

Section I

Introduction to Multimedia Learning

People learn better from words and pictures than from words alone. This hypothesis is the basis for the promise of multimedia learning. Multimedia instruction consists of words and pictures rather than words alone. How can we design multimedia instruction that improves learner understanding of the presented material? This is the central question addressed in this book.

Chapter 1 explores the promise of multimedia learning by offering definitions of key terms and by examining fundamental distinctions that will help you understand research on multimedia learning. A key distinction is between two goals of multimedia research – to contribute to instructional practice (i.e., the science of instruction) and to contribute to learning theory (i.e., the science of learning). The multimedia design principles presented in this book are intended to address both goals and reflect an example of what Stokes (1997, p. 73) calls “use-inspired basic research.”

Chapter 2 explores the science of instruction by summarizing the methods we used to test the instructional design principles described in this book. The chapter gives you examples of the multimedia lessons and tests we used, including computer-based narrated animation, paper-based annotated illustrations, and computer-based games and simulations. I also show you how we created experimental comparisons in which we compared the test performance of a group that learned from a multimedia lesson containing a to-be-tested feature versus a group that learned from the lesson without the feature. In short, this chapter helps you see how the instructional design principles described in this book are based on evidence.

Chapter 3 explores the science of learning by summarizing a research-based theory of how people learn from words and pictures, which I call the cognitive theory of multimedia learning. The theory is

Cambridge University Press

978-0-521-51412-5 - Multimedia Learning, Second Edition

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based on research in cognitive science, including the ideas of dual channels, limited capacity, and active processing. The cognitive theory of multimedia learning can help you understand how we generated to-be-tested design principles and how we explained when the principles do and do not apply. In short, this chapter helps you see how the instructional design principles described in this book are grounded in theory.

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The Promise of Multimedia Learning

Multimedia learning refers to learning from words and pictures. Multimedia instruction refers to the presentation of material using both words and pictures, with the intention of promoting learning. The case for multimedia learning rests on the premise that learners can better understand an explanation when it is presented in words and pictures than when it is presented in words alone. Multimedia messages can be based on the delivery media (e.g., amplified speaker and computer screen), presentation mode (e.g., words and pictures), or sensory modalities (e.g., auditory and visual). The design of multimedia instructional messages can be based on a technology-centered approach that focuses on the capabilities of advanced technologies or on a learner-centered approach that focuses on the nature of the human cognitive system. Multimedia learning may be viewed as response strengthening (in which multimedia environments are used as drill-and-practice systems), information acquisition (in which multimedia messages serve as information delivery vehicles), or as knowledge construction (in which multimedia messages include aids to sense-making). Three possible learning outcomes are no learning (as indicated by poor retention and poor transfer performance), rote learning (as indicated by good retention and poor transfer performance), and meaningful learning (as indicated by good retention and good transfer performance). Meaningful learning outcomes depend on the cognitive activity of the learner during learning rather than on the learner's behavioral activity during learning. The goal of basic research is to contribute a theory of learning (i.e., science of learning), whereas the goal of applied research is to derive principles of instructional design (i.e., science of instruction); merging these goals results in basic research on applied situations where the goal is to derive principles of multimedia design that are both grounded in cognitive theory and supported by empirical evidence.

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WHAT IS MULTIMEDIA INSTRUCTION?

People learn better from words and pictures than from words alone. This straightforward statement summarizes the promise of multimedia learning and is the guiding thesis of this book. In short, I am intrigued by the idea that we can improve people's learning by incorporating effective graphics into verbal material. Does adding graphics to words help people learn better? What makes an effective graphic? How do people learn from words and pictures? These are the questions I address in this book – questions about what works with multimedia instruction and how people learn from multimedia instruction.

The term *multimedia instruction* means different things to different people. For some people, multimedia instruction means that a person sits at a terminal and receives a presentation consisting of on-screen text, on-screen graphics or animation, and sounds coming from the computer's speakers – as with an on-line multimedia encyclopedia. For some people, multimedia instruction means a "live" presentation in which a group of people seated in a room views images presented on one or more screens and hears music or other sounds presented via speakers. Watching a video on a TV screen can be called a multimedia experience because both images and sounds are presented. Another example of

multimedia instruction is a PowerPoint presentation in which someone presents slides from a computer projected onto a screen and talks about each one. Even low-tech environments allow for multimedia instruction, such as a “chalk and talk” presentation in which an instructor writes or draws on a blackboard (or uses an overhead projector) while presenting a lecture. Finally, the most basic form of multimedia instruction is a textbook lesson consisting of printed text and illustrations.

I define multimedia instruction as the presentation of material using both words and pictures, with the intention of promoting learning. By words, I mean that the material is presented in *verbal form* – using printed or spoken text, for example. By pictures, I mean that the material is presented in *pictorial form*, including using static graphics such as illustrations, graphs, photos, or maps, or dynamic graphics such as animations or video. This definition is broad enough to cover each of the multimedia scenarios I just described – ranging from multimedia encyclopedia entries to textbook lessons. For example, in a multimedia encyclopedia the words can be presented as on-screen text or as narration, and the pictures can be presented as graphics or animation. In a textbook, the words can be presented as printed text and the pictures as illustrations (or other kinds of graphics).

