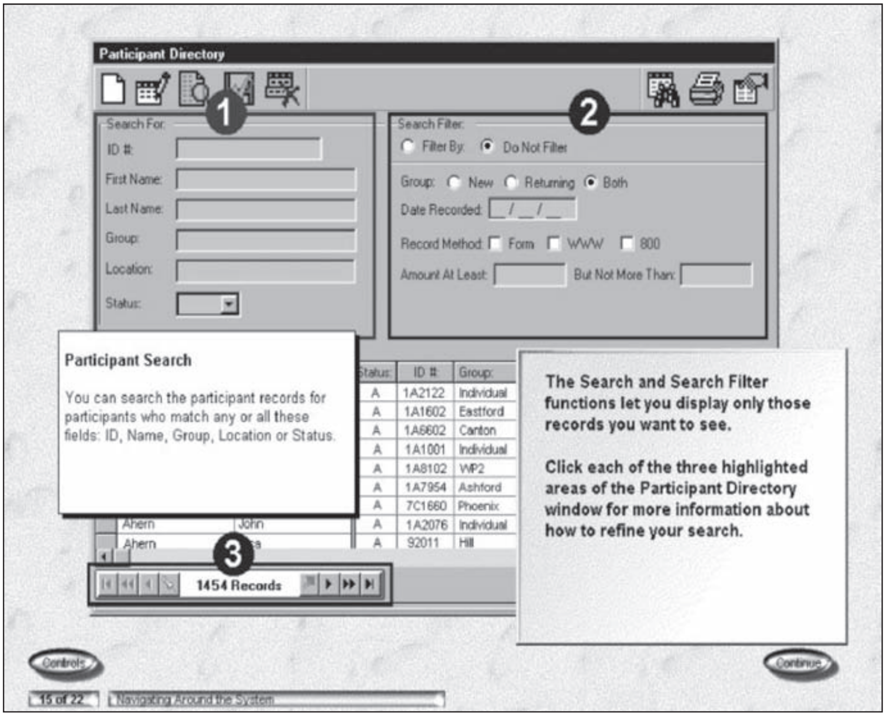
Design Treatment

Naomi meets with the programmer and artist assigned with her to the project. Collaboratively, they design the navigation interface and structure of the multimedia. Since the learners are novice, the content is itself highly graphic, and audio provides the narrative, Naomi's team decides that any supporting text will appear on a drop-shadowed text box in the lower-right-hand corner. Content displays (without system screens) will have a slightly different look (a raised blank rectangle) than system screens.

They plan to use representational graphics of professionals who match the demographics of the learner population and dress appropriately on the job. They decide to use miniature photos of customers to represent the people within the database. Stock photos, in the hands of the artist, will provide a crisp, clean look to the display framework. The graphic artist checks to see what art the corporation already owns, either in the training or the corporate communications group. The team agrees that they can afford a small purchase of royalty-free stock photos.

They also agree to use animation for both the demonstrations of procedures and the illustration of key points. The programmer suggests updating the interface to include a replay function. Because of the profile of the learner population the team feels comfortable relying on contrast to draw attention, using red lines to highlight and red arrows to cue. The shapes of the cueing devices will be distinctive in case there are any colorblind learners. Finally, the artist and programmer suggest a solution to the real-estate need for simultaneously using graphics to teach

Figure 21.2. Basic Template for Teaching Software Screens. The team prepares comps and discusses the look and placement of pop-ups, cueing numbers, and navigational indicators.



Source: Mark A. Palmer.

procedure while showing the system screen, as in Figure 21.2. They know they need to mock up samples and a small prototype, just to make sure their treatment ideas will work.

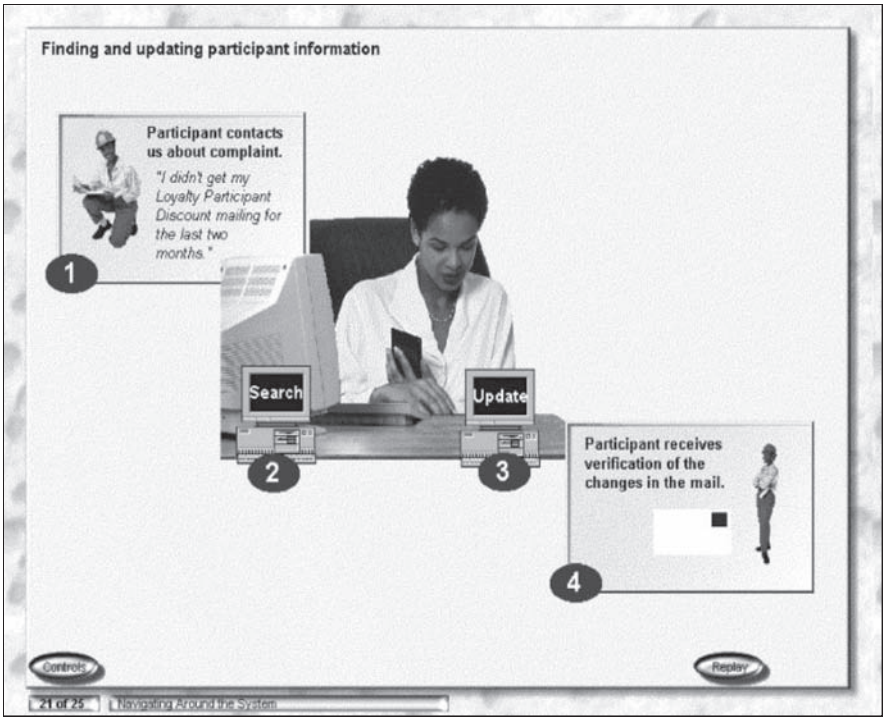
Identify the Communication Function to Match Content Types

Even though the content is mostly procedural, requiring representational graphics, Naomi also knows that the associated knowledge the learners need includes both concept and process content requiring some interpretive and transformation graphics. Also, based on her job analysis, the distinct procedures (search using different filter criteria, entering data, or updating data) are done in various combinations. So she wants separate graphics for each of the procedures so that initially they can be taught independently and then combined in several business case scenarios, both in the lesson demonstrations and for practice exercises. The full combination graphics must fit within the display framework.

Multiple Content: Organizational Visuals

The interface design will provide some grounding of how the multiple-content type pieces fit together, but there will be times that other organizational visuals will help as well. To introduce the search and update procedures, Naomi decides that a process visual will help orient them to how the tasks work together (see Figure 21.3). The team also decides to use a “bird’s-eye view” graphic of particularly complicated screens to orient the learner to the screen’s components.

Figure 21.3. Organizational Visual (Process) Helps Orient Learners.

