CHAPTER OUTLINE

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Does Practice Make Perfect?

WHAT'S NEW IN THIS CHAPTER?

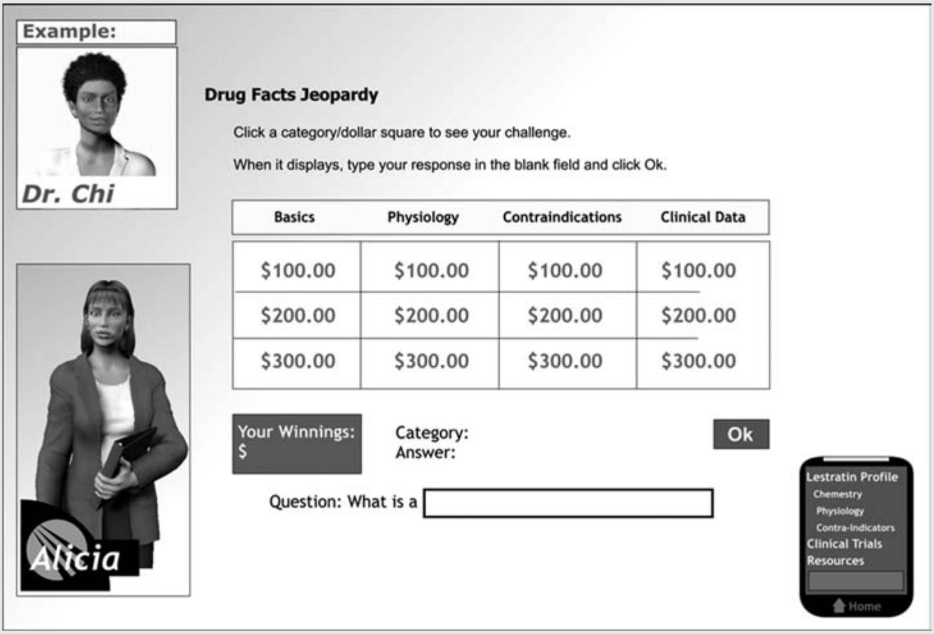
IN THE SECOND EDITION of *e-Learning and the Science of Instruction,* we recommended that you design practice accompanied by feedback to build job-relevant skills and adjust the amount and placement of practice to match job proficiency requirements. These guidelines are still valid today. There has been a moderate amount of new research on practice since our second edition. In this chapter we update the research on practice guidelines and add a new guideline regarding mixing categories of practice in a lesson when it's important to help learners discriminate among different problem types.

As described in our second edition, you should distribute interactions throughout the instructional environment and apply Mayer's multimedia principles to the design and layout of e-learning interactions.

DESIGN DILEMMA: YOU DECIDE

Reshmi, Sergio, and Ben have very different ideas about how to design practice for the pharmaceutical sales lesson. Sergio and Ben want to add a Jeopardy-type game like the one shown in Figure 12.1. They feel that sales staff are competitive and adding some fun games will increase engagement and motivation. Reshmi does not like the Jeopardy idea. She would prefer to include short interactive scenarios about different physician practice settings.

Figure 12.1. A Jeopardy Game Design for the Pharmaceutical Sales Lesson.



Regarding feedback, Reshmi and Ben disagree about what kind of feedback to include. Reshmi wants to tell participants whether they answered correctly or incorrectly and explain why. Ben feels they can save a lot of development time by simply using the automatic program feature of their authoring tool that tells learners whether they are correct or incorrect. Otherwise, the team will have to devote a large block of time to writing tailored explanations for all correct and incorrect response options. Based on your own experience or intuition, which of the following options would you select:

A. Adding some familiar and fun games like Jeopardy will make the lesson more engaging for learners and lead to better learning.

B. It would be better to use physician scenarios as the basis for interactions.

C. The extra time invested in writing tailored feedback explanations will pay off in increased learning.

What Is Practice in e-Learning?

Effective e-learning engages learners with the instructional content in ways that foster the selection, organization, integration, and retrieval of new knowledge. First, attention must be drawn to the important information in the training. Then the instructional words and visuals must be integrated with each other and with prior knowledge. Finally, the new knowledge and skills that are built in long-term memory must be retrieved from long-term memory after the training when needed on the job. Effective practice exercises support all of these psychological processes. In this chapter we will review research and guidelines for optimizing learning from online practice.

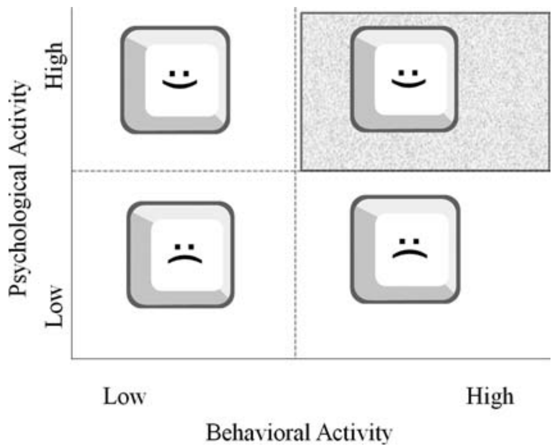
Practice events in e-learning are often referred to as *interactions.* However, there are many types of interactions. For example, Moreno and Mayer (2007) identify interactive categories for navigating, for searching, for controlling the pacing of the presentation, and for dialoging. In this chapter we primarily focus on interactions in the form of questions inserted by the program designer or instructor requiring the learner to respond in ways that promote learning of lesson content.

e-Learning practice interactions may use formats similar to those used in the classroom, such as selecting the correct answer in a multiple-choice list, checking a box to indicate whether a statement is true or false, or even typing in short answers. Other interactions use formats that are unique to computers such as drag-and-drop and simulations.