For purposes of conducting research, I have focused the definition of multimedia instruction on just two presentation formats. I have opted to limit the definition to just two formats – verbal and pictorial – because the research base in cognitive science is most relevant to this distinction. Thus, what I call multimedia learning is more accurately called dual-mode, dual-format, dual-code, or dual-channel learning.

Is *multimedia* a noun or an adjective? When used as a noun, multimedia refers to a technology for presenting material in both visual and verbal forms. In this sense, multimedia means multimedia technology – devices used to present visual and verbal material. When used as an adjective, multimedia can be used in the following contexts:

multimedia learning – learning from words and pictures

multimedia message or *multimedia presentation* – presentations involving words and pictures

multimedia instruction (or *multimedia instructional message* or *multimedia instructional presentation*) – presentations involving words and pictures that are intended to foster learning

My focus in this book is on the design of multimedia instructional messages that promote multimedia learning.

Cambridge University Press

978-0-521-51412-5 - Multimedia Learning, Second Edition

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In the remainder of this chapter, I present the case for multimedia learning, and then I examine three views of multimedia messages, two approaches to multimedia design, three metaphors of multimedia learning, three kinds of multimedia learning outcomes, two kinds of active learning, and two goals of multimedia research.

THE CASE FOR MULTIMEDIA LEARNING

An instructional message is a communication that is intended to foster learning. In presenting an instructional message to learners, instructional designers have two main formats available – words and pictures. Words include speech and printed text; pictures include static graphics (such as illustrations or photos) and dynamic graphics (such as animations or video). For hundreds of years, the major format for presenting instructional messages has been words – including lectures and books. In short, verbal modes of presentation have dominated the way we convey explanations to one another, and verbal learning has dominated education. Similarly, verbal learning has been a major focus of educational research.

The advent of computer technology has enabled an explosion in the availability of visual ways of presenting material, including large libraries of static images as well as compelling dynamic images in the form of animations and video. In light of the power of computer graphics, it may be useful to ask whether it is time to expand instructional messages beyond the purely verbal. What are the consequences of adding pictures to words? What happens when instructional messages involve both verbal and visual modes of learning? What affects the way people learn from words and pictures? In short, how can multimedia presentations foster meaningful learning? These are the kinds of questions addressed in this book.

The case for multimedia learning is based on the idea that instructional messages should be designed in light of how the human mind works. Let's assume that humans have two information processing systems – one for verbal material and one for visual material. Let's also acknowledge that the major format for presenting instructional material is verbal. The rationale for multimedia presentations – that is, presenting material in words and pictures – is that it takes advantage of the full capacity of humans for processing information. When we present material only in the verbal mode, we are ignoring the potential contribution of our capacity to process material in the visual mode as well.

Why might two channels be better than one? Two explanations are the quantitative rationale and the qualitative rationale. The

quantitative rationale is that more material can be presented on two channels than on one channel – just as more traffic can travel in two lanes than in one lane. In the case of explaining how a car’s braking system works, for example, the steps in the process can be presented in words or can be depicted in illustrations. Presenting both is like presenting the material twice – giving the learner twice as much exposure to the explanation. While the quantitative rationale makes sense as far as it goes, I reject it mainly because it is incomplete. In particular, I am concerned about the assumption that the verbal and visual channels are equivalent, that is, that words and pictures are simply two equivalent ways of presenting the same material.

By contrast, the qualitative rationale is that words and pictures, while qualitatively different, can complement one another and that human understanding occurs when learners are able to mentally integrate corresponding pictorial and verbal representations. As you can see, the qualitative rationale assumes that the two channels are not equivalent; words are more useful for presenting certain kinds of material – perhaps representations that are more formal and require more effort to translate – whereas pictures are more useful for presenting other kinds of material – perhaps more intuitive, more natural representations. In short, one picture is not necessarily equivalent to 1,000 words (or any number of words).

The most intriguing aspect of the qualitative rationale is that understanding occurs when learners are able to build meaningful connections between pictorial and verbal representations – such as being able to see how the words “the piston moves forward in the master cylinder” relate to the forward motion of a piston in the master cylinder in an animation of a car’s braking system. In the process of trying to build connections between words and pictures, learners are able to create a deeper understanding than they could from words or pictures alone. This idea is at the heart of the cognitive theory of multimedia learning that is described in Chapter 3.

THREE VIEWS OF MULTIMEDIA MESSAGES

The term *multimedia* can be viewed in three ways – based on the devices used to deliver an instructional message (i.e., the delivery media), the representational formats used to present the instructional message (i.e., the presentation modes), or the sense modalities the learner uses to receive the instructional message (i.e., sensory modalities).

