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Investigating the Importance of Detail Interest Level and Learning Objectives on the Seductive Detail Effect

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INVESTIGATING THE IMPORTANCE OF DETAIL INTEREST LEVEL AND LEARNING OBJECTIVES ON THE SEDUCTIVE DETAIL EFFECT

By

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Preface

This thesis is intended for publication. The initial idea for the project described herein was from Dr. Kelly Steelman. The experimental design, data collection, and analyses described in Chapters 3, 4, and 5 are my original work performed under the guidance of Dr. Steelman. I wrote the manuscript under the careful review of Dr. Steelman.

Acknowledgments

I want to express my gratitude and thanks to my advisor, Dr. Kelly Steelman, for choosing a non-traditional student with all of the associated headaches. I have learned more things from you than I could possibly enumerate. If it's true that we all eventually turn into our advisor, I would be quite proud to be just like you.

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Abstract

The inclusion of interesting but irrelevant details in instructional materials may result in the seductive detail effect, in which the details interfere with learning, recall, and application of core material. Although numerous studies have documented this effect, questions remain about exactly when it occurs, as various factors moderate the effect (Rey, 2012b) and confounds make it difficult to interpret previous results (Goetz & Sadoski, 1995). Here, two studies examined the role of seductive detail interest level and the availability of learning objectives on performance, while controlling for possible confounds. Study 1 found no evidence for either an objective or seductive detail effect. Study 2, utilizing a revised set of seductive details, did demonstrate a seductive detail effect; however, contrary to expectations, the effect emerged only when learning objectives were available. These findings and the implications for developing meaningful guidelines for educators are discussed within the context of the larger literature.

Chapter 1: Introduction

Educators have long struggled with the issue of how to engage learners when the learners may not find the content of the lesson inherently interesting. In fact, as far back as the early 1900s, educational philosopher and psychologist John Dewey discussed the significant role that interest plays in education. However, he also warned against using “fictitious inducements to attention” (Dewey, 1913, p. 7), contending that attempting to artificially enhance interest does nothing to alter the underlying interest level of the content and that interest cannot be externally imposed (Dewey, 1913). However, when faced with students who are continually bombarded with tweets, memes, and other viral media that compete for their attention, educators may be tempted to try to outdo the competition by enhancing not-so-interesting educational materials with spiced-up details, jokes, cartoons, fun facts, videos, animations, songs—anything that may capture and hold learners’ attention, even if the information is not directly relevant to what is being taught.

These types of enhancements are often referred to as *seductive details*. Seductive details are defined by Harp and Mayer (1997) as “interesting but irrelevant details that are added to a passage to make it more interesting.” Similarly, they are described as “propositions presenting irrelevant details—interesting, but unimportant, information” by Garner, Gillingham, and White (1989). Often, these details contain information that is tangential to the main ideas of a lesson, but that may be memorable because it is

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The material in this chapter is being prepared for submission to a journal.

related to newsworthy or even lurid topics, including death, celebrities, and sex (Lehman, Schraw, McCrudden, & Hartley, 2007). Although the details are irrelevant, the motivation for including them is to try to keep learners engaged with the core material, even if it is not interesting to them, so they will be better able to recall and apply it.

Seductive details can occur in almost any form. Most research has examined the seductive details in the form of text and illustrations (Harp & Mayer, 1997, 1998), but some studies have investigated seductive details in other formats, including animations (Mayer & Moreno, 2000), photos (Sung & Mayer, 2012), video clips (Mayer, Heiser, & Lonn, 2001), sounds (Mayer & Moreno, 2000), page “decorations” such as colorful lines or images added to headers and footers (Rey, 2012a), music (Mayer & Moreno, 2000), and details incorporated into spoken lectures (Harp & Maslich, 2005).

To study the effect of seductive details on learning, researchers typically embed the seductive information within some type of informational text. The seductive details that are added are not necessary to achieve the lesson’s learning objectives (Garner, Gillingham, & White, 1989). For example, a lesson about volcanoes may include objectives such as how they develop, which types of volcanoes exist, and where future volcanoes are most likely to occur. Another objective could be to learn about some of the world’s most famous eruptions, such as the 79 A.D. eruption of Mount Vesuvius, which buried Pompeii and Herculaneum, and its massive pyroclastic surge. To add interest to this material, gory details about the victims’ deaths might be included, such as the fact that some of the Pompeii victims died because the intense heat boiled their brains (Hall,

2007). If something like “causes of death” is not included on the list of learning objectives for this lesson, the gory information would be classified as seductive details.

But does the irrelevant information about boiled brains help these students learn the important, core information about volcanoes? Could it possibly have the opposite effect and harm student learning? That is what is posited by the *seductive detail effect*, which holds that people learn more deeply from material that does not include seductive details and that these details may impede learning (Mayer, 2009). Although the purpose of including seductive details is to grab learners’ attention and thereby increase the amount and quality of their learning, learners who encounter seductive details may expend more resources on those details than on the important information being conveyed. A large body of research has found that seductive details can cause learners to recall less of the structurally critical content and more of the irrelevant content (Garner, Brown, Sanders, & Menke, 1992; Wade & Adams, 1990) and to perform worse on problem-solving or transfer tasks (Harp & Mayer, 1997, 1998).

The problem is that, even if educators are aware of the seductive detail effect and refrain from adding seductive information to their materials, students enjoy that type of information and may even expect lessons to include jokes, fun facts, or gory or salacious details. In academia, anecdotal information is often heard about professors whose classes and materials are entertaining and are, therefore, ranked highly by students. Marshall McLuhan famously said: “Anyone who tries to make a distinction between education and entertainment doesn’t know the first thing about either” (McLuhan, 1967, p. 66). McLuhan was discussing information overload in the

electronic age and the fact that students are so very distracted. In fact, some educators find themselves feeling they need to entertain students in order to hold their attention (Logan, 2012). The question to be answered is whether or not the seductive details—the interesting, entertaining information added to lessons and classes—helps or hinders student learning.

Although the seductive detail effect has been well documented, many questions and issues have been raised. Several researchers have pointed out inconsistent results, confounds, and methodological issues with prior studies, leaving it unclear whether educators should add information to capture learners' attention and keep them interested or purge extraneous information that may reduce their ability to learn and apply their knowledge. Or could it be that adding details that help to maintain learners' attention is worth some level of learning degradation that may be caused by the seductive detail effect?

The current project was developed as a first step in testing aspects of the seductive detail effect in order to answer questions (e.g., does the availability of learning objectives reduce the seductive detail effect?), resolve potential issues (e.g., eliminate confounds such as word count), and provide educators and instructional designers with specific guidelines for when—and if—seductive details can harm or help students' learning.

The remaining chapters in this thesis are organized as follows. Chapter 2, "Theoretical Foundations and Background," provides a review of the cognitive theories underlying the seductive detail effect, discusses some of the possible causes of the

effect, and summarizes some of the main research studies that have been conducted on the effect. In addition, it reviews past studies to reveal what has been discovered, along with the limitations of those studies. Chapter 3 presents a study designed to replicate prior studies; the study eliminates some of the confounds of prior studies, including word count and reading level, and, further, tests the effect of the availability of learning objectives, a manipulation that has not received much attention in prior studies. Chapter 4 describes a study that built upon the work begun in the first study by improving the materials (e.g., using a different method of selecting the extraneous details) and addressing other potential methodological issues (e.g., adding a control condition and improving the objectives process), and capturing subjective data related to participants' perceptions of learning. Finally, Chapter 5 discusses the overall project and provides some suggestions and ideas for future work related to the seductive detail effect.

Chapter 2: Theoretical Foundations and Background

Cognitive Load Theory

To achieve strong instructional design, it is critical to understand human cognitive structures and how they are organized into a cognitive architecture. Cognitive load theory (CLT), developed in the 1980s, is one of the main theories that has been used to help apply our knowledge of cognitive structures to instructional design (Sweller, 1988).

The architecture upon which CLT is based centers on a limited-capacity working memory system. Working memory is where we store and manipulate knowledge and perform processing that involves our conscious attention (Baddeley & Hitch, 1974), and it comprises independent processing units for visual and auditory information. Working memory interacts with a virtually unlimited long-term memory (Paas, Renkl, & Sweller, 2003), but working memory is limited in terms of both capacity and duration. While it is often stated that working memory is able to hold about seven elements of information at any time (Miller, 1956), others have suggested that it can probably process "in the sense of combine, contrast or manipulate no more than about two to four novel elements" (Paas & Sweller, 2014, p. 33). In terms of duration, almost all of working memory's content is lost within about 20 seconds, assuming no rehearsal (Peterson & Peterson, 1959).

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Working memory's limitations apply only to new information that is brought into working memory from sensory memory, which stores information from our senses; working memory also uses information that has been previously processed and stored in long-term memory. In long-term memory, information can be stored as schemas, which are frameworks that help us interpret and organize categories of information and mentally represent the relationships between them. Schemas increase the amount of information that can be brought into working memory by grouping sets of information into single units, effectively expanding working memory capacity (Sweller, 1994). Learning takes place when a change occurs in long-term memory, and understanding occurs when all elements of information needed to understand a topic can be processed at the same time in working memory (Paas & Sweller, 2014, p. 36).

CLT suggests that learners can absorb and learn information only if it is presented in a way that does not overload working memory. Instructional designers must, therefore, be mindful of learners' cognitive load, which is the total amount of effort imposed on working memory at a given time by the information being presented (Paas & Sweller, 2014). CLT posits three types of cognitive load—intrinsic, extraneous, and germane—and each type relates to the acquisition, storage, and use of information. Designers do not have control over all three types of cognitive load, but they can help reduce the load by, for example, breaking lessons into smaller segments, dividing information between the visual and verbal channels, and taking advantage of learners' existing schemas to help reduce the load.

Intrinsic cognitive load is due to the inherent complexity of the information that must be processed and is determined by the amount of element interactivity (Sweller, 2010). For example, if a student's task is to learn a list of parts and the purpose of each one, the amount of element interactivity and, therefore, the amount of intrinsic cognitive load, is likely to be low; it is possible to know what a specific part does without knowing what any of the other parts do. On the other hand, if the student is expected to understand how all of the parts connect and work together as a system, he or she must be able to take into account all of the individual parts and their relationships simultaneously; this high level of interactivity results in high intrinsic cognitive load. Intrinsic load is described as being fixed, for a given task with specific knowledge level requirements (Paas & Sweller, 2014). This type of cognitive load can be reduced only by simplifying the nature of the task, such as by breaking it down into smaller chunks, or by increasing the knowledge level of the learners.

Cognitive load can also be imposed by the instructional design: when it is ineffective for learning, it is called *extraneous cognitive load*; when it is effective for learning, it is referred to as *germane cognitive load* (Sweller, 1988).

High levels of element interactivity may also cause *extraneous cognitive load*. In this case, however, the load is due to inappropriate instructional design that increases the number of interactive elements that learners need to process (Sweller, 2010). Some other causes of extraneous load are inserting irrelevant charts or graphs that require extra processing by the learner and creating an interface for an e-learning course that makes reference tools such as dictionaries difficult to find. As a result, learners must use

their limited working memory resources for processing that does not lead directly to the required knowledge acquisition. To reduce or eliminate extraneous cognitive load, instructional designers need to redesign the instructional materials (Paas & Sweller, 2014). For example, one way a designer can reduce cognitive load is to avoid overloading the visual channel by replacing some visual information with auditory information, thereby dividing the working memory load over two channels. This could be done by presenting pictures or animations with audio narration, rather than presenting the narration as on-screen text (Mayer & Moreno, 1998).

While both intrinsic and extraneous cognitive load are related to the characteristics of the learning material, *germane cognitive load* is concerned only with learner characteristics. Germane load does not constitute an independent source of cognitive load. Rather, it refers to the working memory resources that the learner devotes to dealing with the intrinsic cognitive load imposed by the material (Paas & Sweller, 2010). If intrinsic cognitive load is high and extraneous load is low, germane cognitive load will be high, because the learner is able to devote much of her working memory resources to the important material. If extraneous cognitive load increases, germane cognitive load and, thus, learning is reduced: the learner must direct working memory resources toward extraneous elements imposed by the instructional design rather than toward the essential material. Germane load involves the selection of specific instructional design techniques and strategies that teach learners how to learn—for example, rehearsing, over-learning, and using mnemonics. However, such strategies will be effective only if they are at an appropriate level of difficulty for the

learner and when learners are willing to invest effort in them (Paas & Van Gog, 2006).

Considering the three types of cognitive load, the goal of instructional design should be to manage intrinsic load and reduce extraneous load in order to make more working memory resources available for germane load. If fewer working memory resources are devoted to dealing with extraneous cognitive load, more resources will be available to deal with intrinsic cognitive load and germane load (Paas & Sweller, 2014).

Cognitive Theory of Multimedia Learning

Over the last 25 years, Richard Mayer and colleagues have investigated many of the issues related to the effects of instructional materials on cognitive load. Mayer developed a cognitive theory of multimedia learning (CTML), centered on the principle that learners attempt to build meaningful connections between words and pictures and learn more deeply from words and pictures than from words or pictures alone (Mayer, 2009). According to CTML, one of the principle aims of multimedia instruction is to encourage the learner to build a coherent mental representation, or schema, from the presented material. The learner's job is to make sense of the presented material as an active participant, ultimately constructing new knowledge. To many of us, the term "multimedia" might seem to imply computer-based training or presentations involving other technology, but it is important to note that Mayer's definition of multimedia learning includes all types of learning in which people "build mental representations

from words (such as spoken text or printed text) and pictures (such as illustrations, photos, animation, or video)" (Mayer, 2014, pp. 2-3). Multimedia instruction scenarios can range from a tour of a virtual reality environment that includes sights and sounds, to an instructor drawing on a whiteboard while delivering a lecture verbally, to a textbook that contains text and illustrations.

Figure 1 provides an overview of how information is processed according to CTML. The illustration shows that two separate, but connected, subsystems are used for processing visual and auditory information, as in CLT. When we see or hear information, it initially passes through sensory memory. Because the sensory memory channels have limited capacity, we are unable to take in all of the information to which we are exposed; we must select the words or images that we find relevant and store those in working memory as mental representations of the actual sounds and images. Next, we organize the words and images by making connections between them to develop coherent models. Finally, we integrate the verbal and pictorial models with prior knowledge that we have stored in long-term memory.

The CTML is based on three cognitive science principles of learning: the dual-channel assumption, the limited capacity assumption, and the active processing assumption (Mayer & Moreno, 1998; Mayer, 2003).

As discussed earlier, the *dual-channel assumption* contends that working memory has separate, but interconnected, auditory/verbal and visual/pictorial channels. It is based on Baddeley's (1974) theory of working memory and Paivio's (1986; Clark and Paivio, 1991) dual-coding theory. Paivio's (1990) theory assumes that we have

separate systems for processing verbal (words) and non-verbal (pictures, smells, and sounds) information as discussed above.

The *limited capacity assumption* is based on cognitive load theory (Sweller, 1988, 1994) and states that each of the two working memory channels can process a limited amount of information at one time.

The *active processing assumption* suggests that "people actively engage in cognitive processing in order to construct a coherent mental representation of their experiences" (Mayer, 2014, p. 50). Active learning requires three main cognitive processes: selecting relevant words and images for transfer to working memory, mentally organizing the selected words and images into a coherent model in working memory, and integrating the models with each other and with relevant knowledge from long-term memory. Active processing is required for learning to occur, and much of this cognitive processing takes place in working memory.

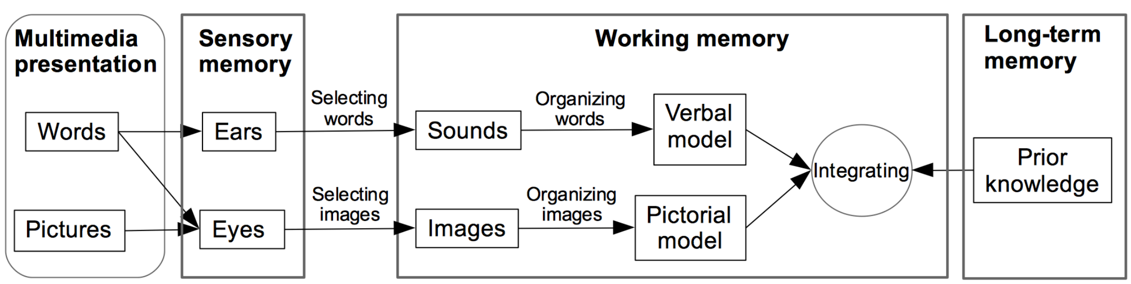

Figure 1. Mayer's cognitive theory of multimedia learning. Boxes represent memory and arrows represent cognitive processes. (Stanislaus Erhardt, 2013, via Wikimedia Commons. Used and adapted under Creative Commons Attribute 3.0 License.)

The task of instructional designers is to create situations in which learners have enough resources to organize information into a coherent mental model and integrate it with prior knowledge, without overloading learners' working memory capacity. Similar to CLT, CLTM defines three types of demands on a learner's information processing system that designers should consider when developing multimedia resources: essential processing, generative processing, and extraneous processing.

Mayer's *essential processing* is analogous to intrinsic cognitive load in CLT. Essential processing is needed to comprehend the material and to represent the material in working memory. It is caused by the inherent complexity of the material—how many interacting elements must be kept in working memory at one time (DeLeeuw & Mayer, 2008).

Mayer defines *generative processing* as "cognitive processing aimed at making sense of the presented material…caused by the learner's motivation to learn" (Mayer, 2014, p. 60). Generative processing encompasses reorganizing incoming information and integrating it with prior knowledge. It is analogous to CLT's germane processing. Some strategies that promote generative processing are summarizing, self-testing, drawing, and imagining.

Similar to CLT's extraneous cognitive load, *extraneous processing* is processing that does not support the instructional goal. It is caused by poor instructional design.

The instructional design goals under CTML are to establish effective techniques to reduce extraneous processing, manage essential processing, and foster generative processing (Mayer, 2014, p. 63). The challenge for instructional designers is to avoid

extraneous overload, which occurs when essential cognitive processing and extraneous cognitive processing exceed a learner's cognitive capacity (Mayer and Fiorella, 2014). This type of overload can occur when either the visual or verbal processing channel—or both—is overloaded. It can occur when materials contain "too much detail, embellishment, or gratuitous information or when the layout of material is confusing" (Mayer and Fiorella, 2014, p. 281).

CTML has yielded theory-based instructional design principles designed to reduce extraneous overload. One of these is the *coherence principle*, which states that people learn more deeply from multimedia when extraneous material is excluded (Mayer, 1999). Employing the coherence principle enables instructional designers to eliminate interesting but irrelevant information—seductive details—in their materials so that learners have more cognitive capacity available for essential (intrinsic) processing.

Empirical Findings of the Seductive Detail Effect

A substantial number of studies have examined the seductive detail effect since the 1980s. Most of the studies compare learning outcomes for core material with core material that has been embellished with text, illustrations, photos, video, or other seductive material that is not required for learning the core material. The outcome measures are typically a recall test score and a transfer or problem-solving test score. Transfer tests are used to measure student understanding; prior research has shown that learners who remember information well may not be as adept at applying that information in solving problems (Harp & Mayer, 1997).

Results have been inconsistent, with some studies indicating that seductive details have a negative effect on learning, others not demonstrating any effect that could be attributed to the details, and still others showing positive effects. In many studies, the inclusion of seductive details reduced the ability of learners to recall structurally important ideas from the core material (Garner et al., 1989; Harp & Mayer, 1998), and learners were better able to recall interesting details than important details (Wade & Adams, 1990). In addition, learners showed reduced ability to solve problems or apply knowledge that required learning the main ideas from the core material (Harp & Mayer, 1997). However, other studies showed positive learning effects from seductive details (Park, Moreno, Seufert, & Brünken, 2011), mixed results (Mayer, Griffith, Jurkowitz, & Rothman, 2008; Sanchez & Wiley, 2006), or no effects (Schraw, 1998).

This section highlights the research in some of the seminal papers, grouped according to the main topics that were investigated or unique areas that were tested.

Interest level and importance level of text. Some of the earliest studies on seductive details were published by Garner et al. (1989), and they established a paradigm that is still generally followed: develop some main content ideas, write some interesting information that may relate to but does not directly support the main ideas, rate that information for interest level and importance, and test people on what they recall. In their first study, the participants—academically proficient graduate students—were asked to read a three-paragraph text about insects that either did or did not contain additional, seductive information. The researchers ensured that the details they manipulated were not extra details that supported the paragraphs' macropropositions, or

main ideas; rather, they were truly seductive, consisting of interesting, but unimportant, information.

Participants were asked to recall "just the really important information" they had read, which should have been the main idea in each of the three paragraphs, to assign the text an overall interest rating, to indicate which piece of information they thought was most interesting, and to perform a matching task related to the content. The researchers expected the participants to rate the seductive details text as more interesting; they did not expect that the readers would be seduced into rating the seductive details as important or into not flagging the main ideas as important. In addition, they did not predict that including the irrelevant details would affect processing of the subordinate details that *were* relevant.

However, the results indicated that participants who read the text that included seductive details recalled about 43% of the main ideas, while those who read the text that did not include seductive details remembered an average of 93% of the main ideas (Garner et al., 1992). When specifying which information was really important, participants exposed to the seductive details listed some of the main ideas along with some of the seductive details. In addition, 30% of the seductive detail participants rated one of the seductive details as the most interesting piece of information in the text. Surprisingly, participants in both conditions rated the overall interest level of the text at 3 on a 5-point scale. The seductive detail effect size for recall of the main ideas was Cohen's *d* of 2.29 (Rey, 2012b).

One issue with this study, and many of the seductive detail studies that followed, was that the text passage containing seductive details was much longer than the passage without the details. It is possible that participants who read the seductive details had difficulty recalling the main ideas simply because they had more text to recall and had not received any cues as to what was important. In addition, when performing the unstructured recall task, participants were instructed to remember "just the really important information you read about insects, not all the information, just the really important information." It seems that some people might find this task challenging unless they were provided with some context, such as the purpose of recalling the information, or a definition of "really important" information (important for what or to whom?).

