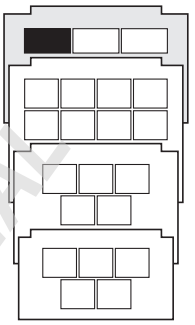
CHAPTER OUTLINE



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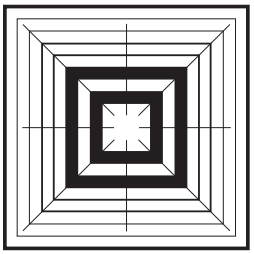
Graphics in the Instructional Landscape

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.

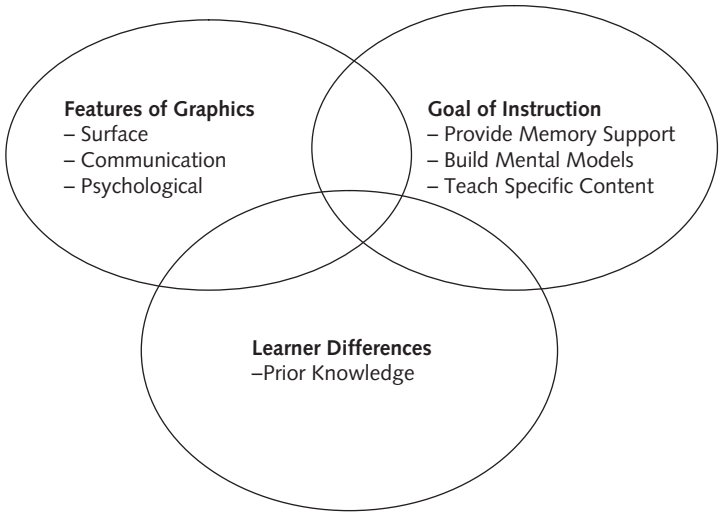
WHICH VISUALS ARE BEST? NO YELLOW BRICK ROAD

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.