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The Delivery-Media View

The most obvious view is that multimedia means the presentation of material using two or more delivery devices. The focus is on the physical system used to deliver the information – such as computer screens, amplified speakers, projectors, video recorders, blackboards, and human voice boxes. For example, in computer-based multimedia, material can be presented via the screen and via the speakers. These devices can be even further broken down by defining each window on a computer screen as a separate delivery device and each sound track coming from a speaker as a separate delivery device. In lecture-based multimedia, material can be presented via a projector onto a screen and via the lecturer's voice. In the strictest interpretation of the delivery-media view, a textbook does not constitute multimedia because the only presentation device is ink printed on paper.

What's wrong with this view of multimedia? Technically, it is the most accurate view because it focuses on the media used to present information, but psychologically, it does more to confuse the issue than to clarify it. The focus is on the devices used to present information rather than on how people learn – that is, the focus is on technology rather than on learners. Therefore, I do not take the delivery media view in this book.

The Presentation-Modes View

A second view is that multimedia means the presentation of material using two or more presentation modes. The focus is on the way that material is represented – such as through the use of words or pictures. For example, in computer-based multimedia, material can be presented verbally as on-screen text or narration and pictorially as static graphics or animation. In lecture-based multimedia, material can be presented verbally as speech and pictorially as projected graphics or video. In a textbook, material can be presented verbally as printed text and pictorially as static graphics.

This view is consistent with a learner-centered approach if we assume that learners are able to use various coding systems to represent knowledge – such as verbal and pictorial knowledge representations. Although conventional wisdom is that a picture can be converted into words and vice versa, research on mental representations suggests that verbal ways of representing knowledge may be qualitatively different from pictorial ways of representing knowledge. In short, the presentation-modes view of multimedia is consistent with a

cognitive theory of learning that assumes humans have separate information-processing channels for verbal and pictorial knowledge. Paivio’s (1986, 2006) dual-coding theory presents the most coherent theoretical and empirical evidence for this idea.

The Sensory-Modality View

The third view, while also consistent with a learner-centered approach, takes a somewhat different approach. According to the sensory-modalities view, multimedia means that two or more sensory systems in the learner are involved. Instead of focusing on codes used to represent knowledge in learners’ information-processing systems, the sensory-modalities view focuses on the sensory receptors the learner uses to perceive the incoming material – such as the eyes and the ears. For example, in a computer-based environment an animation can be presented visually, and a narration can be presented auditorially. In a lecture scenario, the speaker’s voice is processed in the auditory channel, and the slides from the projector are processed in the visual channel. In a textbook, illustrations and printed text are both processed visually, at least initially.

This view is learner-centered because it takes the learner’s information-processing activity into account. Unlike the presentation-modes view, however, the sensory-modalities view is that multimedia involves presenting material that is processed visually and auditorially. This distinction is based on the idea that humans process visual images and sounds in qualitatively different ways. In short, the sensory-modalities view of multimedia is consistent with a cognitive theory of learning that assumes humans have separate information-processing channels for auditory and visual processing. Baddeley’s (1999) model of working memory presents the most coherent theoretical and empirical evidence for this idea.

Table 1.1 summarizes the differences among these three views. In sum, I reject the delivery-media view because it emphasizes the technology over the learner. Both the presentation-modes view and the sensory-modalities view focus on the information-processing system of the learner and assume that humans process information in more than one channel – a proposal that I call the dual-channel assumption. However, they differ in the ways in which they conceptualize the nature of the two channels: the presentation-modes view distinguishes between separate systems for processing verbal and pictorial knowledge, whereas the sensory-modes view distinguishes between separate systems for auditory and visual processing (i.e., for processing

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Table 1.1. Three Views of Multimedia

View	Definition	Example
Delivery media	Two or more delivery devices	Computer screen and amplified speakers; projector and lecturer’s voice
Presentation mode	Verbal and pictorial representations	On-screen text and animation; printed text and illustrations
Sensory modality	Auditory and visual senses	Narration and animation; lecture and slides

sounds and visual images). Although my definition of multimedia learning is based on the presentation-modes view (i.e., multimedia learning involves learning from words and pictures), the sensory-modalities view (i.e., multimedia learning involves learning from auditory and visual material) is also a useful way of conceptualizing the nature of dual channels in the human information system. A goal of the research presented in this book is to examine the relative contributions of both views of multimedia. The theory of multimedia learning presented in Chapter 3 relies on the sensory-modalities view to describe early processing and the presentation-mode view to describe later processing in the learner’s cognitive system.

TWO APPROACHES TO MULTIMEDIA DESIGN

Multimedia represents a potentially powerful learning technology – that is, a system for enhancing human learning. A practical goal of research on multimedia learning is to devise design principles for multimedia presentations. It is useful to distinguish between two approaches to multimedia design – a technology-centered approach and a learner-centered approach.

Technology-Centered Approaches

The most straightforward approach to multimedia design is technology-centered. Technology-centered approaches begin with the functional capabilities of multimedia and ask, “How can we use these capabilities in designing multimedia presentations?” The focus is generally on cutting-edge advances in multimedia technology, so