Two additional experiments examined whether seductive details were interesting primarily because they stood out from core text that was uninteresting (Garner, Alexander, Gillingham, Kulikowich, & Brown, 1991). Students—and teachers—often rate expository text in textbooks as basically uninteresting, and textbooks often contain asides that consist of seductive details. In these studies, seductive details were added to text passages about Stephen Hawking that were rated as either generally interesting or uninteresting. Their recall of the material was measured in an unstructured recall activity (participants were asked to recall the really important information), in a brief recall test (five short-answer questions), and in an activity asking them to provide a title for the passage they had read. The results showed that, in both studies, more than the

80% of participants remembered the moderately interesting information, while the high-interest details were recalled by 35% of participants in one study and 17% in the other.

In these two studies, statistically, *no seductive detail effect was found* in unstructured recall test results, and *positive effects* of seductive details were found in structured recall results (Rey, 2012b). Although these studies are often cited as evidence of the seductive detail effect, they do not indicate that a seductive detail effect exists, mainly because of the lack of a control that did not contain seductive details (Goetz & Sadoski, 1995).

Another set of experiments found no performance differences on recall tests between learners exposed to high- or low-interest details; however, participants exposed to the high-interest details scored lower on the transfer tests (Mayer et al., 2008).

Emotional vs. cognitive interest. A set of experiments by Wade and Adams (1990) attempted to differentiate between the types of interestingness in the seductive details and the main ideas, based on Kintsch's (1980) definitions of cognitively interesting and emotionally interesting. The main ideas were *cognitively interesting*: content that is novel to the reader, potentially arousing a desire to learn more about the unknown. The seductive details were *emotionally interesting*: content that has an affective impact and relates to the human condition, focusing on topics such as death, power, money, and sex. Kintsch thought the best approach was to present text that appealed to both cognitive interest and emotional interest.

Four categories of sentences were established: high importance, high interest (main ideas), high importance, low interest (supporting details), low importance, high

interest (seductive details), and low importance, low interest (common events in a person's history unrelated to the main ideas). Participants read the passage and were then asked to complete an unstructured recall task either immediately after reading the text or one week later. The category of information remembered best was the seductive details (low importance, high interest), followed by the main ideas (high importance, high interest). In other words, high-interest text was most memorable, regardless of its importance; this was true for both high-ability and low-ability readers. Least memorable were the supporting details (high importance, low interest).

This is one of the few seductive detail studies that included a delayed recall test, which is likely more realistic than the typical immediate recall tests. Recall scores were higher for those who tested immediately, and the high-interest text was most memorable for both the immediate and delayed testers.

Seductive details in other media. In the studies described above, the seductive details were in the form of text but, as mentioned earlier, the seductive detail effect has been tested with details in many other forms. In the first experiment that tested seductive illustrations in addition to seductive text (Harp & Mayer, 1997), participants who read a base version of the content, which contained no seductive text or seductive illustrations, performed better on the tests—a free recall test and a set of problem-solving transfer questions—than those exposed to a version that included seductive details. Inclusion of interesting but irrelevant photos decreased learning by 42% for recall of main ideas and 34% for application of learning to a problem-solving task;

adding both seductive illustrations and text decreased recall by 76% and 63%, respectively (percentages from Thalheimer, 2004).

Experiments have also been performed to investigate seductive details in forms other than text and illustrations. In one study that added seductive details in the form of video clips, participants who were not exposed to the seductive details performed better on both retention and transfer tests (Mayer, Heiser, & Lonn, 2001). Other studies demonstrated that adding entertaining but irrelevant auditory material in multimedia material had negative effects on learning as measured by both retention and transfer tests (Mayer & Moreno, 2000).

Signaling and learning objectives. A set of four experiments tested the use of various strategies to provide learners with some guidance as to which information is important, with the assumption that this guidance would help to mitigate the seductive detail effect (Harp & Mayer, 1998). Signaling is considered to be especially helpful for less experienced and less skilled readers (Garner et al., 1991). Participants who read a booklet containing seductive details recalled fewer main ideas and generated fewer transfer solutions than did those who read the content without seductive details, regardless of whether or not the main text ideas were highlighted, learning objectives were provided, or text signaling was used (such as labeling steps and using the term "Definition:"). A seductive detail effect was found in each experiment, and the strategies did not reduce the effect.

Although learning objectives were used in this study, they were not very detailed. The experimenter read the following text to all participants in the objectives

condition: “Your goal while reading is to learn about what causes lightning. While reading you should be looking for the steps involved that lead to a flash of lightning. After reading you will be asked to explain how lightning works.” Learning objectives did not reduce the seductive detail effect. However, learners exposed to the learning objectives recalled significantly more of the main ideas than did those who were not exposed to the objectives.

Another type of signaling that has been studied is related to the placement of text. The Garner et al. (1991) study that was described above manipulated the placement of the seductive detail text: it was either placed in one separate paragraph as an aside or embedded in other paragraphs. The researchers hypothesized that placing the seductive text as an aside would cause learners to be less vulnerable to the seductive detail effect because they would be less likely to be disrupted in trying to construct meaning from the text. They found that, when the detailed paragraph was inserted at the beginning of the text passage, participants were better able to recall main ideas on the unstructured recall test but not on the structured test.

The placement of the seductive detail text was also varied in one of the experiments conducted by Harp and Mayer (1998) previously described: the details were either all placed at the beginning of the text passage, distributed throughout the passage, or all placed at the end of the passage. Situating the details at the beginning of the passage did not improve participants’ recall of main ideas or their transfer scores compared to their performance when the details were distributed throughout the passage. In addition, when the details were placed at the end of the passage, there were

no differences in main idea recall or transfer scores compared to participants who were not exposed to seductive details. However, when the details were positioned at the beginning of the passage, participants recalled more of the *seductive details*. In this case, the researchers were manipulating the detail placement to investigate possible reasons for the seductive detail effect. They concluded that the results suggested that the details interfere with learning by priming inappropriate schemas, and not by distracting the learner or disrupting the passage's coherence.

Cognitive load. The effects of cognitive load levels were examined in an experiment by Park, Moreno, Seufert, and Brünken (2011), which featured an animated lesson that either did or did not include seductive details and imposed either high or low cognitive load. (The participants here were high school students.) The modality of the verbal explanation in the lesson was either high load (on-screen text) or low-load (narration). Participants were asked to self-report their cognitive load in the middle of the lesson and immediately after the lesson. The results showed a main effect of modality and no main effect of seductive details. However, there was a significant interaction between the two factors, which showed that participants scored highest in the narration-seductive detail condition compared to the other three conditions. This indicated that seductive details may have a *beneficial* effect on learning under low cognitive load conditions, but not under high-load conditions. The researchers noted that the results they found could have been due to participants' high levels of prior knowledge. An interesting aspect of this study, is that, according to CLT, the on-screen text condition would be expected to have the higher level of cognitive load, but

participants instead reported higher cognitive load levels in the narration condition. This issue makes the results difficult to interpret.

Assessing the Prior Research

Effect sizes. Assuming there is a negative effect on learning due to seductive details, how large is the effect? An analysis by Thalheimer (2004) examined the results from 24 studies. Sixteen studies demonstrated that adding seductive details harmed learning, with 14 of those indicating a seductive detail effect for recall of main ideas or problem-solving transfer, and two showing the effect for transfer but not recall. Of the other eight studies, seven demonstrated no seductive detail effect, and one indicated that seductive details actually helped learners recall main ideas. The meta-analysis revealed that overall recall scores decreased an average of 19.4% (ES = .70) for the groups exposed to the seductive details compared to the base group. An effect size of .70 is considered to be a medium to large effect size.

A more recent meta-analysis revealed that 11 of 39 studies supported the seductive detail effect, 13 contained mixed results, and 15 did not support the effect (Rey, 2012). With 3535 participants in 34 studies, the weighted mean effect size for retention was $d = .30$ (99% confidence interval 0.20 – 0.39), a small to medium effect size. With 1634 participants in 21 studies, the weighted mean effect size for transfer performance was $d = .48$ (99% confidence interval 0.34 – 0.61), a medium effect size.

Rey found that 17 of the 24 studies that supported or partially supported a seductive detail effect included large effect sizes (Cohen's *d* above .8). Only one study not supporting the effect had a large effect size in the opposite direction. In summary, the meta-analysis indicated support for the existence of the effect in terms of retention and transfer.

Methodological issues. The 2012 meta-analysis conducted by Rey revealed numerous methodological issues with the prior seductive detail research. In a review published in 1995, Goetz and Sadoski strongly criticized the conclusions of seductive detail research that had been conducted up until then. They pointed out that just because learners can recall high-interest, low-importance information (seductive details) better than low-interest, high-importance information does not prove that those details prevent learners from recalling high-importance, low-interest information that they would otherwise have remembered. This section describes some of the methodological issues that Rey, Goetz and Sadoski, and others have noted.

Passage length differences. One of the issues criticized in the early seductive detail studies was the fact that text passages containing seductive details were significantly longer than the passages that did not contain seductive details. For example, in the Garner et al. (1989) study, the passage containing seductive detail sentences was 40% longer than the base passage (Goetz & Sadoski, 1995). This creates the possibility that learners failed to remember the main ideas in the seductive detail passages simply because there was more text to process: the longer seductive detail passages potentially obscured or minimized the potency of the main ideas.

No control condition. Several of the early studies did not include a control condition that contained no seductive details, which made it difficult to determine whether any effects were due only to the high-interest (seductive) details or if the addition of any text, interesting or not, would have affected the recall of main ideas (Garner et al., 1991; Harp & Mayer, 2008). Although Goetz and Sadoski (1995) decried the lack of control conditions in many of the seductive detail studies, Mayer et al. (2008) essentially used the low-interest detail conditions to serve as controls. For the most part, the later studies do incorporate a no-seductive-detail control condition (Sanchez & Wiley, 2006; Park, Moreno, Seufert, & Brünken, 2011).

Lack of objectives. Many studies used an unstructured recall test, in which participants were asked to recall only the really important information (Garner et al., 1989), but they had been given no indication of which information was important. It could be that some learners did not report some of the important information they remembered because they did not recognize it as being important. Instructional objectives establish which instructional material is relevant to the learning task and which material can be considered extraneous details (Rey, 2012). One study found that when learning objectives were provided to learners, performance on material related to the objectives improved by 49% and 47% over situations in which learning objectives were not used (Rothkopf & Billington, 1979). It seems reasonable to expect materials to guide learners in distinguishing which information is important enough to warrant their attention (Goetz & Sadoski, 1995). At least two studies conducted subsequent to Goetz and Sadoski's review incorporated learning objectives (Park, Moreno, Seufert, &

Brünken, 2011; Harp & Mayer, 1998). The Park et al. study did not test the use of the objectives, and the Harp and Mayer study indicated that adding learning objectives helped learners to score higher on both tests of their recall of main ideas (*d* = .35) and on tests of transfer skills (*d* = .60).

Short retention intervals. Most of the studies tested learners almost immediately after they had finished studying the lesson, once again diverging from typical classroom learning/testing protocols. In fact, in one review, the retention interval measured in the studies that were reviewed averaged 4.25 minutes (Thalheimer, 2004). These short retention intervals allow researchers to investigate whether materials can create learning, but not whether they can minimize forgetting (Thalheimer, 2004). Delaying the retention tests could provide critical information about the effects of seductive details. For example, perhaps seductive details are easier to retrieve than main ideas and can serve as retrieval cues for the harder-to-retrieve main ideas over the long term. It is also possible that seductive details are only harmful over short periods of time due to interference and that eventually both the main ideas and the seductive details are equally memorable (Thalheimer, 2004). Conducting experiments with delayed retention tests could uncover more realistic long-term effects or could even demonstrate that the seductive detail effect does not occur in real-world learning environments.

Prior knowledge not assessed or used. Many studies of the seductive detail effect did not directly test learner's prior knowledge of the lesson content but used only self-assessment as a gauge. An exception was Garner et al. (1991) who found that participants with higher levels of domain knowledge performed better on recall

measures. In addition, prior knowledge did not appear to be used as a covariate in most statistical analyses (Rey, 2012b).

Lack of power analysis. Very few of the experimenters conducted a power analysis to determine the sample size needed for significant findings (Rey, 2012b). For example, a study using 12 participants in three conditions found no significant effect on recall or transfer performance (Park and Lim, 2007). Rey conducted a power analysis with an effect size of $f^2 = .15$ and α of .05, which resulted in a power of .50, indicating that the sample size was too small to detect an effect size greater than or equal to $f^2 = .15$.

Use of interesting passages. It is often difficult to find a clear, consistent operational definition of seductive details. Although the term "seductive details" was intended to apply to interesting but irrelevant details (Garner, 1992), some studies have used material that may be inherently interesting, which is not consistent with Garner's assertion that the seductive detail effect occurs when interesting but irrelevant detail is added to generally *uninteresting* text (Goetz & Sadoski, 1995).

Moderators. In Rey's meta-analysis (2012b), the homogeneity statistic was highly significant, which indicates one or more moderator variables affected the results.

Time limits. Rey investigated time limits in the learning and testing phases as possible moderating factors. He found that, when a time limit was included, the seductive detail effect was highly significant, and the effect size was medium to large for both retention and transfer performance. However, when there was no time limit, the effects were not significant, and the effect size was small.

Very short learning sessions are used in almost every study. Thalheimer (2004) found an average learning session length of just under four minutes; this is the maximum amount of time in which learners are allowed to study the lesson, which would be atypical in both classroom and self-study environments. In the studies examined by Rey (2012) that reported time limits for studying the lesson, the study time ranged from 3 minutes to 25 minutes. Because the learning session time is the same across all conditions, this may cause problems for participants in conditions in which there is more content due to the addition of extraneous details. In most of the computer-based lessons, participants can only proceed forward in the lesson and cannot return to previous screens, which, again, is atypical in many learning environments.

Reading time. Using an unstructured recall test and an essay test for measuring recall, Lehmann et al. (2007) attempted to replicate and extend the Harp and Mayer (1997, 1998) studies. Participants who read the text containing seductive details did not perform as well on the recall and essay-writing tasks as did those who read the base text without seductive details. They also looked at reading times and discovered that participants exposed to the seductive details spent less time reading base text sentences than seductive detail sentences.

Working memory capacity. One study investigated the effect of working memory on the seductive detail effect by prescreening participants in advance as to whether their working memory capacity was high or low, based on memory span tasks (Sanchez & Wiley, 2006). The study material included some expository text with either no illustrations, illustrations that were relevant to the lesson, or illustrations that were

irrelevant to the lesson. After reviewing the material on a web page, participants were asked to write an essay and to complete a true/false task in which they indicated whether or not a set of 25 individual statements could be inferred from the text they had read. The results of this study were decidedly mixed: a seductive detail effect was observed only among the participants who were rated low in working memory capacity. The authors contended that the differences between high-capacity and low-capacity learners were actually due to how well learners could handle competition for their attention: "…it is the inability of certain individuals to control their attention that leads them to be seduced and, thus, causes them to understand less of the relevant, important information" (Sanchez & Wiley, 2006, p. 352). Based on this, the authors maintained that the seductive detail effect should be reinterpreted as affecting mainly those people whose working memory capacity is low.

Type of seductive detail. The type of seductive detail used in a study may have an effect on the results—perhaps one type of detail causes more harm than others. Another reason for comparing detail types is that different explanations may underlie different types of details, which may affect instructional design decisions. For text, Rey found a mean weighted effect size of d = .27 for retention and d = .65 for transfer (Rey, 2012b). For illustrations, the values were d = .95 and d = .83, respectively.

In addition, Rey noted other potential moderators, including cognitive load, learning domain, and learner traits, such as self-regulatory skills and extraversion.

How Do Seductive Details Harm Learning?

The cognitive load/working memory limitations posited by the CLT and CTML provide one underlying explanation for how seductive details may harm learning. Many different explanations for the seductive detail effect have been proposed: the overloading working memory explanation, attention distraction, schema interference, and coherence disruption; various studies have supported or not supported each one. In his meta-analysis of the seductive detail effect, Rey (2012b) maintained that, while many studies have tested each explanation, no studies have compared the different explanations. The data seems to suggest that more than one explanation may be responsible, and additional studies must be conducted to determine under which conditions each explanation holds.

Overloading working memory. This explanation is based on both the CLT and CTML. As previously noted, these theories hold that working memory is quite limited and either or both channels can be overloaded. If working memory is overly taxed, learners must spend too much of their limited cognitive resources processing extraneous material and, thus, may not have resources available for the deeper cognitive processing required for the important material (Mayer et al., 2008).

Attention distraction. Harp and Mayer (1998) hypothesized that seductive details may do their damage by causing learners to shift their attention from the important information to the seductive information. Sanchez and Wiley (2006) conducted experiments indicating that the distraction hypothesis applies in particular to

learners with low working memory capacity who have difficulty controlling their attention.

Schema interference. Lehman et al. (2007) attributed the seductive detail effect to the priming of inappropriate schemas. Schemas are used to organize many elements of information into coherent mental representations that can then be stored in long-term memory as one element. If seductive details are present, learners may build their schemas around the irrelevant details rather than around the important information they are intended to learn.

Coherence disruption. Harp and Mayer (1998) also proposed that seductive details impede learning by disrupting the transition between one main idea and the next one. Learners spend time trying to integrate the irrelevant or unimportant information with the main ideas, which interrupts the causal sequence of events they may be trying to build. Introducing a large amount of material that does not fit the idea hierarchy of the core text can disrupt the passage's coherence. If introducing extraneous information masks the main ideas in the original content and disrupts its coherence, then we cannot expect learners to remember the main ideas in the coherent passage—which was not the one they read (Goetz & Sadoski, 1995).

Concrete vs. abstract information. Another possible explanation for the seductive detail effect lies in the dual-coding literature, which has consistently found that learners are far better able to recall concrete details that gives rise to mental images than abstract information (Goetz & Sadoski, 1995). The important but uninteresting information may not have been remembered well because it was general and abstract,

while the seductive details were remembered well because they were concrete and personally involving.

Conclusion

Even though various concerns have been raised about the seductive detail effect since 1995, a number of these issues have not been addressed since then. The most recent studies seem to be moving toward testing seductive details and affect (Knörzer, Brünken, & Park, 2016; Mayer, 2014; Schneider, Nebel, & Rey, 2016), when there still does not even seem to be a consistent operational definition of seductive details or general agreement on when the effect occurs and why. The most recent edition of "The Cambridge Handbook of Multimedia Learning" (Mayer, 2014) discusses seductive details in terms of the coherence principle and states unequivocally that retention and transfer are both improved when seductive details are excluded and that learning environments should be free of seductive details (Mayer, 2014, pp. 125-126). However, based on the studies I have examined, I do not believe that such a black-or-white case can be made for whether the seductive detail effect even truly exists; it seems to very much be a case of "it depends."

For educators, instructional designers, and writers who have long been accustomed to injecting interesting, perhaps irrelevant, information into their lessons in order to win the battle for learner's attention, we need to do a better job of providing clear information about seductive details and the coherence effect. Are seductive details always bad; if not, when are they okay to use? Is there a trade-off that would make

sense—for example, perhaps a small negative effect on learning is worth it if seductive details increase the amount of time learners remain engaged with the material (Thalheimer, 2004). Does the effect apply to adolescent learners; what about older adults? Is the effect more severe when used with some content domains more than others? Does the effect manifest itself only in a lab environment with brief learning and testing times? Are there techniques educators and others can use to mitigate the effects of the details? What are some practical examples of all of this?

This is a long and ambitious list of questions that would take a great deal of experimentation, time, and effort to address. The current project begins with a basic experiment in an attempt to replicate some of the prior studies, while addressing a few of the methodological issues and confounds. Chapter 3 discusses this study.

Chapter 3: Study 1

The purpose of this study was to attempt to replicate prior studies (e.g., Garner, Gillingham & White, 1989; Harp & Mayer, 1998; Mayer, Griffith, Jurkowitz, & Rothman, 2008; Park, Flowerday, and Brünken, 2015), while incorporating changes to eliminate some of the issues and confounds described in the previous chapter.

One criticism of prior seductive detail research was that the amount of content was not the same in the high-interest (seductive) and low-interest detail conditions. For example, in experiment two of the Mayer et al. (2008) study, seductive details comprised 29% of the content compared to 15% for the low-interest details. In this study, the word count and the reading level were carefully controlled across conditions to enable determination of whether a seductive detail effect would emerge when these confounds were eliminated.

The current study also contained conditions in which a list of learning objectives was made available to participants, as in Harp and Mayer (1998). Participants were informed that the list specified what they were expected to learn from the lesson and that they would be tested on that information. The hypothesis was that the objectives would equip learners to ignore the extraneous information and focus on the core content of the lesson.

In addition, a test of prior knowledge was included—which was missing from many previous experiments (Rey, 2012b)—in order to establish a baseline for what

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The material in this chapter is being prepared for submission to a journal.

participants might already know. This was an actual test and not simply a subjective self-assessment of how familiar a participant was with the content.

A large part of the effort for this study involved developing an entirely new lesson and materials that were not based on those used in prior experiments. One of the reviewers of the seductive details studies believed that one of the issues with the prior research was that so many of them used the same or very similar content (Thalheimer, 2004). In fact, in a list of experiments that had tested the seductive detail effect/coherence principle, more than half used or adapted a lesson about lightning that was originally developed in 1996 (Mayer & Fiorella, 2014). The problem with a lack of content variety is that there could be issues with the content itself that are affecting the results—such as a certain writing style—but are not noticed by researchers because they assume the content has been validated through repeated use. Another reason for varying the content is so that researchers can investigate whether there are results or issues that occur only with a specific type of content and whether the seductive detail effect generalizes across a range of lesson content.

