e-Learning and the Science of Instruction

Proven Guidelines for Consumers and Designers of Multimedia Learning

RUTH COLVIN CLARK | RICHARD E. MAYER

About This Book

Why is *e-Learning and the Science of Instruction* important?

This is a book about what works in e-learning. Increasingly, organizations are turning to e-learning to save travel costs and instructional time. In fact e-learning in both synchronous and asynchronous formats is on the rise, accounting for nearly 40 percent of all training delivery of workforce learning. However, dollars saved are only an illusion if the quality of the training suffers.

Many books on the market offer useful advice for design and development of e-learning. Unlike these books, the answers we present are not based on opinion and fads; they are based on empirical research. Much of this new research is inaccessible to those producing or evaluating online learning because it has been distributed primarily within the academic research community. This book bridges the gap by summarizing research-based answers to questions that practitioners ask about effective e-learning.

What's new in the fourth edition?

The popularity of the previous editions of this book is testimony to consumer interest in evidence-based guidelines about how to best use visuals, text, audio, practice exercises, and examples in e-learning. In the fourth edition we have updated the previous edition by adding new research, guidelines, and examples. Based on Richard Mayer's extensive research on serious games, we have a new chapter on the effects of games on learning. We also have a new chapter on engagement in e-learning that presents recent research on generative multimedia learning.

What can you achieve with this book?

If you are a designer, developer, evaluator, or consumer of e-learning, you can use the guidelines in this book to ensure that your courseware meets human psychological learning requirements. In particular you can learn evidence-based ways to:

- Communicate your content with words and visuals

- Use audio to describe visuals

- Avoid overloading learners with extraneous media effects

- Optimize social presence in your courseware

- Apply new research on engagement to your e-learning products

- Design examples and practice exercises that build job-relevant skills

- Determine when and how to use networked collaborative activities

- Build thinking skills through evidence-based methods

- Apply recent evidence on serious games to your portfolio of multimedia products

How is this book organized?

Chapters 1 through 3 lay the foundation for the book by defining e-learning, describing how the methods used in e-learning can promote or defeat learning processes, and summarizing the basic concepts associated with evidence-based practice.

Chapters 4 through 10 summarize the multimedia principles developed over thirty years of research by Richard Mayer and his associates at the University of California. In these chapters you will read the guidelines, the evidence, and the psychology, as well as review examples of how to (1) best use visuals, text, and audio, (2) increase social presence in your lessons, and (3) segment and sequence content in e-learning.

Chapters 11 through 16 focus on evidence-based guidelines related to important instructional methods and approaches in e-learning, including use of examples, practice, and feedback, collaborative learning assignments, navigation tools, and techniques to build thinking skills.

Chapter 17 is new to this edition and summarizes the most recent research on the effects of serious games on learning. In this chapter you will see the evidence that answers three fundamental questions about games: (1) What features promote learning in games? (2) Do games affect basic cognitive aptitudes? and (3) Are games more effective than traditional instructional approaches?

Chapter 18 integrates all of the book's guidelines into a comprehensive checklist and illustrates how they apply in concert to asynchronous and synchronous e-learning examples.

The book's introduction gives you a summary of specific topics in each chapter.

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Proven Guidelines for Consumers and Designers of Multimedia Learning
Fourth Edition

Ruth Colvin Clark • Richard E. Mayer

WILEY

To a new generation of e-learners:

Jacob, Avery, James, Emma, and Caleb (from RM)
Joshua, Matthew, Lennon, and Luke (from RC)

CONTENTS

ACKNOWLEDGMENTS

GETTING THE MOST FROM THIS RESOURCE

Purpose

The training field is undergoing an evolution from a craft based on fads and folk wisdom to a profession that integrates evidence and learning psychology into the design and development of its products. Part of the training revolution has been driven by the use of digital technology to manage and deliver learning solutions. This book provides you with evidence-based guidelines for both self-study (asynchronous) and virtual classroom (synchronous) forms of e-learning. Here you will read the guidelines, the evidence, the psychological theory, as well as review examples to shape your decisions about the design, development, and evaluation of e-learning for workforce learning.

Audience

If you are a designer, developer, evaluator, or consumer of e-learning, this book is for you. You can use the guidelines in this book to ensure that your courseware meets human psychological learning requirements and reflects the most recent research on e-learning methods. Although most of our

examples focus on workforce learning, we believe instructional professionals in the educational and academic domains can equally benefit from our guidelines.

Package Components

For this fourth edition, we have updated the instructor guide that includes resources that can be adapted to various courses that focus on design and development of multimedia learning. To access the instructor guide, use the following link: http://www.wiley.com/WileyCDA/WileyTitle/productCd-1119158664.html.

Our guidelines checklist found in Chapter 18 is also posted on the Wiley website and can be accessed the same URL.

