CHAPTER OUTLINE

Segmenting Principle: Break a Continuous Lesson into Bite-Size Segments

Psychological Reasons for the Segmenting Principle

Evidence for Breaking a Continuous Lesson into Bite-Size Segments

Pretraining Principle: Ensure That Learners Know the Names and Characteristics of Key Concepts

Psychological Reasons for the Pretraining Principle

Evidence for Providing Pretraining in Key Concepts
10

Applying the Segmenting and Pretraining Principles

MANAGING COMPLEXITY BY BREAKING
A LESSON INTO PARTS

WHAT’S NEW IN THIS CHAPTER?

IN SOME OF THE PREVIOUS CHAPTERS you learned how to reduce extraneous processing (that is, processing caused by poor instructional design), by eliminating extraneous words and pictures (Chapter 8), by placing corresponding words and illustrations near each other on the screen (Chapter 5), or by refraining from adding redundant on-screen text to a narrated animation (Chapter 7). In Chapter 2, we introduced the concept of essential cognitive processing that results from the complexity of the material. In this chapter we focus on situations in which learners must engage in so much essential processing that their cognitive systems are overwhelmed. In particular, in this chapter we focus on techniques for managing essential processing, including segmenting (breaking a lesson into manageable segments) and pretraining (providing pretraining in the names and characteristics of key concepts). This chapter represents an update on the growing research base on techniques for managing the learning of complex material.
DESIGN DILEMMA: YOU DECIDE

The Excel lesson team is working on their lesson design. They have completed their job analysis and identified five key steps involved in setting up a spreadsheet. Sergio, the subject-matter expert, offers the team an outline. “Here”, he says, “let me save you some time. This is the outline I use when I teach in the classroom. (See Sergio’s outline in Figure 10.1) It works really well because I teach one step at a time.”

“Thanks, Serg. It really helps to have the content broken out,” Reshmi replies, “but after I reviewed our job analysis, I came up with a slightly different sequence. Take a look.” (See Reshmi’s outline in Figure 10.1). After reading Reshmi’s outline, Sergio reacts: “Wow, Reshmi! I think your outline is confusing. My plan places all of the key concepts with each step. That way they learn each concept in the context in which they will use it! We can use that new screen capture tool to run my slides continuously while the narration plays.” Reshmi is not convinced by Sergio’s argument: “Yes, but your plan lumps a lot of content together. I think it will overwhelm people new to Excel—and many of our learners will be new users.”

Figure 10.1. Two Organizational Sequences for the Excel Lesson.

<table>
<thead>
<tr>
<th>Sergio’s Outline</th>
<th>Reshmi’s Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Introduction</td>
<td>I. Introduction</td>
</tr>
<tr>
<td>II. Step 1 – Enter data in cells</td>
<td>II. What are cells</td>
</tr>
<tr>
<td>A. What are cells</td>
<td>III. What are cell references</td>
</tr>
<tr>
<td>B. What are cell references</td>
<td>IV. About formulas</td>
</tr>
<tr>
<td>III. Step 2 – Enter formula</td>
<td>V. Demonstration: Calculate Jan sales</td>
</tr>
<tr>
<td>A. What are formulas</td>
<td>VI. Practice: Calculate Feb sales</td>
</tr>
<tr>
<td>B. How are formulas formatted</td>
<td>VII. Absolute &amp; relative cell references</td>
</tr>
<tr>
<td>IV. Step 3 – Click on enter key</td>
<td>VIII. Demonstration: Calculate taxes owed</td>
</tr>
<tr>
<td>V. Step 4 – Identify unchanging variables</td>
<td>VIII. Practice: Calculate taxes owed</td>
</tr>
<tr>
<td>A. What are relative and absolute formulas</td>
<td></td>
</tr>
<tr>
<td>VI. Step 5 – Enter a relative and absolute formula</td>
<td></td>
</tr>
</tbody>
</table>

Sergio and Reshmi disagree about the sequencing of content as well as how to display the content. Based on your own experience or intuition, which of the following options would you select?