The goal of the current study was to establish a paradigm that would allow clear demonstration as to whether, and under which conditions, seductive details cause learners to be bewitched, bothered, or bewildered (to paraphrase Goetz & Sadoski, 1995).

Hypotheses

Due mainly to the statistics on effect sizes and other information in the most recent meta-analysis on the seductive detail effect (Rey, 2012b), the hypotheses assume that the seductive detail effect does exist and can be replicated. The three hypotheses are listed below.

- H1: Participants exposed to learning objectives will score higher in core content recall and in transfer skills performance, but lower in seductive detail recall.
- H2: Participants exposed to high-interest seductive details will score lower in core content recall and in transfer skills performance, but higher in seductive detail recall.
- H3: Participants exposed to high-interest seductive details, but not exposed to objectives, will show the lowest transfer skills performance.

Methods

Participants. Participants were 100 students recruited from the Psychology Department subject pool; they received course credit in exchange for their participation. Participants were college students between the ages of 18 and 30 and native English speakers. The mean age of the participants was 19.8 (*SD*=1.17) years, and 26 were women. Students who were majoring in fields directly related to the lesson content (geophysics, geology, or geological engineering) were not prohibited from participating in the study, but were required to indicate if they were majoring or minoring in any of

those fields or if they had taken college-level courses in any of these areas. Two students were majoring in one of the three fields, and 12 had previously taken classes in these areas.

Design. The study employed a 2x2 between-subject design with detail level (high-interest vs. low-interest) and availability of learning objectives (objectives vs. no objectives) as factors. This produced four learning conditions, with two groups consisting of 25 participants, one of 26, and one of 24.

Materials. This section provides information about all of the various materials used in the study, including forms, the lesson, and tests.

Consent and demographics forms. Participants signed a standard consent form and completed a demographics form requesting age, gender, education, and native language information. The form also asked whether the student was majoring or minoring in geophysics, geology, or geological engineering and if he or she had taken any college-level courses in these areas.

Objectives. A single sheet of paper contained the objectives of the learning task. (See Figure 2.) All objectives related to the core content only, and every objective was related to a specific content screen in the lesson.

Introduction to Plate Tectonics: Lesson Objectives

After completing this lesson, you should be able to:

1. Identify two ways in which the Earth's crust and mantle differ.
2. Name the two types of the Earth's crust and list two characteristics of each.
3. Define subduction.
4. Briefly describe the plate tectonics theory.
5. Explain what causes plates to move.
6. List the three types of plate boundaries and describe how plates move at each boundary type.
7. Name at least five plates found throughout the world.
8. Define supercontinent.
9. Name three areas on Earth that are changing due to plate movement, identify the type of plate boundary involved, and indicate what type of geophysical activity might be expected to occur there.

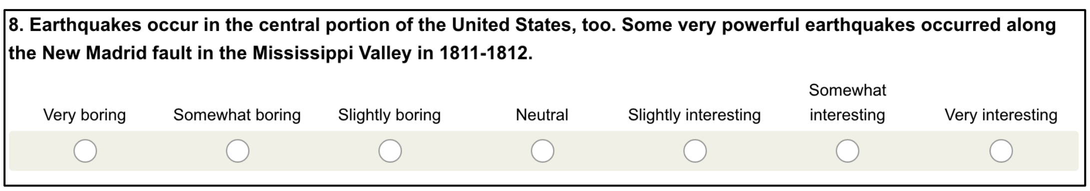
Figure 2. Lesson objectives.

High- and low-interest details. A calibration study was conducted to aid in selecting a set of high-interest (seductive) and low-interest details for use in the experiment. Initially, I wrote material for 40 details related to plate tectonics, chose a minimum of one high- and one low-interest pair for each page of the content, based on ratings from three members of the research team, and then roughly matched the pair for both word count and reading level.

Twenty-seven of the details were chosen for inclusion in a survey distributed through SurveyMonkey®. Survey participants were United States citizens, high school graduates (or equivalent), and between the ages of 18 and 30. Fifty-one people (17

women) completed the survey. Data from ten participants was eliminated from the analysis because they had selected the same rating for all details. Participants had an unlimited amount of time to complete the survey, but the average completion time was approximately 5.25 minutes.

Respondents rated each fact based on how interesting they found the material, using a seven-point, Likert-type scale as shown in Figure 3. Participants were required to enter a response for every question and were given an unlimited amount of time to complete the survey. The order of the details was randomized for each respondent.



8. Earthquakes occur in the central portion of the United States, too. Some very powerful earthquakes occurred along the New Madrid fault in the Mississippi Valley in 1811-1812.

Very boring	Somewhat boring	Slightly boring	Neutral	Slightly interesting	Somewhat interesting	Very interesting
○	○	○	○	○	○	○

Figure 3. Example calibration study question.

For each question, I calculated a mean “interestingness” rating and then rank-ordered the details that were slated to appear on the same page. For each page, I then selected details that respondents rated as high-interest or low-interest overall (based on whether they ranked higher or lower than the midpoint of four) and that were the highest and lowest ranked details for a specific page. Next, Microsoft Word’s tools were used to compare each pair of details to check that the word counts and Flesch-Kincaid reading levels were equivalent, and ran t-tests to check if there were differences between the high- and low-interest details. Each pair of statements was reworded as necessary to match reading level and word counts as closely as possible, with careful

attention paid to not changing the content (and, thus, the interestingness) of the statements. For the 16 details selected, the mean score was 5.45 for high-interest details and 4.65 for low-interest details. Average word count was 38.75 for high-interest details and 34.13 for low-interest details; Flesch-Kincaid reading levels were 10.86 and 10.75 respectively.

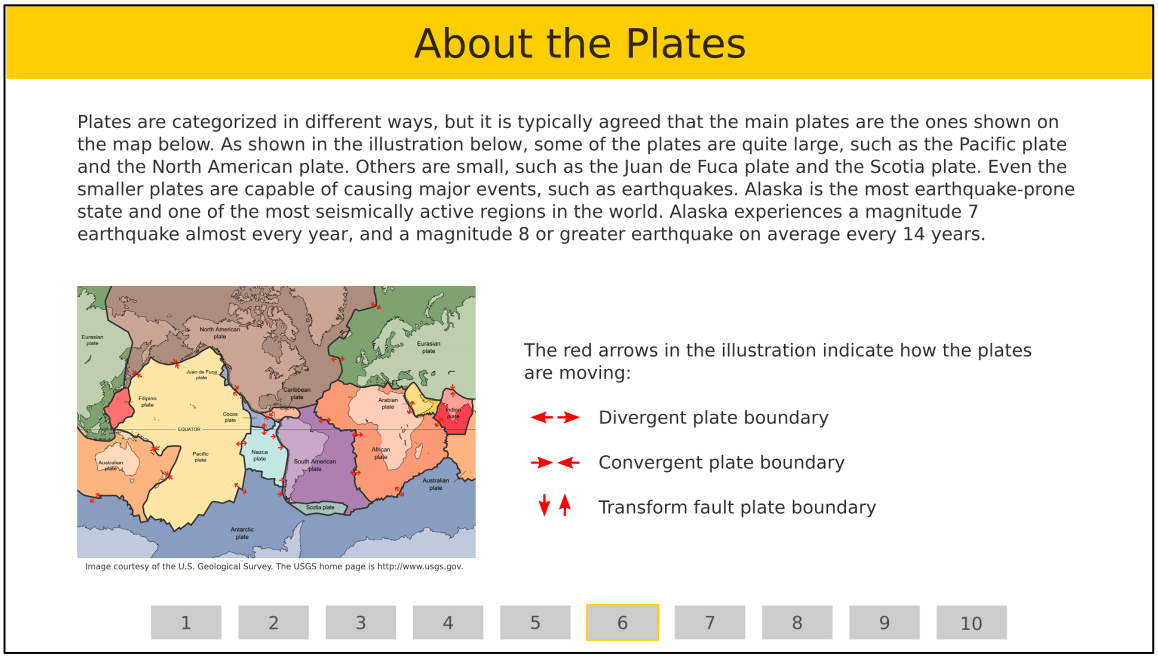
The final sets of details are listed in Appendix A.

Plate tectonics lesson. The lesson was an introduction to the plate tectonics theory in the field of earth science. It was presented using the E-Prime® software and consisted of ten screens that contained text and static images. The first screen provided directions for navigating within the lesson, and the last screen provided references for the lesson's content.

Each of the eight content screens was related to at least one of the learning objectives. All details were incorporated into the core content at appropriate places, where they would blend in well with the core content, and were not flagged or highlighted in any way. I placed the high- and low-interest details in the same position on the page if they fit with the flow of the content; otherwise, they were placed as close to the same position as possible. Two versions of each of the eight screens were created, each containing one high-interest and one low-interest detail. The screens were then assembled into two versions, one that contained all of the high-interest detail screens, and one that contained all of the low-interest detail screens. All of the details were in the form of text; the illustrations used in the lesson were directly related to the core content and were not considered extraneous.

Figure 4 provides screenshots (both high- and low-interest versions) of one of the content screens. A complete set of screenshots is provided in Appendix B.

The eight content screens contained a total of 987 words. In the high-interest detail version, the details consisted of another 308 words that added 31% to the content, for a total of 1295 words. In the low-interest detail version, the details consisted of 273 words, adding 28% to the content, for a total of 1260 words. As previously noted, the details on each page were matched as closely as possible for both word count and reading level. The Flesch-Kincaid reading grade level, as calculated in Microsoft Word, averaged 9.0 for the core content, 10.86 for the high-interest details, and 10.75 for the low-interest details.



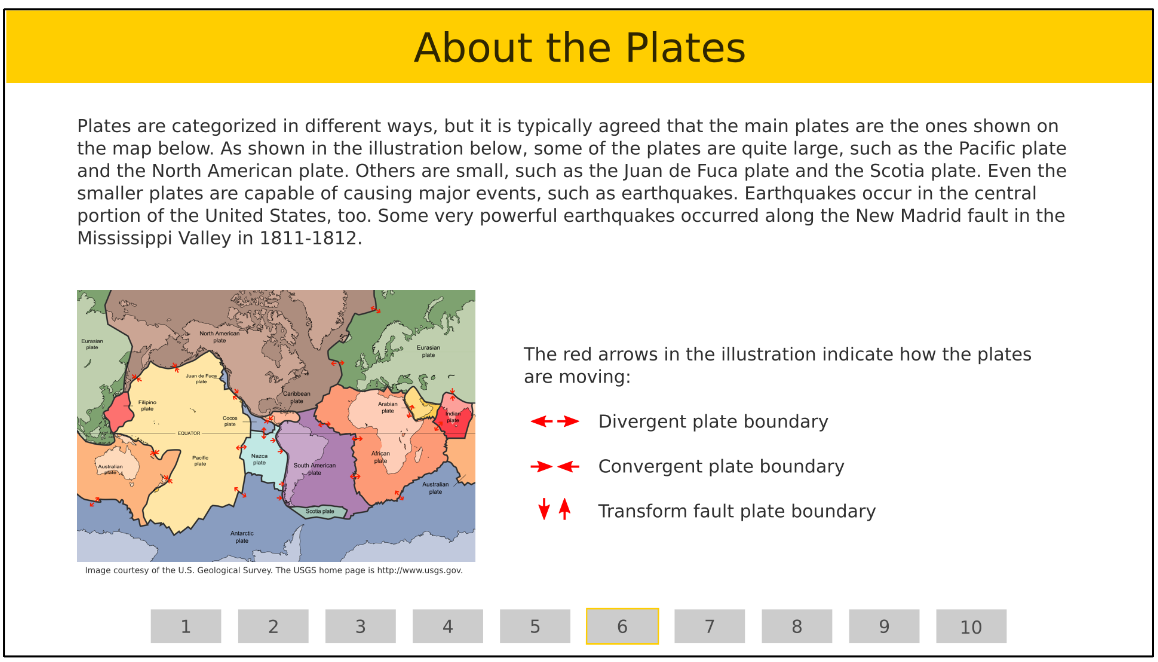


Figure 4. Lesson content for page 6. The top screen contains the high-interest detail, and the bottom screen contains the low-interest detail (in both cases, the last two sentences in the first paragraph).

Pretest. The pretest comprised three basic questions related to plate tectonics, one of which was a multiple-choice question, and two of which were short-answer questions. All tests were created, assembled, and displayed in SurveyMonkey. The questions are listed in Appendix C.

Recall/recognition test. The recall/recognition test included 25 questions: nine questions were related to the core content, eight were related to high-interest details, and eight were related to low-interest details. There were seven short-answer questions, two true/false and 16 multiple-choice (one correct answer per question). Appendix D contains a list of all questions.

Transfer test. The transfer test contained four questions, one multiple-choice, and three short–answer. The questions all related to the core content, and not to the extraneous details. The purpose of these questions was to determine how well participants could apply the knowledge gained from the lesson.

Procedure. After signing a consent form to agree to the terms of the study, participants were asked to complete a demographics form. The experimenter then started the pretest, which participants had five minutes to complete.

Following the pretest, the experimenter gave participants in the two objectives conditions a hard-copy list of learning objectives. The experimenter told participants that the list contained the information they were expected to learn from the lesson. All participants were informed that they would be tested on the objectives afterward. Those

who received the objectives list were allowed to keep the list until the experimenter collected it later. Participants were not permitted to take notes during the lesson.

Next, the experimenter explained the lesson navigation and started the lesson. Half of the participants were exposed to the version containing high-interest details, and half were exposed to the version with low-interest details. Participants were allowed to view each screen for a maximum of 2 minutes, for a total of 20 minutes. After two minutes, the computer would advance to the next screen. There was not a minimum amount of time per screen. Participants could move to the next screen sooner by pressing the spacebar, but they were not permitted to return to previous screens. The software automatically tracked the amount of time participants spent viewing each screen, in milliseconds.

After a participant completed the lesson, the experimenter collected the objectives list (if applicable) and launched the recognition/recall test; participants were given 15 minutes to complete the test. The order of the questions was randomized for each user. Note that all detail questions, both high- and low-interest, were delivered to all participants, providing a means of checking how well participants could guess the answers to questions about the details they did not see.

Finally, the experimenter launched the transfer test, which participants had 10 minutes to complete. The entire experiment took participants less than 60 minutes to complete.

Dependent measures. Table 1 lists the dependent measures collected in the experiment.

Table 1

Dependent measures

Measure	Values
Pretest score	Score range: 0 to 3 points
Pretest time to complete	Maximum time: 5 minutes
Total time spent on lesson content screens	Maximum time: 16 minutes
Recall test, core content	Score range: 0 to 9 points
Recall test, high-interest details	Score range: 0 to 8 points
Recall test, low-interest details	Score range: 0 to 8 points
Recall test, time to complete	Maximum time: 15 minutes
Transfer test score	Score range: 0 to 4 points
Transfer test time to complete	Maximum time: 10 minutes

Analysis. I performed all analyses both including and excluding the students who majored in geophysics, geology, or geological engineering or had taken college-level classes in those areas, and there were no differences in the results; therefore, the following results are based upon analyses of all participants.

For all of the following tests, I analyzed the score means in a 2x2 ANOVA with detail type (high- or low-interest) and objectives (exposed to or not) as between-subjects factors.

Results

Pretest for prior knowledge. All participants completed a pretest that assessed basic knowledge about plate tectonics. The pretest consisted of three questions: two short-answer questions and one multiple choice. No question was answered correctly by every participant, and performance was above chance on the multiple-choice question.

The mean pretest score was 2.37, *SD*=.74, out of a possible 3 points. To ensure that there were no differences in prior knowledge across groups, I ran an ANOVA that indicated no significant score differences among groups based on either detail type, $F(1, 96)= .002$, $p=.96$, $\eta_p^2=0$, or objectives $F(1, 96)=.72$, $p=.4$, $\eta_p^2=.007$. In addition, there were no differences based on an interaction between the two factors, $F(1, 96)=.47$, $p=.5$, $\eta_p^2=.005$.

Study time. Participants were allowed a maximum of 2 minutes to view each page in the computer-based lesson. To calculate the time spent on the lesson, I totaled the amount of time spent on pages 2 through 9; times for pages 1 and 10 were not included, because those pages contained content not related to the plate tectonics material, such as instructions and references. On average, participants used slightly more than half of the available 16 minutes of study time ($M=8.82$, $SD=2.11$).

An ANOVA indicated no main effects of either detail type, $F(1, 96)= .06$, $p=.81$, $\eta_p^2=.001$, or objectives $F(1, 96)=.03$, $p=.88$, $\eta_p^2=.000$, on study time. In addition, there was no interaction between the two factors $F(1, 96)=.23$, $p=.63$, $\eta_p^2=.002$.

A Pearson product-moment correlation coefficient between the amount of study time and the various test scores revealed no relationship between study time and the

core content score, r=0.10, n=100, p=0.32. For those who were exposed to the high-interest details, there was no correlation between study time and the high-details score, r=0.20, n=51, p=0.16; likewise, for those who saw the low-interest details, there was no correlation between study time and the low-details score, r=0.05, n=49, p=0.72. There was, however, a positive correlation between study time and the transfer skills score, r=0.25, n=100, p=0.01, indicating that participants who spent more time reviewing the content were better prepared to apply their newly acquired knowledge to problem-solving tasks.

Recall/recognition test. The recall/recognition test comprised three sets of questions: one set (nine questions) related to the core lesson content, one set (eight questions) related to high-interest details, and one set (eight questions) related to low-interest details.

Core content scores. The core content section of the recall/recognition test was worth nine possible points and consisted of seven short-answer questions and two multiple-choice questions. No question was answered correctly by every participant, and performance was above chance on both multiple-choice questions. The mean score was 7.13 points, SD=1.47.

As shown in Figure 5, the analysis of the scores indicated no main effects of either detail type, $F(1, 96)$=2.55, p=.11, η_p^2=.03, or objectives, $F(1, 96)$=1.75, p=.19, η_p^2=.02. In addition, there was no interaction between the two factors, $F(1, 96)$=.75, p=.39, η_p^2=.01. Although significant results did not obtain, the trends in the data for detail type were consistent with Hypothesis 2; participants who saw the high-interest

details scored lower in core content recall than participants who saw the low-interest details.

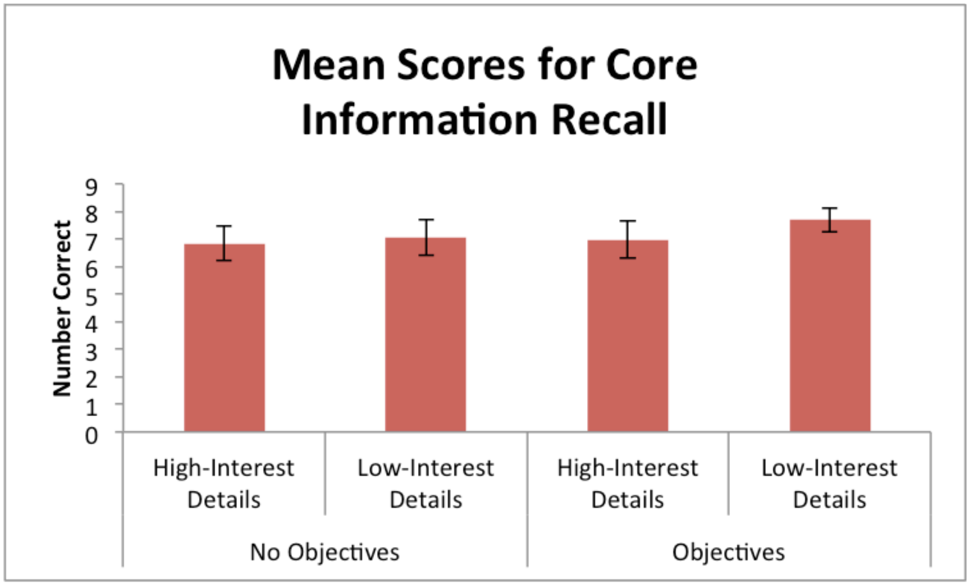


Figure 5. Participant scores on the core content section of the recall/recognition test. Error bars represent 95% confidence intervals.

Each of the nine core content questions on the recall/recognition test was associated with a specific learning objective. The effects of the availability of the objectives and the types of details viewed on participant performance on individual questions was analyzed.

Questions 1 and 7 were multiple-choice, with four response options (only one was correct). As shown in Table 2, a z-test was performed to analyze the percentage of participants in each condition who got each question right. For question 1, a significantly higher proportion of participants got the question right when they had access to the learning objectives *and* viewed the low-interest details (100%) rather than

the high-interest details (84%), z=2.05, p=.04. For those not exposed to the objectives, there was no significant difference between viewers of high- versus low-interest details, z=.922, p=.36. For question 7, a significantly higher proportion of participants got the question right when they did not have access to the learning objectives *and* viewed the low-interest details (100%) rather than the high-interest details (85%), z=2.05, p=.04. For those exposed to the objectives, there was no significant difference between viewers of high- versus low-interest details, z=1.09, p=.28.

Table 2

Comparison of percentage correct on two multiple-choice test questions according to the interest level of details that were viewed and the availability of learning objectives.

Question and Objective	Objectives Available High Interest (N=25)	Objectives Available Low Interest (N=24)	p	Objectives Not Available High Interest (N=26)	Objectives Not Available Low Interest (N=25)	p
Q1/Obj1	84%	100%	.04	92%	84%	.36
Q7/Obj6	96%	88%	.28	85%	100%	.04

The remaining core content questions were all short-answer questions. ANOVAs were conducted on each question's mean score to examine the effects of detail type and availability of objectives. As illustrated in Table 3, there were main effects of detail type for only two of the questions, with the high-interest detail questions scoring higher in both cases; there were no main effects of objectives, and no interaction between detail type and objectives.

Table 3

Comparison of mean scores on seven short-answer test questions according to the interest level of details that were viewed and the availability of learning objectives. Asterisks indicate questions that showed evidence for a seductive detail effect.