Table I.1 summarizes the content of the book's chapters. In this fourth edition, two new chapters have been added. Chapter 11 describes recent evidence related to engagement in e-learning. Chapter 17 draws on Richard Mayer's recent book, *Computer Games for Learning,* and summarizes research about serious games. We have updated research in all chapters and have been able to derive new guidelines based on the accumulation and analysis of many new experiments on the main principles of the book.

Glossary

The glossary provides definitions of the technical terms used throughout the book.

Table I.1. A Preview of Chapters

Chapter	*Topics*
1. e-Learning: Promise and Pitfalls	Our definition of e-learning Research on e-learning effectiveness Potential promise and pitfalls in e-learning Three architectures for e-learning design
2. How Do People Learn from e-Courses?	An overview of human learning processes and how instructional methods can support or disrupt them An Introduction to three forms of cognitive load

Table I.1. (Continued).

Chapter	Topics
3. Evidence-Based Practice	Our definition of evidence-based practice Three approaches to research on instructional effectiveness How to interpret research statistics A description of boundary conditions in experimental comparisons
4. Applying the Multimedia Principle: Use Words and Graphics Rather Than Words Alone	Evidence on learning improvement in e-lessons that include visuals Psychological benefits of visuals Types of visuals that best promote learning Who benefits most from visuals? When to use static illustrations or animations
5. Applying the Contiguity Principle: Align Words to Corresponding Graphics	Evidence for placing on-screen text near the graphics they describe Evidence for sequencing of text or audio in conjunction with visuals The psychological basis for the contiguity principle Situations that most benefit from applying the contiguity principle.
6. Applying the Modality Principle: Present Words as Speech Rather Than On-Screen Text	Evidence for presenting words that describe graphics in audio rather than in text When the modality principle does and does not apply Effective and ineffective applications of the modality principle as well as the psychological basis for the modality principle
7. Applying the Redundancy Principle: Explain Visuals with Words in Audio OR Text But Not Both	Evidence for use of audio to explain graphics rather than audio and redundant text that repeats the audio Situations when adding on-screen text to narration is a good idea
8. Applying the Coherence Principle: Adding Extra Material Can Hurt Learning	Evidence for omitting extraneous words, distracting graphics and stories, as well as sounds and background music Psychological basis for the coherence principle How to add interest to e-learning without violating coherence

Table I.1. (Continued).

Chapter	Topics
9. Applying the Personalization and Embodiment Principles: Use Conversational Style, Polite Wording, Human Voice, and Virtual Coaches	Evidence for using conversational style, voice quality, and polite speech to improve learning Evidence for best use of computer agents to present instructional support Evidence for how to maximize learning benefits from computer agents
10. Applying the Segmenting and Pretraining Principles: Managing Complexity by Breaking a Lesson into Parts	Evidence for breaking a continuous lesson into bite-size segments and allowing learners to access each segment at their own rate Evidence for sequencing key concepts in a lesson prior to the main procedure or process of that lesson
11. Engagement in e-Learning	Our definition of engagement A distinction between psychological and behavioral engagement A summary of evidence-based methods that promote generative mental load
12. Leveraging Examples in e-Learning	What are worked examples? Evidence for the benefits of worked examples Principles to optimize learning from worked examples
13. Does Practice Make Perfect?	Our definition of practice in e-learning Evidence for the benefits of practice Principles to optimize learning from practice exercises
14. Learning Together Virtually	Our definition of collaborative learning Situations under which collaborative learning is most effective A structured collaboration process shown to optimize learning outcomes
15. Who's in Control? Guidelines for e-Learning Navigation	The distinction between learner and program control Do learners make good instructional decisions? Guidelines and evidence for implementation of learner control
16. e-Learning to Build Thinking Skills	Can thinking skills be trained? Our definition of thinking skills Guidelines for design of e-learning to promote thinking skills

Table I.1. (Continued).

Chapter	Topics
17. Learning with Computer Games	Are games relevant to workforce learning? Which features improve a game's effectiveness? Does game playing improve cognitive skills? Are games more effective than traditional instructional approaches?
18. Applying the Guidelines	A checklist and summary of all the guidelines in the book A summary of the effect sizes for the major book guidelines Three short discussions of how the guidelines apply to e-learning samples

CHAPTER OUTLINE

1

e-Learning

PROMISE AND PITFALLS

CHAPTER SUMMARY

IN THIS CHAPTER we define e-learning as instruction delivered on a digital device that is intended to support learning. In e-learning the delivery hardware can range from desktop or laptop computers to tablets or smart phones, but the instructional goal is to support individual learning or organizational performance goals. Our scope includes e-learning designed for self-study available upon demand (asynchronous e-learning) as well as instructor-led e-learning presented at a fixed time (synchronous e-learning). Among these two forms of e-learning, we include e-courses developed primarily to provide information (inform courses) as well as those designed to build specific job-related skills (perform courses).