However, the psychological effectiveness of a practice exercise is more important than its format. In Chapter 1, we introduced the Engagement Matrix shown in Figure 12.2. Practice exercises will fall into one of the right-hand quadrants of the matrix since they require a behavioral response. However, if the behavior falls into the lower right quadrant, the result is mindless activity that does not support processing associated with the learning goal. Instead it is important to design practice that will fall into the upper right quadrant in which learners are both behaviorally and psychologically active.

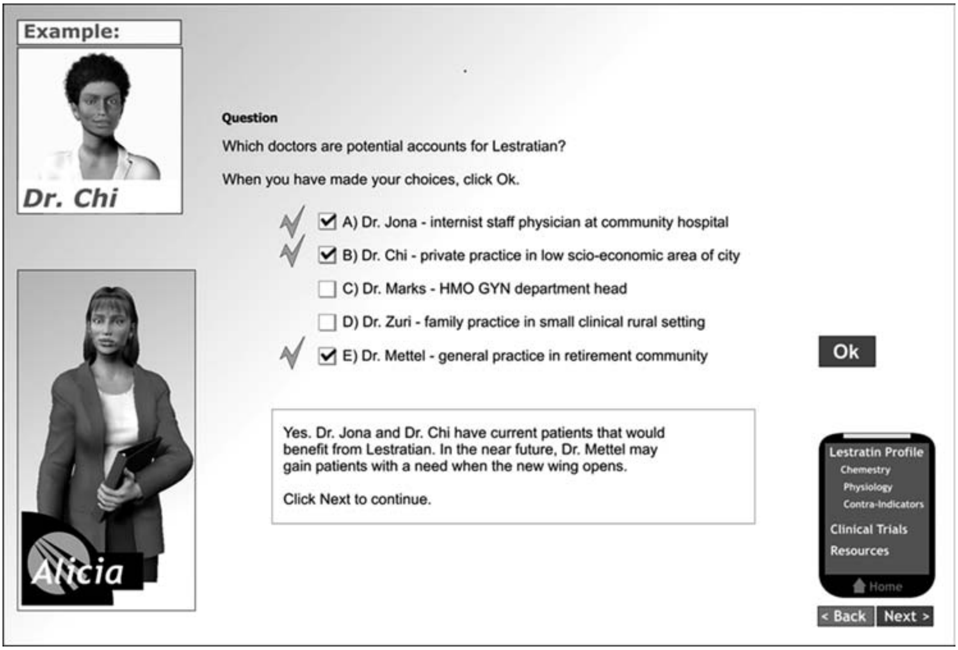
Figure 12.2. Practice Exercises Should Fall into the Upper Right Quadrant of the Engagement Matrix.

Adapted from Stull and Mayer, 2007.



For example, you could ask a multiple-choice question about a new drug requiring learners to recognize drug facts such as contraindications, dosages, and so forth. To respond to this type of question, the learner need only recognize the facts provided in the lesson. We call these kinds of interactions *"regurgitative."* Regurgitative questions promote shallow processing and we place them in the lower right quadrant of the Engagement Matrix. Regurgitative questions are common in training because they are quick and easy to develop. In contrast, to respond to the question in Figure 12.3, the learner needs to apply his or her understanding of the drug features to physician profiles. This question involves not only behavioral activity but also productive psychological

Figure 12.3. This Multiple-Select Question Requires the Learner to Match Drug Features to the Appropriate Physician.



engagement. This question requires a deeper level of processing than a multiple-choice fact recognition question and falls into the upper right cell of the Engagement Matrix.

The Paradox of Practice

We've all heard the expression that "practice makes perfect," but how important is practice to skill acquisition? Studies of top performers in music, games such as chess and Scrabble, and sports point to the criticality of practice in the development of expertise. Sloboda, Davidson, Howe, and Moore (1996) compared the practice schedules of higher and lower performing teenage music students of equal early musical ability and exposure to music lessons. All of the students began to study music around age six. However, the higher performers had devoted much more time to practice. By age twelve, higher performers were practicing about two hours a day, compared to fifteen minutes a day for the lower performers. The researchers concluded that "there was a very strong relationship between musical achievement and the amount of formal practice undertaken" (Sloboda, Davidson, Howe, & Moore, 1996, p. 287). In fact, musicians who had reached an elite status at a music conservatory had devoted over ten thousand hours to practice by the age of twenty! More recent comparisons of elite and average level Scrabble players found that in a ten-year period, elite players devoted an average of 3,541 hours to serious study, compared to 886 hours for average players (Tuffiash, Roring, & Ericsson, 2007).

However, time devoted to practice activity does not tell the whole story. Most likely you know individuals of average proficiency in an avocation such as golf or music who spend a considerable amount of time practicing with little improvement. Based on studies of expert performers in music, sports, typing, and games such as Scrabble, Ericsson (2006) concludes that practice is a *necessary but not sufficient condition* to reach high levels of competence. What factors differentiate practice that leads to growth of expertise from practice that does not?

Ericsson (2006) refers to practice that builds expertise as *deliberate practice.* He describes deliberate practice as tasks presented to performers that "are initially outside their current realm of reliable performance, yet can be mastered within hours of practice by concentrating on critical aspects and by gradually refining performance through repetitions after feedback" (p. 692). Deliberate practice involves five basic elements: (1) effortful exertion to improve performance, (2) intrinsic motivation to engage in the task, (3) carefully tailored practice tasks that focus on areas of weakness, (4) feedback that provides knowledge of results, and (5) continued repetition over a number of years (Kellogg & Whiteford, 2009).

For example, elite Scrabble players devoted time to skill-practice exercises directly related to Scrabble scores such as analysis of their own previous Scrabble games, anagramming, and studying word lists. They focused on Scrabble-specific payoff skills such as seven-letter words that earn bonus points and words that use high-scoring letters such as Q and Z. However, elite players did not differ from average players regarding time devoted to activities not directly related to Scrabble such as playing other word games and puzzles (Tuffiash, Roring, & Ericsson, 2007).