Question/ Objective	Objectives Available High Int. (N=25)	Objectives Available Low Int. (N=24)	Objectives Not Available High Int. (N=26)	Objectives Not Available Low Int. (N=25)	p values (effects of details, objectives, interaction)
Q2/Obj3	.52	.71	.52	.46	.39, .10, .10
Q3/Obj6	.74	.78	.83	.83	.71, .25, .74
Q4/Obj9	.92	.98	.94	.86	.79, .27, .11
*Q5/Obj4	.84	.96	.77	.86	.03, .07, .77
*Q6/Obj2	.79	.91	.70	.86	.02, .25, .72
Q8/Obj5	.64	.75	.60	.70	.19, .56, .97
Q9/Obj8	.72	.73	.71	.64	.56, .36, .45

Detail scores. As a manipulation check, all participants were required to complete *both* the high- and low-interest test questions, even questions about the type of detail they had not viewed. For example, participants who had viewed the high-interest details in the lesson were presented with questions on *both* the high- and low-interest details.

The high-interest detail group of questions consisted of eight questions: seven were multiple-choice questions, and one was true/false. No questions were answered correctly by all participants; performance was above chance on all but the true/false

question, which was not significantly below chance. Overall, participants scored 4.57 (*SD*=2.09) out of a total of 8 points.

As illustrated in Figure 6, the analysis of the high-interest detail scores indicated a main effect of detail type, $F(1, 96)= 181.18$, $p<.001$, $\eta_p^2=.65$, and no main effect of objectives, $F(1, 96)=.26$, $p=.61$, $\eta_p^2=.003$. In addition, there was no interaction between the two factors, $F(1, 96)=.89$, $p=.35$, $\eta_p^2=.01$.

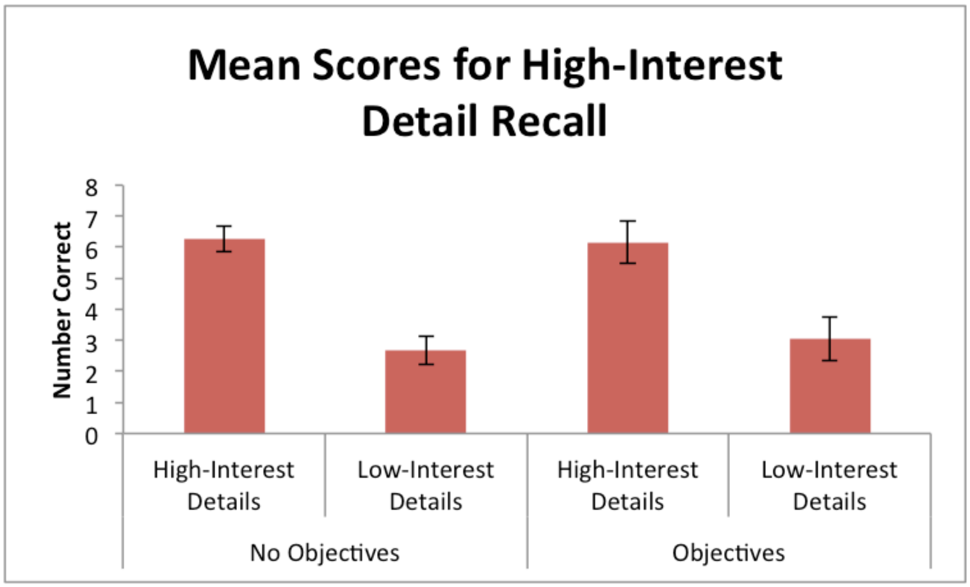


Figure 6. Participant scores on the high-interest details test questions, with and without objectives. Error bars represent 95% confidence intervals.

The low-interest detail group of questions also consisted of eight questions: seven multiple-choice questions, and one true/false question. No questions were answered correctly by all participants, and performance was above chance on every question. The mean score was 5.65 (*SD*=1.42) out of eight possible points.

As illustrated in Figure 7, the analysis of the low-interest detail scores indicated a main effect of detail type, $F(1, 96)= 25.35$, $p<.001$, $\eta_p^2=.21$, and no main effect of objectives, $F(1, 96)=.9$, $p=.35$, $\eta_p^2=.01$. In addition, there was no interaction between the two factors, $F(1, 96)=2.0$, $p=.16$, $\eta_p^2=.02$.

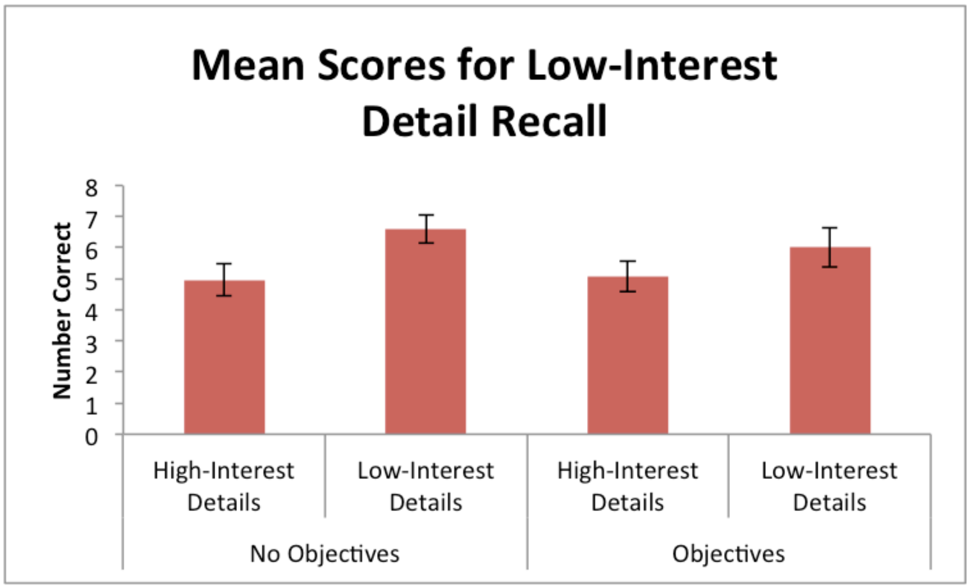


Figure 7. Participant scores on the low-interest details test questions, with and without objectives. Error bars represent 95% confidence intervals.

It would be expected that people who actually saw the high-interest details would score higher on the high-interest detail questions than those who did not see those details, and vice versa. However, the high- and low-interest detail participants both scored well on the low-interest detail questions, even though only the low-detail participants saw that information. On the high-interest questions, there was a greater difference between the two group means, as illustrated in Table 4.

Table 4

Comparison of scores on details test questions according to the type of detail content that was viewed.

	Low-Interest Details Score		High-Interest Details Score	
Condition	*M*	*SD*	*M*	*SD*
Viewed low-interest details (*N*=49)	6.31	1.31	2.86	1.10
Viewed high-interest details (*N*=51)	5.02	1.24	6.22	1.36
Mean difference	1.28		3.35	

Transfer skills test. The transfer skills test contained four questions worth a total of four points and consisted of one multiple-choice and three short-answer questions. No question was answered correctly by every participant, and performance was above chance on the multiple-choice question. The mean score was 3.07 points, *SD*=.83.

As Figure 8 illustrates, the analysis of the scores showed no main effects of either detail type, $F(1, 96)= 1.89$, $p=.17$, $\eta_p^2=.02$, or objectives $F(1, 96)=.05$, $p=.82$, $\eta_p^2=.001$. In addition, there was no interaction between the two factors $F(1, 96)=.39$, $p=.53$, $\eta_p^2=.004$.

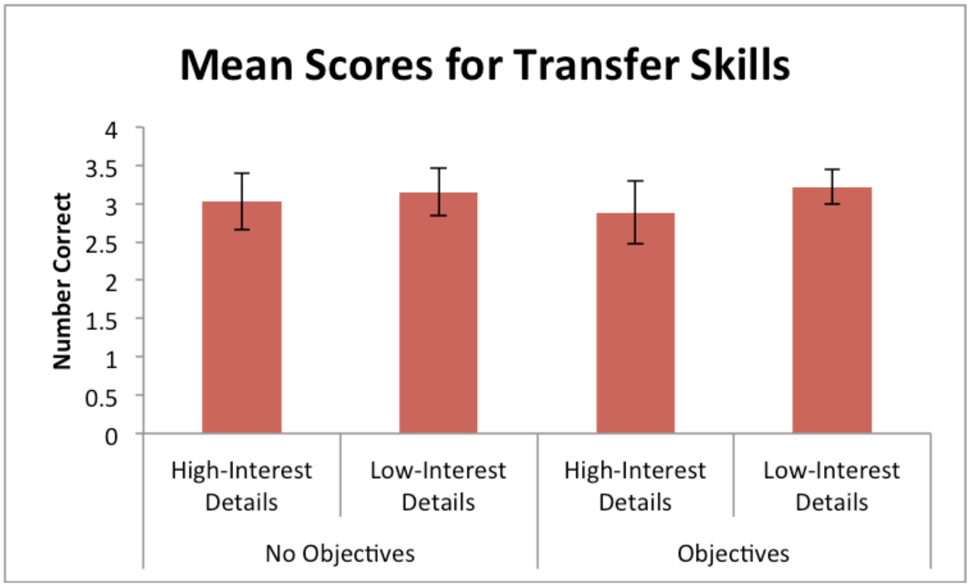


Figure 8. Participant scores on the transfer skills test, which had a possible score of 4 points. Error bars represent 95% confidence intervals.

Discussion

The data did not provide support for any of the three hypotheses:

1. There was no effect of learning objectives on any of the test scores.
2. There was no effect of the details' interest level of any of the scores.
3. There was no interaction between the high-interest details and the objectives.

In reviewing the study, I identified various issues that potentially affected the results as described below.

Hypothesis 1 – no effect of objectives. I expected that participants who were exposed to the learning objectives would perform better, because they should have known in advance which information was important to remember. On the core content

test (possible score of 9.0), the mean score for those who saw the objectives was 7.32 (*SD* = 1.42), and 6.94 (*SD* = 1.51) for those who did not see the objectives. Perhaps the participants did not pay enough attention to the objectives; although all participants in the objectives conditions received a paper copy of the objectives, the researchers observed that, in many cases, participants glanced at the objectives briefly, and then did not seem to refer to them again.

Another possibility is that the objectives were, for one reason or another, ineffective. As previously described, the Harp and Mayer (1998) study also tested the effect of objectives and obtained effects for both recall and transfer skills. My objectives were much more detailed than those of Harp and Mayer. Maybe they are *too* detailed and require the learner to keep too many ideas in mind at one time, particularly if they only glance at them once, causing some extraneous cognitive load.

Hypothesis 2 – no effect of interest level. The current study attempted to find a performance difference between learners exposed to high-interest details and those exposed to low-interest details, and there was no evidence of this. The mean core content score for high-interest details was 6.90 (*SD* =1.58) and the mean core score for low-interest details was 7.36 (*SD* = 1.33) out of 9 points; for transfer skills the means were 2.96 (*SD* = .96) and 3.18 (*SD* = .65) out of 4 points, respectively. These results provide some possible evidence that the seductive detail effects found in prior research may have been driven by (or at least exacerbated by) differences in word count or reading level, rather than by differences in interest level alone. However, all of the previous studies that were examined did not use only printed text (some contained

narrated text), and other studies utilized various types of media such as illustrations and animations that would not be counted in word count and reading-level analyses.

Another possible reason for not obtaining a seductive detail effect is that perhaps the high- and low-interest details used were not substantially different enough to elicit the effect. Many studies (Lehman et al., 2007) have used a rating system in which the detail statements were calibrated for interest, which was done for this study, as well as importance, which was not done. Maybe the importance levels of the high-interest details in my study were too high, and learners considered them to be high-interest/high-importance rather than high-interest/low-importance (seductive) details. Also, some problems with the ratings data was encountered; as previously mentioned, about 20% of the data had to be eliminated because the participants had selected the same rating for every statement. It is possible that some of the remaining data was also not valid. Another potential issue with the details is that perhaps they are not different enough from the core content in terms of interest.

In this experiment, the low-interest details served as controls, but the lack of a control condition that contained *no* extraneous details means that I cannot be certain there was not a performance difference from simply adding content, be it high- or low-interest. In other words, although I can state that I found no effect of interest level, I am unable to say whether there was an effect of added information. The seminal Garner et al. (1989) study did include a control condition, but did not compare low-interest and high-interest details; however, they did obtain a very large seductive detail effect of 2.29. Among the differences between that study and mine are that they used no

illustrations (I did, although they were not seductive), there was much less content (only three main ideas), and the content was delivered in hard-copy form rather than on a computer. Although the issue has not yet been investigated, it is possible that the amount of content and the number of main ideas make a difference.

Hypothesis 3 – no interaction between high-interest details and objectives. An interaction effect did not emerge for any of the test results, likely because neither of the study's manipulations appeared to have any effect. Certainly, if participants ignored the objectives, that would not be expected to mediate a seductive detail effect anyway—even if the effect had obtained.

What's Next?

There are a host of interesting questions that remain to be answered about the seductive detail effect, based on the current study:

1. Are there aspects of the objectives that could be improved, both content-wise and the way they are handled procedurally, to make them more effective?
2. Could the selection process for the high-and low-interest details be refined to address some of the issues noted above?
3. Would adding a control condition indicate there is an effect of adding content that has nothing to do with the added content's interest level?
4. Are there aspects of the core content or the details test questions that could be improved—are the tests too easy?

The next chapter presents Study 2, which addresses some of these questions.

Chapter 4: Study 2

The concluding sections of Chapter 3 noted several potential reasons for not achieving the expected results in Study 1 and posed questions that remained to be answered related to objectives, the selection process for the details, a control condition, and the tests. Study 2 replicates and extends Study 1 to address these issues. The main differences between Study 1 and Study 2 include:

New extraneous details. New details were written and pilot-tested to establish a definite interest-level difference between the core text and the extraneous details and to better differentiate between the high- and low-interest details. The lesson and all tests, except the pretest, were updated to reflect the new details.

A control group. Study 2 included a control group that was not exposed to seductive details. This allowed comparison between the low-interest details group and control group to determine if there were performance differences between participants whose version of the lesson contained no details and those whose version contained low-interest details. In addition, this enabled examination of whether or not the interest level of the details influenced performance above and beyond increasing the word count.

Change to the objectives procedure. The procedure in the objectives condition was revised to better emphasize the objectives and help ensure that participants paid attention to them. Under the new procedure, the researcher read through the objectives with the participants before they started the lesson. After Study 1 was completed, there

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The material in this chapter is being prepared for submission to a journal.

was a concern that there were too many objectives (nine) for the amount of content the lesson contained. The number of objectives could have been overwhelming, causing participants to ignore them. To address this, the list was collapsed to four objectives.

Participants' working memory resources. Before performing any other tasks, participants completed a numerical version of the Stroop task. The interference score derived from this task is often used to measure how well people can inhibit information that is not relevant to the task they are performing (Kane & Engle, 2003; MacLeod, 1991). Interference scores, thus, are used as a measure of working memory capacity, with a higher interference score indicating a lower level of working memory capacity.

Participants' performance predictions. After completing the lesson, but before each test, participants predicted how well they would perform on the core content test and on the transfer test. Following the test, participants rated their perceived performance. These two measures were used in an exploratory analysis to determine whether there were differences in confidence levels among the conditions. For example, participants who were exposed to the more interesting content may have conflated the interest level of the content with their level of learning, leading those in the high-interest details condition to make inaccurate predictions about their test performance. Likewise, perhaps participants who were exposed to the objectives perceived that they knew the material better than they did and, therefore, over-estimated how well they would perform on the tests compared to those in the no-objectives condition.

Participants' perceived level of cognitive load. Following the lesson, participants were asked to rate how much mental effort they thought they had to expend

while studying the lesson. This provides some indication of subjective cognitive load in each condition.

Hypotheses

The hypotheses for Study 2 were as follows:

- H1: Participants exposed to learning objectives will score higher in core content recall and in transfer skills performance.
- H2: Participants exposed to high-interest details will score lower in core content recall and in transfer skills performance than those in the no-details or low-interest details condition.
- H3: Participants exposed to high-interest details, but not exposed to objectives, will show the lowest transfer skills performance.
- H4: Participants exposed to high-interest details will report higher levels of cognitive load than those in the low- or no-details conditions

Methods

Participants. A power analysis was run using two different methods to determine the sample size required to achieve a medium effect size. One method (Ellis, 2012) yielded a sample size of 128, and the other (Kohn & Jarrett) yielded a sample size of 126. The experiment required six groups. Based on a sample size of 128 divided by six, rounding up yielded 22 participants per group, a total of 132 participants.

Participants were 132 students (35 women) recruited from the Psychology Department subject pool; they received course credit in exchange for their participation.

All were native English speakers between the ages of 18 and 30 (M_{age}=19.9, SD=0.5). One participant was majoring in geophysics, geology, or geological engineering, and 22 had previously taken a class in one of these areas.

Design. The study utilized a 3x2 design with detail type (none, low-interest, or high-interest) and objectives (exposed to or not) as between-subjects factors. Thus, there were six learning conditions in the study.

Materials. This section provides information about the various materials used in the study, including the lesson content and tests.

Consent and demographics forms. Participants signed a standard consent form and completed a demographics form requesting age, gender, education, and native language information. The form also asked whether the participant was majoring or minoring in geophysics, geology, or geological engineering and if he or she had taken any college-level courses in these areas.

Stroop task. Working memory was assessed using the numerical Stroop task from the Psychology Experiment Building Language (PEBL) (Mueller). In this task, participants see numbers on the screen and are asked to indicate the total number of characters they see (Hernández, Costa, Fuentes, Vivas, and Sebastián-Gallés, 2010); for example, “222” requires a response of “3.” By default, this PEBL task delivers a practice round followed by two actual rounds of the task, each consisting of 28 trials for each condition. PEBL automatically captures response times for all trials in milliseconds. The Stroop interference score, calculated as incongruent response time minus congruent response time, was used as a measure of working memory capacity.

Objectives. A single sheet of paper contained the objectives of the learning task. (See Figure 9.) The first three objectives related to the core content, and the fourth one related to the transfer test. Each objective was related to one or more content screens in the lesson.

Introduction to Plate Tectonics: Lesson Objectives

After completing this lesson, you should be able to:

1. Define terms related to plate tectonics, such as mantle, crust, subduction, and supercontinent.
2. Define the plate tectonics theory and explain what causes plates to move.
3. Identify the three types of plate boundaries, and describe the plate movement at each boundary type.
4. Name three areas on Earth that are changing due to plate movement and indicate what type of geophysical activity might be expected to occur at each location.

Figure 9. Lesson objectives, Study 2.

Text details. To ensure the seductive details were appropriately rated as high-interest and low-importance as per the categories specified by Wade & Adams (1990), a new set of potential details was written for each page in the lesson, with an eye toward where they could be incorporated on the page. The adapted versions of Wade and Adams' four categories were: high importance/medium interest (main ideas), low importance/medium interest (supporting details), low importance/high interest (high-interest seductive details), and low importance/low interest (low-interest extraneous details).

To aid in the selection of details that were of lower importance than the core content and identification of well-differentiated low- and high-interest details, a pilot study was conducted that required participants to rate the interest level and importance of all of the core content statements and a set of potential low- and high-interest details.

The ratings study was conducted online through SurveyMonkey®. Survey participants were United States citizens, high school graduates (or equivalent), and between the ages of 18 and 30; most were university students. Seventy people (25 women) took the survey, with 64 completing it. Data from nine participants was eliminated from the analysis because their native language was not English (five participants) or they got the “trap” questions wrong, which indicated they had not been reading the questions (four participants).

This ratings study, based on that of Lehman et al., 2007, asked participants to rate the interest and importance of the core text sentences and a set of extraneous details, including both those used in Study 1 and potential new extraneous sentences (included in Appendix F). Participants first read a list of objectives and then read the core content from the plate tectonics lesson with no extraneous details. Next, participants were presented with each sentence from the lesson and asked to indicate how important each sentence was to learning the content specified in the objectives. Participants were then presented with each sentence from the lesson again and asked to indicate how interesting it was. Finally, participants rated the importance and interestingness of each of the extraneous details.

Respondents rated each fact using a seven-point, Likert-type scale as shown in Figure 10. Participants were required to enter a response for every question and were given an unlimited amount of time to complete the survey. The order of the details was randomized for each respondent.

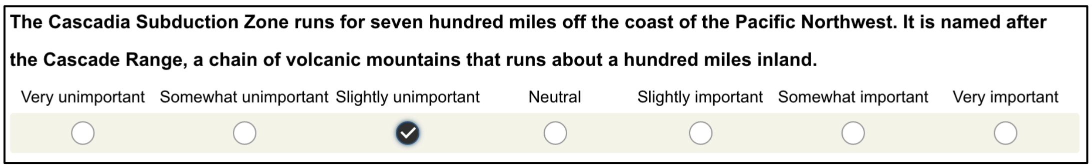

Figure 10. Example calibration study question, Study 2.

Mean importance and interest scores were calculated for all detail statements and then a median split was used to distinguish the low/high importance and interest statements. Mean scores were calculated for the core content statements. The high-interest details selected were the statements that ranked high in interest and low in importance; in addition, they were required to be higher in interest and lower in importance than the mean scores for the core text. In the previous study, the reading levels of the details were higher than those of the core content; therefore, editing was performed as necessary to align these more closely. The word counts of the low- and high-interest statements were also matched even more closely than in Study 1.

The mean interest and importance ratings for the core content and the 16 selected details are show in Table 5. The final sets of details are listed in Appendix G.

Table 5

Mean interest level, importance rating, and reading level for the core content and 16 selected details used in Study 2, plus word counts for the low- and high-interest details.

