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WHAT’S NEW IN THIS CHAPTER?

SINCE OUR SECOND EDITION of e-Learning and the Science of Instruction, there continues to be a wealth of research focused on worked examples. The most recent research has extended guidelines on worked examples used to illustrate well-structured math solutions to worked examples for tasks that involve problem solving and multiple appropriate solutions. This research leaves us with important new guidelines for development of worked examples to build critical thinking skills that require flexible and creative approaches.

We have also added important new research on modeling examples—worked examples that incorporate people as they are solving problems or as they demonstrate interpersonal tasks such as teaching or selling. As in our first editions, we discuss the application of the multimedia principles to worked examples as well as design techniques to promote far transfer.
What Are Worked Examples?

Examples are one of the most powerful methods you can use to build new cognitive skills, and they are popular with learners. Learners often bypass verbal descriptions in favor of examples. For example, LeFevre and Dixon (1986) evaluated learners who were free to study either textual descriptions or examples to help them complete problem assignments. The information in the text was deliberately written to contradict the examples. By evaluating the learners’ solutions, it was clear that the learners used the examples, not the text, as their preferred resource.

In this chapter we write about a specific type of example called a worked example. A worked example is a step-by-step demonstration of how to perform a task or solve a problem. Worked examples can be designed to help learners build procedural skills such as how to use a spreadsheet or strategic skills such as how to conduct a negotiation. In Figure 11.1 we show a three-step worked example used in a statistics lesson to illustrate calculation of probability. In Figure 11.2 we show a screen capture from part of a worked...
Figure 11.1. A Worked Example of a Probability Problem.

Problem: From a ballot box containing three red balls and two white balls, two balls are randomly drawn. The chosen balls are not put back into the ballot box. What is the probability that the red ball is drawn first and a white ball is second?

<table>
<thead>
<tr>
<th>First Solution Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of balls: 5</td>
</tr>
<tr>
<td>Number of red balls: 3</td>
</tr>
<tr>
<td>Probability of red ball first: 3/5 = 0.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Solution Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of balls after first draw: 4 (2 red and 2 white balls)</td>
</tr>
<tr>
<td>Probability of a white ball second: 2/4 = 0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third Solution Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability that a red ball is drawn first and a white ball is second: 3/5 x 1/2 = 3/10 = 0.3</td>
</tr>
<tr>
<td>Answer: The probability that a red ball is drawn first and a white ball is second is 3/10 or 0.3</td>
</tr>
</tbody>
</table>

Figure 11.2. A Modeled Worked Example from a Sales Lesson.

Example:

Dr. Chi: I have a lot of overweight patients in my practice. Can you just highlight the contraindications?
Alicia: The key ones are pregnant or nursing mothers, any liver disease, and patients with a history of depression although your Lestratin drug sheet lists others. Are many of your overweight and obese patients already taking weight-reducing drugs?
example from our pharmaceutical sales lesson. While worked examples are not new, we have new evidence on worked examples to support learning of strategic skills including video or animated examples that model thinking or interpersonal skills.

**Worked Examples for Strategic Tasks**

Most of the early research on worked examples focused on relatively straightforward tasks that illustrated the steps to solve a well structured mathematical problem such as the probability problem we show in Figure 11.1.

However, research reported since our second edition has demonstrated the benefits of worked examples for strategic tasks such as how to construct an effective argument, how to devise a mathematical proof, or how to troubleshoot equipment. These research studies are especially relevant to workforce learning goals that involve higher level cognitive tasks and problem solving such as consultative selling, financial analysis, troubleshooting, diagnosis, report writing, and many managerial tasks.

**Modeling Examples**

A modeling example is a worked example in which a human provides a demonstration of how to complete a task, usually accompanied by commentary. The early worked examples primarily illustrating mathematical content were generally displayed with words (in text or in audio) and perhaps simple diagrams similar to the example we show in Figure 11.1. People were typically not included. In contrast, a modeling example involves a demonstration from a person that may be mediated in a face-to-face classroom by an instructor or by a video-recorded or animated demonstration.