A. Sergio’s plan is better because it teaches all content in context of the procedure.
Chapter 10: Applying the Segmenting and Pretraining Principles

Segmenting Principle: Break a Continuous Lesson into Bite-Size Segments

How can you tell that material is so complex that it will overload the learner's cognitive system? A good way to gauge the complexity of a lesson is to tally the number of elements (or concepts) and the number of interactions among them. For example, consider a narrated animation on how a bicycle tire pump works that has the script: “When the handle is pulled up, the piston moves up, the inlet valve opens, the outlet valve closes, and air enters the cylinder. When the handle is pushed down, the piston moves down, the piston moves down, the inlet valve closes, the outlet valve opens, and air exits from the cylinder through the hose.” In this case there are five main elements—handle, piston, cylinder, inlet valve, and outlet valve. The relations among them constitute a simple chain in which a change in one element causes a change in the next element and so on. Overall, this is a fairly simple lesson that probably requires just two segments—one showing what happens when the handle is pulled up and one showing what happens when the handle is pushed down.

Next, consider a lesson on lightning formation, such as shown in Figure 10.2. This is a much more complex lesson because it has many more elements—warm and cold air, updrafts and downdrafts, positive and negative particles in the cloud, positive and negative particles on the ground, leaders and return strokes, and so on. This lesson can be broken into sixteen segments, each describing one or two major steps in the causal chain, such

B. Reshmi’s plan is better because she has separated the key concepts from the procedure.
C. It is better to let the lesson “play” like a video so learners have a continuous picture of the entire procedure.
D. It is better to let the learners control the sequence by selecting screens in small bites so they can work at their own rate.
E. Not sure which options are correct.
as, “Cool moist air moves over a warmer surface and becomes heated.” Each of the frames shown in Figure 10.2 constitutes a segment—involving just a few elements and relations between them.

As training professionals, you have probably worked with content that was relatively simple as well as with content that was more complex. For example, if you are teaching a class on editing text in Microsoft Word, you need to teach a four-step procedure. First, learners must use the mouse to select the text they want to edit. Second, they click on the scissors icon to cut the text from its present location. Next, learners place their cursors at the insertion point and click on the paste icon. This software procedure is quite linear and relatively simple. It is made easier by having only a few steps and by using onscreen icons that call up familiar metaphors such as scissors.
for cutting. However, in many cases, your content is more complex than this example. Even an introductory Excel class offers greater degrees of complexity. As you can see in Figure 10.3, constructing a formula in Excel can be quite complex for someone new to spreadsheets and to Excel. One of the key concepts involves the construction of a formula that uses the correct formatting conventions to achieve the desired calculation. For someone new to Excel, we would rate this as a more complex task than the word processing editing task.

When the material is complex, you can’t make it simpler by leaving out some of the elements or steps in the explanation—because that would destroy the accuracy of the lesson. However, you can help the learner manage the complexity by breaking the lesson into manageable segments—parts that convey just one or two or three steps in the process or procedure or describe just one or two or three major relations among the elements. We recommend that you break a complex lesson into smaller parts, which are presented one at a time. We call this recommendation the segmenting principle.
Psychological Reasons for the Segmenting Principle

Suppose that, as part of an e-course, the learner clicked on an entry for “lightning” from a multimedia encyclopedia and then watched a 2.5-minute narrated animation explaining lightning formation—as shown in Figure 10.2. The figure shows some of the frames in the animation along with the complete spoken script indicated in quotation marks at the bottom of each frame. As you can see, the lesson is complex—with many interacting elements—and is presented at a fairly rapid pace. If a learner misses one point, such as the idea that a cloud rises to the point that the top is above the freezing level and the bottom is below, the entire causal chain will no longer make sense. If a learner is unfamiliar with the material, he or she may need time to consolidate what was just presented. In short, when an unfamiliar learner receives a continuous presentation containing a lot of interrelated concepts, the likely result is that the cognitive system becomes overloaded—too much essential processing is required. In short, the learner does not have sufficient cognitive capacity to engage in the essential processing required to understand the material.

