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LEARNING SOLUTIONSSM

Practical Applications of Technology for Learning e-Magazine

THIS WEEK: Design Strategies

Efficiency in e-Learning: Proven Instructional Methods for Faster, Better, Online Learning

By Frank Nguyen and Ruth Colvin Clark

Spinning logos, three-dimensional graphics, animated transitions, audience interaction, audio narration, background music, walls of text – at first glance, this may look like a description of a glitzy new Super Bowl commercial or Hollywood's next major blockbuster movie. However, it is in fact a description of an e-Learning course.

In an effort to engage learners and to maximize their learning experience, e-Learning developers often experiment with various combinations of instructional methods and media. For example, access the first three screens from a sample Web-based lesson located at <http://www.clarktraining.com/mttest>. After reviewing these screens, grade this small sample on its instructional effectiveness from A to F, and list some reasons for your grade. Use the checklist in Table 1 on page 2 to identify the instructional treatments that you observe.

Using the same checklist, consider the e-Learning courses that your organization develops. What instructional methods do these courses typically employ? What combinations of media do you use? How do you currently provide practice and assessment? Do learners complain that the courses are too long? Too boring? What methods have you used to improve the quality of your e-Learning?

Instructional designers face the constant challenge of balancing many considerations affecting learning. Of all the guidelines from research offering advice on these matters, few are more challenging than those dealing with cognitive load. How much is too much? Is cognitive load always bad? In this article, two authors who have focused on these questions give you the answers, and a systematic view of the redundancy rule that will help you solve many similar problems.

A publication of



This article provides practical, research-based guidelines that you can readily apply to your courses to make them more efficient. Efficient instruction leads to better learning, faster learning, or both. In an age of increased information load and decreased training time, maximum efficiency is more important than ever! To understand how you can make your courses more efficient, we will first look at *cognitive load theory* and how it relates to human learning. Then we will examine the three types of cognitive load that instructional materials impose on the learner. Finally, we will review three guidelines that you can use to make your learners' experience more effective and more efficient.

Cognitive load theory

In 1956, George Miller introduced the *magical number 7±2*. According to this psychological principle, working memory can only process seven chunks of information at any given time, plus or minus two items. Once a learning task exceeds these cognitive limits, our ability to process and retain information diminishes. As an example, consider which task is more difficult: trying to memorize and recite a seven-digit phone number, or a

sixteen-digit credit card number.

Since the introduction of Miller's 7±2 rule, John Sweller, Professor in the School of Education, University of New South Wales, has expanded and refined Miller's original concept into an updated, comprehensive set of instructional principles. This framework is called *cognitive load theory* and is based on 25 years of research. The goal of cognitive load theory is to construct an efficient instructional environment that leverages and maximizes finite

Table 1 *Instructional media checklist*

	Sample lesson	Your organization
Audio narration		
Graphics: static		
Graphics: animated		
Graphics: 3D		
Music		
Page transitions		
Simulations: software		
Simulations: other		
Text: static		
Text: animated		
Video		



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Important Announcement



Between January 2002 and August 2005, this publication was known as **The eLearning Developers' Journal™**. In September 2005, we changed the name of the publication to **Learning Solutions e-Magazine™** and completely redesigned the layout to make it more reader-friendly. Since its inception, this publication has focused on being a forum for members to share their strategies, techniques and best practices for designing, developing and managing e-Learning. While the editorial focus of the publication will not change, we believe this new name will more accurately reflect the true content and audience of the publication which is much more than just developers. We hope you like the new name and layout and we certainly hope you continue to find value in this important publication of **The eLearning Guild**.

Learning Solutions e-Magazine™ is designed to serve as a catalyst for innovation and as a vehicle for the dissemination of new and practical strategies, techniques, and best practices for e-Learning design, development and management professionals. It is not intended to be THE definitive authority... rather, it is intended to be a medium through which e-Learning professionals can share their knowledge, expertise, and experience. As in any profession, there are many different ways to accomplish a specific objective. **Learning Solutions** will share many different perspectives and does not position any one as "the right way," but rather we position each article as "one of the right ways" for accomplishing an objective. We assume that readers will evaluate the merits of each article and use the ideas they contain in a manner appropriate for their specific situation.

The articles in **Learning Solutions** are all written by people who are actively engaged in this profession – not by journalists or freelance writers. Submissions are always welcome, as are suggestions for future topics. To learn more about how to submit articles and/or ideas, please visit our Web site at www.eLearningGuild.com.

working memory capacity.