We review two types of modeled examples: (1) cognitive models, which focus on skills such as how to set up an Excel spreadsheet and (2) interpersonal skills models, which focus on social skills such as how to sell a new product. A cognitive model uses an individual, usually an instructor or a tutor, to demonstrate how he or she resolves a problem. For example, a video may show a dialog between a student trying to solve a physics problem and the tutor guiding the student through the solution. In contrast, an interpersonal skills model typically shows expert performance of a task involving
social skills such as a teacher managing a classroom or a salesperson discussing product features with the client, as shown in Figure 11.2.

The Psychology of Worked Examples

Sweller (2004) proposed a “Borrowing and Reorganizing Principle” of human learning. He suggests that the main path to building new knowledge in long-term memory is through imitating others—in other words to borrow knowledge that others have acquired and to reorganize it into workable knowledge in long-term memory. Worked examples offer an especially efficient opportunity to borrow knowledge from others.

Traditional training plans present some guidelines or steps along with one or two examples followed by many practice exercises. However, research shows that learning is more efficient with a greater initial reliance on worked examples in place of some practice exercises. While studying an example (in contrast to solving a problem), working memory is relatively free to borrow and reorganize new knowledge. Once basic knowledge structures have formed, practice helps learners automate the new knowledge. In other words, you can reduce extraneous cognitive load by initially relying on worked examples that promote borrowing and then transition into practice exercises that help more learners consolidate and automate new knowledge and skills.

Evidence for the Benefits of Worked Examples

The early research on worked examples compared the learning outcomes of studying algebra examples to working multiple algebra practice problems (Sweller & Cooper, 1985). One lesson version (all practice) assigned learners eight practice problems. The second lesson version (examples–practice pairs) assigned learners a worked example followed by a practice exercise four times. In this version the learner would study an example followed by a similar practice problem, then study a second example followed by another similar practice problem, continuing this pattern two more times. Both groups were exposed to eight problems, with the worked example group only solving four of the eight. Following the lesson, learners took a test with six new
problems similar to those used in the lessons. The results are shown in Table 11.1. It’s not surprising that those who worked all eight problems took a lot longer to complete the lesson—almost six times longer! Notice, however, that the number of errors during training and in the test was higher for the all-practice groups (that is, the groups that were given problems to solve without any worked examples). This was the first of many experiments demonstrating the benefits of replacing some practice with worked examples.

Since those initial studies, worked examples have proven beneficial for learning not only in structured domains such as algebra and statistics, but also for more strategic skills such as identifying design styles (Rourke & Sweller, 2009), learning argumentation techniques (Schworm & Renkl, 2007), electrical troubleshooting (van Gog, Paas, & van Merrienboer, 2008), geometry proving skills (Hilbert, Renkl, Kessler, & Reiss, 2008) and application of teaching principles (Moreno & Ortegano-Layne, 2008; Moreno & Valdez, 2007).

Research since our second edition has focused on instructional methods you can use to maximize the benefits of worked examples. We organize the evidence into the following principles:

Principle 1: Fade from worked examples to problems
Principle 2: Promote self-explanations

Table 11.1. Worked Example Problem Pairs Result in Faster Learning and Performance.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Worked Examples–Practice Pairs</th>
<th>All Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Time (Sec)</td>
<td>32.0</td>
<td>185.5</td>
</tr>
<tr>
<td>Training Errors</td>
<td>0</td>
<td>2.73</td>
</tr>
<tr>
<td>Test Time</td>
<td>43.6</td>
<td>78.1</td>
</tr>
<tr>
<td>Test Errors</td>
<td>.18</td>
<td>.36</td>
</tr>
</tbody>
</table>

From: Sweller and Cooper (1985).
Principle 3: Include instructional explanations of worked examples in some situations
Principle 4: Apply the multimedia principles to examples
Principle 5: Support learning transfer