In our second edition, we showed evidence that practice should be job-relevant, distributed throughout the learning environment, and that more practice leads to improved performance. We update and extend these recommendations with the following guidelines:

Principle 1: Add sufficient practice interactions to e-learning to achieve the learning goal

Principle 2: Mirror the job

Principle 3: Provide effective feedback

Principle 4: Distribute and mix practice among learning events

Principle 5: Apply the multimedia principles

Principle 6: Transition from examples to practice gradually

Practice Principle 1: Add Sufficient Practice Interactions to e-Learning to Achieve the Objective

Practice exercises are expensive. First, they take time to design and to program. Even more costly will be the time learners invest in completing the practice. Does practice lead to more learning? How much practice is necessary? In this section we describe evidence that will help you determine the optimal amount of practice to include in your e-learning environments.

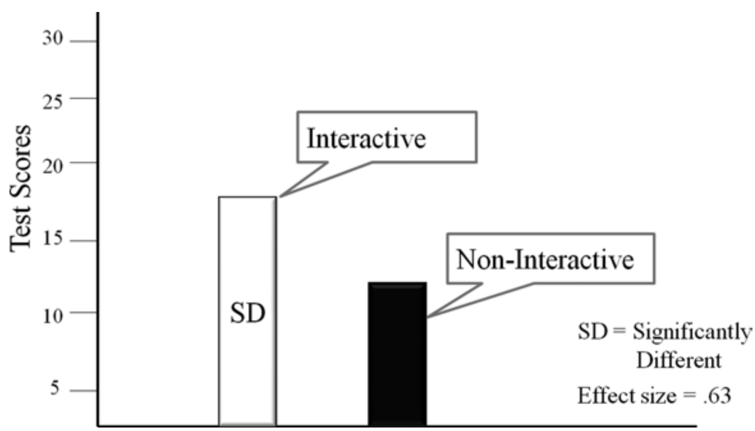
The Benefits of Practice

Some e-learning courses in both synchronous and asynchronous formats include little or no opportunities for overt practice. In Chapters 1 and 2 we classified these types of courses as receptive. Can learning occur without practice? How much practice is needed?

Moreno and Mayer (2005, 2007) compared learning from a Design-A-Plant game described in Chapter 9. In the game participants construct plants from a choice of roots, leaves, and stems in order to build a plant best suited to an imaginary environment. The object of the game is to teach the adaptive benefits of plant features for specific environments, such as heavy rainfall, sandy soil, and others. They compared learning from interactive versions in which the learner selected the best plant parts to survive in a given environment with the same lesson in which the on-screen agent selected the best parts. As you can see in Figure 12.4, interactivity improved learning with an effect size of .63, which is considered moderate.

In the same research report, a second form of interactivity asked learners to explain why an answer was correct or not correct to promote reflection on responses. This treatment is similar to self-explanations of a worked example that we discussed in Chapter 11. Asking learners to provide an explanation proved beneficial when the on-screen agent rather than the learners selected the plant parts. In fact, learner explanations promoted learning only when learners explained correct answers from the agent rather than their own answers, which may have been incorrect. From these results we conclude that interactions are beneficial to learning but that one form of interaction (either selecting the plant parts OR giving an explanation for correct selections made by the agent) is probably sufficient. In other words, strike a balance with practice assignments that require enough processing for learning but do not overload learners.

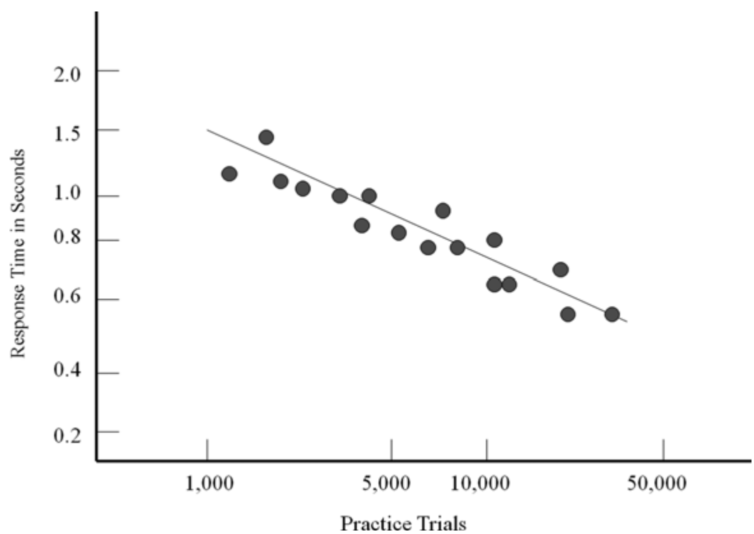
Figure 12.4. Better Learning from e-Learning with Interactions.
Based on data from Experiment 2, Moreno and Mayer, 2005.



Practice Benefits Diminish Rapidly

Practice can improve performance indefinitely, although at diminishing levels. Timed measurements of workers using a machine to roll cigars found that, after thousands of practice trials conducted over a four-year period, proficiency continued to improve (Crossman, 1959). Proficiency leveled off only after the speed of the operator exceeded the physical limitations of the equipment. In plotting time versus practice for a variety of motor and intellectual tasks, a logarithmic relationship has been observed between amount of practice and time to complete tasks (Rosenbaum, Carlson, & Gilmore, 2001). Thus the logarithm of the time to complete a task decreases with the logarithm of the amount of practice. This relationship, illustrated in Figure 12.5, is called the *power law of practice.* As you can see, while the greatest proficiency gains occur on early trials, even after thousands of practice sessions, incremental improvements continue to accrue. Practice likely leads to improved performance in early sessions as learners find better ways to complete the tasks and in later practice sessions as automaticity increases efficiency.