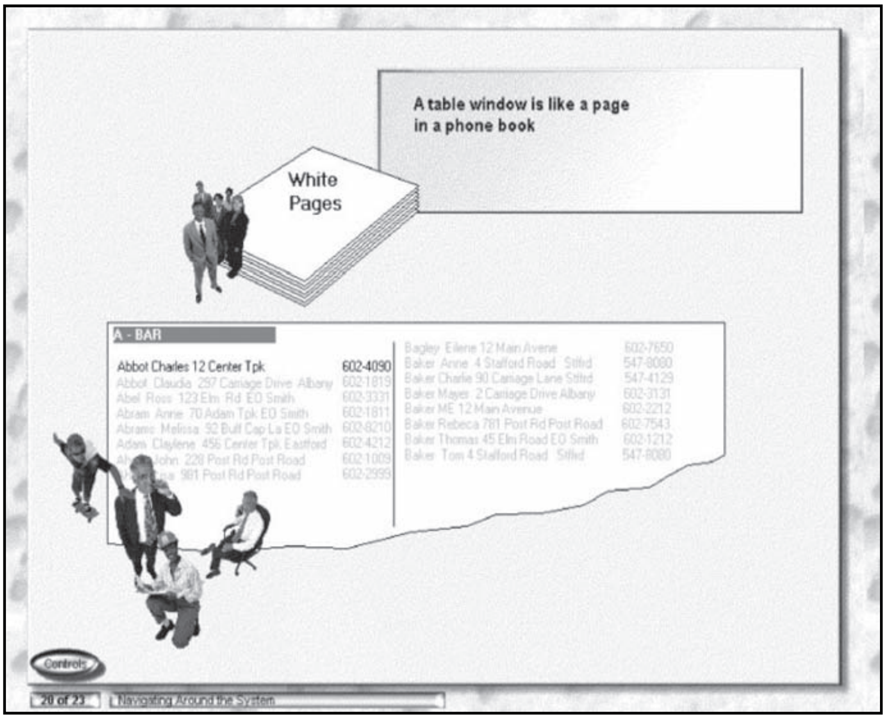


Source: Mark A. Palmer.

Concepts

For instruction about concept content, the team decides to use representational graphics based on the actual screens, but simplified in order to minimize cognitive load and support transfer. Naomi decides that some concepts could use an analogy to help novice learners more readily understand the key points (see Figure 21.4). She plans to use the same placement, color, and alignment to reinforce the association among graphics and the system screen. In some cases, the team may need to also use an interpretive graphic, but again they decide to teach most concepts in terms of the system screen elements. Where applicable, the learner will see the concept

Figure 21.4. Analogy Graphic to Help Novice Users. The novice learner is introduced to the idea of data organized into usable formats through the analogy of the phonebook.



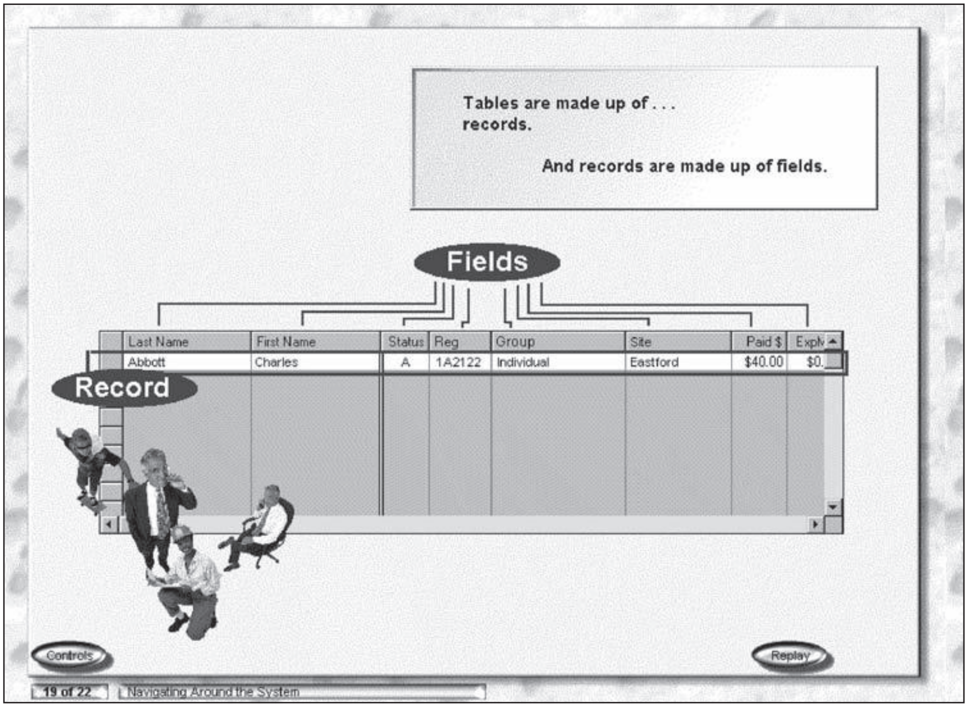
Source: Mark A. Palmer.

information in isolation, then, with a dynamic morphing transition, see it as it appears within the system (see Figure 21.5).

Procedures

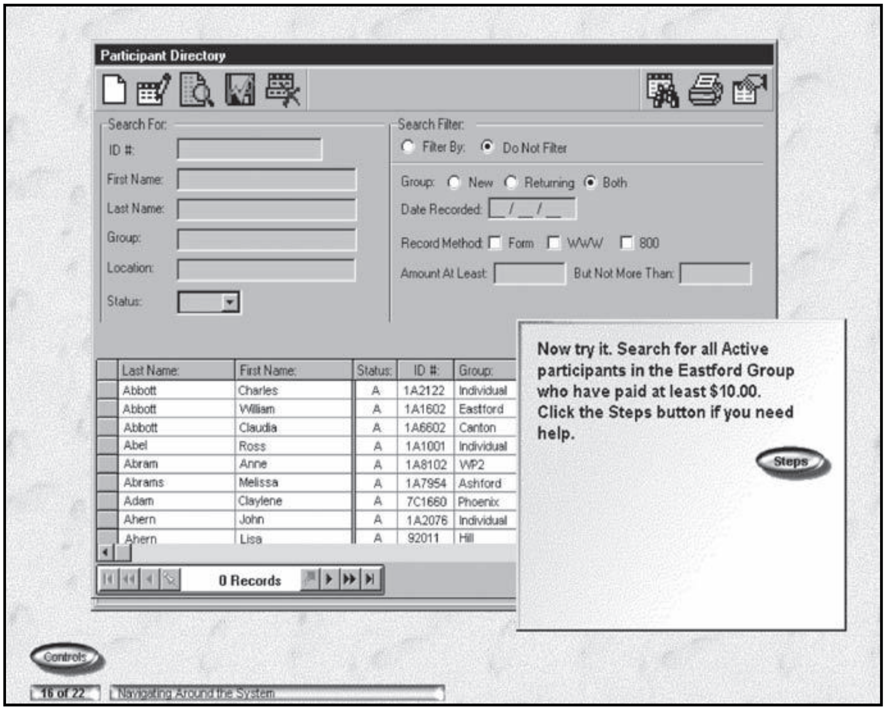
For the procedures themselves, the team decides to use representational graphics of the actual system screens. To keep the training visually distinct from the real system that may be open on the learner's desktop, they center the simulated system screens on a background that is clearly the e-learning course. This bordering effect will help avoid confusion should the learners take the training on their workstations. Finally, the dynamic aspect of the animation and interactions will allow the learn-

Figure 21.5. Phone Book Graphic from Figure 21.4 Dissolves to Screen That Shows Records and Fields.