Worked Example Principle 1: Fade from Worked Examples to Problems

In fading, you first provide a fully worked example similar to the examples in Figures 11.1 and 11.2. You follow the initial example with a second example, in which most of the steps are worked out and the learner completes the final steps. As examples progress, the learner gradually completes more of the steps. You end with a practice problem the learner must solve entirely on his or her own. Figure 11.3 illustrates the concept of fading. The grey area represents steps demonstrated by the instruction and the white area represents steps completed by the learner. Suppose, for example, you were teaching probability calculations in a statistics class. You start with a fully worked example, as represented by the all grey circle on the left in Figure 11.3. Next you fade out the last steps in a second worked example, as shown in

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Figure 11.3. Fading from a Full Worked Example to a Practice Problem.
From Clark, Nguyen, and Sweller, 2006.
Figure 11.4. A Faded Worked Probability Problem.

**Problem:** The bulb of Mrs. Dark’s dining room table is defective. Mrs. Dark had six spare bulbs on hand. However, three of them are also defective. What is the probability that Mrs. Dark first replaces the original defective bulb with another defective bulb before then replacing it with a functioning one?

**First Solution Step**

| Total number of spare bulbs: | 6 |
| Number of defective spare bulbs: | 3 |
| Probability of a defective bulb first | $\frac{3}{6} = \frac{1}{2} = .5$ |

**Second Solution Step**

| Total number of spare bulbs after a first replacement trial: | 5 (2 defective and 3 functioning spares) |
| Probability of a functioning bulb second: | $\frac{3}{5} = .6$ |

**Third Solution Step**

| Probability of first replacing the original defective dining room bulb with a defective bulb first and then replacing it with a functioning one: ? |
| Please enter the numerical answer below: |

Figure 11.4. In this problem, the first two steps are worked by the instruction and the learner is required to complete the final step. This example matches the second circle in Figure 11.3. At the end of the series, a probability problem is assigned to the learner as a practice problem to work on his or her own. In progressing through a series of faded worked examples, the learner gradually assumes more and more of the mental work until at the end of the sequence he or she is completing full practice problems.

Although worked examples are proven to be the most effective path during the initial stages of learning, as learners gain more expertise, worked examples can actually impede learning. This phenomenon is an example of the **expertise reversal effect** that we discussed in Chapter 4. In expertise reversal, an instructional method that benefits novice learners does not help and sometimes even hinders learning of high knowledge learners (Kalyuga, 2007). For example, novices benefit from the cognitive load relief of studying an example rather than solving a problem as the basis for initial learning.
However, once the new knowledge is stored in memory, studying a worked example adds no value. In fact, the worked example may conflict with the learner’s unique approach to completing the task. At that point, learners need to practice in order to automate their new skills.

Worked Example Principle 2: Promote Self-Explanations

A potential problem with worked examples is that many learners either ignore them altogether or review them in a very shallow manner. Chi and others (1989) found that better learners reviewed worked examples by explaining to themselves the principles reflected in the examples. For example, when studying the worked example shown in Figure 11.1, a shallow processor might be thinking: “To get the answer they multiplied 3/5 by 1/2.” In contrast, a deeper processor might be thinking: “To determine the probability of two events, you have to multiply the probability of the first event by the probability of the second event assuming the first event happened.” The shallow processor more or less repeats the content of the example, in contrast to the deeper processor, who focuses on the principles being illustrated. Thus, successful learning from worked examples requires psychological engagement.

To overcome this potential limitation of worked examples, you can encourage deeper learning through techniques that promote deeper processing of worked examples. Two proven techniques are adding self-explanation questions and promoting collaborative explanations of worked examples.

Add Self-Explanation Questions to Your Worked Examples

A self-explanation question is an interaction—often multiple choice in e-learning—that requires the learner to review the worked out step(s) and identify the underlying principles or rationale behind them. Note that the worked example we show in Figure 11.5 includes a multiple-choice question next to the first worked step. The learner is required to identify the principle that supports each step demonstrated in the worked example. In Figure 11.6, we add a self-explanation question to our pharmaceutical sales modeling example. The goal of any self-explanation question is two-fold.
Figure 11.5. A Self-Explanation Question Focused on First Solution Step of Probability Problem.