One solution to this dilemma that we recommend is to break the lesson into manageable parts, such as sixteen segments with a “Continue” button in the bottom right corner of each. Figure 10.4 shows an example of a frame from one of the segments. As you can see, the learner receives a short clip approximately ten seconds in length, along with one sentence describing the actions that are depicted. The learner can completely digest this link in the causal chain before clicking on the “Continue” button to go on to the next segment. This technique—which can be called segmenting—allows the learner to manage essential processing. Thus, the rationale for using segmenting is that it allows the learner to engage essential processing without overloading the learner’s cognitive system.

We saw that a lesson on Excel offers greater complexity than one on text editing. In a procedural lesson you can let an animated sequence play continuously, demonstrating how to complete a task such as construct or enter a formula. Alternatively, you can divide the procedure into two or three segments, presenting each one independently with a continue button. In the segmented version, the learner receives only a small amount of content and then clicks on the lower right hand “Continue” button when he or she is ready to move to the next small bite. For someone new to Excel, the segmented version will impose less mental load.
Evidence for Breaking a Continuous Lesson into Bite-Size Segments

The previous section tells a nice story, but is there any evidence that segmenting helps people learn better? The answer is yes. Mayer and Chandler (2001) carried out the study using the lightning lesson as described in the previous section. They found that learners who received the segmented presentation performed better on transfer tests than the learners who received a continuous presentation, even though identical material was presented in both conditions. In a similar study, prospective teachers who viewed a continuous twenty-minute video that demonstrated various exemplary teaching techniques performed worse on a transfer test than did students who received the identical video broken into seven segments, each focusing on one technique (Moreno, 2007).

In another set of studies (Mayer, Dow, & Mayer, 2003), students learned how an electric motor works by watching a continuous narrated animation or by watching a segmented version. In the segmented version, the learner could click on a question and then see part of the narrated animation, click on another question and see the next part, and so on. The material was identical for both the continuous and segmented versions, but learners performed much better on transfer tests if they had received the segmented lesson. Overall, in three out of three studies the results provided strong positive
effects for segmenting, yielding a median effect size of about 1. We conclude that there is tantalizing preliminary evidence in favor of segmenting, but additional research is needed.

Schar and Zimmermann (2007) compared learning from an animation lesson that played continuously without controls for pausing with an animation that included a pause button. Having a pause button would allow learners to stop and start the animation when they desired. They found no differences in learning in the two versions, primarily because most learners did not use the pause button, instead allowing the animation to play as a continuous presentation. Therefore, both experimental groups ended up with more or less the same treatments. The research team suggests that you design animated sequences to stop at a logical segment with a continue button for the learner to resume play, as shown in Figure 10.4. As we will see in Chapter 14, learners—especially novice learners—may not make good instructional decisions and instead benefit from greater instructional control. In other words, the lesson designer can best determine optimal segments and insert pauses at those points rather than relying on the learner to make that determination.

**Pretraining Principle: Ensure That Learners Know the Names and Characteristics of Key Concepts**

Segmenting appears to be a promising way to address the situation in which the learner is overloaded by the need to engage in essential processing—that is, the learner is overwhelmed by the amount of essential processing required to understand a complex lesson. In this section, we examine a related technique, which can be called the *pretraining principle*: Provide pretraining in the names and characteristics of the key concepts in the lesson. For example, before viewing a narrated animation on how the digestive system works, learners could receive pretraining in which they learn the names and locations of key body parts such as the esophagus, epiglottis, trachea, pharynx, upper esophageal sphincter, lower esophageal sphincter, and stomach.
We mentioned previously that for a new student or instructor, using the various facilities in the virtual classroom can be overwhelming. Therefore, we recommend a quick orientation session at the start of a virtual classroom session that applies the pretraining principle. During the orientation, the instructor can show the different parts of the virtual classroom, as in Figure 10.5, followed by some introductory exercises during which each student uses those facilities. We also categorized learning how to use Excel formulas as another complex task. To apply the pretraining principle, the lesson shown in Figure 10.6 begins by teaching formula formatting conventions. Following this portion of the lesson, the instructor demonstrates the procedure of how to enter a formula into a spreadsheet.