Source: Mark A. Palmer.

Figure 21.6. Interaction with Screen Display Before the Learner Conducts the Search.



Source: Mark A. Palmer.

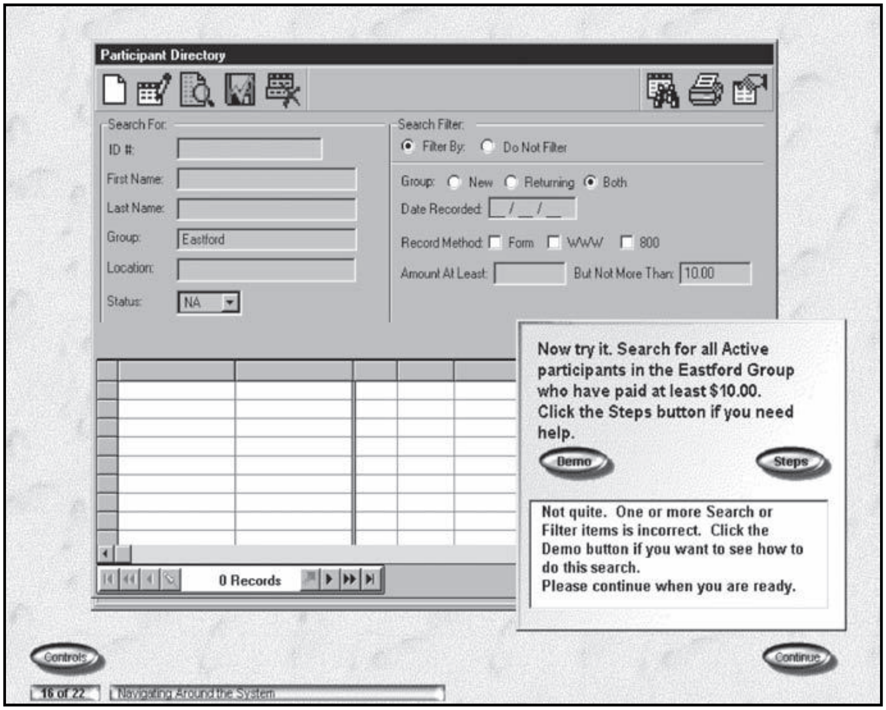
ers to see how their actions affect the results of their search and the participant database (see Figures 21.6 and 21.7).

Apply Principles of Psychological Instructional Events to Visual Design Decisions

Attention

Because the team decided on a course-wide treatment to support attention through arrows and red line highlighting, Naomi has a clear idea of the basic approach. In some situations, she knows she will need additional attention-grabbing techniques, such as contrast in color and typeface in the callouts embedded in the graphic, to point out specific content. After she tests the interaction illustrated in Figure 21.7

Figure 21.7. The Same Interaction Screen After the Learner Tries to Do a Filtered Search.



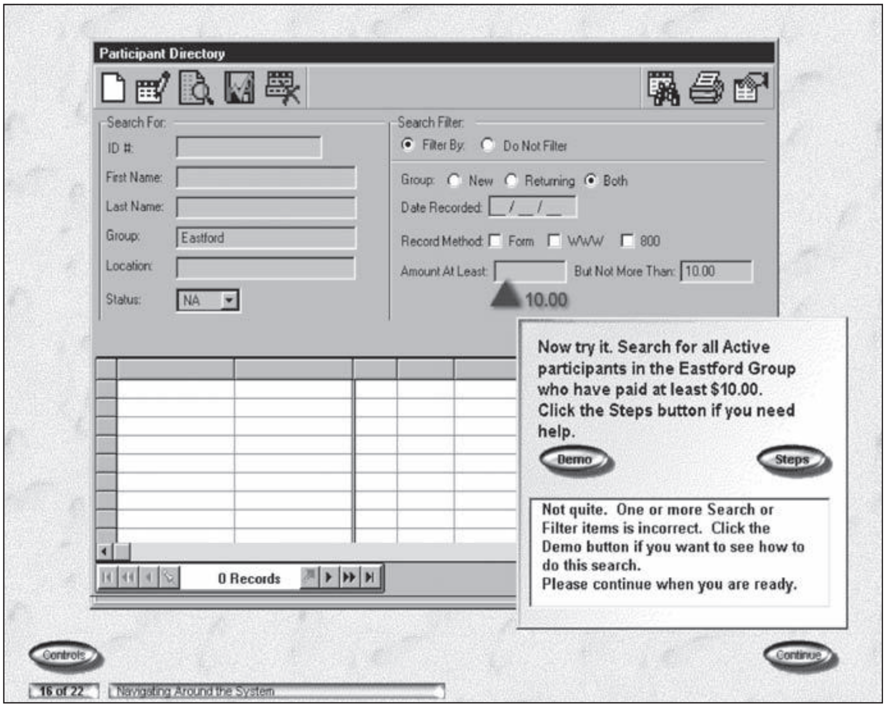
Source: Mark A. Palmer.

with users, Naomi decides she also wants to draw attention to the correct entry field on the wrong answer feedback (see Figure 21.8 on the next page).

Load

Naomi applies the modality principle to reduce cognitive load by using a narrator. Because audio carries the story line and guides the learner, Naomi has audio begin the moment each screen displays so the learner doesn't sit staring, waiting to be told what to do. Since audio is ephemeral, she provides memory support with brief on-screen text bullets of the main points. The narrator will describe the content synchronized with the bullets as they appear on screen. Any other text will appear sequenced after the audio to avoid cognitive overload. It will appear on a

Figure 21.8. Revised Version of Figure 21.7.



Source: Mark A. Palmer.

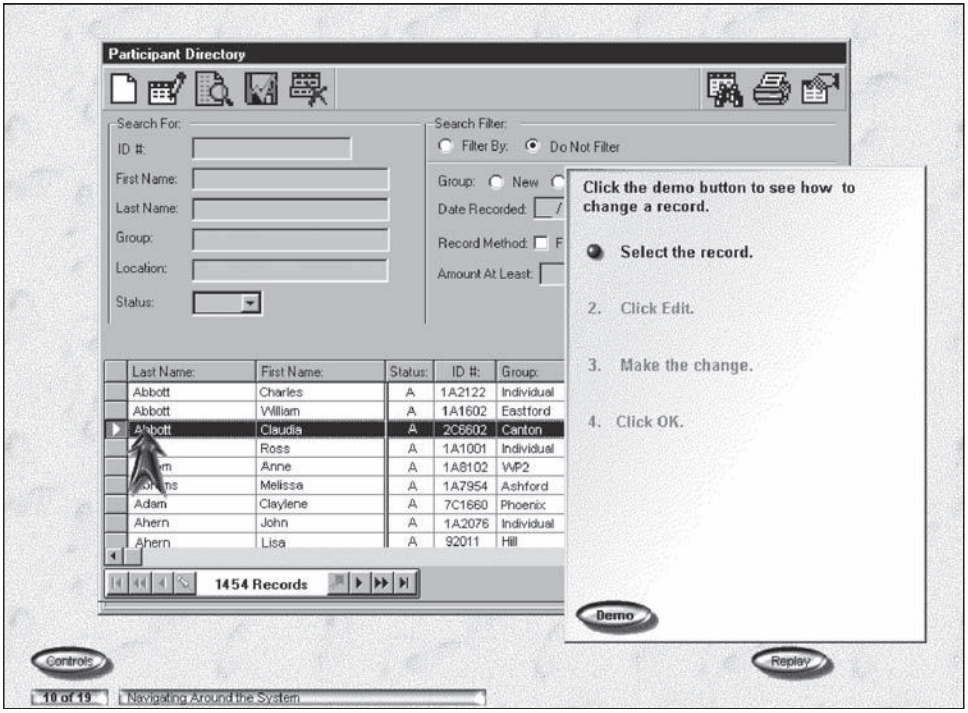
separate layer "closer" to the learner, to clearly illustrate that it is not part of the system screen. The team argues about adding a separate replay button on demos. But ultimately they decide the Replay function associated with each screen display to the demonstrations is sufficient.