Text	Interest	Importance	Word Count	Reading Level
Core content	4.69	5.50		8.85
Low-interest details	4.11	4.15	57.25	10.19
High-interest details	5.37	4.12	58.00	10.16

Plate tectonics lesson. Three versions of the lesson were created, one containing low-interest details, one containing high-interest details, and one containing no extraneous details. The low- and high-interest versions of the lesson from Study 1 were updated with new details to reflect the results of the text-rating experiment described above. The lesson was an introduction to the plate tectonics theory in the field of earth science. It was presented using the E-Prime® software and consisted of ten screens that contained text and static images. The first screen provided directions for navigating within the lesson, and the last screen provided references for the lesson's content.

Each of the eight content screens was related to at least one of the learning objectives. Each screen contained text-based core content and illustrations only if they were directly related to the core content. Extraneous details were incorporated at appropriate places, where they would blend in well with the core content. They were not flagged or highlighted in any way. Low- and high-interest details were placed in the same position on the page if they fit with the flow of the content or, if not, as close to the same position as possible.

Figures 11, 12, and 13 are screenshots (the no-details version and low- and high-interest versions) of one of the content screens. A complete set of screenshots is provided in Appendix H.

The eight content screens contained a total of 987 words of core content. The low-interest detail version included an additional 458 words, adding 46% to the content, for a total of 1445 words. The high-interest detail version included an additional 464 words that added 47% to the content, for a total of 1451 words. The Flesch-Kincaid reading grade level, as calculated in Microsoft Word, averaged 8.85 for the core content, 10.19 for the low-interest details, and 10.16 for the high-interest details,.

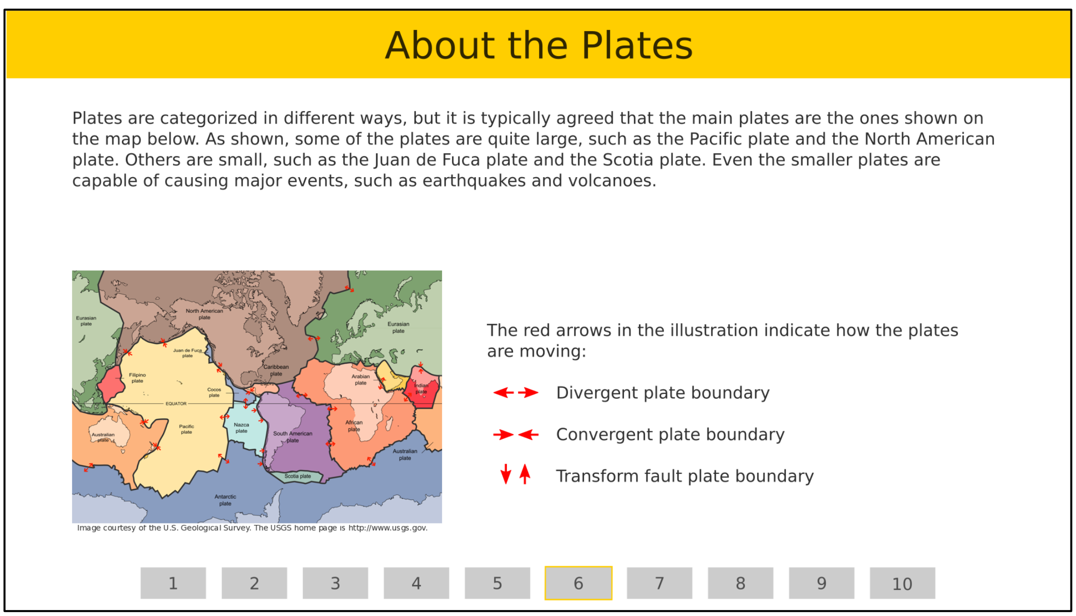

Figure 11. Lesson content for screen 6 with no extraneous details.

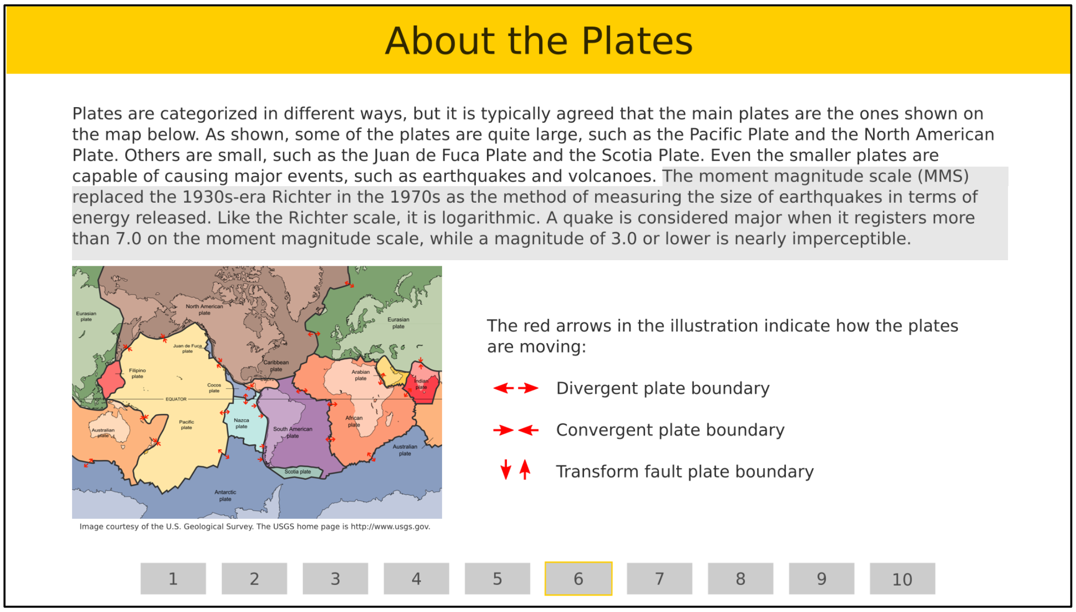

Figure 12. Lesson content for screen 6, containing the low-interest detail (the shaded area at the end of the first paragraph).

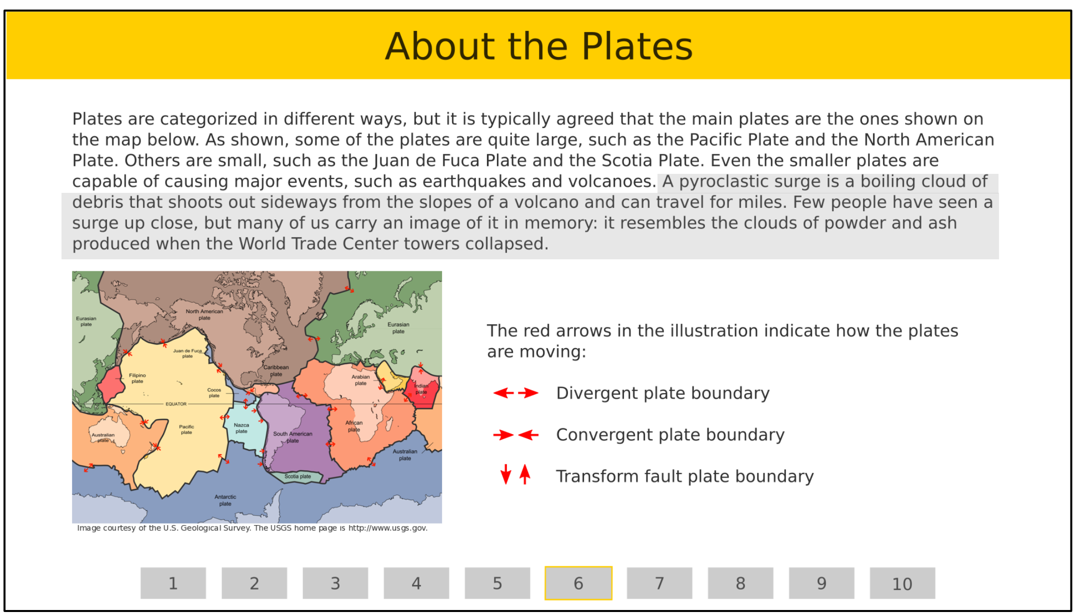

Figure 13. Lesson content for screen 6, containing the high-interest detail (the shaded area at the end of the first paragraph).

Pretest. The pretest comprised four basic questions related to plate tectonics, two of which were multiple-choice questions, and two of which were short-answer questions. All tests were created, assembled, and displayed in SurveyMonkey. The questions are listed in Appendix C.

Core content test. The core content consisted of ten multiple-choice questions, each worth one point. The questions were all related to the core lesson content and not to the low- or high-interest details. Each question contained four response options (only one was correct). The order of the questions was randomized for each user. Appendix I contains a list of all questions.

Details test. This test covered only the extraneous details and consisted of 16 questions, eight low-interest and eight high-interest, each of which was worth one point. All detail questions, both low- and high-interest, were delivered to all participants, providing a means of checking how well participants could guess the answers to questions about the details they did not see. For example, participants who had viewed the high-interest details in the lesson were presented with questions on *both* the high- and low-interest details, and participants who saw no extraneous details still took the test.

Transfer test. The transfer test contained four questions, one multiple-choice, and three short–answer, and was worth five points; one of the short–answer questions contained two parts, worth one point each. The questions all related to the core content, and not to the extraneous details. The purpose of these questions was to determine how well participants could apply the knowledge gained from the lesson.

Procedure. After signing a consent form, participants completed a demographics form. The experimenter led the participant to a computer and explained the Stroop task, which took participants approximately five minutes to complete. The experimenter then started the pretest, which participants also had five minutes to complete.

Following the pretest, the experimenter gave participants who were in the objectives condition a hard-copy list of learning objectives. The experimenter told participants that the list contained the information they were expected to learn from the lesson and that the information may appear on the tests. The experimenter read through the list of objectives with each participant and asked if he or she had questions. Those who received the objectives list were allowed to keep the list until the experimenter collected it later. Participants were not permitted to take notes during the lesson.

Next, the experimenter explained the lesson navigation and started the lesson. Participants were allowed to take as much time as needed to review the lesson. They could move to the next screen by pressing the spacebar, but were not permitted to return to previous screens. The software automatically tracked the amount of time participants spent viewing each screen, in milliseconds.

After a participant completed the lesson, the experimenter collected the objectives list (if applicable). The experimenter then asked the participant to select a rating for how well she thought she would do on the test. The experimenter launched either the core content test or the transfer skills test; participants were given 10 minutes to complete either test. The order of these tests was counterbalanced, with the

participant taking the other test following the detail test (below). After the participant completed the test, she was asked to select a rating for how well she thought she had done on the test.

After completing either the core content or transfer test, participants took the detail test, which they had 16 minutes to complete. Then participants took either the core content or transfer test, whichever one they had not already taken.

The entire experiment took participants less than 60 minutes to complete.

Dependent measures. Table 6 lists the dependent measures collected in the experiment.

Table 6

Dependent measures, Study 2.

Measure	Values
Stroop task interference time/ working memory	Incongruent time minus congruent time in milliseconds
Pretest score	Score range: 0 to 5 points
Study time on lesson content screens	Time in minutes/seconds
Cognitive load rating	Range: 1 to 7
Core content test score	Score range: 0 to 10 points
Core content test prediction, before test	Range: 1 to 7
Core content test assessment, after test	Range: 1 to 7
Details test performance, high-interest details	Score range: 0 to 8 points
Details test performance, low-interest details	Score range: 0 to 8 points
Transfer test score	Score range: 0 to 5 points
Transfer test prediction, before test	Range: 1 to 7
Transfer test assessment, after test	Range: 1 to 7

Analysis. Test scores were analyzed in 3x2 ANCOVAs with detail type (none, low-interest, or high-interest) and objectives (exposed to or not) as between-subjects factors. To control for each participant's level of working memory, Stroop interference scores were included as a covariate. (Note: The statistical tests were conducted both with and without the covariate; since it had an effect in some cases, ANCOVA results are reported in the following sections, and effects of working memory are noted.)

For all *post hoc* t-tests, Bonferroni adjustments were selected in SPSS. SPSS adjusts the *p*-values based on the number of possible pair-wise comparisons so that it is not necessary to adjust the *p*-value criterion. For example, if there are three comparisons, SPSS multiplies the *p*-values by three.

All analyses were performed both including and excluding the 22 participants who majored in geophysics, geology, or geological engineering or had taken college-level classes in those areas. There were differences in the results for those participants; for example, the mean prescore for the geology-related majors was 3.82 compared to 3.05 for all other participants. In addition, their core content scores were at or close to ceiling in some cases (a perfect 10.0 for those in the objectives/high-interest detail condition and 9.8 for those in the no objectives/high-interest detail condition). For those reasons, the 22 participants with geology-related majors were excluded in the results discussed in this chapter. Note that excluding the data had a negligible effect on the study's power.

An ANCOVA was also run for the subjective cognitive load measure, and within-subject ANCOVAs were run for the subjective predictions for the core and transfer test performance.

Results

Working memory task. The Numerical Stroop Task yielded a response time for each participant, in milliseconds, for both incongruent trials and congruent trials. The congruent value was subtracted from the incongruent value to yield an interference score, which was used to indicate working memory levels. The mean interference score was 74.48 ms (*SD*=34.10). An ANOVA indicated no significant interference score differences among groups based on either detail type, $F(2, 126)=.17$, $p=.84$, $\eta_p^2=.003$, or objectives $F(1, 126)=.25$, $p=.62$, $\eta_p^2=.002$. There were also no differences based on an interaction between the two factors, $F(2, 126)=.41$, $p=.67$, $\eta_p^2=.01$. Although the condition groups are well matched for working memory, working memory is included as a covariate in subsequent analyses as it accounts for some of the score variances within groups.

Pretest for prior knowledge. All participants completed a pretest that assessed basic knowledge about plate tectonics. No question was answered correctly by every participant. Performance was above chance on both of the multiple-choice questions.

The mean pretest score was 3.05 (*SD*=1.07), out of a possible 5 points. An ANCOVA indicated no difference in pretest scores among groups based on either detail type, $F(2, 103)=.69$, $p=.5$, $\eta_p^2=.01$, or objectives $F(1, 103)=.52$, $p=.47$, $\eta_p^2=.01$,

controlling for working memory. The effect of working memory was not significant, $F(1, 103)=.04$, $p=.85$, $\eta_p^2<.001$. In addition, there were no differences based on an interaction between detail type and objectives, $F(2, 103)=.39$, $p=.68$, $\eta_p^2=.01$.

Study time. Participants were given an unlimited amount of time to view each page in the computer-based lesson. To calculate the time spent on the lesson, I totaled the amount of time spent on pages 2 through 9; pages 1 and 10 contained content not specifically related to the plate tectonics material, such as instructions and references, and were excluded.

An ANCOVA indicated a significant main effect of detail type on study time $F(2, 103)=3.1$, $p=.05$, $\eta_p^2=.06$. As shown in Table 7, Bonferroni *post hoc* tests revealed that the amount of study time was significantly less in the no-detail condition than in the low- or high- interest detail conditions, with $p=.04$ in both cases. There was no significant effect of objectives on study time, $F(1, 103)=.28$, $p=.6$, $\eta_p^2=.003$, and no interaction between the two factors $F(2, 103)=1.01$, $p=.37$, $\eta_p^2=.02$. The effect of working memory on study time was significant, $F(1, 103)=5.00$, $p=.03$, $\eta_p^2=.05$, with lower working memory capacity associated with longer study times.

Table 7

Comparison of lesson study time according to the type of details that were viewed.

Condition	*M*	*SE*
Viewed low-interest details (*N*=38)	9 min 20 sec	31 sec
Viewed high-interest details (*N*=34)	9 min 28 sec	32 sec
Viewed no details (*N*=38)	7 min 49 sec	31 sec

To determine whether participants spent more time reading the content in the two conditions in which there was more to read (the low- and high-interest detail conditions), the reading rate per page was also calculated. (See Table 8.) The ANCOVA yielded no significant main effect of detail type $F(2, 103)=1.52$, $p=.22$, $\eta_p^2=.03$, objectives $F(1, 103)=.05$, $p=.83$, $\eta_p^2=.003$, or working memory $F(1, 103)=2.33$, $p=.13$, $\eta_p^2=.02$. There was no interaction between details and objectives $F(2, 103)=1.06$, $p=.13$, $\eta_p^2=.02$. Thus, although participants spent more time reading the content in the low- and high-interest detail conditions, they did not spend more time than would be expected based only on the additional number of words included in those conditions.

Table 8

Reading rates per page, in words per second.

Condition	*M*	*SE*
Viewed low-interest details (*N*=38)	2.8	0.85
Viewed high-interest details (*N*=34)	2.9	1.09
Viewed no details (*N*=38)	2.51	1.05

Correlations were calculated to assess the relationship between study time and test performance across all conditions. A Pearson product-moment correlation coefficient revealed no relationship between study time and core content score, r=.03, n=110, p=.73 or the overall details score, r=.06, n=110, p=0.51. In addition, there was no correlation between study time and the transfer skills score, r=.14, n=110, p=.14.

Mental effort. Participants were asked to rate their level of mental effort while completing the lesson, using a 7-point Likert-type scale where 1 was extremely low and 7 was extremely high. The mean level of mental effort was 3.95 (SD=1.03).

An ANCOVA indicated no significant differences in mental effort among groups based on either detail type, F(2, 103)=.13, p=.88, η_p^2=.003, or objectives F(1, 103)=.15, p=.7, η_p^2=.001, controlling for working memory. There were no differences based on an interaction between detail type and objectives, F(2, 103)=1.62, p=.20, η_p^2=.03. The effect of working memory on mental effort was significant, F(1,

103)=3.94, p=.05, η_p^2=.04; lower levels of working memory capacity were associated with higher levels of mental effort.

Correlations were calculated to determine if there were relationships between mental effort and performance on any of the tests. A Pearson product-moment correlation coefficient revealed one significant relationship, which was between mental effort and the transfer skills score, r=.20, n=110, p=.04. This indicated that a higher reported level of mental effort was associated with a higher score on the transfer skills test. There were no significant correlations between mental effort and the core content test score, r=.03, n=110, p=.78, or the detail test score, r=-.17, n=110, p=.08.

Core content test. The core content test was worth ten possible points. No question was answered correctly by every participant, and performance was above chance on all questions. Participants across all conditions scored extremely high on the test, with a mean overall score of 9.01 (*SD*=1.37) out of 10 points and 9.29 (*SD*=.91) in the objectives condition. Figure 14 contains a graph of the mean scores by condition.

An ANCOVA of the scores indicated no significant main effect of detail type, $F(2, 103)$=1.19, p=.31, η_p^2=.02, controlling for working memory. There was an effect of objectives, $F(1, 103)$=4.8, p=.03, η_p^2=.05, with higher scores when objectives were available. There was also a significant interaction between detail type and objectives, $F(1, 103)$=3.55, p=.03, η_p^2=.07.

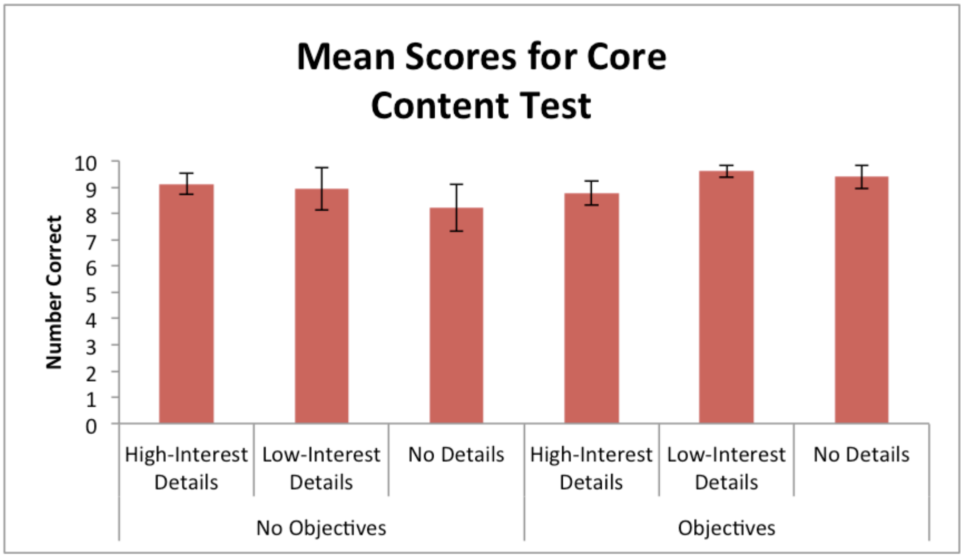

Figure 14. Participant scores on the core content test. Error bars represent 95% confidence intervals.

To identify the source of the interaction, additional ANCOVAs were run separately for the no objectives and the objectives conditions. When objectives were available, there was a significant effect of detail type, $F(2, 52)=4.82$, $p=.01$, $\eta_p^2=.16$. When objectives were not available there was no significant effect of detail type, $F(2, 50)=1.78$, $p=.18$, $\eta_p^2=.07$.

For the objectives available condition, individual sample *t*-tests were conducted to compare the core test score means in the low-, high-, and no-detail conditions, and the results provided evidence of a seductive detail effect. The results provided evidence of a seductive detail effect, with significantly higher scores in the low-interest details condition ($M=9.6$, $SD=.50$) than in the high-interest details condition ($M=8.78$, $SD=1.0$); $t(36)=-3.24$, $p<.01$. There was also a significant difference between the no-

details (*M*=9.44, *SD*=.98) and the high-interest detail conditions (*M*=8.78, *SD*=1.00); $t(34)=-2.01$, $p=.05$. There was no significant difference between the no-details and low-interest conditions.

The effect of working memory on the core content test score was not significant, $F(1, 103)=1.11$, $p=.3$, $\eta_p^2=.01$.

Details test. All participants completed a test that contained questions about *both* the high- and low-interest details included in the lesson, even questions about the type of details they had not viewed.

High-interest detail questions. Eight questions were related to the high-interest details. None of these questions were answered correctly by all participants, and performance was above chance on all questions.