Figure 12.5. The Power Law of Practice: Speed Increases with Practice But at a Diminishing Rate.



Elite performers in athletics, music and games such as chess and Scrabble have devoted more than ten thousand hours to deliberate practice. However, proficient performance in most jobs will not require elite levels of performance. You will need to consider the return on investment on your practice interactions. How much practice will you need to provide to ensure your learners have an acceptable level of job proficiency? We turn to this question next.

Adjust the Amount of Practice Based on Task Criticality

Schnackenberg and others compared learning from two versions of computer-based training, one offering more practice than the other (Schnackenberg, Sullivan, Leader, & Jones, 1998; Schnackenberg & Sullivan, 2000). In their experiment, two groups were assigned to study from a full practice version lesson with 174 information screens and sixty-six practice questions or from a lean practice version with the same 174 information screens and twenty-two practice questions. Participants were divided into high- and low-ability groups based on their grade point averages and randomly assigned to complete either the full- or lean-practice versions. Outcomes included scores on a fifty-two-question test and average time to complete each version. Table 12.1 shows the results.

Table 12.1. Better Learning with More Practice.

From Schnackenberg, Sullivan, Leader, and Jones, 1998.

	Lesson with 66 Questions		*Lesson with 22 Questions*	
Ability Level	Low	High	Low	High
Test Scores	32.25	41.82	28.26	36.30
Time to Complete Lesson (minutes)	146	107	83	85

As expected, higher-ability learners scored higher and the full version took longer to complete. The full version resulted in higher average scores, with an effect size of .45, which is considered moderate. The full-practice version resulted in increased learning for both higher- and lower-ability learners. The authors conclude: "When instructional designers are faced with uncertainty about the amount of practice to include in an instructional program, they should favor a greater amount of practice over a relatively small amount if higher student achievement is an important goal" (Schnackenberg, Sullivan, Leader, & Jones, 1998, p. 14).

Notice, however, that lower-ability learners required 75 percent longer to complete the full-practice version than the lean-practice version for a gain of about four points on the test. Does the additional time spent in practice warrant the learning improvement? The answer in this research, as in your own training, will depend on the consequences of error on task performance.

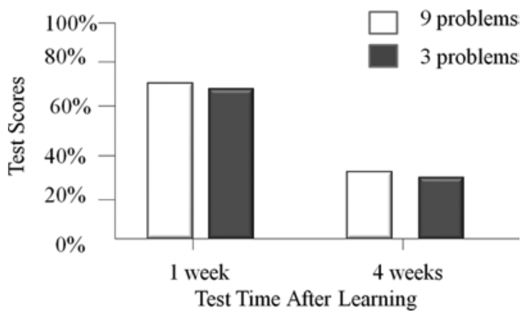
Limited Benefits of Over-Learning in Mathematics

During a lesson, learners may practice until they correctly solve one or two problems or they may continue to practice after obtaining a correct answer. Over-learning refers to situations in which learners continue to practice after they have correctly solved one or two practice problems. A number of studies have shown benefits of over-learning. However, most experiments have measured learning quite soon after the practice sessions—usually less than one hour. What benefits might over-learning have over a longer retention period?

Rohrer and Taylor (2006) assigned college students a letter permutation problem in which they determined how many different combinations could be made out of a letter sequence such as abbbcc. The tutorial taught a mathematical procedure for calculating permutations and then assigned practice problems. One group completed three practice problems. A second group completed nine practice problems. Three practice problems proved sufficient for most subjects to learn the permutation procedure. Therefore, the nine-problem group served as an "over-learning" group.

Figure 12.6. No Learning Benefits Gained from Over-Learning.

Based on data from Experiment 2, Rohrer and Taylor, 2006.



As you can see in Figure 12.6, there were no differences between low- and high-practice groups either on a one-week or on a four-week test. The research team recommends that "assignments should err slightly in the direction of too much practice, perhaps by including three or four problems relating to each new concept in the most recent lesson. However, beyond these first three or four problems, the present data suggest that the completion of additional problems of same type is a terribly inefficient use of study time" (p. 1218).

If your goal is to build knowledge and skills, you need to add practice interactions. To decide how much practice your e-learning courses should include, consider the nature of the job task and the criticality of job performance and include more practice for highly critical skills.

Practice Principle 2: Mirror the Job

Skill building requires practice on the component skills that make up the infrastructure of a specific work domain. Therefore, your interactions must require learners to respond in a job-realistic context. Questions that ask the learner to merely recognize or recall information presented in the training will not promote learning that transfers to the job.

Begin with a job and task analysis in order to define the specific cognitive and physical processing required in the work environment. Then create *transfer appropriate interactions*—activities that require learners to respond in similar ways during the training as in the work environment. The more the features of the job environment are integrated into the interactions, the more likely the right cues will be encoded into long-term memory for later transfer. The Jeopardy game shown in Figure 12.1 requires only recall of information. Neither the psychological nor the physical context of the work environment is reflected in the game. In contrast, the question shown in Figure 12.3 requires learners to process new content in a job-realistic context and therefore is more likely to support transfer of learning.

For the most part, avoid interactions that require simple regurgitation of information provided in the training program. These questions do not support the psychological processes needed to integrate new information with existing knowledge. They can be answered without any real understanding of the content, and they don't implant the cues needed for retrieval on the job. Instead, as you design your course, keep in mind the ways that your workers will apply new knowledge to their job tasks.

Practice Principle 3: Provide Effective Feedback

In a comparison of meta-analyses of 138 different factors that affect learning, Hattie (2009) ranked feedback as number ten in influence. In spite of the known benefits and extensive use of feedback, hundreds of research experiments on feedback reveal both positive and negative effects and few consistent patterns (Kluger & DeNisi, 1996; Shute, 2008). As with many instructional methods, some factors that influence the effectiveness of feedback include the learning objectives and associated tasks, features of the learner, including prior knowledge and self-confidence, as well as how and when feedback is formulated and presented to learners. Here we provide a brief summary of some guidelines to consider when designing feedback.