**Problem:** From a ballot box containing three red balls and two white balls, two balls are randomly drawn. The chosen balls are not put back into the ballot box. What is the probability that a red ball is drawn first and a white ball is second?

<table>
<thead>
<tr>
<th>First Solution Step</th>
<th>Total number of balls: 5</th>
<th>Number of red balls: 3</th>
<th>Probability of a defective bulb first $\frac{3}{5} = .6$</th>
</tr>
</thead>
</table>

Please enter the letter of the rule/principle Used in this step:

**Probability Rules/Principles:**

- a) Probability of an event
- b) Principle of complementarity
- c) Multiplication principle
- d) Addition principle

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Figure 11.6. A Self-Explanation Question Encourages Deeper Processing of the Sales Modeled Example.

**Example:**

Dr. Chi

**Question**

In this instance, why is it important to verbally recap the doctor’s questions about contra indicators? When you have made your choices, click Ok.

- [ ] A) Provides the doctor with an opportunity to give you more details
- [ ] B) Establishes that you are listening actively to her issues
- [ ] C) Lets you tailor her questions to match Lestrian’s benefits
- [ ] D) Demonstrates your knowledge of Lestrian’s benefits

**Ok**
First, it discourages bypassing the worked example because an overt response is required. Second, by asking learners to identify the rationale that underlies each step, they are encouraged to process that step in a meaningful way.

Self-explanation questions will require additional time for the developer to construct and for the learner to respond. Do we have evidence that this time investment will pay off? Atkinson, Renkl, and Merrill (2003) compared the learning of high school students from faded worked examples that included self-explanation questions like the one in Figure 11.5 with the same faded worked examples without questions. As you can see in Figure 11.7, adding the questions resulted in greater learning from the worked examples.

Encourage Self-Explanations Through Active Observation

In this section, we review new research showing the benefits of collaboration during observational learning of modeled examples. Observational learning refers to watching a human tutor explain problems to a student. Chi, Roy, and Hausmann (2008) found that pairs of learners solving physics problems while viewing a video recording of a tutor helping a student solve the same problem, learned as much as the students who were directly tutored. The video recording provided a modeled worked example, and the assigned problem ensured that learners actively processed the worked example.
The research team calls this technique *active observing*, defined as “observing that facilitates engagement with the materials so as to encourage deeper processing” (Craig, Chi, & VanLehn, 2009, p. 781). The research team derived three conditions to maximize the benefits of active observing. First, learners should solve problems as they observe the video; second, they should do so in pairs rather than working alone; and third, best learning stems from video models using high ability tutees who ask the tutor deeper level questions than lower ability tutees do.

Research on active observing is in its early stages. Because of the potential efficiencies of distributing a recorded model of a tutoring session to many learners, this technique has high potential for applications in workforce learning. We need to determine the extent to which active observing will apply to problem-solving domains other than physics and can be adapted to online collaboration.

**Worked Example Principle 3: Include Instructional Explanations of Worked Examples in Some Situations**

In our second edition, we recommended adding instructional explanations to worked examples. For example in e-learning, a “help” button might offer more specific details or rationale for the guidelines illustrated in the worked example. A number of studies showed positive learning benefits of adding help, provided either on demand or simply included as part of the worked example.

However, evidence accumulated in the last few years suggests that instructional explanations can be problematic—sometimes even depressing learning (Renkl, Hilbert, & Schworm, 2009). Under what conditions are instructional explanations of a worked example helpful?