Figure 10.5. Pretraining Illustrates the Parts and Functions of the Virtual Classroom Interface.

Psychological Reasons for the Pretraining Principle

The pretraining principle is relevant in situations when trying to process the essential material in the lesson would overwhelm the learner's cognitive system. In these situations involving complex material, it is helpful if some of the processing can be done in advance. When you see a narrated animation on how the digestive system works, for example, you need to build a cause-and-effect model of how a change in one part of the system causes a change in the next part and so on, and you need to understand what each part does. We can help the learner understand the cause-and-effect chain by making sure the learner already knows the name and characteristics of each part. When you hear a term like “upper esophageal sphincter” in a narrated animation, you need to try to figure out what this term refers to and how it works. Learners who are more familiar with the content area may not need pretraining because they already know the names and characteristics of key
concepts. In short, pretraining can help beginners to manage their processing of complex material by reducing the amount of essential processing they do at the time of the presentation. If they already know what terms like “upper esophageal sphincter” mean, they can devote their cognitive processing to building a mental model of how that component relates to others in the causal chain. Thus, the rationale for the pretraining principle is that it helps manage the learner’s essential processing by redistributing some of it to a pretraining portion of the lesson.

To implement the pretraining principle, evaluate the material you need to teach—such as a procedure or how a process works. If it is complex for your audience, then identify key concepts that could be presented prior to teaching the main lesson. For example, you could begin with a short section on the key concepts, even including a practice exercise on them. For example, in Figure 10.7 we show an example that applies both segmenting and

Figure 10.7. This Lesson Applies Both Segmenting and Pretraining Principles.
With permission from Raytheon Professional Services.
pretraining to a technical lesson on how transmissions work. Tabs are used to segment content into small chunks and the names of the parts of the transmission are labeled in the first tab. Note, however, in this example as well as in Figure 10.5, the parts are shown in the context of the entire screen interface or equipment sketch. In this way, the individual parts shown during pretraining maintain the context to the whole environment. After the pretraining, you can move into the main lesson—such as describing how to carry out a procedure or how a process works.

Evidence for Providing Pretraining in Key Concepts

Suppose we asked some learners to watch a sixty-second narrated animation on how a car’s braking system works (that is, no pretraining condition), containing the script: “When the driver steps on a car’s brake pedal, a piston moves forward in the master cylinder. The piston forces brake fluid out of the master cylinder and through the tubes to the wheel cylinders. In the wheel cylinders, the increase in fluid pressure makes a smaller set of pistons move. Those smaller pistons activate the brake shoes. When the brake shoes press against the drum, both the drum and the wheel stop or slow down.” Figure 10.8 shows part of the animation that goes with this script. As you can see, this lesson is somewhat complex, partly because it contains some unfamiliar terms. It describes interactions

Figure 10.8. Part of a Multimedia Presentation on How Brakes Work.
among many parts such as brake pedal, piston in master cylinder, brake fluid in tube, pistons in wheel cylinders, brake shoes, drum, and wheel. The learner must learn the relations among the parts as well as the characteristics of the parts themselves.