An ANCOVA for the high-interest details score indicated a main effect of detail type, $F(2, 103)= 13.68$, $p<.001$, $\eta_p^2=.21$, and no main effect of objectives, $F(1, 103)=.25$, $p=.62$, $\eta_p^2=0$, when controlling for working memory. In addition, there was no interaction between the two factors, $F(2, 103)=2.07$, $p=.13$, $\eta_p^2=.04$. The effect of working memory was not significant, $F(1, 103)=2.55$, $p=.11$, $\eta_p^2=.02$. Figure 15 illustrates the mean scores for each condition.

In a further examination of the significant detail type effect on the high-interest detail questions, Bonferroni *post hoc* tests revealed that the mean score was significantly higher in both the low-interest and high-interest detail conditions than in the no-detail condition, with $p<.001$ in both cases. Participants who saw the high-interest details in the lesson would be expected to score higher on a test covering those

details than participants who did not see them, namely those in the no-details and low-interest details conditions. Although the high-interest detail group scored significantly higher than those in the no-details condition, they did not score significantly higher than the low-interest detail group. Refer to Table 9.

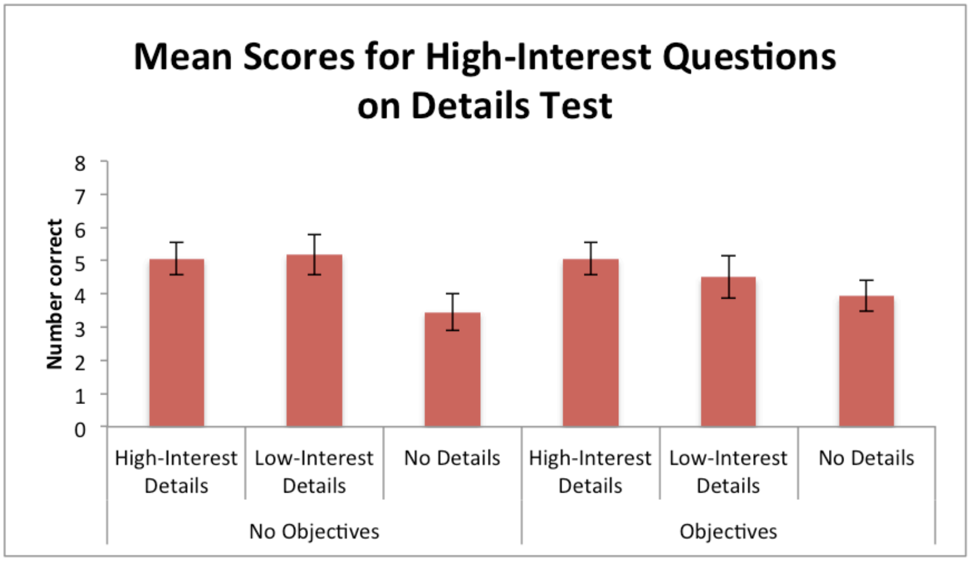

Figure 15. Participant scores on the high-interest detail test questions. Error bars represent 95% confidence intervals.

Low-interest detail questions. The remaining eight questions in the details test were related to the low-interest details. No questions were answered correctly by all participants, and performance was above chance on all questions.

An ANCOVA run on the low-interest detail scores indicated a main effect of detail type, $F(2, 103)=8.2$, $p<.001$, $\eta_p^2=.14$, when controlling for working memory. In a further examination of this effect, Bonferroni *post hoc* tests revealed that the mean score was significantly higher for those who saw the low-interest details than for those in

either the high-interest detail (*p*=.04) or no-detail condition (*p*<.001). This would be expected, because only participants in the low-interest condition saw the low-interest details in the lesson.

There was no main effect of objectives in the low-interest detail questions, $F(1, 103)=.38$, $p=.54$, $\eta_p^2=.00$ and no interaction between details and objectives, $F(2, 103)=.85$, $p=.43$, $\eta_p^2=.02$. The effect of working memory was not significant, $F(1, 103)=1.4$, $p=.25$, $\eta_p^2=.01$. Table 9 provides the mean scores for each condition, and Figure 16 contains a graph of the mean scores.

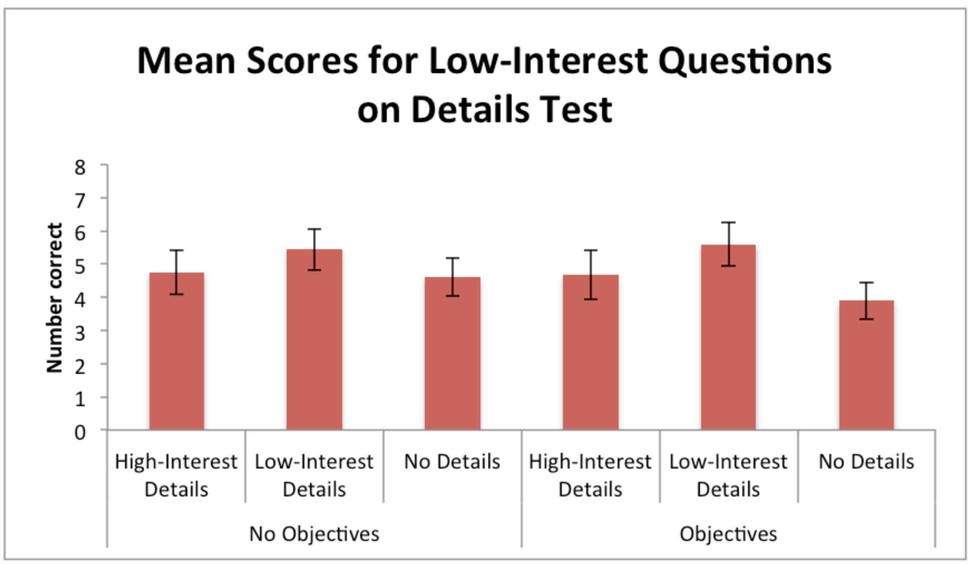

Figure 16. Participant scores on the low-interest detail test questions. Error bars represent 95% confidence intervals.

As indicated in Table 9, those who saw the low-interest details scored .71 points higher on the low-interest detail questions than they did on the high-interest detail questions. On the other hand, those who saw the high-interest details scored only .35

points higher on the high-interest detail questions than they did on the low-interest detail questions. Participants who saw no details scored the lowest on both sets of questions, but scored .58 points higher on the low-interest details than they did on the high-interest details. These results may indicate that the answers to the low-interest detail questions were easy to guess, even if you had not seen the material in the lesson.

Table 9

Comparison of scores on details test questions according to the type of detail content that was viewed, collapsed across objectives.

	Low-Interest Details Score		High-Interest Details Score	
Condition	*M*	*SD*	*M*	*SD*
Viewed low-interest details (*N*=38)	5.53	1.43	4.82	1.41
Viewed high-interest details (*N*=34)	4.71	1.47	5.06	1.01
Viewed no details (*N*=38)	4.26	1.29	3.68	1.16

Transfer skills test. The transfer skills test was worth a total of five points. No question was answered correctly by every participant, and performance was above chance on the multiple-choice question. The overall mean score was 3.96 points, *SD*=1.04.

Figure 17 illustrates the transfer skills test scores for each condition. An ANCOVA revealed no main effects of either detail type, $F(2, 103)=2.11$, $p=.13$,

η_p^2=.04, or objectives $F(1, 103)$=1.17, p=.28, η_p^2=.01, when controlling for working memory. The effect of working memory was not significant, $F(1, 103)$=.49, p=.49, η_p^2=.01. There was, however, an interaction between detail type and objectives $F(2, 103)$=3.39, p=.04, η_p^2=.06.

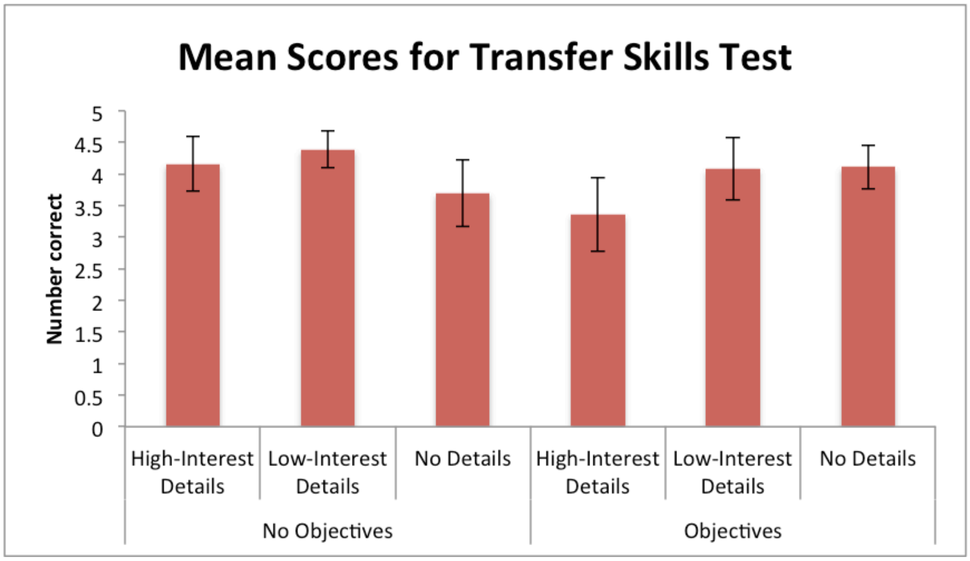

Figure 17. Participant scores on the transfer skills test, which had a possible score of 5 points. Error bars represent 95% confidence intervals.

To identify the source of the interaction, additional ANCOVAs were run separately for the no objectives and the objectives conditions. When objectives were not available, there was a non-significant effect of detail type, $F(2, 50)$=2.78, p=.07, η_p^2=.1; this was also the case when objectives were available, $F(2, 52)$=2.80, p=.07, η_p^2=.1. In the objectives condition, however, there was a trend toward a seductive detail effect with lower scores in the high-interest condition (M=3.36, SD=1.27) than in the low-interest condition (M=4.08, SD=1.12); $t(36)$=-1.84, p=.07. In addition, there was a

significant difference between the no-details scores (*M*=4.11, *SD*=.76) and the high-interest detail scores (*M*=3.36, *SD*=1.27); $t(34)=-2.15$, $p=.04$. There was not a significant difference between the no-details and low-interest details scores.

In the no objectives condition, in contrast, there was no evidence for a seductive detail effect, with no significant difference in transfer scores between the low- and high-interest detail conditions or between the no-details and high-interest detail conditions. There was, however, a significant difference between the no-details and the low-interest detail conditions, $t(36)=2.18$, $p=.04$. Notably, the direction of this effect is opposite of what one would expect from a word-count effect (no-details scores: *M*=3.7, *SD*=1.2; low-interest detail scores: *M*=4.39, *SD*=.63).

Subjective performance ratings. Participants made subjective evaluations of how they anticipated they would perform before taking the core and transfer skills tests and how they perceived they had performed after taking each test. There were two suppositions here: 1) Participants who were exposed to high-interest details would predict that they would perform better on the core content and transfer tests than those exposed to low-interest details; and 2) Participants who were exposed to objectives would predict better performance on the core content and transfer tests than those who were not exposed to objectives.

For the core test, an ANCOVA revealed no significant differences among participants' pre-test self-assessments, controlling for working memory, based on objectives availability $F(1, 103)=1.80$, $p=.18$, $\eta_p^2=.02$, detail type $F(2, 103)=.34$, $p=.71$, $\eta_p^2=.01$, or on an interaction between the two factors $F(2, 103)=.09$, $p=.91$, $\eta_p^2=.002$.

The effect of working memory was also not significant, $F(1, 103)=.32$, $p=.57$, $\eta_p^2=.003$. The prediction that the high-interest detail participants ($M=4.50$, $SD=1.02$) would predict better performance than would the low-interest detail participants ($M=4.61$, $SD=.97$) was not upheld.

In addition, an ANCOVA revealed no significant differences among participants' post-test self-assessments, controlling for working memory, based on objective availability $F(1, 103)=.03$, $p=.86$, $\eta_p^2<.001$, detail type $F(2, 103)=1.93$, $p=.15$, $\eta_p^2=.04$, or on an interaction between the two factors $F(2, 103)=.18$, $p=.84$, $\eta_p^2=.003$. The effect of working memory was also not significant, $F(1, 103)=1.06$, $p=.31$, $\eta_p^2=.01$.

A Pearson product-moment correlation coefficient revealed a significant relationship between the subjective pre-test core score assessment and the actual core test score in three of the six conditions, as shown in Table 10. It is interesting that in both the low- and high-interest detail conditions, when objectives were available, the pre-test prediction correlated significantly with the actual test score. However, when objectives were not available, there were no correlations in these conditions. This indicates that participants who knew what they were expected to learn were better at predicting how well they would perform on the core test.

Table 10

Correlations of pre-test performance assessment and actual score for the core content test, by objectives availability and detail level.

	Objectives Available			Objectives Not Available		
	r	*p*	N	*r*	*p*	N
No details	.32	.2	18	.74	<.001	20
Low-interest details	.47	.04	20	.08	.78	18
High-interest details	.65	<.01	18	.16	.57	16

A Pearson product-moment correlation coefficient revealed no significant relationship between the subjective pre-test transfer score assessment and the actual transfer skills test score in any of the six conditions, as shown in Table 11.

Table 11

Correlations of pre-test performance assessment and actual score for the transfer skills test, by objectives availability and detail level.

	Objectives Available			Objectives Not Available		
	r	*p*	N	*r*	*p*	N
No details	.1	.7	18	-.17	.48	20
Low-interest details	.09	.72	20	-.58	.82	18
High-interest details	-.28	.26	18	-.08	.78	16

Discussion

A discussion of each of the hypotheses for Study 2 is provided below, followed by discussion about some factors in the study, such as working memory.

Hypothesis 1 – Effect of objectives. As previously noted, the objectives procedure was changed for Study 2 in an attempt to force participants to better attend to them. In addition, the number of objectives was reduced. The Study 2 core test results indicated a main effect of objectives, along with a significant interaction between objective availability and detail type. Participants who saw learning objectives scored higher in both the no-details and low-interest details conditions, indicating that the availability of learning objectives may have helped participants attend to the relevant information within the lesson. Notably, the effect did not obtain in the high-interest details condition.

Could the difference in the objectives effect have been related to participants skipping over the details? The data does not support that. The high-interest detail group outperformed the no-detail group on the high-interest detail test, indicating that those participants did not completely ignore the seductive details. Further, participants in the high-interest detail groups performed equally well on the high-interest detail questions, regardless of whether or not they viewed objectives, indicating that participants in the objectives condition did not necessarily skip over the seductive details. However, the same pattern of results was also true for participants in the low-interest detail groups, indicating that those in the low-interest detail group also did not use objectives to skip over extraneous details. In addition, the increases in reading time between the no-details group and the details groups was proportional to the addition of the detail content, suggesting that participants read the extraneous content. Thus, it appears that although participants paid attention to the objectives for the most part, the objectives did not

impel them to completely disregard the details. It may also indicate that the detail test questions were easy to get right, even if participants did not pay a lot of attention to the related content.

On the transfer skills test, there was also a significant interaction between the availability of objectives and detail type with scores higher when objectives were **not** available. Contrary to expectation, when the interaction was analyzed according to detail type, scores were significantly higher in the high-interest details condition when objectives were not available compared to when they were not available. In this case, perhaps the objectives were an added distraction when coupled with highly interesting details.

Hypothesis 2 – Effect of details. Hypothesis 2 predicted that participants exposed to high-interest details would score lower in core content recall and in transfer skills than participants in the no-details or low-interest details condition and that those in the no-details condition would score highest. Analysis of the core and transfer test data provided partial support for this hypothesis. The pattern of transfer skills scores aligned with the hypothesis, with the high-interest details condition having the lowest score; however, the detail effect emerged only when taking objectives into account, as described in the next section.

For the core test scores, there was no main effect of detail type, and the ordering of scores in the no-details, low-interest details, and high-interest details conditions was inconsistent with this hypothesis. Ceiling effects on the core test, however, may have limited the interpretability of those results.

Hypothesis 3 – Effect of high-interest details without objectives on transfer skills performance. According to this hypothesis, participants exposed to high-interest details, but not exposed to objectives, would show the lowest transfer skills performance. Although a significant interaction did obtain, the predicted pattern of effects did not. Instead, there was a non-significant trend (p=.07) toward a seductive detail effect in the objectives condition, with participants in the high-interest details condition scoring lower than those in the low-interest details condition.

A similar pattern of effects emerged in the core content test scores. In the objectives available condition, the high-interest detail scores were significantly lower than both the low-interest details and the no-details scores. The current data, therefore, provides no evidence that the availability of learning objectives can protect against the seductive detail effect. Although the reason behind the observed pattern of effects is unclear, one possibility is that the availability of learning objectives may have increased the learner's cognitive load and therefore contributed toward the seductive detail effect. The lack of differences in reported cognitive load does not support this assertion, although it is possible that the cognitive load measure used in the study was not sufficiently sensitive.

Hypothesis 4 – Effect of subjective cognitive load rating. This hypothesis stated that participants in the high-interest details condition would report higher levels of cognitive load than those in the low-interest or no-details conditions. Participants self-rated one question regarding cognitive load: "We'd like to know how hard you felt you had to work to understand the lesson content. While studying the lesson, my mental

effort was…" This question was based on the one used in a study by Park, Moreno, Seufert, and Brünken, 2011.

There was no main effect of interest level on reported cognitive load values, so this hypothesis was not supported. The main issue here may have been a difference between the construct I intended to measure, cognitive load, and what participants thought the question meant by mental effort. Mental effort could have been conflated with attention, motivation, or even something like how hard participants found it to stay awake.

Although this hypothesis does not relate to performance, there was a correlation between cognitive load and the transfer skills score, indicating that a higher reported level of mental effort was associated with a higher score on the transfer skills test. Some research has suggested that seductive details may have a positive effect on learners in low cognitive load conditions (Park, Moreno, Seufert, and Brünken, 2011), but that was not observed here. It is possible that those who reported the higher levels of cognitive load were simply more attentive to the material but did not feel overloaded.

Study time. Could the results have been affected by participants in some conditions simply spending more time reading the lesson? Importantly, an analysis of the reading rate showed that although participants spent more time studying the lesson in the detail conditions, the increase in study time was simply proportional to the increased word count. Participants did not spend more time reading the content in the two conditions in which there was more material (the low- and high-interest detail

conditions), than would be expected based on the fact that there were additional words to read.

The analysis of the time spent reviewing the lesson indicated that participants in the no-details condition spent significantly less time studying than did those in the two details conditions. This makes sense, because there was less text to read when there were no added details. In Study 2, the time limit for reading the lesson was eliminated because of the possibility that time limits might lead to lower performance if, for example, participants could not review the material in the amount of time allowed (Rey, 2012b). In Study 2 with no time limit, the mean amount of study time was 8.86 minutes, SD=3.26, and in Study 1 it was 8.82 minutes, SD=2.11, with a limit on study time. Removing the time limit made almost no difference on the amount of study time.

Working memory capacity. A previous study found that the seductive details effect occurred only for participants who were low in working memory capacity (Sanchez and Wiley, 2006). In Study 2, working memory was used as a covariate in all of the analyses because it affected the test results, although the effects were not significant. Working memory capacity did have a significant effect on study time, with lower levels associated with higher amounts of study time. In addition, working memory capacity also had a significant effect on cognitive load; participants scoring lower in working memory capacity reported higher levels of cognitive load.

Conclusion. In contrast to Study 1, Study 2 did find some evidence for the seductive detail effect; however, contrary to the hypotheses, the effect emerged only when objectives were available. There was also evidence that changes made to both the

objectives content and the procedure were effective, with Study 2 results showing a significant main effect of objectives and significant interaction between objectives availability and detail level. In addition, Study 2 revealed several issues about the seductive detail effect that could be further investigated, such as whether detail length matters, interest type, and how much more interesting high-interest details must be as compared to the core text. The next chapter provides a broader discussion of those issues and of the Study 1 and Study 2 results and considers the implications of the current data for developing guidelines for instructors.

Chapter 5: General Discussion

The current project examined the seductive detail effect to answer questions about exactly when the effect occurs and to resolve issues such as possible confounds with word count and reading levels, the influence of objectives on the seductive detail effect, lack of a control condition containing no extraneous details in prior studies, and a more effective way of rating the importance and interest levels of the content and the extraneous details. The project's long-term applied goal was to compile specific guidelines for educators and instructional designers about whether and how seductive details should be incorporated into their materials.

Review of Study 1 and 2. Study 1 attempted to replicate prior seductive detail studies that had found better performance among participants exposed to low-interest details than to high-interest details (Mayer et al., 2008). When controlling for noted confounds in the literature, such as word count and reading level, the seductive detail effect did not obtain: on both the core content test and the transfer skills test, scores were not significantly different between participants exposed to low-interest details and those exposed to high-interest details. Study 2 addressed potential methodological issues in Study 1 by adding a control condition that contained no extraneous details, selecting extraneous details on the basis of both interest and importance, and simplifying the learning objectives. Despite these changes, Study 2 did not reveal a consistent detrimental effect of high-interest details on core content recall and transfer skills scores; however, a seductive detail effect was observed in some very specific

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The material in this chapter is being prepared for submission to a journal.

scenarios. For the core content tests, an interaction between detail level and objectives availability emerged, with a significant seductive detail effect only when objectives were provided. A similar interaction occurred in transfer skills test scores, and there was a trend toward a seductive detail effect, again, only when objectives were provided. Surprisingly, despite an expected interaction between details and objectives, this pattern of results is inconsistent with the hypothesized interaction: rather than objectives reducing the seductive detail effect, the opposite proved true. Why did objectives seem to enhance the seductive detail effect? One possibility considered is that perhaps the objectives added to learners' cognitive load; however, the cognitive load data from the study provides no support for that supposition.