Provide Explanatory Feedback

Take a look at the two feedback responses to the incorrect question response shown in Figures 12.7 and 12.8. The feedback in Figure 12.7 tells you that your answer is wrong. However, it does not help you understand why your answer is wrong. The feedback in 12.8 provides a much better opportunity for learning because it incorporates an explanation. A missed question is a teachable moment. The learner is open to a brief instructional explanation that will help build the right mental model. Although the benefits of explanatory feedback seem obvious, crafting explanatory feedback is much more

Figure 12.7. This Feedback Tells the Learner That the Response Is Incorrect.

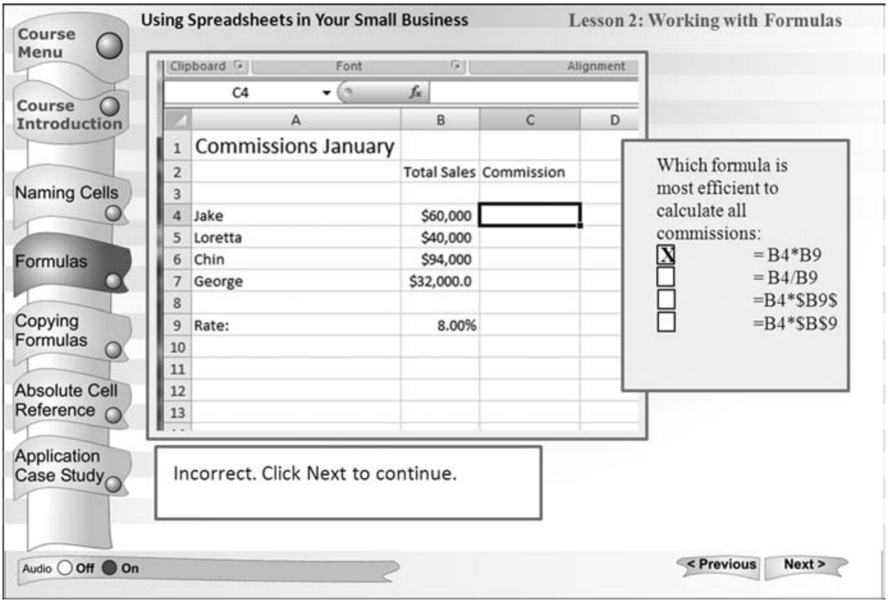
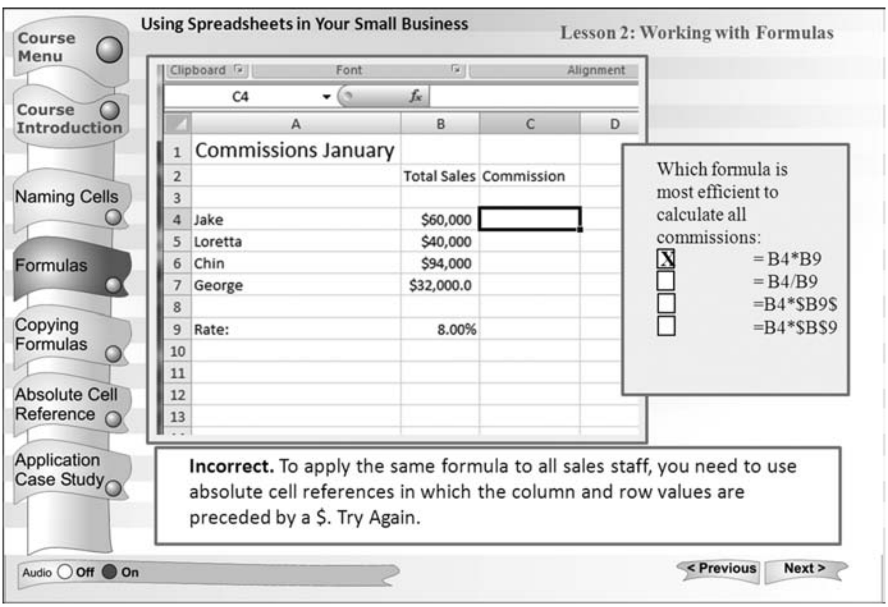


Figure 12.8. This Feedback Tells the Learner That the Response Is Incorrect and Provides an Explanation.

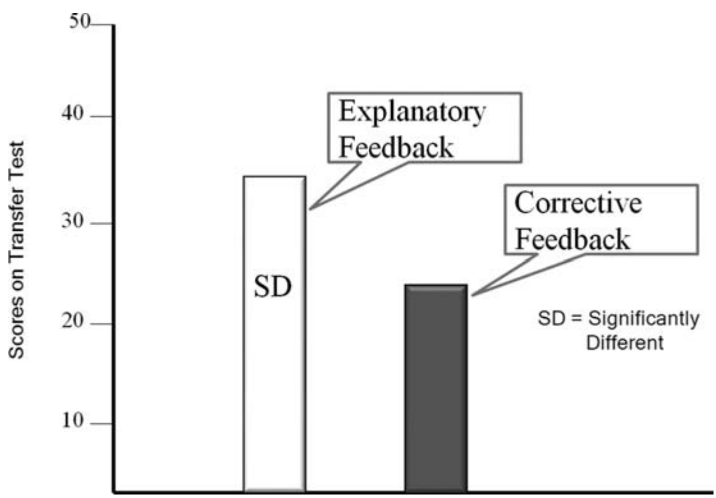


labor-intensive than corrective feedback, which can be automated in many authoring tools with only a few key strokes. What evidence do we have that explanatory feedback will give a return sufficient to warrant the investment?