However, the benefits gained from these new technologies depend on the extent to which they are used in ways compatible with human cognitive learning processes and based on research-based principles of instructional design. When technophiles become so excited about cutting-edge technology that they ignore human mental limitations, they may not be able to leverage

technology in ways that support learning. Instructional methods that support rather than defeat human learning processes are an essential ingredient of all effective e-learning courseware. The most appropriate methods depend on the goals of the training (for example, to inform or to perform); the learner's related skills (for example, whether they are familiar with or new to the skills); and various environmental factors, including technological, cultural, and pragmatic constraints.

In this chapter we lay the groundwork for the book by defining e-learning and identifying both the potential and the pitfalls of digital training.

What Is e-Learning?

We define e-learning as instruction delivered on a digital device (such as a desktop computer, laptop computer, tablet, or smart phone) that is intended to support learning. The forms of e-learning we examine in this book have the following features:

- Stores and/or transmits lessons in electronic form on external drives, the cloud, local internal or external memory, or servers on the Internet or intranet.

- Includes content relevant to the learning objective.

- Uses media elements such as words and pictures to deliver the content.

- Uses instructional methods such as examples, practice, and feedback to promote learning.

- May be instructor-led (synchronous e-learning) or designed for self-paced individual study (asynchronous e-learning).

- May incorporate synchronous learner collaboration as in breakout rooms or asynchronous collaboration as on discussion boards.

- Helps learners build new knowledge and skills linked to individual learning goals or to improved organizational performance.

As you can see, this definition has several elements concerning the what, how, and why of e-learning.

What. e-Learning courses include both content (that is, information) and instructional methods (that is, techniques) that help people learn the content.

How. e-Learning courses are delivered via digital devices using words in the form of spoken or printed text and pictures such as illustrations, photos, animation, or video. Some forms of e-learning called asynchronous e-learning are available on demand and designed for individual self-study. We show a screen shot from an asynchronous class on Excel in Figure 1.1. These courses are typically self-paced, allowing the individual learner to access training at any time or any location on their own. Other formats, called synchronous e-learning, virtual classrooms, or webinars, are designed for real-time instructor-led training. We show a screen shot from a virtual classroom in Figure 1.2. Synchronous e-learning allows students from New York to New Delhi to attend an online class taught by an instructor in real time. However, synchronous sessions are also often recorded, allowing them to be viewed by a single learner in a self-paced (asynchronous) manner. Synchronous and asynchronous forms of e-learning may support collaboration with others through applications such as wikis, breakout rooms, chat, discussion boards, media pages, and email. Many organizations combine instructor-led virtual classroom sessions, self-study sessions, and collaborative knowledge sharing opportunities in blended learning solutions.
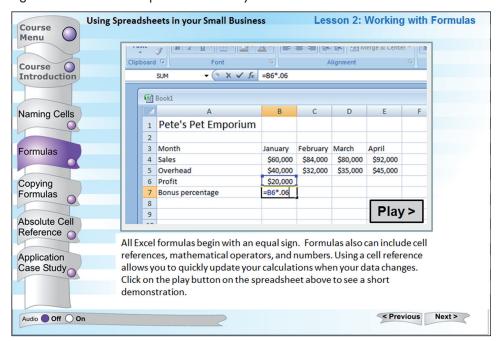
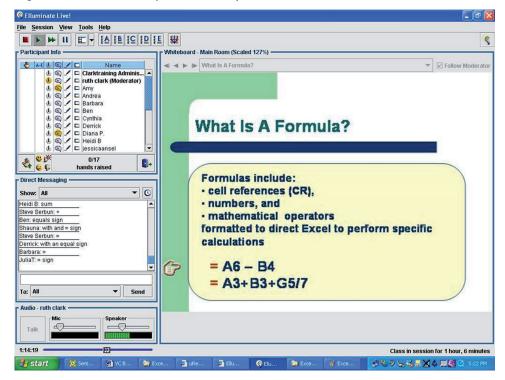Figure 1.1. A Screen Capture from an Asynchronous Excel Lesson.

Figure 1.2. A Screen Capture from a Synchronous Excel Lesson.

Why. e-Learning lessons are intended to help learners reach personal learning objectives or perform their jobs in ways that improve the bottom line goals of the organization.

In short, the "e" in e-learning refers to the "how"—the course is digitized so it can be stored in electronic form. The "learning" in e-learning refers to the "what"—the course includes content and ways to help people learn it—and the "why" of e-learning is the purpose: to help individuals achieve educational goals or to help organizations build skills related to improved job performance.

Our definition states that the goal of e-learning is to build job-transferable knowledge and skills linked to organizational performance or to help individuals achieve personal learning goals. Although the guidelines we present throughout the book also apply to lessons designed for school-based or general-interest learning goals, our emphasis is on instructional programs that are designed for workforce learning. To illustrate our guidelines, we draw on actual training courseware from colleagues who have given us permission to use their examples. In addition, we have built two sets of storyboards: one