What can be done to provide some pretraining so the learner can be relieved of some of the essential processing during the narrated animation? Mayer, Mathias, and Wetzell (2002) constructed a short pretraining episode in which learners saw a labeled diagram of the braking system on the screen and could click on any part, as shown in Figure 10.9. When they clicked on a part, they were told the name of the part and its main characteristics. In three separate studies, learners who received this kind of pretraining before the narrated animation performed better on transfer tests than did learners who did not receive pretraining, yielding a median effect size of .9. The results from one of these studies is shown in Figure 10.10.

In an e-learning environment, students learned to solve electronics troubleshooting problems better if they received factual information before training, rather than within the context of training (Kester, Kirshner, & van
Merrienboer, 2006). In another set of studies (Pollock, Chandler, & Sweller, 2002), electrical engineering trainees took a course that included a multimedia lesson on conducting safety tests for electrical appliances. The no-pretraining group was shown how all the electrical components worked together within an electrical system. The pretraining group first was shown how each component worked individually. Across two separate experiments, the pretraining group outperformed the no-pretraining group on transfer tests, yielding effect sizes greater than 1. Overall, there is encouraging preliminary evidence for the pretraining principle, but an important possible boundary condition is that the effect may be strongest for low-knowledge learners (Pollock, Chandler, & Sweller, 2002).

What We Don’t Know About Segmenting and Pretraining

Research on segmenting and pretraining is not as well developed as research supporting other principles in this book, so we need a larger research base that examines whether the effects replicate with different materials, learners, and learning contexts. We do not yet know how big a segment should be, that is, we need to determine how much information should be in a bitesized chunk. Should a segment last for ten seconds, thirty seconds, sixty seconds, or more? How do you determine where to break a continuous lesson into meaningful segments? The issue of how much learner control is optimal is examined in Chapter 14, but also is not a resolved issue. We also
do not yet know how best to identify key concepts that should be included in pretraining or how extensive the pretraining needs to be. Is it enough for learners to simply know the names and locations of the key components in a to-be-learned system? Also, there may be situations in which learning will be better when key concepts are presented in the context of an authentic task such as in whole-task learning designs. We will discuss these designs in more detail in Chapter 15. Answering these questions depends, in part, on the characteristics of the learner, especially the learner’s prior knowledge.

**DESIGN DILEMMA: RESOLVED**

The Excel e-learning team was debating the best way to sequence and to display their content. The options considered were:

A. Sergio’s plan is better because it teaches all content in context of the procedure.

B. Reshmi’s plan is better because she has separated the key concepts from the procedure.

C. It is better to let the lesson “play” like a video so learners have a continuous picture of the entire procedure.

D. It is better to let the learners see the lesson in small bites so they can work at their own rate.

E. Not sure which options are correct.

Our first question is whether setting up a spreadsheet is a complex task. The answer is “yes” for learners who are new to electronic spreadsheets. There are a number of concepts to consider and to weigh when setting up a spreadsheet. Given a complex instructional goal, we recommend applying the segmenting and pretraining principles suggested in Options B and D. We do agree that it’s a good idea to teach the supporting concepts in job context and recommend that these concepts be shown in the context of setting up a simple spreadsheet. If you plan to use an animated sequence, we recommend that you pause the animation at logical intervals, giving the learner the option to replay or continue the animation when he or she is ready.
WHAT TO LOOK FOR IN e-LEARNING

☐ Material is presented in manageable segments (such as short clips of narrated animation) controlled by the learner, rather than as a continuous unit (such as a long clip of narrated animation).

☐ Animation sequences pause at logical segments with provision of a replay or continue button.

☐ Key concepts are named and their characteristics are described before presenting the processes or procedures to which the concepts are linked.

☐ Concepts or terms included in pretraining are introduced in the context of the whole process or procedure.

COMING NEXT

One of the most popular and powerful instructional techniques is the example. Just about all effective lessons incorporate examples. What is the best way to use examples in your e-lessons? How can examples actually accelerate learning? How can you make examples engaging? In the next chapter you will learn important guidelines and the evidence behind the guidelines for the best design, placement, and layout of examples in your e-learning.

Suggested Readings