Renkl (2011) describes three situations (what instructional psychologists call *boundary conditions*) in which adding explanations has proven helpful. First, adding explanations can be effective when conceptual understanding is the goal rather than problem solving performance. Second, explanations are most helpful when there are no self-explanation questions requiring a
learner response. Learners may invest less effort in a self-explanation question if an instructional explanation is available. Finally, explanations seem especially effective with mathematical content, perhaps because many learners are intimidated by mathematics. The worked example we show in Figure 11.1 meets all three of these criteria. This worked example may benefit by adding an explanation.

We look forward to additional research suggesting the kinds of explanations to provide learners and when a self-explanation question is more effective than providing an instructional explanation.

**Worked Example Principle 4: Apply Multimedia Principles to Examples**

In Chapters 4 through 10 we presented Mayer’s multimedia principles pertaining to the use of graphics, text, audio, and content sequencing. Some of the earliest research on worked examples found that they failed to have a positive effect when the multimedia principles were violated. For example, if the contiguity principle was violated by separating text steps from a relevant visual in a worked example, split attention negated the benefits of the worked example. To maximize the cognitive load benefits of worked examples, it is important that you apply the multimedia principles to their design. In this section we show you how.

**Illustrate Worked Examples with Relevant Visuals:**

**Multimedia Principle**

We saw in Chapter 4 that relevant visuals benefit learning, in contrast to lessons that use text alone to present content. The same guideline applies to design of worked examples. Where possible, include relevant visuals to illustrate the steps. For example, when demonstrating how to enter a formula into an Excel spreadsheet, a screen shot of a spreadsheet with data provides a relevant visual.

Moreno and Valdez (2007) and Moreno and Ortegano-Layne (2008) compared learning of teaching principles from lessons with no examples with lessons that added classroom modeled examples presented in narrative text, in video, and in animation.
As you can see in Figure 11.8, the visualized case examples—either video or animation—resulted in better learning than text or no-example groups, which did not significantly differ from each other.

**Present Steps with Audio—NOT Audio and Text: Modality and Redundancy Principles**

In Chapters 6 and 7 we summarized research showing that learning is better when a relevant visual is explained with words presented in audio rather than text or audio and text. The same guideline applies to worked examples. Leahy, Chandler, and Sweller (2003) compared learning from a worked example of how to calculate temperature changes from the graph shown in Figure 11.9. Three different modality combinations were used to present the steps: text, audio, and text plus audio. The text version looked similar to Figure 11.9, with the three numbered steps explained with callouts near the relevant part of the graph. In the audio version, the text you see in Figure 11.9 was presented with audio narration only and the callouts did not appear. The audio and text version used the text callouts similar to

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**Figure 11.8. Better Learning from Case Examples in Video or Animation Than Text or No Example.**

Based on data from Moreno and Ortegano-Layne, 2008.
The research team found that, for complex problems for which cognitive load would be the highest, learning was better when the graph was explained with audio alone. Keep in mind, however, that applying the modality principle sometimes creates more cognitive load than it saves. For example, you should avoid audio in situations in which learners need to refer to words at their own pace. For example, when including self-explanation questions, present the steps and the question in text, permitting flexible review of those steps in order to correctly identify the appropriate principle. In addition, we saw in Chapter 7 that learning is not hurt and can even be helped when a few important words are placed in text on the screen and elaborated with audio.

**Present Steps with Integrated Text: Contiguity Principle**

We recommend that you make audio the default modality option in multimedia lessons when presenting steps related to a visual. However, examples should be presented in text when you need to accommodate learners who may have hearing impairments, who are not native speakers of the language used in the instruction, or who may not have access to technology that can...
deliver sound, as well as to help learners review steps in faded worked examples or steps accompanied by self-explanation questions. When using text to present steps accompanied by a visual, implement the contiguity principle by placing the text close to the relevant visual.