Evidence for Benefits of Explanatory Feedback

Moreno (2004) compared learning from two versions of a computer botany game called Design-A-Plant, described previously in this chapter. Either *corrective* or *explanatory feedback* was offered by a pedagogical agent in response to a plant design. For explanatory feedback, the agent made comments such as: "Yes, in a low sunlight environment, a large leaf has more room to make food by photosynthesis" (for a correct answer) or "Hmmm, your deep roots will not help your plant collect the scarce rain that is on the surface of the soil" (for an incorrect answer). Corrective answer feedback told the learners whether they were correct or incorrect but did not offer any explanation. As you can see in Figure 12.9, better learning resulted from explanatory feedback, with a large effect size of 1.16. Students rated the version with explanatory feedback as more helpful than the versions with corrective feedback. Moreno and Mayer (2005) reported similar results using the same botany game environment in a follow-up study. They found that explanatory feedback resulted in much better learning than corrective feedback, with a very high effect size of 1.87.

Figure 12.9. Better Learning from Explanatory Feedback.
From data in Experiment 1, Moreno, 2004.



Focus Learner Attention to the Task—Not the Learner

In a review of feedback drawing on multiple research studies, Hattie and Gan (2011), Shute (1998), and Kluger and DeNisi (1996) recommend that feedback should focus learner attention to the task or task process but minimize responses that the learners will perceive as feedback on themselves. For example, the feedback in Figure 12.8 tells the learner he or she is wrong and includes an explanation. This feedback, as well as the Design-A-Plant feedback described in the previous paragraphs, are examples of task-focused feedback. In contrast, feedback that involves some kind of normative information such as a grade or even feedback that involves praise can direct attention to the ego and result in diminished effects. Hattie and Gan (2011) comment that "Praise usually contains little task-related information and is rarely converted into more engagement, commitment to the learning goals, enhanced self-efficacy, or understanding about the task" (p. 261).

If the learner is solving a problem, process feedback would focus on the strategies the learner used. For example, feedback in a search strategies lesson might say: "You could likely get more relevant search hits by using the 'BUT NOT' instead of the 'AND' operator."

Provide Step-by-Step Feedback When Steps Are Interdependent

In many problem-solving tasks, a wrong step early in problem solving can derail the remaining attempted steps. Corbalan, Paas, and Cuypers (2010) compared the effects of feedback given on the final solution with feedback given on all solution steps on learning and motivation in linear algebra problems. The research team found that participants were more motivated and had better learning outcomes when feedback was provided on all solution steps rather than just the final step. The research suggests that electronic environments should incorporate step-wise guidance in highly structured subjects such as linear algebra.

In contrast to highly structured domains such as mathematics, there is some evidence that delayed feedback may be more effective for conceptual or strategic skills as well as for simpler tasks (Shute, 2008). However, we will need more research for firm recommendations on the timing of feedback for different tasks and learners.

Tips for Feedback

- After the learner responds to a question, provide feedback that tells the learner whether the answer is correct or incorrect and provide a succinct explanation.
- Focus the explanation in the feedback on either the task itself or on the process involved in completing the task.
- Avoid feedback such as "Well Done!" that draws attention to the ego and away from the learning.
- Likewise, avoid normative feedback such as grades that encourage learners to compare themselves with others.
- Emphasize progress feedback in which attention is focused on improvement over time.
- Position the feedback so that the learner can see the question, his or her response to the question, and the feedback in close physical approximation to minimize split attention.
- For multi-step problems for which steps are interdependent, provide step-by-step feedback.
- For a question with multiple answers, such as the example in Figure 12.4, show the correct answers next to the learner's answers and include an explanation for the correct answers.

Practice Principle 4: Distribute and Mix Practice Among Learning Events

We've seen that the benefits of practice have a diminishing effect as the number of exercises increases. However, there are some ways to extend the long-term benefits of practice just by where you place and how you sequence even a few interactions.

Distribute Practice Throughout the Learning Environment

The earliest research on human learning conducted by Ebbinghaus in 1913 showed that distributed practice yields better long-term retention. According to Druckman and Bjork (1991), "The so-called spacing effect—that practice sessions spaced in time are superior to massed practices in terms of long-term retention—is one of the most reliable phenomena in human experimental psychology. The effect is robust and appears to hold for verbal materials of all types as well as for motor skills" (p. 30). As long as eight years after an original training, learners whose practice was spaced showed better retention than those who practiced in a more concentrated time period (Bahrick, 1987).

The spacing effect, however, does not result in better immediate learning. Only after a period of time are the benefits of spaced practice realized. Since most training programs do not measure delayed learning, the benefits of spaced practice often go unnoticed. Only in long-term evaluation would this advantage be seen. Naturally, practical constraints will dictate the amount of spacing that is feasible.

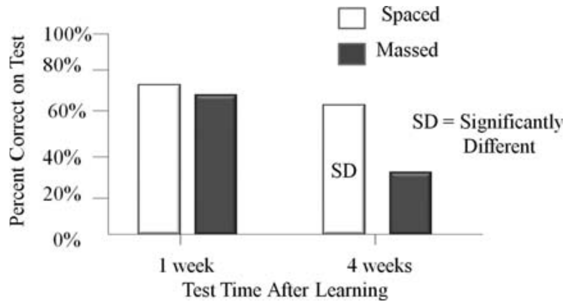
At least three recent studies show the benefits of distributed practice. Two studies focused on reading skills and a third on mathematics. Seabrook, Brown, and Solity (2005) showed that recall of words among various age groups was best for words in a list that were repeated after several intervening words than words that were repeated in sequence. To demonstrate the application of this principle to instructional settings, they found that phonics skills taught in reading classes scheduled in three two-minute daily sessions showed an improvement six times greater than those practicing in one six-minute daily session.

