ABSTRACT

Throughout the history of education as a social science, empirical research has been conducted on various representation modes of knowledge and their impact on learners. Although a number of nonobjectivist philosophies have been put forth in education, research in knowledge representations continues to be dominated by a paradigm of knowledge transfer. This chapter uses a three-tier toolbox metaphor for media-based instructional design. The top tier addresses learning theories, the middle tier addresses multimedia models, and the bottom tier addresses specific text, visuals, audio, and animation/video design guidelines.
KEYWORDS

**Baddeley’s memory model:** An information-processing model that emphasizes the different short-term memory stores for visual (the sketchpad) and auditory (the phonological loop) information.

**Cognitive load theory:** Cognitive model of information processing that emphasizes a conceptual mental workload in understanding human thought.

**Cognitive models:** Descriptions of human thought processes via metaphorical constructs. These constructs may or may not represent actual biological structures. The value of any model is judged by its utility in representing or predicting actual thought, not by the degree of accuracy in depicting brain structure.

**Construction–integration model:** Cognitive model for understanding the processing of text; this model suggests a continual multi-leveled process of building and confirming a cohesive mental model from a text document and a reader’s prior knowledge.

**Dual-coding theory:** Cognitive model of information processing that emphasizes the unique contributions of verbal and visual subsystems in understanding human cognition.

**Extraneous load:** In cognitive load theory, the workload component associated with information that is not directly relevant to a particular content area.

**Germane load:** In cognitive load theory, the workload component associated with strategies that require processing but in doing so make the relevant content more accessible.

**Interactive multimedia:** The use of more than one form of media (such as text, visuals, video, animation, and audio) in a way in which a user has a great deal of control over the choice or progress of the program.

**Intrinsic load:** In cognitive load theory, the workload component associated with a particular content area and its level of complexity.

**Long-term memory:** Component of the information-processing model of cognition that represents information stored, presumably for the life of an individual.

**Phonological loop:** In Baddeley’s memory model a short-term memory component devoted to retaining auditory information.

**Redundancy:** The presentation of information multiple times either in the same or in different forms; the value of redundancy in communication is context dependent and debated.

**Sensory memory:** Component of the information-processing model of cognition that describes the initial input of information (such as vision or hearing).

**Short-term memory:** Component of the information-processing model of cognition that describes a person’s attention.

**Visual sketchpad:** In Baddeley’s memory model a short-term memory component devoted to visual and spatial information.

**Visuals:** A form of media in which information is presented visually; text may or may not be considered a visual form.

**Zone of learnability:** In the construction-integration model of text processing, a hypothesized optimal overlap between a text document and a reader’s prior knowledge.

INTRODUCTION

This chapter presents a number of research-based guidelines for using media to support learning. Advances in technology and easy access to images, sound, video, and animation, make the development of information-rich learning environments within the reach of most instructional designers today. Although these media are increasingly sophisticated and varied, access does not necessarily turn the average designer into an expert one. Efforts to enhance instruction are equally capable of the opposite effect when media are poorly implemented.

Increasingly experimental, modality-specific, and cognitively focused research provides new ways to measure and map brain activity in the context of media-facilitated instruction. Today’s instructional designer is equipped with a growing body of skills and knowledge, a metaphorical toolbox overflowing with information. Knowing how to use this information is increasingly challenging. For one, the toolbox is messy, as is the process of design (Meikle, 2005) and models used by instructional designers (Bichelmeyer, 2005). Unclear guidelines and the nature of academic rhetoric contribute to the confusion.

The purpose of this chapter is to break from convention to untangle some of the confusion. Recent developments in cognitive load theory (Merriënboer and Sweller, 2005) restate the importance of decreasing content complexity to increase meaningful learning. In keeping with this goal, we share here a simplified view of media research, returning to a number of selected theories and guidelines considered worthy of attention. Given their observed application in a number of settings they possess an arguable degree of merit.