**Present Steps in Conceptually Meaningful Chunks:**
*Segmenting Principle*

Often worked examples may include eleven or more steps. Learners may follow each step individually, failing to see the conceptual rationale for the steps or for combinations of steps. For example, in the probability problems shown in Figures 11.1 and 11.4, the steps are grouped into three segments, each segment illustrating the application of a probability principle. Atkinson and Derry (2000) showed that, in multimedia, better learning results from worked examples in which each step is presented on a new screen in a building fashion rather than when the steps are presented all together. Your challenge is to group your steps into meaningful chunks and draw learner attention to those chunks by visually isolating them, by building them through a series of overlays, or by surrounding related steps with boxes to signal the underlying principles.

**Present Steps with Learner Control of Pacing:**
*Segmenting Principle*

In Chapter 10 we showed that, for complex content, learning was better when students could move through screens at their own pace by clicking on the “continue” button rather than viewing the content in a non-stop video manner. This guideline also applies to worked examples that are complex. After a few steps, an animated demonstration should pause, allowing the learner to click “continue” when they are ready to move forward.

**Familiarize Learners with Example Context:**
*Pretraining Principle*

Have you ever found that you could not really understand an example because the content used as context for the example was unfamiliar? If learners are viewing an example and lack knowledge of both the learning goal and
Chapter 11: Leveraging Examples in e-Learning

the context for the example, the value of the worked example may be at risk. Imagine that your instructional goal is to teach how to write an effective learning objective. If you were to use unfamiliar technical content, say geometry or electronics, in your examples of effective learning objectives, learners can become bogged down in the technical content and fail to learn the guidelines of objective construction.

Hilbert, Renkl, Kessler, and Reiss (2008) pre-tested learners on the content knowledge of the worked examples used in their research and found a significant correlation between knowledge of the example content and acquiring the intended skills. Renkl, Hilbert, and Schworm (2009) recommend pretraining when the example content will be difficult to understand. Alternatively, as you design worked examples, select illustrative content that is likely to be familiar to your learners. Rather than using geometry or electronics, use a more familiar context such as basic Internet searching or everyday skills such as brushing teeth or cooking.

Worked Example Principle 5: Support Learning Transfer

Since the publication of the second edition, much research on worked examples has focused on use and design of worked examples for what we call far transfer learning of strategic tasks.

In some training situations, the main goal is to teach learners procedures—tasks that are performed pretty much the same way each time they are completed. Accessing your e-mail or filling out a customer order form are two typical examples. When teaching procedures, your goal is to help learners achieve near transfer. In other words, your goal is to help learners apply steps learned in the training to similar situations in the work environment.

However, in other situations your goal is to build job skills that will require the worker to use judgment in order to adapt strategies to new work situations. In a sales setting, for example, the product, the client, and the situation will vary each time. It is not productive to teach sales skills as an invariant set of steps because each situation will require adaptation. Rather, you need to teach a set of strategies. Your goal is to help learners adapt strategies
learned in the training to the work environment, where each situation will vary. When teaching strategies, your goal is to help learners achieve far transfer. Management training, customer service training, consultative selling, and non-routine troubleshooting are all examples of tasks that require far transfer skills.

Design Guidelines for Far Transfer

Worked Examples

The key to success in design of worked examples for far transfer learning is to illustrate guidelines with differing contexts and to promote learner processing of those examples. In this section we will offer guidelines for creating varied context worked examples and for encouraging learners to engage with those worked examples in ways that promote deeper, more flexible knowledge.

Far Transfer Guideline 1: Use Varied Context Worked Examples

Let’s begin our discussion of varied context examples with a short demonstration. Take a minute to review the following tumor problem.

**THE TUMOR PROBLEM**

Suppose you are a doctor faced with a patient who has a malignant tumor in his stomach. It is impossible to operate on the patient, but unless the tumor is destroyed, the patient will die. There is a kind of ray that at a sufficiently high intensity can destroy the tumor. Unfortunately, at this intensity, the healthy tissue that the rays pass through on the way to the tumor will also be destroyed. At lower intensities, the rays are harmless to healthy tissue but will not affect the tumor either. How can the rays be used to destroy the tumor without injuring the healthy tissue? (Duncker, 1945).