Figure 1, at right, illustrates three factors to consider when applying principles derived from cognitive load theory: the learners' level of expertise, the complexity of your content and, of course, the instructional materials. As part of the analysis phase, you should determine whether your course's target audience includes learners with no prior knowledge of the subject matter, with some intermediate knowledge, or perhaps even with advanced expertise. In addition, you should analyze your instructional objectives to determine whether they are simple or complex. The guidelines of cognitive load theory must be adapted based on the complexity of the content and on the experience of the learners.

In addition to these factors, one should also consider the media used to deliver the instruction. Two common e-Learning delivery media are asynchronous Web-based training (WBT) courses and synchronous virtual classroom sessions. These delivery media have unique attributes that impose varying levels of cognitive load. For instance, since an instructor facilitates virtual classroom sessions, such sessions reduce the learner's ability to control the pace of the course, as one might find with a WBT, and therefore impose greater cognitive load. For the same reason, certain types of methods or media such as animations or video may impose more cognitive load on the learner.

Types of cognitive load

Table 2, at right, summarizes the three types of cognitive load: intrinsic, extraneous, and germane. Certain forms of cognitive load are beneficial while others waste limited mental resources. Your goal as an e-Learning developer should be to balance these three forms of cognitive load in your instructional materials to maximize learning efficiency.

Figure 2, at right, illustrates how an e-Learning course designer can exploit these three types of cognitive load. Intrinsic cognitive load will depend on the complexity of your instructional content. Therefore, your goal as an instructional designer is to *manage intrinsic load* by segmenting and sequencing your instructional materials to help the learner deal with the complexity of the content. Extraneous cognitive load imposes mental work that does not promote learning. Think of extraneous cognitive load as irrelevant load. There are a number of guidelines for *minimizing extraneous load*, many involving the appropriate use of visuals, audio, and text in your training environment. In contrast, germane cognitive load is actually beneficial to learning. Therefore, to improve the efficiency of your e-Learning courses, you should *maximize the*

opportunities for germane load.

The three forms of cognitive load are additive. To optimize instructional efficiency you should manage intrinsic cognitive load, minimize extraneous cognitive load, and maximize germane cognitive load. To hear a brief introduction to extraneous and germane cognitive load from Dr. John Sweller, access the

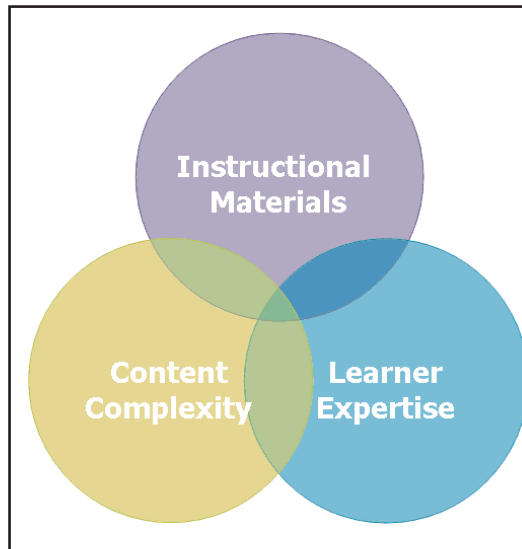


Figure 1
Three factors that affect cognitive load

Table 2 Types of cognitive load

Type	Definition	Example
Intrinsic	Mental work imposed by the complexity of the content. Primarily determined by your instructional goals.	<ul style="list-style-type: none"> Calculating complex Excel formulas Learning how to drive a car Preparing income tax returns
Extraneous	Mental work irrelevant to the learning goal. Under control of the trainer or instructional designer.	<ul style="list-style-type: none"> Edutainment courses Web-based training courses overloaded with instructional media
Germane	Mental work imposed by instructional activities that benefit the instructional goal.	<ul style="list-style-type: none"> Providing instructional examples Practice and assessment