Rawson and Kintsch (2005) compared learning among groups of college students who read a text once, twice in a row, or twice with a week separating the readings. They found that reading the same text twice in a row (massed practice) improved performance on an immediate test, whereas reading the same text twice with a week in between readings (distributed practice) improved performance on a delayed test.

Rohrer and Taylor (2006) used mathematical permutation problems described previously in this chapter and compared the effects of spaced and massed practice on learning one week and four weeks after practice. After completing a tutorial in Session 1, students were assigned ten practice problems. The massed group worked all ten practice problems in the second session, whereas the spaced practice group worked the first five problems in

Session 1 and the second five problems in Session 2. As you can see in Figure 12.10, learning in the two groups was equivalent after one week, but spaced learners had much better four-week retention of skills.

Figure 12.10. Best Learning on the Delayed Test Among Students Practicing Math Problems in a Spaced Format.



Taken together, evidence continues to recommend practice that is scheduled throughout a learning event rather than concentrated in one time or place. To apply this guideline, incorporate review practice exercises among the various lessons in your course and within a lesson distribute practice throughout the lesson rather than all in one place. Also consider ways to leverage media in ways that will extend learning over time. For example, schedule an asynchronous class a week or so prior to an instructor-led synchronous session. Follow these two sessions by a third learning event in which participants complete a workplace assignment to be reviewed by a supervisor. The use of diverse delivery media to spread practice over time will improve long-term learning.

Mix Practice Types in Lessons

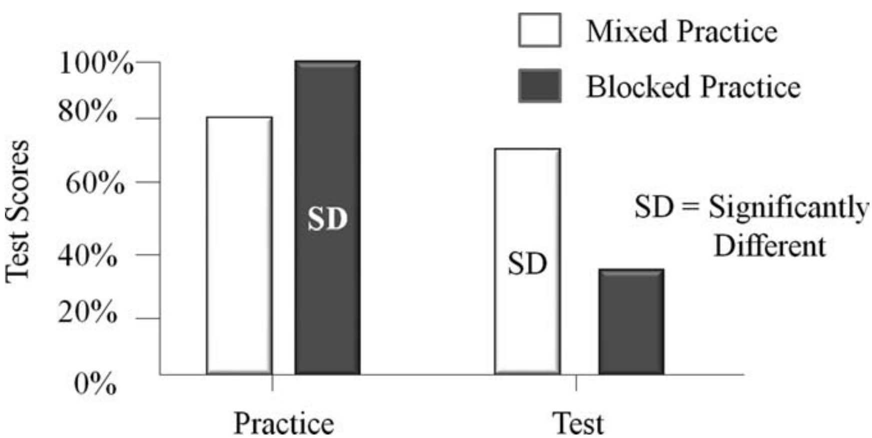
Imagine you have three or more categories of skills or problems to teach, such as how to calculate the area of a rectangle, a circle, and a triangle. A traditional approach is to show an example followed by practice of each area calculation separately. For example, first demonstrate how to calculate the area of a rectangle followed by five or six problems on rectangles. Next show how to calculate the area of a circle followed by several problems on circles.

This traditional approach is what instructional psychologists called "*blocked practice.*" Practice exercises are blocked into learning segments based on their common solutions.

Recent research, however, suggests that a mixed practice format will lead to poorer practice scores but, counter-intuitively, pay off in better learning on a test given a day later. Taylor and Rohrer (2010) asked learners to calculate the number of faces, edges, corners, or angles in four unique geometric shapes. Following a tutorial that included examples, learners were assigned thirty-two practice problems—eight of each of the four types. The blocked group worked eight faces problems, eight edges problems, eight corners problems, and eight angles problems, for a total of thirty-two problems. The mixed group worked a practice problem from each of the four types eight times, also for a total of thirty-two problems. For example, in the mixed group the learner would work one problem dealing with faces followed by a problem dealing with edges, then a problem dealing with corners, and finally a problem dealing with angles. This pattern was repeated eight times. One day after practice, each student completed a test. As you can see in Figure 12.11, the practice scores in the blocked practice group were higher than those in the mixed group. However, the mixed practice group scored much better on the test.

Figure 12.11. Mixed Practice Leads to Poorer Practice Scores But Better Learning.

Based on data from Taylor and Rohrer, 2010.



Recall from Chapter 11 that varied context examples led to better learning than examples that used a similar cover story. The benefits of mixed practice may be based on a similar mechanism. By mixing together problems that must be discriminated in order to identify the most appropriate solution, learners receive much more discrimination practice. In situations where problem types are easy to discriminate, mixed practice may have less benefit.

Tips for Determining the Number and Placement of Practice Events

We have consistent evidence that practice interactions promote learning. However, the greatest amount of learning accrues on the initial practice events. Over-learning, at least in a structured domain such as mathematics, has not proven beneficial. We also know that greater long-term learning occurs when practice is distributed throughout the learning environment rather than all at once. In addition, when it's important to discriminate among different problem types, it's better to mix types during practice than to group them by the same type. To summarize our guidelines for practice we recommend that you:

- Analyze the task performance requirements:
  - Is automatic task performance needed? If so, is automaticity required immediately or can it develop during job performance?
  - Does the task require an understanding of concepts and processes along with concomitant reflection?
- For less critical tasks or for tasks that do not require automaticity, avoid over-learning that wastes time.
- Assign larger numbers of exercises when automaticity is needed.
- For tasks that require automatic responses, use the computer to measure response accuracy and response time. Once automated, responses will be both accurate and fast.
- Distribute practice among lessons in the course, within any given lesson, and among multiple learning events.
- In synchronous e-learning courses, extend learning by designing several short sessions of one to two hours with asynchronous practice assigned between sessions.

- When your goal is to teach discrimination among problem types, mix types together during practice rather than segregating them by type.

Practice Principle 5: Apply Multimedia Principles

In Chapters 4 through 9, we presented six principles for design of multimedia pertaining specifically to the use of graphics, text, and audio in e-learning. Here are some suggestions for ways to apply those principles to the design of practice interactions.