The team agrees to animate demonstrations of all procedures, breaking each demo down into a few steps, since the learner is novice and working memory is limited to 7 +/− 2 chunks. Naomi assumes that she can safely avoid overtaxing even her most overwhelmed learner by keeping the total number of steps within any demo to no more than five. As the audio plays, each step is cued, using arrows, highlighting, and bolding (see Figure 21.9).

Activate Prior Knowledge

As Naomi develops her content, she is consistently on the lookout for sections where the novice learners might benefit from graphics that activate prior

Figure 21.9. Sample Template for the Multimedia Demonstrations.



Source: Mark A. Palmer.

knowledge. The phone book analogy she used previously in Figure 21.4 to introduce basic database concepts is one example.

Transfer and Cognitive Motivation

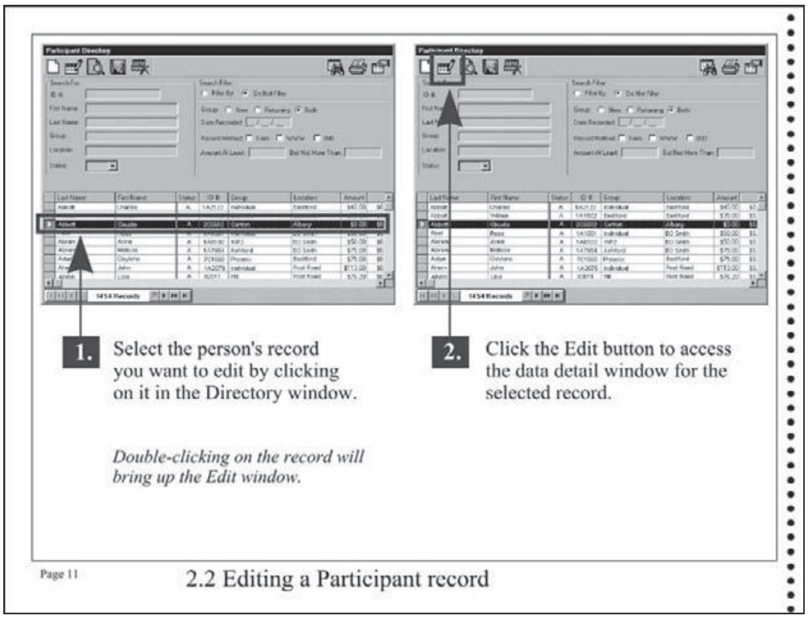
Naomi likes the graphic technique of dynamically morphing the concept graphic into the system screen as a way of reinforcing the conceptual underpinnings of the system. She also builds practices using graphic representations of the actual screens to support transfer. The initial exercises start as basic problems, but as the exercises build, Naomi adds job-based complexity by including graphics of customers and audio of their telephone call requests and by asking the learners to respond by interacting with the representational screen graphics.

Alternative Training Delivery Medium

Naomi decides to accommodate accessibility by also providing a separate, print publication that contains the same instruction. After the multimedia development is complete, Naomi starts designing a print version employing similar attention, load, transfer, and motivation techniques. She designs a freestanding reference that boldly calls out exactly what needs to be done for each task. The visual approach is graphics-dominant, with the graphics the first thing the learner sees on each page and carrying the story line. She relies on the attention grabbers of callouts, labels, and highlighting arrows to supplement the instruction (Figure 21.10).

She also designs a job aid card for quick reference. Her job aid card is text-dominant, where the learner can read down through the steps. The graphics provide supporting illustration (see Figure 21.11). When she completes her assignment, all the pieces of the package are tested out in a pilot. Graphics and content are adjusted based on the results and the pilot participant feedback.

Figure 21.10. Print-Based Version of the Same Content as Figure 21.9.



Source: Mark A. Palmer.

Figure 21.11. Job-Aid Card for Same Content as Figure 21.9.

2.2 Editing a Participant record

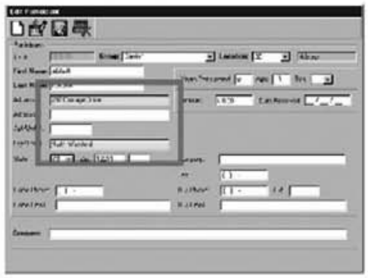
1. Select the person's record you want to edit by clicking on it in the Directory window.

Double-clicking on the record will bring up the Edit window.

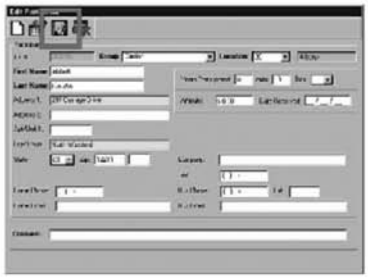
2. Click the Edit button to access the data detail window for the selected record.

3. The date for the selected participant displays in the Edit Participant window.
Make your changes to the participant's information in the appropriate fields.

In this example, changes are typed into the address fields.



4. Click OK to save the change and exit the Edit Participant window.



Source: Mark A. Palmer.

THE INVESTMENT CLUB'S FINANCIAL BASICS TRAINING

A regional investment club contracts George, a freelance instructional designer, to create a course on financial basics for their website.

Define Goals

Their business goal is to offer education to their membership and the general public. They don't care about tracking or any recordkeeping. Although their motivation is somewhat altruistic, they also want to attract dues-paying members by offering small, free courses on money basics. One of their key educational points for their first effort is: "Only when money is used in ways congruent with individual values and goals does it have meaning. Money in itself means nothing." And so, true to their nature, they want the courses to provide real value and not just be advertising glitz. George establishes the overall goals:

- *Business need:* Provide money management education and value to club membership and interested guests.
- *Instructional need:* When learners complete the course, they will be able to determine their goals, their values, their income and their spending, and whether their money decisions are aligned.

Given these goals, George determines that the course is to inform and to build far-transfer, problem-solving skills and associated knowledge.