What are some possible solutions to the tumor problem? The preferred solution is to aim several weak rays from different directions so they converge on the tumor. This problem was used in a classic experiment in which
different groups had different pre-work assignments (Gick & Holyoak, 1980). One group read a story about a general who captured a mined fortress by splitting up his troops and attacking from different directions. Another group read the fortress story, plus a story about putting out a fire on an oil rig. A single hose was not able to disperse sufficient foam, so the fire was put out by directing many small hoses toward the middle of the fire. In these three stories, the contexts are quite different. One is about a medical problem, another is about a fire, and a third is about a fortress. However, the underlying principle—a convergence principle—is the same.

Gick and Holyoak (1980) found that most individuals who tried to solve the tumor problem without first reading any other stories did not arrive at the convergence solution. Even those who read the fortress problem prior to the tumor problem did not have much better luck solving the tumor problem. But the group that read both the fire and the fortress stories had much better success. By studying two examples from different contexts that reflect the same principle, learners were able to abstract the underlying principle that connected them. An important implication is that people are better able to abstract a general principle or procedure when they learn about it in many different contexts.

When teaching far transfer skills, build several (at least two) worked examples in which you vary the context but illustrate the same guidelines in each. For example, the pharmaceutical sales lesson shown in Figure 11.10 uses three physicians, each with different practice and patient profiles. In this lesson the learner will observe a worked example involving Dr. Chi. Next they will practice sales skills with Dr. Jones and Dr. Valdez, who have different practice parameters.

Creating several examples of different contexts will increase your development time. Do we have any evidence that varied context examples promote learning? The answer is yes. Quilici and Mayer (1996) created examples to illustrate three statistical tests of t-test, correlation, and chi-square. Each of these test types require a different mathematical procedure and are most appropriately applied to different types of data. For each test type, they created three examples. Some example sets used the same context. For example, the three t-test problems used data regarding experience and typing speed,
the three correlation examples used data regarding temperature and precipitation, and the three chi-square examples included data related to fatigue and performance. An alternative set of examples varied the context. For example, the t-test was illustrated by one example that used experience and typing speed, a second example about temperature and precipitation, and a third example about fatigue and performance.

After reviewing the examples, participants were tested for their understanding of the different statistical categories. As shown in Figure 11.11, the varied context examples led to significantly greater discrimination among the test types.

**Far Transfer Guideline 2: Include Self-Explanation Questions**

Schworm and Renkl (2007) reported that worked examples helped learners build argumentation skills only when learners were required to respond to self-explanation questions that focused on the argumentation principles. In
their research student teachers were assigned to lesson versions that did or did not accompany video examples of argumentation with self-explanation questions. Learning to apply argumentation skills was better when self-explanation questions were included.

**Far Transfer Guideline 3. Require Active Comparison of Varied Context Examples**

Gentner, Loewenstein, and Thompson (2003) designed a lesson on negotiation skills that focused on the benefits of a negotiated strategy based on a safeguard solution rather than a less effective tradeoff solution. They presented one worked example of negotiation that involved a conflict between a Chinese and American company over the best way to ship parts. They illustrated both the tradeoff (less effective) and the safeguard (more effective) negotiation strategies using the shipping context. In the next part of the lesson, they illustrated the safeguard and tradeoff solutions using a different context involving a conflict between two travelers over where to stay on a planned trip.

The placement of and engagement with the different examples was varied in three lesson versions, as illustrated in Figure 11.12. In one version (separate examples lesson) participants reviewed the shipping and traveling examples, each on a separate page. After reading each example, participants
were asked questions about each individual example such as, “What is going on in this negotiation?” In this lesson version, learners reviewed each example separately, rather than make a comparison between them. In a second version (comparison examples lesson), participants saw both examples displayed on the same page and were directed to think about the similarities between the two situations. A third group (active comparison of examples lesson) was presented the full shipping example on one page. A summary of the shipping example was placed on the second page that also presented the full traveler example. In this version, learners were required to respond to questions about the similarities between the two examples. A fourth group received no training.