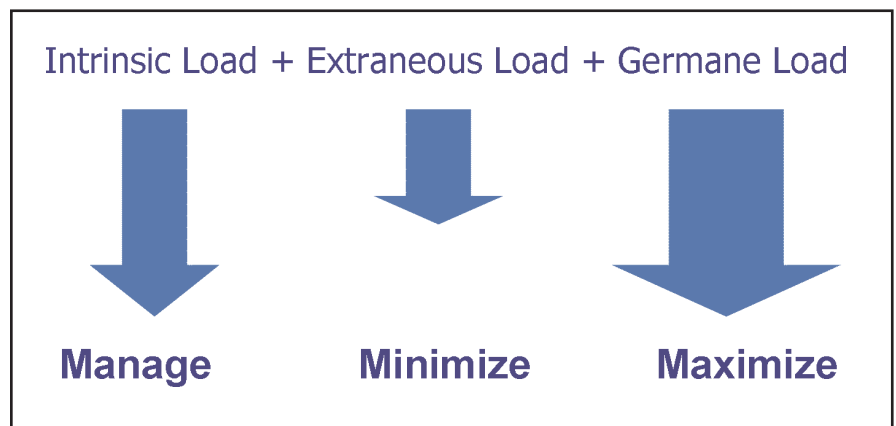


Figure 2 Balancing three sources of cognitive load to maximize efficiency

video located at <http://www.clarktraining.com/mtest/> video. When the video screen appears, press the play button to hear the commentary.

Manage intrinsic load: Teach supporting knowledge separate from teaching procedure steps

Compare the two course sequence plans shown in Figures 3 and 4, below. Which one do you believe imposes more intrinsic load?

Many e-Learning courses focus on teaching learners how to perform procedural software tasks, such as the one shown in Figures 3 and 4. You could use a simple table, job aid or even a software simulation to demonstrate how to create a formula in Microsoft® Excel. One way that you can manage the

How to Create an Excel Formula

Steps:

1. Select the cell in which you want the calculation to appear
 - cells are designed by a reference to the column letter and row number such as B6 or C3
2. Type an = sign into the selected cell
 - all formulas begin with an = sign
3. Enter the cell references and operators into the selected cell as needed to accomplish the desired calculation
 - legal operators for formulas are:
 - + , - , / , and x
 - by using the cell references rather than actual numeric values, when you update any value in a cell, the formula will automatically update.

Figure 3 Lesson Outline 1

How to Create an Excel Formula

About Formulas:

- Formulas allow you to calculate the values in a designed set of cells so that if you change any value, the formula will automatically update


Formula Formats:

- Formulas always begin with =
- Formulas are made up of operators:
 - + , - , / , and x
- Operators are applied to cell references
 - Cells are designed by column letter and row number such as B6 or C3

Steps:

1. Select the cell in which you want the calculation to appear
2. Type the formula into the cell

Figure 4 Lesson Outline 2



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intrinsic load imposed by this procedural content is to segment supporting knowledge from the actual procedure itself.

For example, in Figure 3, note that background information that supports each respective step is presented concurrently with that step. While a learner needs this supporting knowledge, research by Pollock and colleagues (see References at the end of this article) indicates that novice learners benefit when they learn supporting information separately from complex procedural content. By sequencing supporting facts, concepts, and principles prior to the procedure, as in Figure 4, you can improve the efficiency of your instruction.

Minimize extraneous load: Avoid redundant expressions of content

There are a number of cognitive load principles that, when applied, reduce extraneous cognitive load. Here we review one of these: *redundancy*. Redundancy refers to learning inefficiencies that result when we provide learners with too much information.

Rapid e-Learning tools make the development of multimedia quick and easy. Not only can you provide simple text and graphics in your course, but you can also easily create and embed audio and video clips directly into your online content. As you begin to integrate these forms of rich instructional media, do you think it would be better to provide learners with the audio narration only, a text script, or both?

Consider the sample Web-based lesson you reviewed at the beginning of this article. You may have noted at the time that the lesson included audio narration. You may have also noted that a written transcript of the audio narration was included in the bottom right hand corner of the course interface. This redundant audio and written text is shown in Figure 5 on page 6.

In our forthcoming book titled *Efficiency in Learning*, Ruth Clark, Frank Nguyen, and John Sweller summarize research studies that indicate e-Learning courses with redundant audio and text will overload cognitive resources and depress learning. For example, a series of studies by Mayer, Heiser, and Lonn,

e-Learning for e-Learning Professionals...

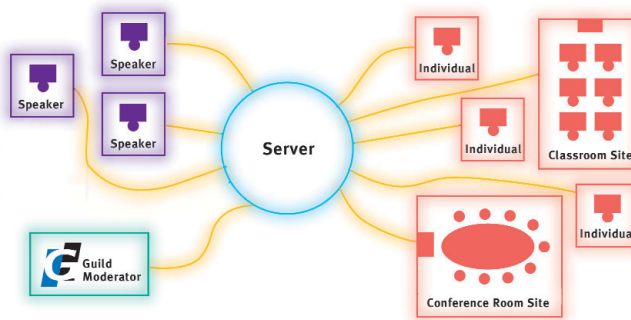
The eLearning Guild's ONLINE FORUM™ SERIES

The eLearning Guild has created *The Guild Online Forum Series*, a new series of online events that will be held throughout 2005. You can register to participate as an individual or as a group in a one-day "virtual conference" every month that includes four highly interactive seventy-five minute sessions designed to explore a specific topic.