AN ORGANIZATION SCHEME FOR DESIGN PRINCIPLES

Figure 8.1 uses a toolbox analogy to illustrate a suggested framework for organizing media-based design principles. A three-tier approach consists of general
learning theories at the top tier, multimedia-learning theories at the middle tier, and specific mode-based guidelines for text, visuals, audio, and animations/video at the lowest and most easily accessed tier.

**Four Related Learning Theories**

Theories of learning contribute to our understanding of how media might be presented for effective learning and performance, particularly those theories that are based in the cognitive sciences, the study of how knowledge is acquired. Four related learning theories important to designers and researcher are summarized: (1) information-processing theory, (2) dual-coding theory, (3) cognitive load theory, and (4) Baddeley’s model of memory (see Figure 8.2). Information-processing theory provides an overview and perspective of memory structure important to the understanding the significance of dual-coding theory, cognitive load theory, and Baddeley’s model of memory.

**Information-Processing Theory**

A number of theories describe the transfer of information through memory (Atkinson and Shiffrin, 1968; Broadbent, 1984; Lockhart and Craik, 1994; Norman and Bobrow, 1975; Waugh and Norman, 1965). Atkinson and Shiffrin (1968) proposed a model based on two types of memory: short-term memory (including sensory and working memory) and long-term memory. This dual-store model of memory is commonly referred to as information-processing theory. In this model, short-term memory is very limited in duration (only seconds) and capacity. A component of short-term memory is working memory, a system that performs an executive capacity by managing and manipulating information that constitutes a learner’s current attention. Long-term memory has a seemingly infinite duration and capacity.

The interaction of short-term and long-term components is the focus of learning. Although virtually anyone can attend to a particular stimulus, learning is dependant on the transfer of relevant information to long-term memory and its retrieval when performance is required. Instructional designers are fundamentally concerned with the function of working memory. Regardless of the medium, relevant information must gain the attention of the learner, be held in working memory, and ideally be in a form that is readily incorporated into long-term memory.
**Dual-Coding Theory**

Pavio’s research (1971, 1986) extended the general information-processing theory by suggesting separate verbal and visual subsystems of memory. Information presented in either form, verbal or visual, is coded in either a visual memory store or a verbal memory store. These separate memory systems are each capable of activating the other, as well as converting information from one form to another. Words can be coded in a verbal format but are also capable of being converted to an image format, if prior knowledge allows. The same can be said for images whose form can be converted to a verbal description. From Paivio’s point of view, the connection between the visual and verbal codes strengthens memory. To information designers, presenting the combination of visual and verbal information is likely to increase the chances of recognition and recall, due to the strengthened associations afforded by dual coding.

**Cognitive Load Theory**

Cognitive load theory (CLT) relies on the core components of the information-processing model (short-term, working, and long-term memory) but focuses particularly on the limitations of working memory. From the perspective of cognitive load theory, instructional materials should be created for a theoretical optimal cognitive load. In other words, cognitive overload impairs learning; cognitive underload does not generate interest. Cognitive load theory is particularly applicable to instructional designers, and this chapter. According to Sweller et al. (1998, p. 262), “Limited working memory is one of the defining aspects of human cognitive architecture and, accordingly, all instructional designs should be analyzed from a cognitive load perspective.”

Cognitive load refers to the amount of information presented and how well that amount compares with the size of working memory. Optimal load varies, based on the level of learner expertise. Novice learners with limited prior knowledge are more likely to process simple, sequential structures with limited threats to overloading memory. Expert learners, on the other hand, are able to accommodate richer, more complex information loads due to their developed schemas or knowledge representations that make integration of new information possible. Optimally, the designer’s task is to structure information that fits within existing schema (i.e., prior knowledge). Individual differences in both prior knowledge and effective working memory size are particularly troublesome when designing materials to be used by wide ranges of learners.