Determine the Context

Next George surveys the learning landscape.

Learner Profile

Based on his survey of the investment club's existing membership, George knows he needs to accommodate novice or intermediate learners who have enough interest to seek out an investment club. The target audience includes many senior citizens. He makes several assumptions that the learners are English-speaking, interested in managing their own money, and are located in the Four Corners region of the Western United States.

Learning Environment

Because the program is available via the club's website, George cannot anticipate every possible platform that the learners have. He decides to target the most common browser and connectivity of the average home users, recognizing that many seniors might be using older, slower computers.

Pragmatic Issues

The club doesn't have a large budget. The lessons will be offered without charge, so they want George to focus on good design and programming; for art, they'd like George to use what is freely available. They don't have a schedule, but would like comps or screen shots for their next national conference, in three months' time.

Design Visual Approach

Image

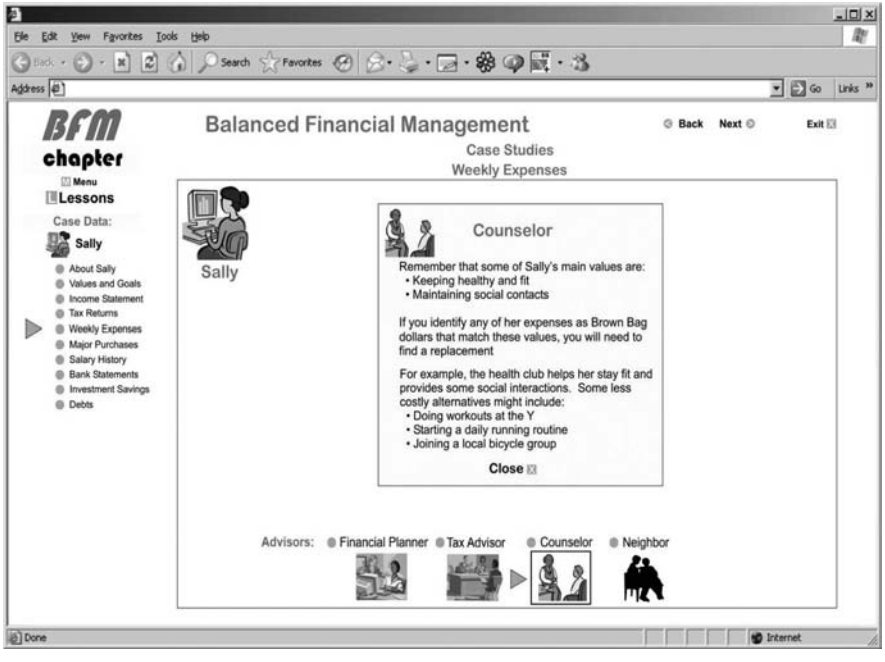
George knows that the art must be branded to identify the investment club's national affiliate, Better Financial Management or BFM. So he uses the national organization's logo, color scheme, and style guides. He does not need to include branding for the Four-Corners chapter, since the club doesn't feel the need to have any graphic identification.

Preliminary Assessment of the Graphic Requirements of the Course

He decides that, even though his art budget is practically nonexistent, he needs at least an original interactive graphic charting for the learner how much even small savings can add up over time. It can be a grabber and motivator and help the learner interpret the key money concepts. George quickly recognizes that dynamic graphics that vary based on learner input could be the heart of the course's value. He decides to approach the client, saying, "I would be remiss if I did not mention that by not having much in the art budget, you may be missing an opportunity to really entice potential members."

The client, grateful for George's honest input, agrees to the one interactive graphic he described but decides that, since this is such a new venture for them, they will wait and see how the first offering goes before doing more. If it is successful, they will update the course with dynamic, interactive graphics and build their other courses using the same approach. Although he disagrees, George accepts their decision and decides to do what he can to make this first effort enough of a success to warrant future offerings.

Figure 21.12. George's Comp for the Interface Royalty-Free Clip Art.



From analyzing the content, George knows he has some real-estate issues with potentially very crowded screens. He also wants to have graphics to represent different advisors and, potentially, different types of people who need help managing their money. The advisors and their advice must be simultaneously visible (contiguity principle) with the instructional text within the case study (see Figure 21.12).

Design Treatment

George decides that engaging learners in solving real financial problems will be more motivational than a traditional tutorial approach to learning. In addition, because the course will be on the web, George decides to provide a high degree of learner control. His design provides plenty of support for the novice learner as well. Since the training is not required, but completely optional, the navigational design and graphics should not be restrictive. George feels that his approach also is aligned with the club's business purpose of helping individuals make appropriate financial decisions.

George turns his attention to designing the display framework for the course and how it will fit into the investment club's existing website. George notes the basic image the site projects and plans to use some of the same components in his course to provide continuity. In the instructional lessons, he decides to center the clip art graphic on the screen as one would a header in a chapter. He knows it's not the best design, but because his graphics budget is so limited, he decides to try it out.

He looks through all of his source materials to assess what might be his worst-case real-estate usage. He has three types of information that might need to be simultaneously accessible—the lesson content, the case studies, and the advisors. But because he does not want to dedicate the entire page to navigation, he decides to nest the advisors on each case study (see Figure 21.12). They are available in relationship to a particular case, but not when the learner is in a lesson topic. The navigation, although not glitzy, telegraphs to the learners where they are in the overall course structure. The interface itself provides an organizational graphic of how all the various components are related.

Given the client's response, the content, the purpose, and the platform, commercial web, and the unknowns of the individual user's computer, George decides a text-dominant layout will work best. He decides to take a low-end approach because of what he knows about a variety of delivery platforms. He works with a programmer to create the course in web-native tools in order to support the browser and bandwidth most common to home users. The entire course will be text and graphics, without audio or video, partially because of budget constraints as well as the target audience.

Identify Communication Function to Match Content Types

Multiple Content: Organizational Visuals

Most of George's multiple content graphic treatment is handled through his design for interface graphics.