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Individual or Site Registration:

Participate as an individual or you can pay a site fee, set up your meeting room, and have your e-Learning team participate in an Online Forum as a group!



Here's a brief description of the next Online Forum in the series...

DECEMBER 8, 2005

The Future of e-Learning

What is the future of e-Learning? In 2000 e-Learning was hyped to be the be-all and end-all of training methods. Back then it was projected to deliver 70% of all training by the year 2003! Obviously that did not happen, but where is e-Learning going? This Online Forum will examine both the current and future states of e-Learning. It will explore recent trends such as m-Learning, Knowledge Management, performance support, and new technologies and tools and how they have impacted e-Learning. You will also learn about future trends and how they will influence e-Learning. Both regional and global initiatives in e-Learning will be explored.

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and by Moreno and Mayer (see References) found that learners who received a multimedia lesson with animation and audio narration alone performed on average 79% better than learners who received a lesson containing animations, audio, and redundant text. In short, when you are delivering audio narration in an e-Learning course, it is better to suppress any redundant written text. If the available technology or learners' language expertise prevent you from delivering audio in your e-Learning course, it is better to provide text only.

The redundancy principle stresses that less is usually more. For example, while it's usually better to describe a visual with audio alone as discussed above, sometimes any words – whether text or audio – added to a visual are redundant. This is either because the visual is inherently self-explanatory such as the example in Figure 6, below, OR because the audience is already familiar with the visual and thus the visual is self-explanatory to that audience.

For example Kalyuga and colleagues (see References) over a series of three sessions trained technical apprentices how to interpret the circuit diagrams of a motor. Initial learning was best from lessons that included diagrams described by text than from lessons with diagrams alone. However, by the third session, this pattern reversed and the lessons with diagrams alone led to better learning than the diagram and text versions. As learners gained expertise with the diagram, the textual descriptions became redundant and depressed learning efficiency.

Maximize germane load: Help learners exploit examples through self-explanations


Recall that germane cognitive load is mental work that leads to learning. We know that examples are one of the best ways to promote learning. However, in many cases learners skip examples or only give them a cursory review. Research has shown that students who study and process examples deeply learn more than students who either ignore examples or process them in a shallow way. One sign of deep processing of examples is when learners explain the examples to themselves. Chi and others (see References) found high-achieving students generated more self-explanations while studying science examples than did lower-achieving students. On average, the high-achieving students created 15.5 self-explanations for each example while lower-achieving students only generated 2.75. What can you do to ensure that your learners process your examples effectively?

Figure 7 on page 7 shows how the addition of a multiple choice question to an example can encour-

age learners to process the example deeply. In order to answer this question, the learner needs to review the example and to identify the principles behind the steps. As a result of this deep processing, learners will build an accurate mental model from the example. However self-explanations require mental processing in working memory. Since this processing results in better learning, prompted self-explanations are one of a number of instructional methods you can use to impose germane cognitive load.

Conclusion

Today's e-Learning authoring tools provide developers with many exciting ways to combine instructional methods and media to create compelling training content. Done well, your e-Learning courses can

 **Figure 5** The use of text and audio of that text is a redundant expression of content. From *Efficiency in Learning* (2005)