The research on cognitive load describes three categories of load: intrinsic load, extraneous load, and germane load (Paas et al., 2003). *Intrinsic load* refers to the nature of the content and its level of complexity. Complexity can be defined in terms of element interactivity, or the extent to which a learner must understand instructional content that overlaps and interacts with other instructional content. High content interactivity describes complex relationships in which the various components can only be understood as part of a larger system. Low content interactivity describes information that is more easily understood in isolation, because it requires an understanding of fewer elements. Learning concepts, for example, would be more likely to involve high element interactivity than learning facts, which would involve low element interactivity. An instructional designer cannot modify intrinsic load because it refers to the complexity of the information itself.

*Extraneous load* can be thought of as the noise, or superfluous elements of communication, that act as barriers to learning due to the increased load they place on memory. For example, using a large number of fonts in a section of text does not add to the content but rather adds to the extraneous load as the reader attempts to assign meaning to the various changes.

*Germane load* can be thought of as those things that a designer can do to facilitate optimal load, such as chunking content, sequencing it, and providing analogies that can help people understand new information more quickly. A designer can work to reduce a high intrinsic load by both reducing extraneous and increasing germane load.

Although cognitive load theory is particularly well suited for the discussion of issues regarding the creation of instructional materials, it is not the sole model for understanding mental workload. Terms such as exerted mental effort are often used in research studies, but other than a gross comparison of higher and lower load or difficulty, the concept is not well defined. A mental workload example from human factors describes a model in which a limited amount of attention resources must be shared by perception, working memory functions, metacognitive oversight, and execution of a response (Wickens, 1984).

**Baddeley’s Model of Memory**

Baddeley’s research (2000) attempted to further clarify the capacities of working memory. Working memory is composed of a central executive function. This central executive function is involved in focusing attention, switching attention, and dividing attention. In Baddeley’s model, the executive function monitors a
visual sketchpad (visual and spatial memory), a phonological loop (auditory memory), and an episodic buffer. This episodic buffer is the area that interfaces with the visual sketchpad and the phonological loop and binds or integrates this information. In a sense, Baddeley’s model attempts to reconcile the understanding of short- and long-term memory from information processing with the channels of different information streams from dual coding.

Of interest to instructional designers is the idea that the episodic buffer is not considered part of long-term memory. It may be possible to design and organize information for optimal use of this buffer. If the learner does not need to perform low-level integration and organization, more mental effort would be freed to perform other functions conducive to long-term storage and recall. Working memory can retrieve information from the episodic buffer, creating relatively new representations while at the same time also retrieving information from long-term memory. The unique juxtaposition of information in the episodic buffer may explain some aspects of problem solving and creativity.

MULTIMEDIA GUIDELINES

Two prominent theories of multimedia (see Figure 8.3) (Mayer, 2001, Park and Hannafin, 1993) suggest a number of guidelines, which are summarized in Table 8.1. Park and Hannafin (1993) based their work on an extensive review of the research and proposed an overarching framework for interactive multimedia design using 20 design principles. Recently, Mayer’s (2001) multimedia theory suggested seven design principles that focus specifically on the interaction of audio, text, and visuals in a number of controlled experiments. Table 8.1 provides the authors’ classification of combined multimedia design principles in the context of cognitive load theory. Principles are placed in cell locations most directly related to their connotation with the purpose of showing potential connections between theories.

Presentation Guidelines for Text, Visuals, Audio, and Animation/Video

Guidelines for text, visuals, audio, and animation/video are reviewed in this section (see Figure 8.4).