A review of the meta-analysis (Rey, 2012b) indicates that it is not unusual for seductive details studies to yield inconsistent results. The meta-analysis lists findings for 14 experiments that included seductive text passages. Four of these found a seductive detail effect, five showed mixed results (such as no effect for recall, but an effect for transfer), and five found no seductive detail effect. The effect has been studied under a host of conditions, including differing percentages of seductive text, diverse subject matter, whether seductive details were compared to core text that did not contain details or to low-interest details, different methods of assessment, variations in number of participants and participant age groups, placement of the seductive text, and use of time limits. However, the basic effect remains inconsistent, and many studies reference effects found in earlier studies that contained confounds.

Details and detail ratings. The null results in Study 1 may have suggested that the previously observed seductive detail effect was driven more by the specific characteristics of the details than by their interest levels or that the seductive details were not sufficiently differentiated to elicit the effect. To test this possibility, Study 2 utilized a new set of seductive details that were selected based on a systematic evaluation. The process, described in Chapter 4, involved rating both the ideas in the core text and the low- and high-interest details in terms of interest and was based on previous studies (Wade & Adams, 1990; Lehman et al., 2007). The relevance of both the details and the core text to the information specified by the learning objectives was rated, which meant that all of the text used in the lesson could be ranked on the basis of interest level and importance. In addition, because some of the same details were rated for both Study 1 and Study 2, I was able to compare the ratings; for the common details, the ratings correlation was .89. The fact that interaction effects were observed within both the core and transfer test scores in Study 2, indicating a seductive detail effect, suggests that the Study 1 details may not have been differentiated enough.

Could it be that the high-interest seductive details used in Study 2 are still not sufficiently interesting to elicit the seductive detail effect across both of the objectives conditions—are they less seductive than details used in other studies? Table 12 provides a selection of high-interest statements from other studies that elicited the effect as well as some high-interest details from Study 2. Comparing these in terms of content, I do not believe that the current study's high-interest details are generally less interesting than those from the other studies; for example, the Pompeii detail seems to be at least as

interesting as the lightning detail and comparable in word count. One thing that is apparent is that most of my details tend to be quite lengthy, as shown in Appendix A and Appendix F. Although a sampling of other studies shows they do have some long details, in general, theirs are much shorter than mine. In terms of a seductive detail effect, perhaps longer details do not pack the same “punch” as shorter details; even if learners have objectives to tell them they do not need to attend to certain details, they might need to read quite a bit of extraneous text before realizing that a long detail can be ignored. I plan to conduct another study using shorter details.

Another potential issue with the details is the type of interest they evoke. There are two main types of interest level in text, according to Kintsch (1980): cognitive interest and emotional interest. Cognitive interest is engaged by content that helps the reader understand the material, such as explanatory summaries, or that helps her to make connections among the pieces of information she has been given. Emotional interest can increase a reader’s emotional arousal and help her to focus more on the content, which ideally would lead to increased learning. Generating text that evokes emotional interest is often done by including extraneous information about topics such as death, power, money, and sex (Kintsch, 1980).

Table 12

Examples of highly rated seductive details.

Seductive Detail Text	Source
The majority of sword swallowers employ a guiding tube, which they have previously ingested and hence their performances are less dangerous.	Mayer et al., 2008
When a Click Beetle is on its back, it flips itself into the air and lands right side up while it makes a clicking noise.	Garner et al., 1989
The use of ATP is the basis of all living processes. Within every muscle movement, ATP is spent. In sports like running or ballsports, in hard physical jobs, or even while doing activities like typing, the body needs energy. This energy is provided in [sic] form of ATP.	Park et al., 2011
Approximately 10,000 Americans are injured by lightning every year. Eyewitnesses in Burtonsville, Maryland, watched as a bolt of lightning tore a hole in the helmet of a high school football player during practice. The bolt burned his jersey, and blew his shoes off. More than a year later, the young man still won't talk about his near death experience.	Harp & Mayer, 1998
When Mount Vesuvius erupted in 79 A.D., destroying Pompeii, thousands of citizens were killed. The volcano's heat boiled their brain tissue, which then burst out in small, scalding explosions that left blue-black burn marks on the bone. Moisture from vaporized flesh and blood combined with volcanic ash to create a plaster-like material, which preserved the bones.	Current studies
A pyroclastic surge is a boiling cloud of debris that shoots out sideways from the slopes of a volcano and can travel for miles. Few people have seen a surge up close, but many of us carry an image of it in memory: it resembles the clouds of powder and ash produced when the World Trade Center towers collapsed.	Current studies

Although Kintsch thought that material should be balanced between emotional and cognitive interest, it can be difficult to come up with emotionally interesting details about many domains, such as plate tectonics. As shown in Table 12, some of the Study 2 details related to death; some of the others related to interesting places around the world and earthquake and volcano sites in the US, which could potentially generate emotional interest. Overall, though, the details in the current study may be more cognitively than emotionally interesting. Despite the inclusion of some emotionally interesting topics, even the highest rated seductive detail scored only 5.47 on a 7-point interest scale. The details in the current studies that have an emotional component are overwhelmingly negative. Perhaps the quality of the emotion in the details—negative or positive—influenced the seductive detail effect? One study demonstrated that induced negative emotions had a facilitating influence on learning outcomes, while induced positive emotions had a suppressing influence (Knörzer, Brünken, and Park, 2016).

Perhaps seductive details need to be qualitatively far more interesting and far less related to the core content to elicit the effect? To test this hypothesis, I am planning a study with the same core content, but using “super-seductive” details consisting of facts about disaster and apocalyptic-themed Hollywood movies that feature volcanoes and earthquakes. The goal is to generate and test details with interest-level ratings far higher than those of the core text. Although long-term retention of content was not tested in the current studies, perhaps highly seductive details—and short details—would be remembered for a longer period of time than would long details.

The current project highlights the importance of obtaining reliable ratings of the content's importance and interest. Although high-interest seductive details were always rated as significantly more interesting than low-interest details and the core content, the extant literature does not provide standard definitions or guidance as to how interesting a detail must be to qualify as a seductive detail. Perhaps there are other dimensions that could be used in developing and rating details, such as a scale based on Kintsch's cognitive vs. emotional interest, or on Schraw and Lehman's (2001) personal vs. situational interest (a desire to understand a topic that persists over time vs. interest that is spontaneous and context-specific). Also, some details may seem more or less interesting when they are read in context than when they are read as stand-alone statements in ratings studies; it might be worthwhile to develop a way to have the details rated in context.

In the current studies, the low-interest details are not technically seductive details according to the standard definition (Garner et al., 1991) because each one was rated as numerically less interesting than the core text. In these studies, the low-interest details were not intended to provide supporting material for the core content; however, they bring to mind Ellis' concept of "catalytic" content (J. Ellis, 2012). He contends there is another category of content that is added to text passages not because it directly relates to the learning objectives or is of particular interest to learners, but because it "introduces, supports, contextualizes, exemplifies or reinforces that primary content which is relevant and essential in terms of addressing or achieving the learning outcomes." It could be that some of the extraneous details are inadvertently catalytic

and end up being beneficial to learning. Maybe that is one reason that, in the list of 14 seductive text experiments in the meta-analysis (Rey, 2012b), seductive details had positive effects in two of the experiments (Garner et al., 1991). If indeed catalytic content plays a role here, then it may be another confound that has not been addressed in prior studies. Additional studies should be conducted to determine the conditions under which extraneous details may have a positive influence on learning outcomes, so that educators can be provided with guidelines about these types of details.

Content. As noted previously, the seductive text studies analyzed in the meta-analysis covered a range of subjects, from lightning to Stephen Hawking to digestion to the development of stars. One problem with the current studies may be that the plate tectonics content is not difficult enough for college students, who were likely exposed to this content in middle school Earth Science classes. Although a participant may not achieve a high score on the pretest, having prior exposure to the content might reduce the amount of cognitive load required to re-learn the information and learn new, related material. If the lesson did not impose a very high level of intrinsic load, then adding extraneous load in the form of seductive details is not an issue. This highlights the importance of considering both the complexity of material and the participants' educational history when investigating the seductive detail effect. In my case, another future project is to develop a new lesson that will be more challenging for participants who are college age and attending a highly technical, STEM-focused school, something involving a novel learning experience that does not involve incremental learning.

Possible ideas include topics in the humanities field involving poetry, literature, art, or music.

Objectives. The influence of learning objectives on the seductive detail effect has not been widely studied. As noted in Chapter 2, perhaps only three of the prior studies incorporated objectives, but two of them found that providing objectives greatly increased learner performance (Rothkopf & Billington, 1979; Harp & Mayer, 1998). Because Study 1 showed no significant effects of objectives, before Study 2, improvements were made to the objectives' content and the way in which they were handled procedurally. This resulted in a significant interaction of objective availability and detail type on both the core test and transfer skills test results: participants exposed to learning objectives scored higher in both the no-details and low-interest details conditions, but not in the high-interest details condition. Since these results in the high-interest detail condition are contrary to expectations, further investigation is needed to establish why the objectives were ineffective (or possibly, detrimental) in this condition.

Conclusion. The common message to educators regarding seductive details is, "Excluding all irrelevant but sometimes seductive details that are extraneous to learning has a positive effect on elaborative learning and transfer (Mayer, 2014)." Based on the results of the current studies and on the literature, this admonition needs to be qualified. The current studies and the previous meta-analysis (Rey, 2012b) highlight the fact that the seductive detail effect is inconsistent as to the conditions under which it emerges.

The applied goal of the current project was to develop a set of meaningful, easy-to-follow guidelines for when and how practitioners should incorporate seductive

details into their learning materials. However, my research demonstrated the difficulty of writing details that were seductive under any condition. Despite carefully writing details with both emotional and cognitive interest and pre-testing them for both interest level and relevance, the observed effects were much smaller than those reported in the meta-analysis. It is unclear whether the current results are driven by some aspect of the content or of the details, but effective guidelines will need to take into account both factors.

Based on the research to date, I am not yet able to offer useful, practical guidelines to practitioners about the seductive detail effect. The current work highlights numerous concerns about aspects of the seductive detail effect, including the definition of seductive details, the possible role of catalytic content, and potential mediating factors such as the availability of learning objectives. Further research is required in these areas before strong recommendations can be made. So what is an educator to do? Given the fact that the effect does not seem to be as straightforward as some research has implied, and the fact that the little research that has been done has not demonstrated the seductive detail effect outside of the lab (Muller, Lee, & Sharma, 2008), perhaps educators shouldn't be as worried about including interesting, but irrelevant information as Mayer would have them believe. Until more specific guidelines can be developed, educators' time may be better spent designing learning materials that take advantage of other well-tested instructional design principles such as the modality principle and the signaling principle than combing through written materials to excise potential seductive details.

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Appendix A

High- and Low-Interest Details, Study 1

Table A1

Pairs of high- and low-interest extraneous details used in Study 1.

	High-Interest	Low-Interest
Page 2	The deepest hole that has ever been drilled into the Earth's crust is the Kola Superdeep Borehole, which is 7.5 miles deep. Digging had to stop at that depth because the temperature had already reached 356 °F.	Lava is the name for magma that has erupted onto the Earth's surface—the red-hot material spilling from volcanoes. You can see lakes made of lava at five places in the world, including Kilauea in Hawaii.
Page 3	A chain of volcanoes formed at a subduction zone is called a **volcanic arc**. The Indonesian Island Arc contains some of the most powerful volcanoes in the world.	Basalt is the dark, heavy, volcanic rock that makes up most of the world's oceanic crust. Compared to the familiar granite of the continents, basalt is darker, denser and finer grained.
Page 4	The Pacific Plate is moving to the northwest at approximately 1.8 inches per year. At this rate, Los Angeles and San Francisco will be next-door neighbors in about 15 million years; in an additional 70 million years, Los Angeles residents will find themselves with an Alaska zip code.	A recent study at a Midwestern university showed that the North American tectonic plate moved at a rate of about 10 inches per year—1.1 billion years ago. That is about twice as fast as plates typically moved at that time.
Page 5	"The Big One" is a hypothetical earthquake of magnitude approximately 8 or greater that is expected to happen along the San Andreas Fault. Such a quake will produce devastation to human civilization within about 50 to 100 miles of the quake zone, especially in urban areas like San Francisco.	One of the side effects of plates colliding or sliding past each other is that the tremendous heat and pressure resulting from the plate movement changes the rock in the plates to new kinds of rock. For example, the basalt in an oceanic plate can be changed into a new kind of rock called schist.

Page 6	Alaska is the most earthquake-prone state and one of the most seismically active regions in the world. Alaska experiences a magnitude 7 earthquake almost every year, and a magnitude 8 or greater earthquake on average every 14 years.	Earthquakes occur in the central portion of the United States, too. Some very powerful earthquakes occurred along the New Madrid fault in the Mississippi Valley in 1811-1812.
Page 7	The Rift Valley has been a rich source of hominid fossils that allow the study of human evolution. One of the most well-known fossils from this region is "Lucy," a hominid skeleton dating back over 3 million years.	The East African Rift System (EARS) is unusual in that there are three plates moving apart: the Arabian Plate, the Nubian African Plate, and the Somalian African Plate.
Page 8	The odds are approximately one in three that a big earthquake will occur at the Cascadia subduction zone in the next fifty years. One government agency predicts that this earthquake could kill as many as 13,000 people.	A craton is a large area of continental crust that is fairly rigid and has been stable for millions of years. The North American craton covers most of the United States and Canada and limits how far the North American Plate can bulge and compress.
Page 9	Fossils provide evidence of previous location of plates. Marine fossils discovered in Antarctica tell us that Antarctica was once located near the equator and had a tropical climate.	The last supercontinent was formed about 300 million years ago. The current continents were all connected at that time, and the Earth contained only one large ocean.

Appendix B

Lesson Content Screens, Study 1

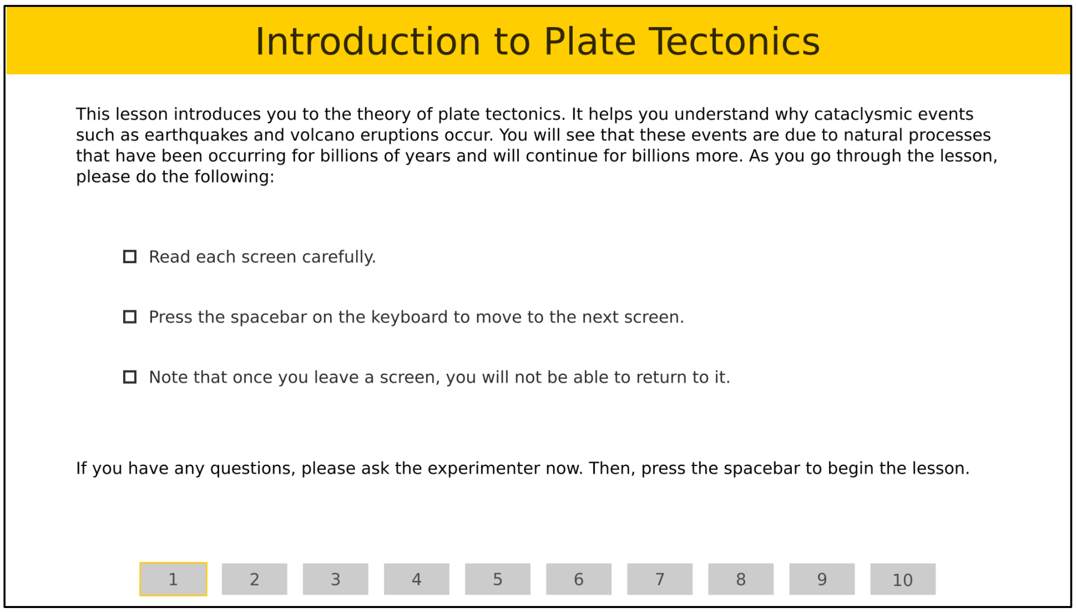


Figure B1. High-interest detail screen from lesson, page 1.

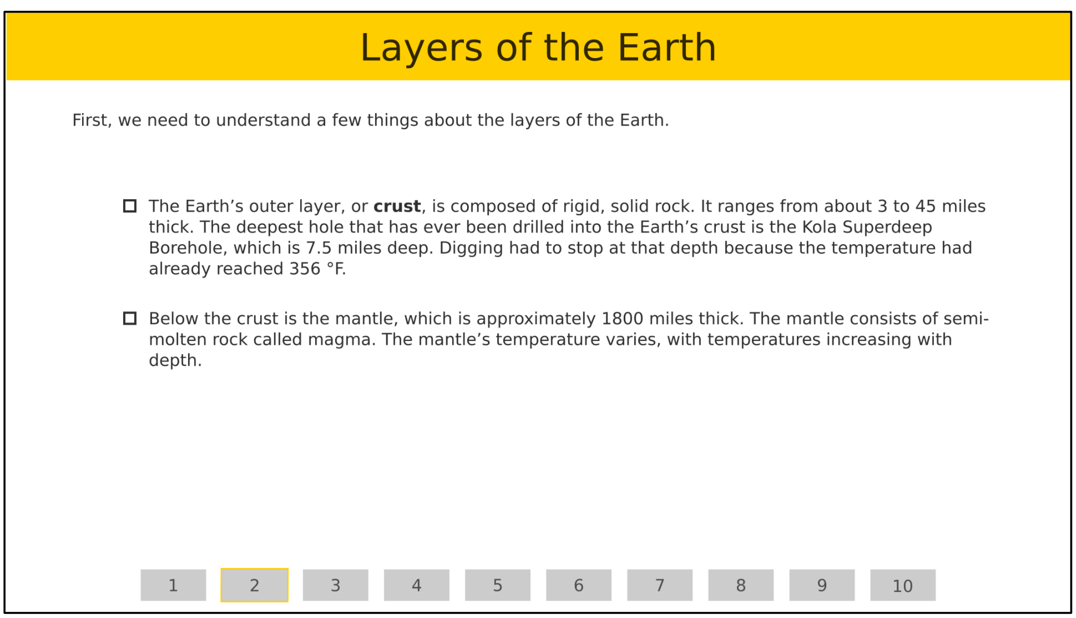


Figure B2. High-interest detail screen from lesson, page 2.

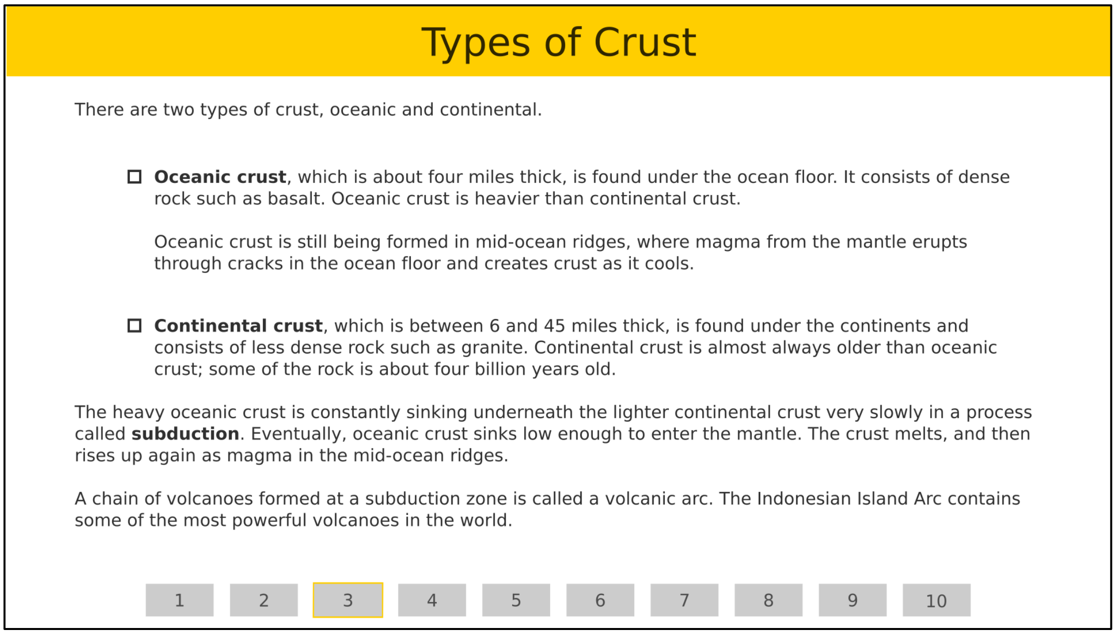


Figure B3. High-interest detail screen from lesson, page 3.

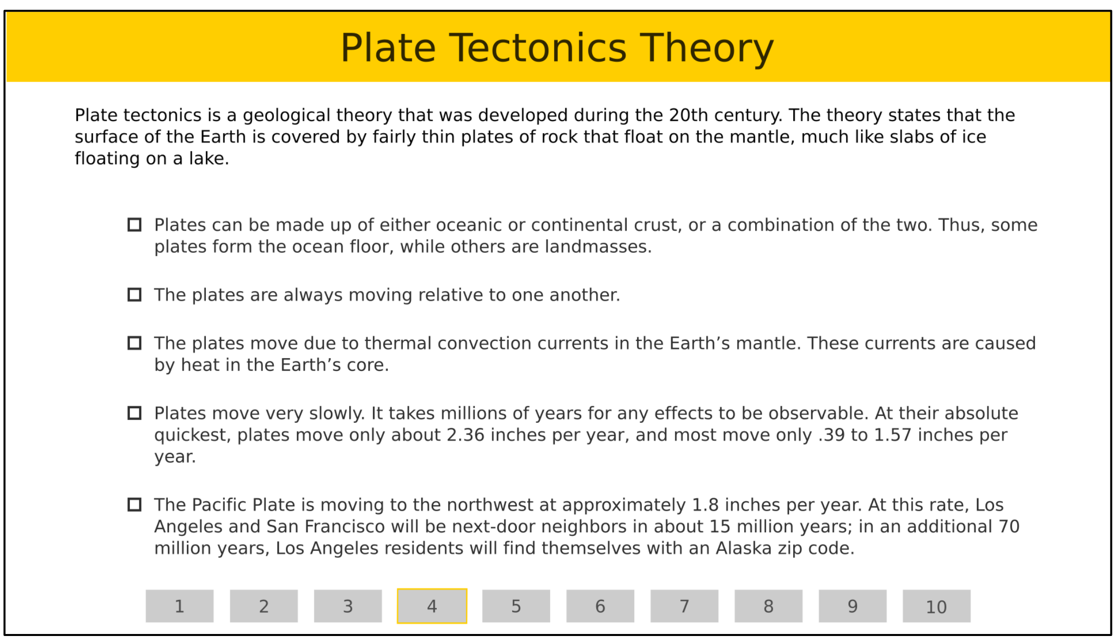


Figure B4. High-interest detail screen from lesson, page 4.

