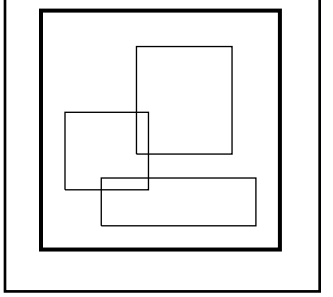
CHAPTER 2



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.

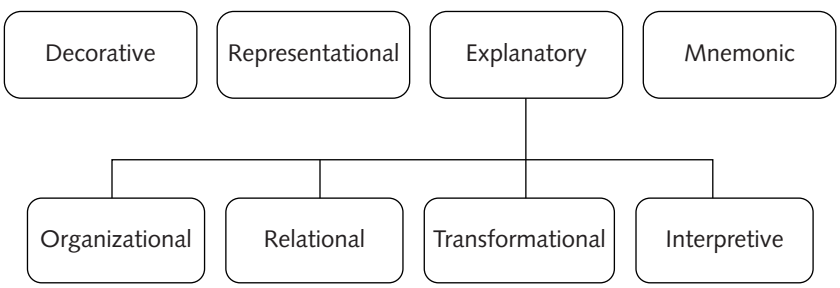


Figure 2.2. A Decorative Graphic.

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

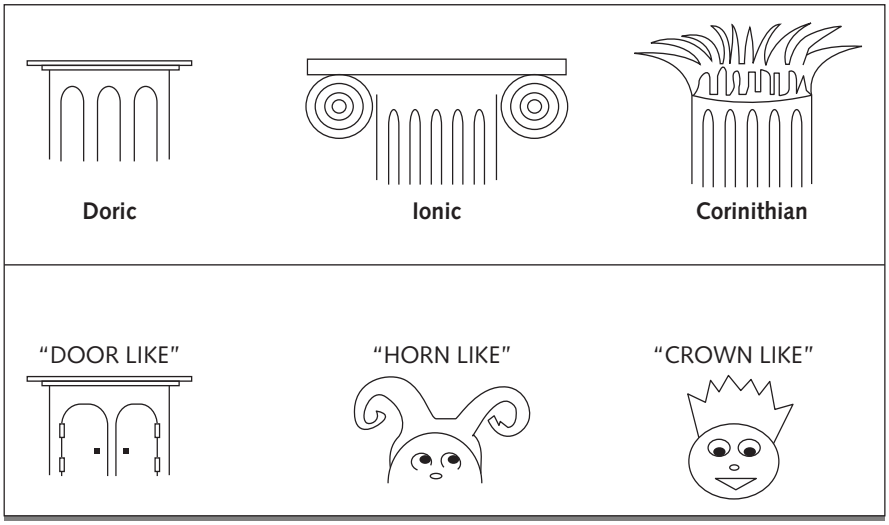
Representational

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

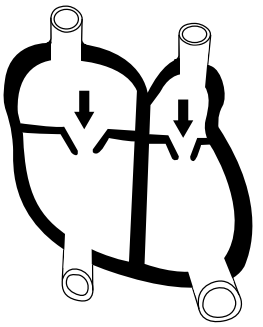
Transformational visuals communicate change over time or over space. The surface features of transformational graphics can include animations, video, or line drawings with movement indicators. A common use of transformational visuals is to teach or provide reference to the steps needed to perform a procedural 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.

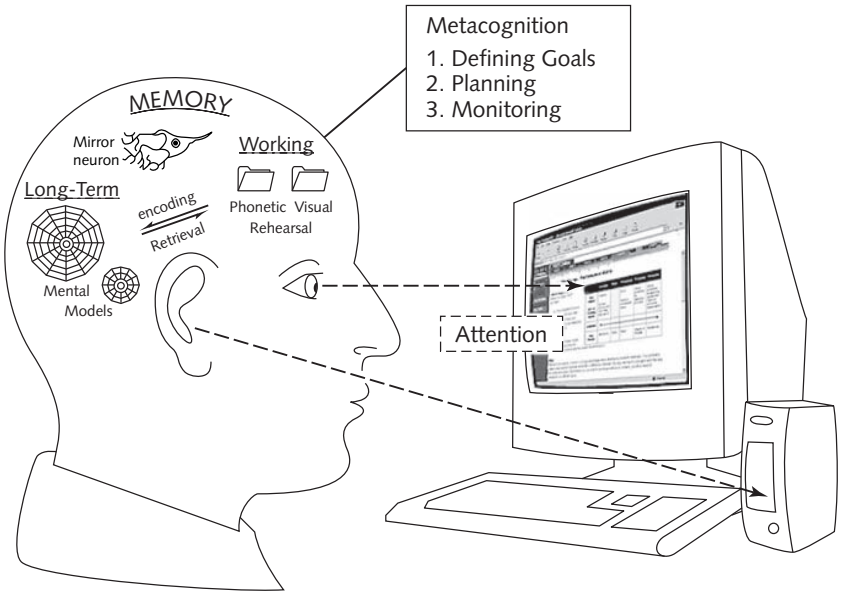
How Learning Happens

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

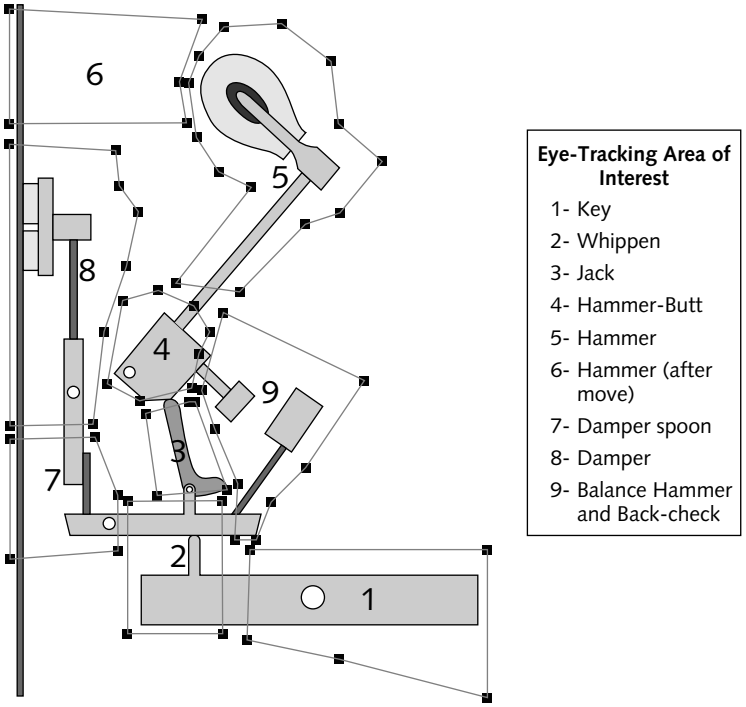
Knowledge tests tell us the value of different experimental treatments such as graphics added to text compared to text alone. However, additional types of data can give us insight into how or why one treatment was more effective than another. Recently, psychologists have used eye-tracking data to indicate 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.