Text Guidelines

Textual information has long been the backbone of formal education. Although the use visual and spoken language information predates the development of written text in human history, the use of text as an augment to human memory provided a great leap forward in educational settings. The guidelines in this section of the chapter focus on the work of Walther Kintsch (1998). Whereas many forms of mediated instruction have been used only over the last 100 years, written text has been used and developed for thousands of years. During the 1970s, in part as an attempt to
represent knowledge with computers, two key ideas for further understanding of text processing were explored: proposition representation and schema theory. From the perspective of text processing, a proposition is a predicate and a number of arguments that together form an idea or unit of information. For those doing research with text, it was important to distinguish between an idea and the multiple ways of expressing that idea into English or any other language. Decoding natural language into propositions, or a propositional network (complex ideas required that propositions could refer to other propositions in a tree-like structure of meaning), provided a standardized way of referring to meaning that attempted to minimize variations in language, word choice, or other subtleties of expression. Whereas propositions focused on lower-level understanding that would be built up, schema theory provided a top-down view of understanding. Although propositions could explain understanding in terms of basic units of understanding, it did very little to explain the advantages of prior knowledge. Rarely are we
forced to interpret new information or situations that are so foreign that previous knowledge does not play a large role. Proponents of schema theory have pointed out that a very large proportion of situations we encounter are actually routine in nature. These routines can be expressed as schemas, which are scripts or templates for understanding. Although the details and exceptions can be numerous, the concept of schema provided an essential top-down unifying structure and reflected the pattern-seeking behavior of individuals. When presented with novel situations, it is not uncommon for learners to attempt to make the information fit a preexisting schema.

Propositional representation and schema theory have provoked numerous studies and research in the areas of linguistics, computer science, and cognitive psychology. Over a period of years, Kintsch developed a model of text comprehension that built on this pioneering work. In 1998, he summarized his construction–integration model in a text appropriately called *Comprehension: A Paradigm for Cognition* (Kintsch, 1988).

The construction–integration model proposes two phases to understanding text. First, during the construction phase, readers create an approximate, but incoherent, mental model from textual input and their own goals and prior knowledge. The second (integration) phase involves consolidating local constructions into a cohesive meaning and discarding those local constructions that do not fit. These phases occur at the word level, at the sentence level, and with larger portions of text. They are performed automatically with familiar material and under learner control by active readers. The construction–integration model takes into account both bottom-up and top-down processing. It also provides a way to understand very different types of textual comprehension (e.g., metaphors, humor, abstractions) with simple, robust processes. Kintsch made an important distinction between the textbase, which is a representation of the information contained in the text, and the situational model, which is the information the reader takes from the text, including elaborations and connections based on prior knowledge.

Although Kintsch’s construction–integration model has many implications for both researchers and instructional designers, those that are particularly relevant to this chapter are provided in Table 8.2. These are consistent with generally accepted guidelines for writing texts simply because the model was constructed to subsume findings from previous research, and the model suggests that empirical data provide the foundation for creating good instructional texts for readers.

One aspect of the model that is particularly important to point out is Kintsch’s zone of learnability. This is an intentional analog to Vygotsky’s zone of proximal development (1978). Kintsch described a good text as one that provides an appropriate amount of overlap between the new information in the text and the learner’s situational model (i.e., relevant prior knowledge). An obvious implication is that if there is too much overlap the reader can gain no new information from the text. The less obvious implication is that the presence of familiar information in terms or words, structure, and other content is a necessary scaffold to promote deeper understanding. A minimal text, in which information is broken down and context is removed, may be as ineffective as an overly complex text. Additional and redundant text may be necessary to support the construction of deeper meaning.

As with earlier theoretical work with text, the construction–integration model has spawned further research that may extend the model or suggest alternatives. It has also led to a particular method of study—latent semantic analysis—which provides additional computational techniques for understanding text.