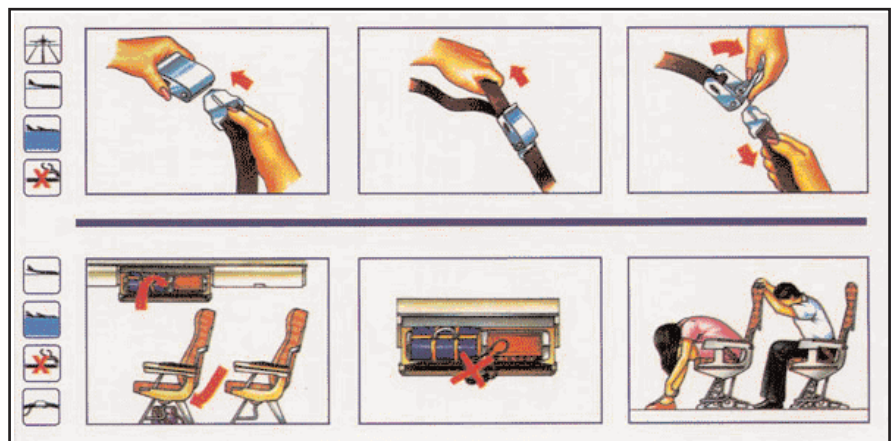
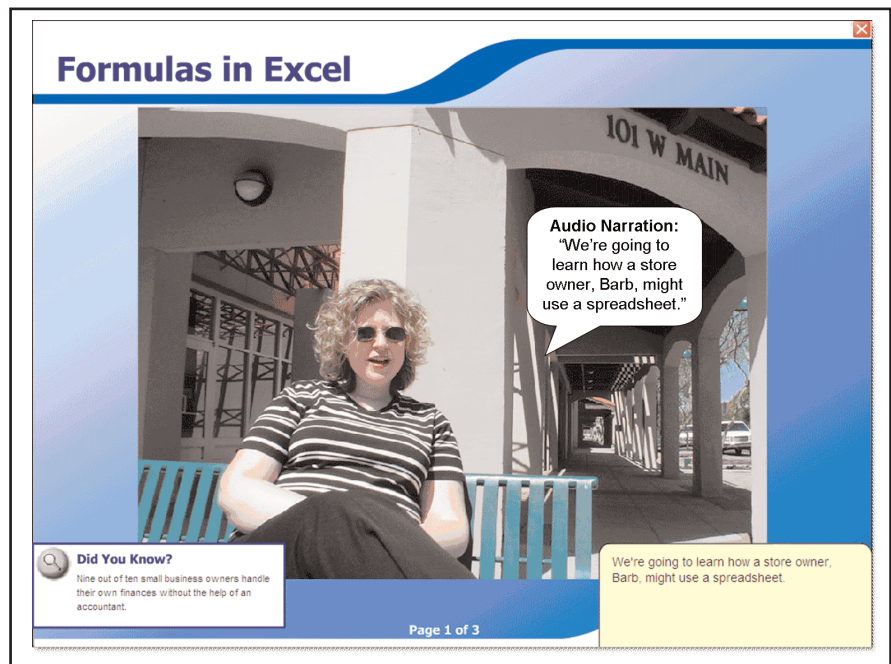



Figure 6 Airline safety card with self-explanatory visuals. From *Efficiency in Learning* (2005)

be well-oiled, efficient learning environments that enable your learners to learn faster, better or both. Done poorly, they could become minefields of information that look more to your learners like letters and numbers flying across *The Matrix* than pages of an e-Learning course.

To avoid overloading your students, apply research-based principles that manage intrinsic, minimize extraneous, and maximize germane cognitive load in your e-Learning courses. The three principles discussed in this article are among a number of cognitive load guidelines proven to improve the quality of your instructional materials. 

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Her professional practice focuses on translating instructional research into practical guidelines for training professionals. She has written five books and many articles on evidence-based practice in instruction. Contact Ruth by email at ruth@clarktraining.com or by telephone at 602.230.9190.



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Additional information on the topics covered in this article is also listed in the Guild Resource Directory.

 **Figure 7** An inserted question prompts learner self-explanation of examples. From *Efficiency in Learning* (2005)

	A	B	C	D	E	F
1	Barbara's Bargain Basement Boutique					
2						
3		Sam	Staci			
4	Base Hourly Wage	\$2.50	\$2.00			
5	Hours Worked	24	20			
6	Base Subtotal	\$60.00	\$50.00			
7	Sales	\$5,281	\$5,100			
8	Sales Commission	2.0%	2.0%			
9	Commission Subtotal	\$105.62	\$103.80			
10	20% Tax on Salary	=(B6+B9)*0.2				
11	Take Home Pay					
12						
13						
14						
15						
16						
17						
18						

Barb would like to calculate the tax she needs to withhold from Sam's paycheck. Here is what Sam earned for the hours he worked and his commission from sales.

To calculate Sam's check, Barb can follow a simple three-step process:

- 1) Enter = in cell B10
- 2) Enter base formula: B6 + B9*0.2
- 3) Enter parentheses (B6+B9)*0.2

Practice: Select the formula rule implemented in Step 3.

- operator symbols
- order of operations rule
- start of formula rule
- execution of formula



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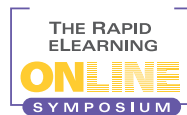
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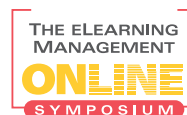
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