Following the training, all participants were tested in a role-played face-to-face negotiation over salary. As you can see in Figure 11.13, the third version lesson that required an active comparison of the two examples resulted in best learning. This experiment is especially relevant to workforce learning practitioners, as the task involved negotiations—a common soft skill taught
in workforce learning—and the learning was measured by a role-play performance test. What we learn from this experiment is when presenting varied context examples, it is better (1) to display them in a contiguous fashion such as on the same page and (2) to ask questions that promote active comparisons of the examples.

**What We Don’t Know About Worked Examples**

We have learned a great deal in the past few years about the most effective way to design worked examples to maximize learning. Still there are a number of issues that remain to be resolved.

1. **When to use fading versus self-explanation questions.** A few recent studies that used both fading and self-explanation questions to promote deeper processing of worked examples found that self-explanation questions alone led to best learning (Hilbert, Renkl, Kessler, & Reiss, 2008). Perhaps a combination of fading and self-explanation questions added too much cognitive load for more complex skill domains. Future research should help us define how and when to use fading and self-explanation questions.
2. *How to design and use modeling examples.* In this edition, we added new research on both cognitive and interpersonal skill modeling examples. It will be helpful to see whether guidelines we have presented that apply to traditional worked examples also apply to modeling examples. For example, will a modeling example benefit from fading, from self-explanation questions, or from comparisons? Also since modeling examples often use video, how can extraneous load from the visuals be minimized?

3. *How active observation can be applied to workforce learning.* We reviewed some promising research showing the learning value of pairs of learners observing a tutor-tutee dialog on a physics problem while solving the same problem. To what extent will these results apply to less structured domains? Can active observation techniques be effectively implemented in asynchronous e-learning?

**DESIGN DILEMMA: RESOLVED**

In the pharmaceutical sales course, Reshmi wants to add some interactivity to the video examples with self-explanation questions or with faded examples that learners must complete. Matt agrees with the benefits of interactivity but feels it would be less expensive to incorporate some collaborative learning activity around the videos.

A. Reshmi is correct. Video examples should be accompanied by questions that engage learners in the examples.

B. Asking learners to complete a partial example would be better than asking questions about the examples.

C. Matthew is correct. It would be more effective to ask learners to review examples in pairs.

We have evidence in this chapter that potentially could support any of the above engagement strategies. We know that worked examples have potential to accelerate learning, but techniques such as fading, self-explanation questions and active observations are needed to maximize their value. We will need further research to determine when and for whom each of the engagement strategies described above would be most effective.
WHAT TO LOOK FOR IN e-LEARNING

- Worked examples that fade from a full worked example into a full problem assignment
- Worked examples accompanied by self-explanation questions
- Worked examples in which learners collaborate on solving a problem while viewing a tutor-tutee dialog about that problem (that is, active observation)
- Worked examples that offer instructional explanations of the worked steps when the learning goal involves conceptual knowledge and when no self-explanation questions are included
- Worked examples that minimize cognitive load by applying appropriate multimedia principles
  - Use relevant visuals
  - Explain visuals with audio or text—not both
  - Integrate explanatory text close to relevant visual
  - Segment worked examples into chunks that focus attention to underlying principles
  - Present complex examples under learner control of pacing
  - Offer pretraining of technical context that is unfamiliar to learners or use a familiar context
- Multiple varied-context worked examples for far transfer learning
- Interactions that encourage learners to actively compare sets of varied context examples for far-transfer learning

COMING NEXT

Although we recommend that you replace some practice with worked examples, you will still need to include effective practice in your training. In the next chapter we offer evidence for the number, type, design, and placement of practice, along with new guidelines on design of practice feedback that will optimize learning.
Suggested Readings

Gentner, D., Loewenstein, J., & Thompson, L (2003). Learning and transfer: A general role for analogical encoding. *Journal of Educational Psychology, 95*(2), 393–408.