**Visual/Graphic Guidelines**

The instructional benefit of visuals has a long history in the research (Tversky et al., 2002) and perhaps is best summarized in Mayer’s (2001, p. 184) multimedia principle: “Students learn better from words and pictures than from words alone.” The terms *visual*, *graphic*, and *image* are used interchangeably in the literature. A visual is typically thought of as a form of communication that is not verbal. Braden (1996) identified five categories of visuals that have been studied by educational researchers:

- Semiotics and film/video conventions
- Signs, symbols, and icons
- Images and illustrations
- Multi-images
- Graphic representation, including text as visuals

Saunders (1994) defined graphics as a prepared form of visual communication. Graphics can be:

- Symbols (pictographic or abstract)
- Maps
- Graphs
- Diagrams
- Illustrations or rendered pictures (realistic to abstract)
- Models
- Composite graphics (multi-images)
- Photographs (still or moving)
Guidelines for the design of visuals based on cognitive theory are presented in Table 8.3 (Lohr, 2007). These guidelines are based on Mayer’s learning principles of (1) selection, (2) organization, and (3) integration and are directly related to the three parts of learner memory: short-term memory, working memory, and long-term memory.

**Auditory Guidelines**

Educationally, auditory information is generally thought of in the form of spoken language. Although semantically similar, the information found in spoken vs. written language is processed differently. Auditory information also describes nonsemantic information,
such as alarms and sound effects, and highly specialized information in the form of music. In the case of music, some skills such as recognizing relative pitch may be taught; however, others, such as the recognition of absolute pitch (requiring a stable long-term memory of a reference pitch), may involve specialized brain mechanisms and require acquisition relatively early in life (Levitin and Rogers, 2005).

Bishop and Cates (2001) provided a framework for thinking of instructional sound from a cognitive perspective (see Table 8.4). Although their primary goal was investigating the potential of sound in support of instructional software, the framework also is useful for considering the medium of sound in isolation. The three types of noise come from the work of Shannon and Weaver, which has been interpreted by Bishop and

### Table 8.3
Guidelines for the Design of Instructional Visuals

<table>
<thead>
<tr>
<th>Learning Principle</th>
<th>Description</th>
<th>Guidelines for Text, Images, and Data Displays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection</td>
<td>The selection process addresses the mind’s tendency to organize information into figure and ground categories.</td>
<td>Make figure and ground distinctions as clear as possible to reduce the amount of information that memory needs to process.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contrast type, shape, color, and size in graphic and data displays to separate important from less important information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Principle is related to Park and Hannafin’s principles 3, 7, and 9 to structure information in ways that complement the cognitive process and internal representations.)</td>
</tr>
<tr>
<td>Organization</td>
<td>Organization is based on the mind’s tendency to process and remember chunks of information that in turn are arranged hierarchically.</td>
<td>Shape information structures to show subordinate, superordinate, and coordinate relationships, including those related to time and direction. Outlines, arrows, and lists are commonly used to establish hierarchy in a visual.</td>
</tr>
<tr>
<td>Integration</td>
<td>The integration principle is based on the Gestalt theory that the whole is greater than the sum of its parts. A person’s prior experience allows him or her to see that whole, even when presented with only a part.</td>
<td>Use grid structures to organize and integrate information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group items into meaningful units. Greater understanding is achieved when parts, or elements of a message, are attended to as a whole, not selectively.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mayer’s principle 7 focuses on the importance of presenting information in ways that require less cognitive effort from the learner—in other words, reduce the cognitive load yet maintain a focus on the parts-to-whole relationships.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repeat and align text, shape, color, and size to connect items.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Place similar items in closer proximity than dissimilar items.</td>
</tr>
</tbody>
</table>