Modality and Redundancy Principles

According to the modality principle described in Chapter 6, audio should be used to explain visuals in your lesson. However, audio is too transient for practice exercises. Learners need to refer to the directions while responding to questions. Any instructions or information learners need in order to answer a question should remain in text on the screen while the learner formulates a response.

Previously in this chapter, we focused on the importance of explanatory feedback. Feedback should also be presented in text so that learners can review the explanations at their own pace. Based on the redundancy principle described in Chapter 7, use text alone for most situations. Do not narrate on-screen text directions, practice questions, or feedback.

Contiguity Principle

According to the contiguity principle, text should be closely aligned to the graphics it is explaining to minimize extraneous cognitive load. Since you will be using text for your questions and feedback, the contiguity principle is especially applicable to design of practice questions. Clearly distinguish response areas by placement, color, or font and place them adjacent to the question. In addition, when laying out practice that will include feedback to a response, leave an open screen area for feedback near the question and as close to the response area as possible so learners can easily align the feedback to their response and to the question. In multiple-choice or multiple-select items, use color or bolding to show the correct options as part of the feedback.

Recent research shows that contiguity applies also to the type of behavioral interaction required. Rey (2011) found greater transfer learning from a simulation in which learners adjusted parameters via either scroll bars or drag and drop than by text input. Having to split attention between the keyboard and the screen when inputting text depressed learning. We will need more research indicating the tradeoffs to different forms of physical engagement during e-learning.

Coherence Principle

In Chapter 8 we reviewed evidence suggesting that violation of the coherence principle imposes extraneous cognitive load and may interfere with learning. Specifically, we recommended you exclude stories and graphics added for entertainment value, complex graphics, background music and sounds, and detailed textual descriptions. Our bottom line is *less is usually more.*

We recommend that practice opportunities be free of extraneous visual or audio elements such as gratuitous animations or sounds (applause, bells, or whistles) associated with correct or incorrect responses. Research has shown that, while there is no correlation between the amount of study and grade point average in universities, there is a correlation between the amount of *deliberate practice* and grades. Specifically, research recommends study in distraction-free environments, that is, alone in a quiet room rather than with a radio or in a team leads to better learning (Knez & Hugge, 2002; Plant, Ericsson, Hill, & Asberg, 2005). During virtual classroom synchronous sessions, the instructor should maintain a period of silence during practice events.

Tips for Applying the Multimedia Principles to Your Interactions

- Include relevant visuals as part of your interaction design.
- Align directions, practice questions, and feedback in on-screen text so that learners can easily see all the important elements in one location.

- Minimize split attention in behavioral response required by using on-screen rather than keyboard input modes.
- Minimize extraneous text, sounds, or visuals during interactions.

Practice Principle 6: Transition from Examples to Practice Gradually

Completing practice exercises imposes a great deal of mental load. In Chapter 11, we showed evidence that using healthy doses of worked examples along with practice will result in more efficient learning. In fact, faded worked examples are a proven strategy to impose load gradually as learners gain expertise. Start with a full worked example and gradually increase the amount of work the learner must perform, ending with a full practice assignment, as described in Chapter 11.

What We Don't Know About Practice

We conclude that, while practice does not necessarily lead to perfect, deliberate practice that includes effective feedback does. We still need to know more about the best types of feedback to give. For example, should feedback be detailed or brief? Is feedback provided immediately after a response always most effective? Finally, we need to know more about the source of feedback. In some situations, guided peer feedback has proven effective. Under what conditions can peer feedback supplement instructor feedback?

DESIGN DILEMMA: RESOLVED

The pharmacological sales design team had disagreements about the type of practice and practice feedback to include in the new product lesson leading to the following alternatives:

A. Adding some familiar and fun games like Jeopardy will make the lesson more engaging for learners and lead to better learning.

B. It would be better to use physician scenarios as the basis for interactions.

C. The extra time invested in writing tailored feedback explanations for practice responses will pay off in increased learning.

Based on the research we have summarized in this chapter, we recommend Options B and C. Games like Jeopardy reinforce factual level learning. Instead, questions that require learners to apply factual information to a work-realistic scenario would mirror the job and promote transfer of learning. Regarding Option C, we have evidence that explanatory feedback does pay off in additional learning.

WHAT TO LOOK FOR IN e-LEARNING

- ☐ Job-relevant overt practice questions that require participants to apply new content in authentic ways
- ☐ Feedback that not only tells the respondent whether an answer is correct or incorrect but gives an explanation as well
- ☐ Explanatory feedback that focuses on the task or on the task process
- ☐ The number of practice opportunities reflects the criticality of the job skills and the need for automaticity
- ☐ Practice exercises distributed throughout the learning event
- ☐ For less critical tasks that do not require over-learning, fewer practice exercises
- ☐ For learning to respond to categories of problems, practice interactions mix categories
- ☐ Practice exercises that minimize extraneous cognitive load by applying appropriate multimedia principles
  - Use relevant visuals
  - Use text to provide directions and feedback close to related visuals or response areas
  - Avoid split attention with response formats
  - Avoid gratuitous sounds or other distractions
- ☐ Faded worked examples that end in a practice assignment

COMING NEXT

From discussion boards to blogs to breakout rooms and social media, there are numerous computer facilities for synchronous and asynchronous forms of collaboration among learners and instructors during e-learning events. There has been a great deal of research on how to best structure and leverage online collaboration to maximize learning. Unfortunately, we still have few solid guidelines from that research. In the next chapter we look at what we know about online collaboration and learning.

Suggested Readings

Hattie, J., & Gan, M. (2011). Instruction based on feedback. In R.E. Mayer & P.A. Alexander (Eds.), *Handbook of research on learning and instruction.* New York: Routledge.

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