Principle-Based Training

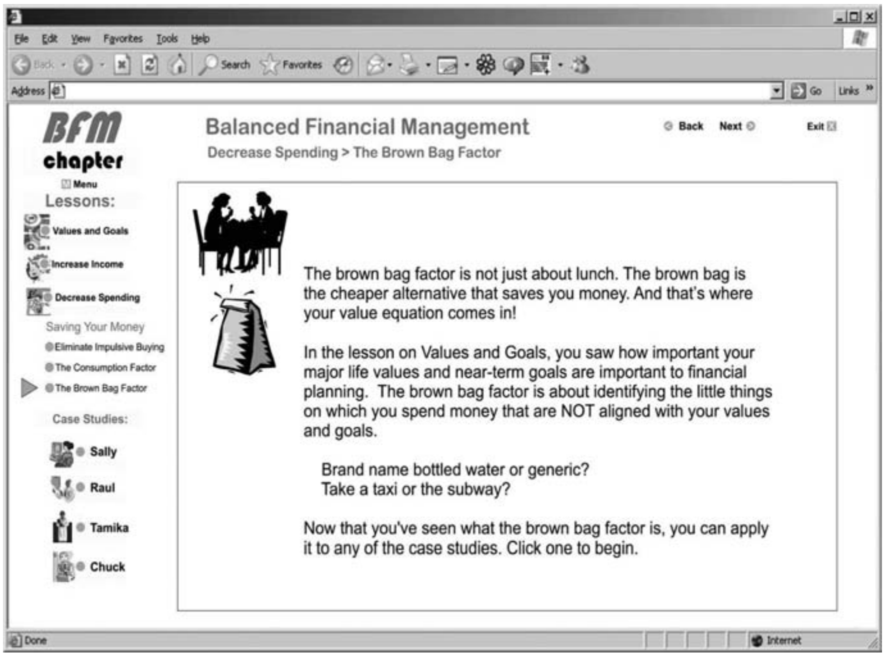
George's instructional content is principle-based. Principle-based training often requires original art to communicate relationships to show the transformation of items over time or space to help learners interpret complex ideas. George's dilemma is that he has little or no budget for original art. Because he knows he is limited to the clip art the client owns, he uses it primarily as representational figures for the case studies and the advisors. As the task is principle-based, he concentrates on simple lists and charts for explanatory visuals that can aid the learners to envision the input, the transformations, and the outcomes. He can create some charts and lists on his own, and he has the okay to develop the one interactive graph that allows learners to calculate savings over time, intrinsically motivating for the types of learners who would access an investment club website.

Apply Principles of Psychological Instructional Events to Visual Design Decisions

Awaken Prior Knowledge and Support Transfer

George rereads Kosslyn's *Graph Design for the Eye and Mind* to make sure he doesn't undermine the power of his charts and graphs by poor execution. To

Figure 21.13. Brown-Bag Representational Graphic.

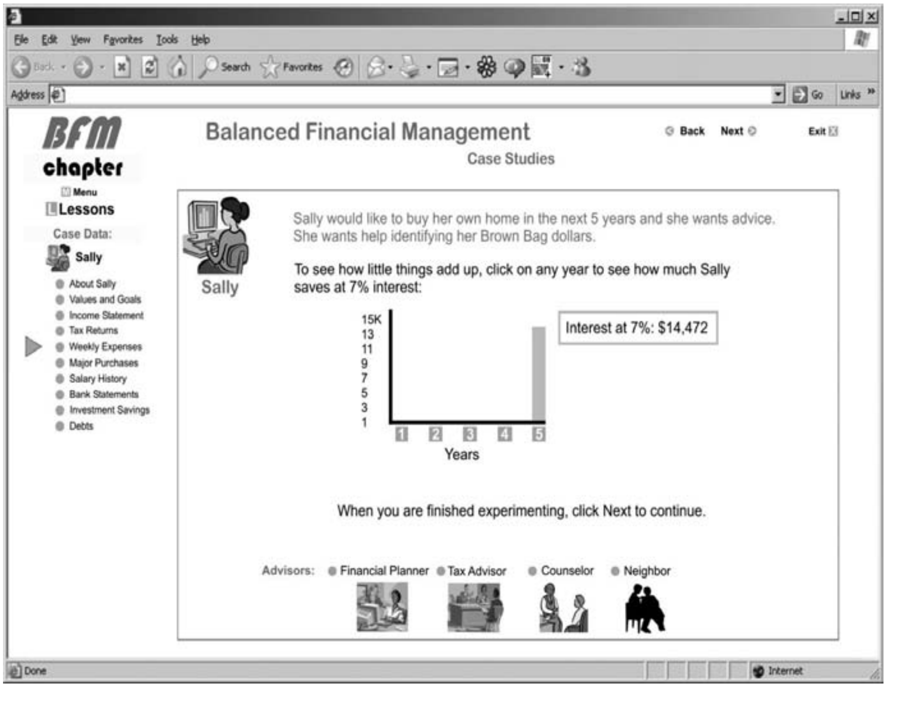


embed a cue for and to awaken prior knowledge, he decides to use a graphic. He calls his metaphor the "brown-bag factor" (see Figure 21.13). He also selects graphics that suggest other analogies such as "money down the drain."

If Building Far-Transfer Skills, Apply Mental Model Principles

To help learners build mental models that they can apply to their own financial decisions, George uses a problem-centered learning design. He includes short case scenarios in which the learner is asked to provide financial advice. He also includes an interactional relational graphic that illustrates how small savings can add up over time (see Figure 21.14).

Figure 21.14. Dynamic Calculation Screen. The design allows learners to discover the impact of their various choices.



Alternative Training Delivery Medium

The investment club likes the e-learning module. Six months after its launch and based on its success, they ask George to also create a booklet that they can hand out at the informational seminars that they hold throughout the region.

Because he hadn't planned for a second delivery medium, George finds he needs to reorganize the information. He decides to break up the case studies and use parts within each lesson as illustrations. In the case study segments, he uses a two-page spread, with the case study information on the left-side page and a four-block layout for the advisors on the right side (see Figure 21.15). He no longer can use dynamic animations and interactive calculators, so he devises worksheets for

Figure 21.15. Two-Page Spread for the Investment Club's Print-Based Booklet.

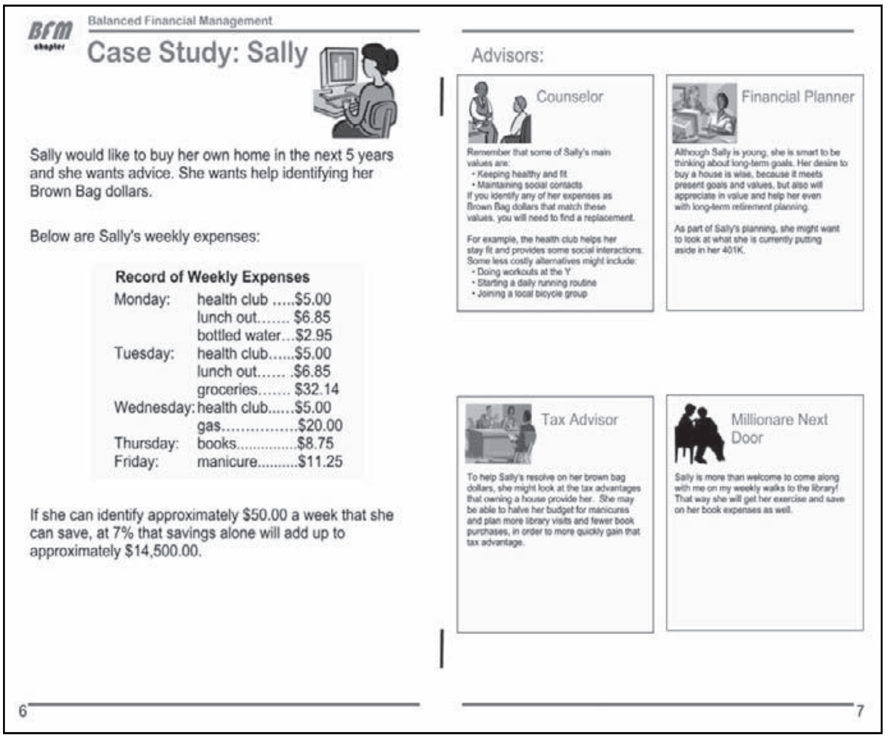


Figure 21.16. Print-Based Worksheet Design.