### Table 8.4
Cognitive Framework for Instructional Sound

<table>
<thead>
<tr>
<th>To overcome:</th>
<th>Acquisition noise</th>
<th>Processing noise</th>
<th>Retrieval noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>The message should contain:</td>
<td><strong>Content redundancy</strong> to amplify the content for message transmission (encourages noise-defeating learner acquisition states)</td>
<td><strong>Context redundancy</strong> to supply the context for message interpretation (encourages noise-defeating learning processing strategies)</td>
<td>Construct redundancy to cue appropriate constructs for message understanding (encourages noise-defeating learner retrieval schemes)</td>
</tr>
<tr>
<td>Selection</td>
<td>1. Use sound to help learners direct attention.</td>
<td>2. Use sound to help learners isolate information.</td>
<td>3. Use sound to help learners tie into previous knowledge.</td>
</tr>
<tr>
<td>Analysis</td>
<td>4. Use sound to help learners focus attention.</td>
<td>5. Use sound to help learners organize information.</td>
<td>6. Use sound to help learners build on existing knowledge.</td>
</tr>
<tr>
<td>Synthesis</td>
<td>7. Use sound to help learners hold attention.</td>
<td>8. Use sound to help learners elaborate on information.</td>
<td>9. Use sound to help learners prepare knowledge for later use.</td>
</tr>
</tbody>
</table>

Cates (2001) from a cognitive instructional viewpoint. Acquisition noise interferes with the reception of an instructional message. Processing noise refers to problems with understanding the message that has been received. Retrieval noise is a mismatch between an understood message and prior knowledge, experience, or attitudes.

Redundancy in auditory information is important to understand in the context of the temporally based nature of the medium. Baddeley’s phonological loop (2001) is the short-term memory related to auditory information. Although his focus was on the processing of spoken language, one can consider the short-term memory of other forms of sound (such as music or sound effects) as being under the same limitations. Neisser (1967) referred to this as echoic memory. Upon hearing a sound, a person is able to replay a brief portion of it in this short-term memory for further processing. This partially explains the “cocktail party effect,” in which a person is engaged in a conversation to the exclusion of numerous others talking in the same room. Short-term audio memory allows that person, in a limited sense, to monitor and switch attention to a different conversation upon hearing his or her name or some other attention-grabbing piece of information.

Bishop and Cates (2001) (see Table 8.4) suggested the use of redundancy to overcome the temporal nature of audio communication. Content redundancy refers to the retransmission or amplification of the audio information. Context redundancy involves presenting semantic information in multiple ways to ensure that it is perceived correctly. Finally, construct redundancy attempts to emphasize the link between the information and prior knowledge.

**Animation/Video Guidelines**

Animation and video are described together because they share similar characteristics (e.g., a time component, presentation of motion or change). In addition, the advent of digital technologies for both animation and video production has blurred the distinction between artificial and real representations. Researchers who examine the impact of animation in education must consider the critiques leveled at any media comparison study. As is often the case, animation provides a simplified visual view of a process or behavior that otherwise might be presented in a classroom with models or via video footage; however, animation may be able to uniquely portray an educational concept that might otherwise be difficult to visualize. It may also be used for financial or logistical reasons in lieu of another approach; for example, Adamo-Villani and Beni (2004) described a system that uses realistic three-dimensional animation for the purpose of teaching finger spelling via sign language. Research focused on the use of animation most often describes its use with other forms of presentation. In general, guidelines for its effectiveness can be categorized using a cognitive framework similar to the one used for multimedia. Table 8.5 categorizes findings from a number of studies within the context of the components of cognitive load theory.

**THE NEED FOR CONTINUED RESEARCH**

Although no single cognitive theory of learning or multimedia model can explain in sufficient detail all the functions of memory, the theories and models presented in this chapter have much to offer to an understanding of instructional media design. Perhaps a more complex theory and model will be eventually proposed that subsumes a majority of research in cognitive psychology and instructional multimedia; however, it is likely that such a complicated theory and model would be more difficult to translate into prescriptions for practice.

Although most of the guidelines in this chapter represent the work of many experimental studies, their selection and categorization are dependent on the authors’ interpretation of the research and are therefore subject to the biases of their perspectives. A comprehensive review of new research will be necessary on a periodic basis to ensure that the most worthy design guidelines are shared. Some might consider a more rigorous approach to the assignment of guideline classifications needed.

Perhaps most needed is a more integrative set of guidelines within the various presentation modes. Whereas visual and animation/video media share an organizational theme similar to the multimedia framework, the text and audio guidelines have unique organization schemes, which makes the relationships between the different models more difficult to understand.

Other topics of future research include the comparison of research-based guidelines to the guidelines used in settings that are more applied and less research oriented. The restrictions encountered by the realities of production are worthy of investigation. Although design focuses on optimal presentation, dynamics within the workplace often curtail the effectiveness of a product. As a case in point, the first author’s graphic design textbook promoted guidelines for the effective display of graphics that were clearly violated by the book itself due to the overriding importance of reducing publication costs. Knowing ahead of time what these realities are would be beneficial to the designer.
TABLE 8.5
Cognitive Framework for Animation/Video

<table>
<thead>
<tr>
<th>Theory Components</th>
<th>Description</th>
<th>Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing germane load</td>
<td>Hays (1996) demonstrated that low-spatial-ability participants made greater gains when animations were used as opposed to static graphics or no graphics. Schnottz and Rasch (2005) described the value of animations for learners with low learning prerequisites. Learners with high learning prerequisites received more value from manipulating pictures themselves. Bishop and Cates (2001) described the technique of visual description that provides access to television, movies, etc., for individuals with visual impairments. They suggested that the technique might also be useful for promoting comprehension for those with average vision.</td>
<td>Design effects are stronger for low-knowledge learners than for high-knowledge learners and for high spatial learners rather than low spatial learners (Mayer’s principle 7).</td>
</tr>
<tr>
<td>Reducing intrinsic load</td>
<td>Reiber (1996) found that animated graphic feedback could produce gains in tacit knowledge when compared with text-only feedback. Garcia (1998) described the benefit of students creating animations in their understanding of science content. Catrambone and Seay (2002) found that animations aided in students’ understanding of algorithms when compared to the same text followed by still frames. It was particularly helpful for students in a weak-text vs. an improved-text condition. Bodemer et al. (2005) demonstrated how exposure to static sources of information prior to work with dynamic, interactive visualizations can support learning. Koroghlanian and Klein (2004) found that participants exposed to animations will spend more time in the instruction than those given only static images. Hegarty et al. (2003) found no difference between static and dynamic diagrams in the understanding of dynamic processes; however, they suggested that participants’ ability to create animated mental models from static diagrams might be the reason for the lack of difference.</td>
<td>Employ organizing activities (invested mental effort, elaboration, articulation, knowledge differentiation) (Park and Hannafin’s principles 5, 8, 12, and 14). Present corresponding words and pictures simultaneously rather than successively (Mayer’s principle 3).</td>
</tr>
<tr>
<td>Reducing extraneous load</td>
<td>Linebarger (2001) found that the use of captions with video programs resulted in greater word recognition for young children and related positive effects. The researcher also reported that captions lessened attention to visual and audio distractions in the video presentation. Caspi et al. (2005) found that video recordings of lectures did influence the message being delivered to students and that mismatches of the medium and the message may have a negative result on cognitive and affective outcomes.</td>
<td>Finding conflicts with Mayer’s principle to use animation and narration rather than animation, narration, and text (Mayer’s principle 5). Exclude rather than include extraneous words, pictures, or sounds (Mayer’s principle 4).</td>
</tr>
</tbody>
</table>

SUMMARY
This chapter presents a three-tier toolbox metaphor for guiding the design of a number of presentation media. The designer typically reaches for the elements on the third tier, the most concrete and accessible elements of design: text, visuals, audio, and animation/video. Understanding first-tier elements that include cognitively based theories of learning (information-processing theory, dual-coding theory, cognitive load theory, and Baddeley’s memory theory) in turn helps the designer more clearly understand second-tier multimedia models (Mayer, 2001; Park and Hannafin, 1993) and their relationship to mode-based guidelines. The relationship between the three tiers is appealing, but more research is needed to articulate a more fully integrative design toolbox.

REFERENCES


* Indicates a core reference.