BFM chapter

Balanced Financial Management

Identify Your Brown Bag Savings

1. Your weekly expenses:

Total:

2. Identify those you can eliminate and total:

Total:

Weekly Savings Total:
Monthly Savings Total:
Yearly Savings Total:

10

Example: Savings of $200.00 a month at 4% compounded annually

Year:	Save:	Principal:
1	$ 2,400	$ 2,496
2	$ 2,400	$ 5,092
3	$ 2,400	$ 7,791
4	$ 2,400	$ 10,599
5	$ 2,400	$ 13,519
6	$ 2,400	$ 16,556
7	$ 2,400	$ 19,714
8	$ 2,400	$ 22,998
9	$ 2,400	$ 26,414
10	$ 2,400	$ 29,967
11	$ 2,400	$ 33,661
12	$ 2,400	$ 37,504
13	$ 2,400	$ 41,500
14	$ 2,400	$ 45,656
15	$ 2,400	$ 49,978

Use the interest calculator at http://www.bfmnational.com to see how much you can save.

11

the learners to fill out with examples that they can reference as they determine their savings plans (see Figure 21.16).

Naomi and George represent two quite different scenarios in which a systematic design model and the guidelines of this book were applied to plan graphics that promoted the instructional goals within each unique learning landscape. We hope that the guidelines and the visual design model we have described in this book will help you find a happy medium between wall-of-words lessons lacking visuals altogether and excessive thematic treatments that use elaborate graphics in ways that disrupt learning processes.

GLOSSARY

Abstract concept	A concept that lacks parts and boundaries and can be represented by an interpretive graphic. Integrity and quality are two examples.
Activation of prior knowledge	Transfer of relevant memories from long-term memory into working memory in preparation for learning. New content from the lesson is integrated into activated prior knowledge to form new mental models.
Advance organizer	A device included at the start of a lesson to activate prior knowledge or build a high-level knowledge overview.
Agent	See *online agent.*
Analogy	An instructional method that uses familiar content from a different domain that has similar functions or features as new lesson content. Used to teach new content in terms of familiar knowledge.
Animation	Series of images that simulate motion.
Attention	Focusing of limited psychological capacity onto specific elements in the environment.
Asynchronous	Lack of temporal concurrence; not occurring at the same time.

Automaticity	The ability to access knowledge and skills without using attention or working memory resources. Includes motor skills such as driving or typing and cognitive skills such as reading. Many practice sessions are required to achieve automaticity.
Chart junk	A term attributed to Edward Tufte to describe the extraneous detail included in charts and graphics that detracts from the point.
Cognitive interest	Engagement with instructional materials as a result of their comprehensibility. Building materials with high cognitive interest supports motivation.
Cognitive load	See *mental load.*
Cognitive motivation	Persistence in completing an instructional goal resulting from clarity of the training materials.
Coherence principle	People learn more deeply from multimedia lessons when distracting stories, graphics, and sounds are eliminated.
Comparative advance organizer	A device to activate prior knowledge by referencing something analogous to the new knowledge and skills in the lesson introduction.
Comps or Comprehensives	Visualization of the idea for an illustration or design, usually created as a guide for clients. "Tight comps and loose comps refer to the degree of detail, rendering and general accuracy" (*Graphic Artists Guild Handbook*, 12th ed., 2007).
Concept	Lesson content that refers to a category of objects or ideas that includes multiple instances usually referenced by a single word. Contrast with *Fact.*
Concrete fact	Factual content that has parts and boundaries and can be visualized with a representational graphic. Compare with *Discrete fact.*

Coordinate concept	Two or more concepts that can be classified in the same subclass. For example, dog and cat are coordinate concepts under the superordinate concept of pet.
Contiguity principle	People learn more deeply when corresponding printed words and graphics are placed close to one another on the screen or when spoken words and graphics are presented at the same time.
Counterexample	A non-instance of a concept; an example used to teach a lesson concept by showing an instance of a related but separate concept. For example, cat is a counterexample for the concept dog. Also called non-example.
Cue	A device used to draw attention to part of the instructional environment, for example, a circle or arrow directing the eye to part of a complex graphic.
Decorative graphic	A visual used to add aesthetic appeal or humor.
Design brief	Loosely, a description of the proposed physical characteristics of the product, such as size, paper, screen resolution if applicable, particular visual style, and other descriptive information about the final product.
Directive instruction	An instructional approach that uses short lessons and provides rules or steps, examples, and practice with feedback.
Discovery learning	An instructional approach in which learners are expected to build mental models with little or no guidance.
Discrete fact	Factual content in the form of isolated quantitative or qualitative data.
Divided attention	The ability to multitask by allocating mental capacity to multiple tasks. Because additional mental resources are required, divided attention should be minimized during learning.

Dual encoding	A psychological theory that there are two distinct and independent cognitive systems for processing and storing information: one for images and one for words.
Dummy	A roughly drawn mockup of a book, brochure, or catalog idea. It is usually the size, dimension, and rough number of pages as is intended for the final product.
Edutainment	An instructional approach intended to improve motivation by embedding instruction in entertaining course elements such as games or popular film themes.
Effect size	A statistic indicating how many standard deviations difference there is between the mean score of the experimental group and the mean score of the control group. An effect size of .8 or greater indicates a high degree of practical significance.
Emotional interest	Engagement in instructional materials based on content that reflects universal themes of life, death, sex, curiosity, or other emotive themes. Can be used to motivate learning but may have negative side-effects.
Encoding	Integration of new information in working memory into long-term memory for permanent storage.
Expertise reversal	Refers to instructional methods that help novices learn but have no effect or are even harmful for experienced learners.
Explanatory graphic	Any visual that helps learners build mental models by illustrating relationships among content elements. Includes organizational, relational, transformational, and interpretive categories.
Exploratory lessons	Lessons that are high in learner control and rely on the learners to select instructional materials they need.

Expository advance organizer	A device to build a high-level knowledge structure during a lesson introduction to help learners organize content details in the lesson. An overview of the lesson content.
Extraneous load	Mental work that is irrelevant to learning that results from ineffective instructional techniques such as placing a related graphic and text in two separate pages or screen locations.
Eye tracking	A data collection method used to infer the focus of attention during reading or learning.
Fact	Lesson content that is unique and specific information. Contrast with *Concept.*
Far-transfer tasks	Tasks that require learners to apply what they have learned in a novel situation, such as adjusting a general principle for a new problem. Contrast with *Near-transfer tasks.*
Focused attention	The ability to devote mental capacity to one part of the environment when there are distractions in other parts of the environment. Compare with *Divided attention.*
Germane load	Mental work that is relevant to the goal of the instruction. Contrast with *Extraneous load.*
Graphic	Any iconic (pictorial) representation designed to optimize learning and work performance. Includes illustrations, drawings, charts, photos, organizational visuals, animation, and video. Also called a *visual.*
Guided discovery instruction	An instructional approach in which the learner tries to accomplish an authentic job task, along with guidance from the instruction about how to process the incoming information. Problem-based learning and scenario-based learning are two forms of guided discovery instruction.

Identical elements principle	A transfer theory stating that new skills must be learned in the same context in which they will be applied.
Illustration	Depiction of visual elements using various media and techniques such as pen and ink, watercolor, and computer drawing packages.
Instructional method	A technique in a lesson intended to facilitate one or more psychological processes that underlie learning.
Interpretive graphic	A visual used to illustrate an invisible theory, principle, or cause-and-effect relationship.
Layout	Sometimes called a *Dummy*. A layout "may vary from a few scraggly pencil lines indicating type areas and rectangles showing size and position of illustrations to carefully pasted compositions that make use of dummy type (i.e., type of the size, weight, shape, and kind intended) and photos of the illustrations" (Jan White, 1982).
Learner control	Allowing the learner to control the presentation of the lesson such as the pacing, topics, and instructional elements such as practice or examples.
Learning styles	An individual difference that influences how learning benefits from various instructional methods. A common learning style is visual, audio, or kinesthetic, indicating the modality from which an individual learns most effectively.
Long-term memory	Part of the mental system that stores memories in a permanent form. Has a large capacity but cannot process information. A repository of knowledge and skills.
Media	A physical device on which graphics are displayed, such as paper or screen.

Mental load	The amount of work imposed on working memory during learning. It is affected by the amount of processing working memory must do while holding information in its limited storage capacity. Mental load is influenced by the amount of complexity or interactivity in lesson content as well as the prior knowledge of the learner.
Mental model	Knowledge structures stored in long-term memory that support human reasoning processes. Also called *schema*.
Metacognition	Awareness and control of one's mental processing, including setting goals, monitoring progress, and adjusting strategies as needed.
Mind map	A visual note-taking process that includes key words and pictures illustrating the relationships among concepts.
Mirror neuron system	A part of the brain designed to learn by observation that bypasses limited working memory capacity.
Mnemonic graphic	A visual that provides retrieval cues.
Modality principle	People learn more deeply from multimedia lessons when graphics are explained by audio narration rather than on-screen text.
Modeled art	Computer generated (CG)—A faithful reproduction of reality, using various media, including computer-generated drawing packages.
Motivation	Any factor that causes a learner to initiate and complete an instructional goal.
Near-transfer tasks	Tasks that require the learner to apply a well-known procedure in the same way as it was learned. Routine tasks. Compare with *Far-transfer tasks.*
Online agent	A character included in an asynchronous e-learning lesson that guides or promotes learning.

Organizational graphic	A visual that shows qualitative relationships among content. A tree diagram is a common example.
Performance aid	A reference resource that provides information that helps workers complete job tasks while they are working. Also known as a *job aid.*
Performance analysis	Research to determine what interventions will best support organizational goals and, if training is an intervention, what medium is the best delivery solution. Also called *needs assessment.*
Personal interest	Engagement in instructional materials as a result of the learner's individual predispositions, hobbies, or avocations.
Photographic art	Captured image, using photographic (film or digital) technologies.
Principles	Tasks completed in unique ways each time based on the work circumstances. See also *Far-transfer tasks.*
Principle-based lessons	Lessons based on guidelines that must be adapted to various job situations.
Procedural lessons	Lessons designed to teach step-by-step skills that are performed the same way each time. See also *Near-transfer tasks.*
Procedures	Tasks completed in routine ways by following the same steps each time. See also *Near-transfer tasks.*
Principle-based lessons	Lessons based on guidelines that must be adapted to various job situations. See also *Far-transfer tasks.*
Problem-centered learning	An instructional approach in which learning is situated in the context of solving authentic work assignments or problems.
Process	Lesson content that communicates a flow of events such as in a business or scientific process.
Real estate	The physical dimensions on the medium that the graphic consumes.

Receptive instruction	Training that primarily presents information without explicit guidance to the learner for how to process it. Usually does not include learner interaction. Classroom lecture or video documentaries are often presented in a receptive manner.
Redundancy principle	People learn more deeply from a multimedia lesson when graphics are explained by audio narration alone rather than audio narration and on-screen text.
Rehearsal	Active processing of information in working memory, including mentally organizing the material.
Relational graphic	A visual used to show quantitative relationships among two or more variables. Bar charts and pie charts are common examples.
Representational graphic	A visual intended to depict an object, such as a screen capture.
Retrieval	Transferring information stored in long-term memory to working memory. Also called *retrieving process.*
Retrospective cases	A case study usually presented in video that shows actual unscripted work situations. Compare to *Interactive cases.*
Roughs	Loosely drawn ideas in pencil on paper.
SCORM	Advanced Distributed Learning's (ADL) Applied Sharable Content Object Reference Model. The SCORM is a collection of specifications based on other guidelines (including the AICC) that provide some standardization for instructional content delivered via the web.
Script	The actual words to be spoken or appear on screen. Used primarily in film and e-learning. Often used to communicate sequence and visual effects as well as actual words to be spoken or read.

Seductive detail	A story or graphic added to a lesson in order to increase the learner's interest but which is not essential to the learning objective.
Shot list	The list of still photos needed during a photo shoot with specifications as to location, character, and camera angle required. May also include other production information as needed.
Simulation	An interactive environment in which features in the environment behave similarly to real-world events.
Situational interest	Attraction to instructional materials as a result of the design of the materials.
Spatial ability	An aptitude that supports the visualization of spatial changes such as 3D rotations.
Storyboard	From the film industry, a rough drawing that has the same aspect ratio as the finished product. In e-learning used to show placement of text and graphics. Depending on the design and production team, may be used as a communication tool for file names, programming specifications, and original renditions.
Successive graphic displays	Visual treatments in which related graphic information is distributed over several pages or screens, making it difficult to view them simultaneously.
Surface features	The outward appearance or features of graphics such as animation or line drawing.
Synchronous	Occurring in "real time"; events that exist at the same time.
Tangible concept	A concept with parts and boundaries that can be visualized with a representational graphic.
Task analysis	Research to define the knowledge and skills to be included in training based on observations of performance and interviews of performers. Also called *job analysis*.

Transfer	Application of previously learned knowledge and skills to new situations encountered after the learning event.
Transformational graphic	A visual used to show changes in objects over time or space.
Varied context examples	Examples that have different surface features but illustrate a similar idea or principle.
Virtual reality	Interactive three-dimensional world that dynamically changes as the user moves through and views it.
Visual argument	The effectiveness of graphics at communicating complex content due to fewer psychological processing demands placed on working memory than text.
Visual literacy	The learner's inclination and ability to attend to and to process graphic information. See also *Metacognition.*
Working memory	Part of the mental system in which the learner actively (consciously) processes incoming information from the environment and retrieved information of long-term memory. Working memory has two channels (visual and auditory) and is limited in capacity.

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ABOUT THE AUTHORS

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ISBN 978-0-470-54744-1
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