Plate Movement

The edges of the plates are called **plate boundaries**. These are the spots at which major geological events occur—earthquakes, volcanoes, and mountain-building processes. Where plates meet, molten magma is able to force its way to the surface and escape as lava. Plates move at one of three types of boundaries:

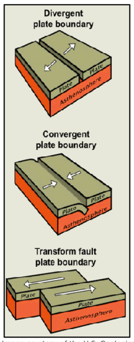


Image courtesy of the U.S. Geological Survey. The USGS home page is http://www.usgs.gov.

Divergent boundaries are places at which plates move away from each other. A **rift** is a weak place in the Earth's crust due to the separation of two plates. Magma can ooze up from the mantle into the crack between the plates and can make the ocean basin wider; this is known as sea-floor spreading. An example is the Mid-Atlantic Ridge, which is widening the Atlantic Ocean.

Convergent boundaries are places at which plates come together in different ways. One method is that one plate slides underneath the other into the mantle, where it is destroyed. Another method is when two plates collide and force up huge mountain ranges. The collisions often cause volcanoes. One example is the Indian plate pushing against the Eurasian plate, which in turn pushes up the Himalayas.

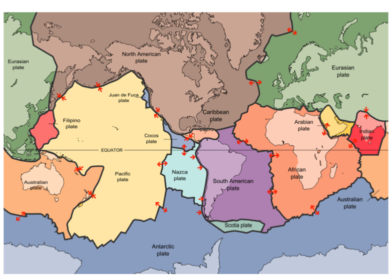
Transform fault boundaries are where plates slide past each other, ideally with little or no vertical movement, either in opposite directions or in the same direction but at different speeds. A well-known example is the San Andreas Fault in California, which is responsible for some of the most devastating earthquakes in U.S. history. "The Big One" is a hypothetical earthquake of magnitude approximately 8 or greater that is expected to happen along the San Andreas Fault. Such a quake will produce devastation to human civilization within about 50 to 100 miles of the quake zone, especially in urban areas like San Francisco.

1 2 3 4 5 6 7 8 9 10

Figure B5. High-interest detail screen from lesson, page 5.

About the Plates

Plates are categorized in different ways, but it is typically agreed that the main plates are the ones shown on the map below. As shown, some of the plates are quite large, such as the Pacific plate and the North American plate. Others are small, such as the Juan de Fuca plate and the Scotia plate. Even the smaller plates are capable of causing major events, such as earthquakes. Alaska is the most earthquake-prone state and one of the most seismically active regions in the world. Alaska experiences a magnitude 7 earthquake almost every year, and a magnitude 8 or greater earthquake on average every 14 years.



The red arrows in the illustration indicate how the plates are moving:

- Divergent plate boundary
- Convergent plate boundary
- Transform fault plate boundary

1 2 3 4 5 6 7 8 9 10

Figure B6. High-interest detail screen from lesson, page 6.

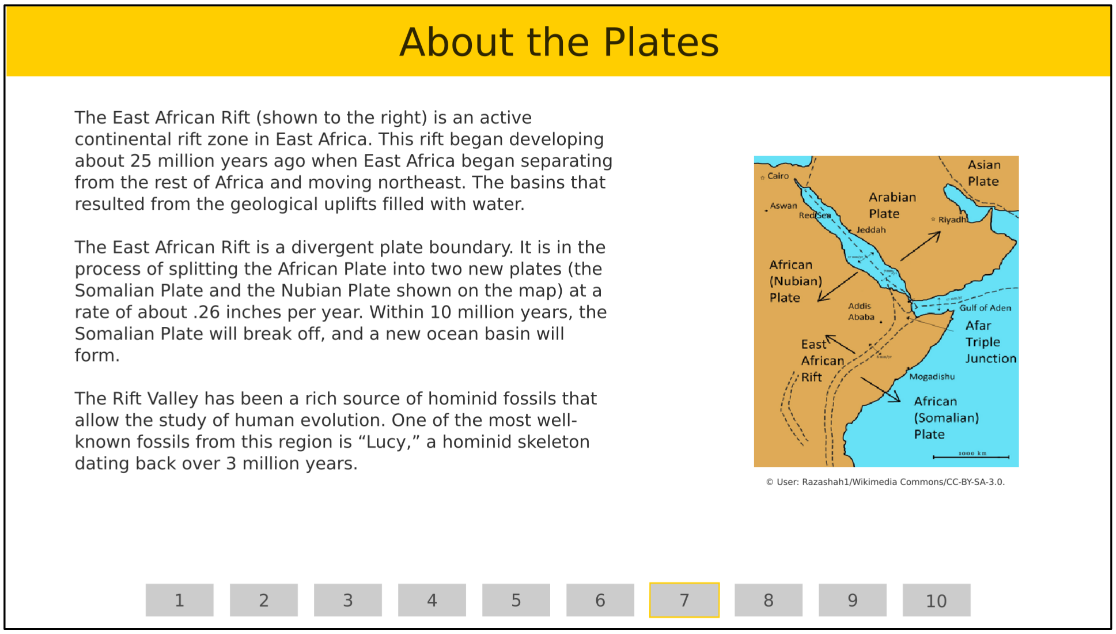


Figure B7. High-interest detail screen from lesson, page 7.

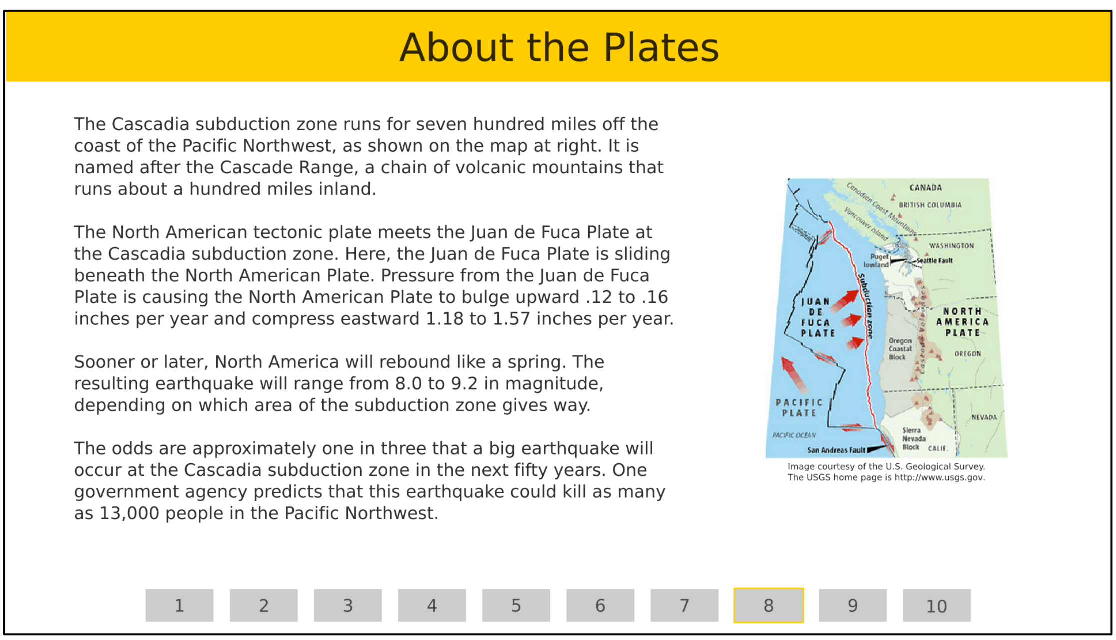


Figure B8. High-interest detail screen from lesson, page 8.

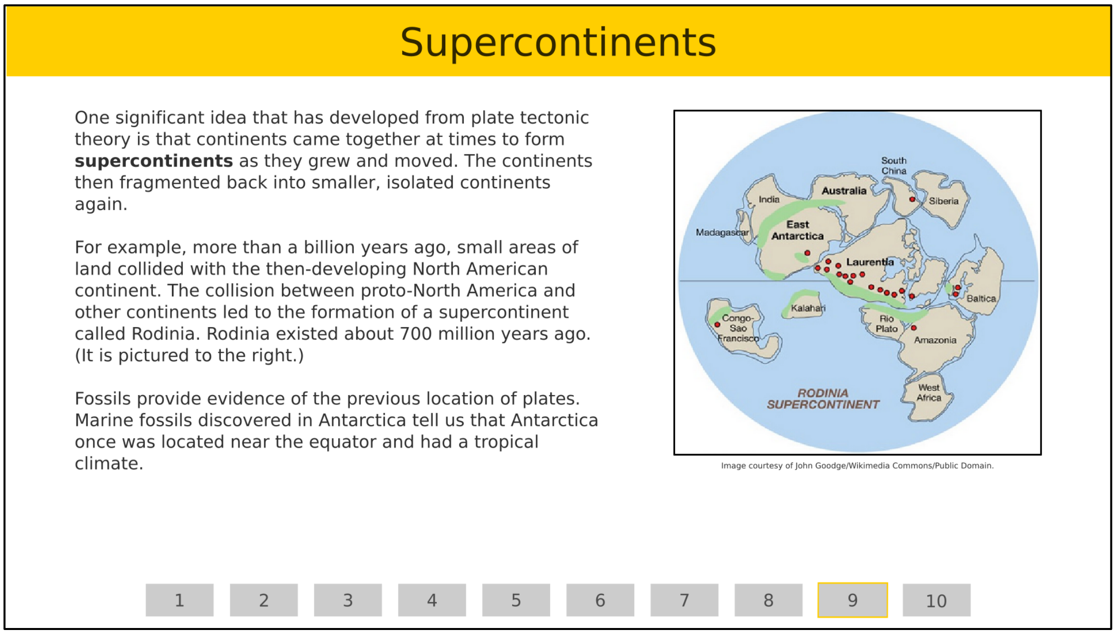


Figure B9. High-interest detail screen from lesson, page 9.

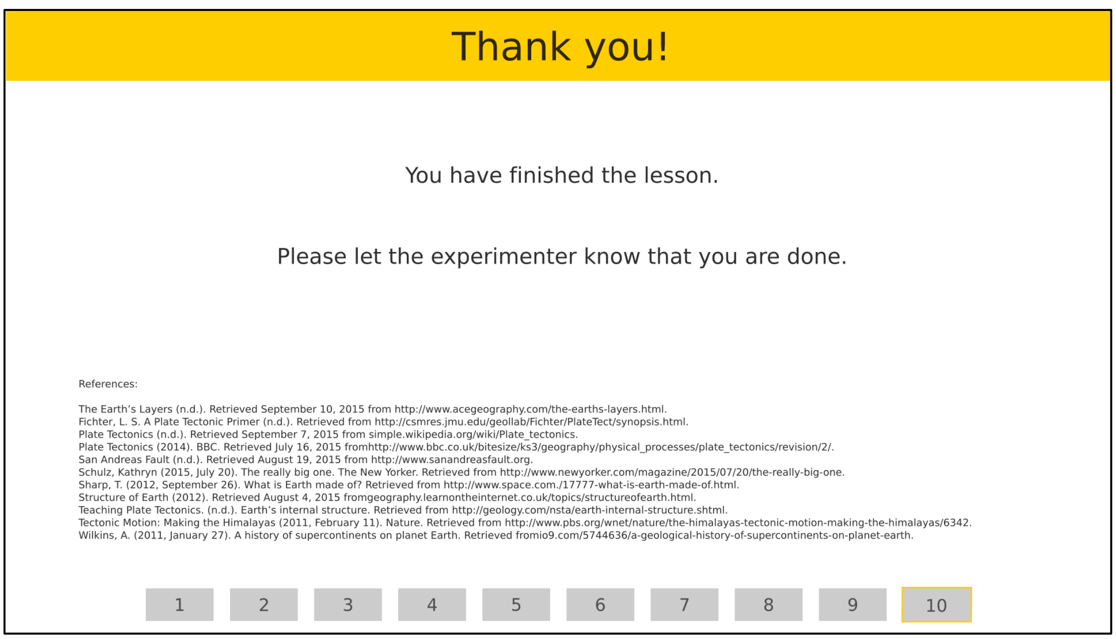


Figure B10. High-interest detail screen from lesson, page 10.

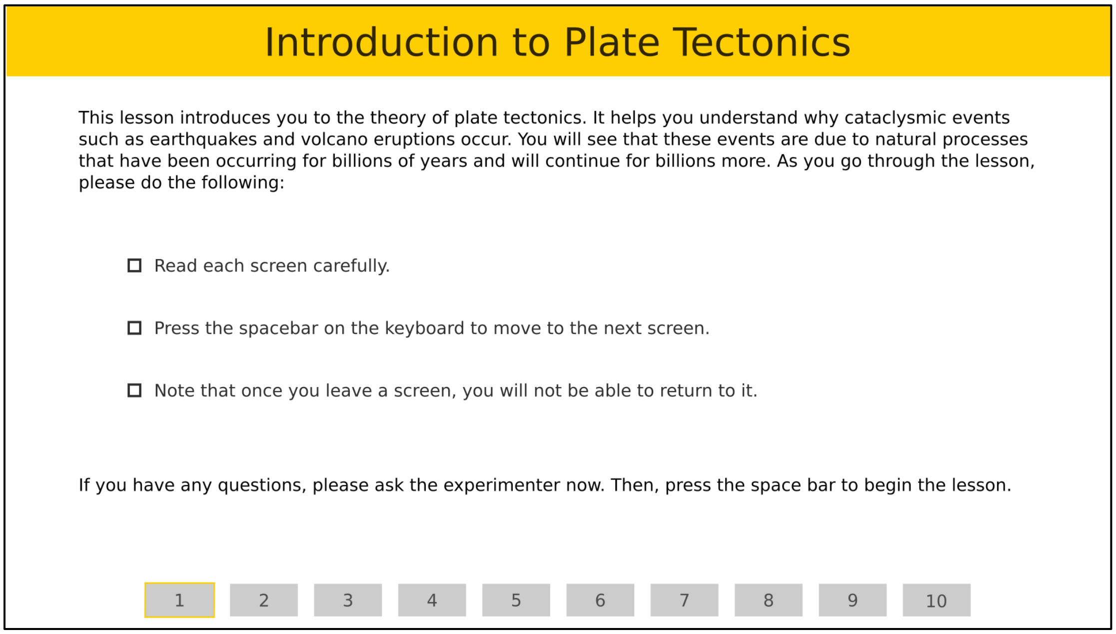


Figure B11. Low-interest detail screen from lesson, page 1.

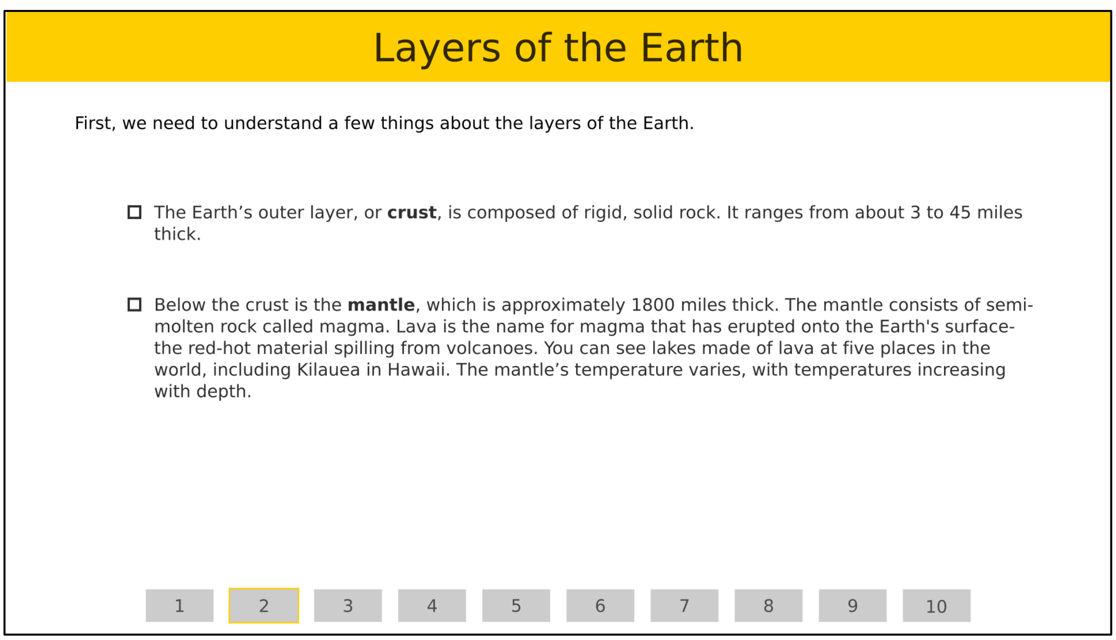


Figure B12. Low-interest detail screen from lesson, page 2.

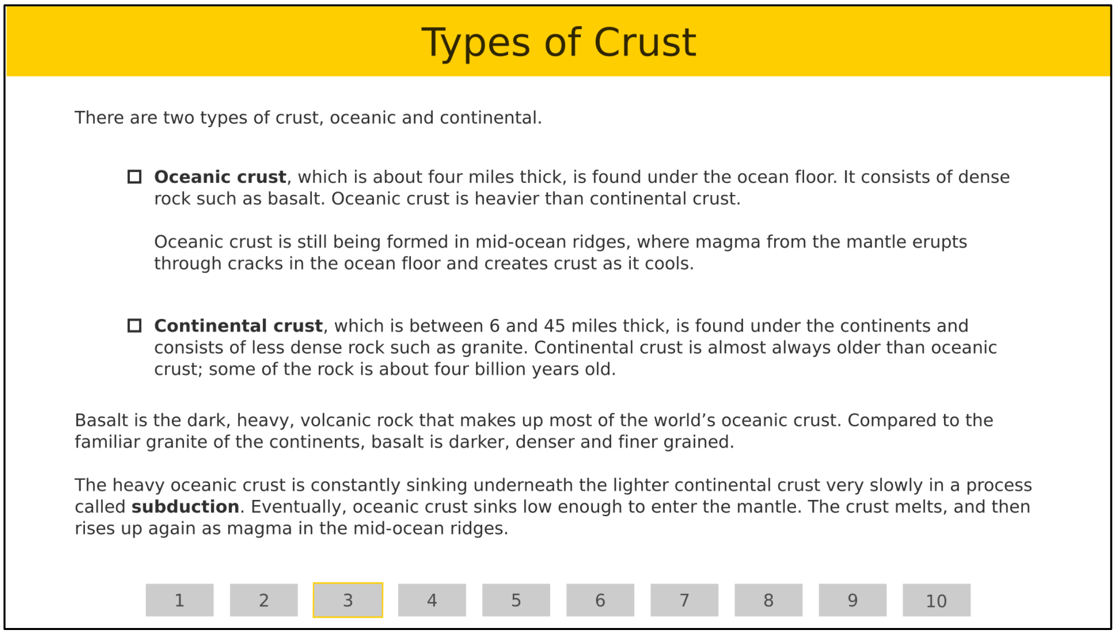


Figure B13. Low-interest detail screen from lesson, page 3.

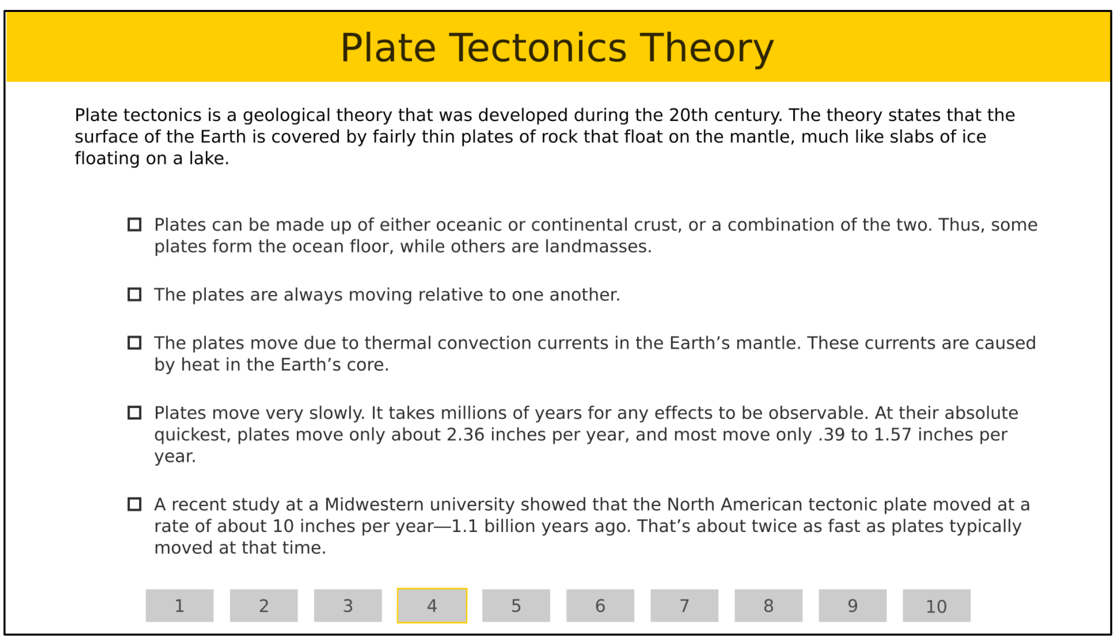


Figure B14. Low-interest detail screen from lesson, page 4.

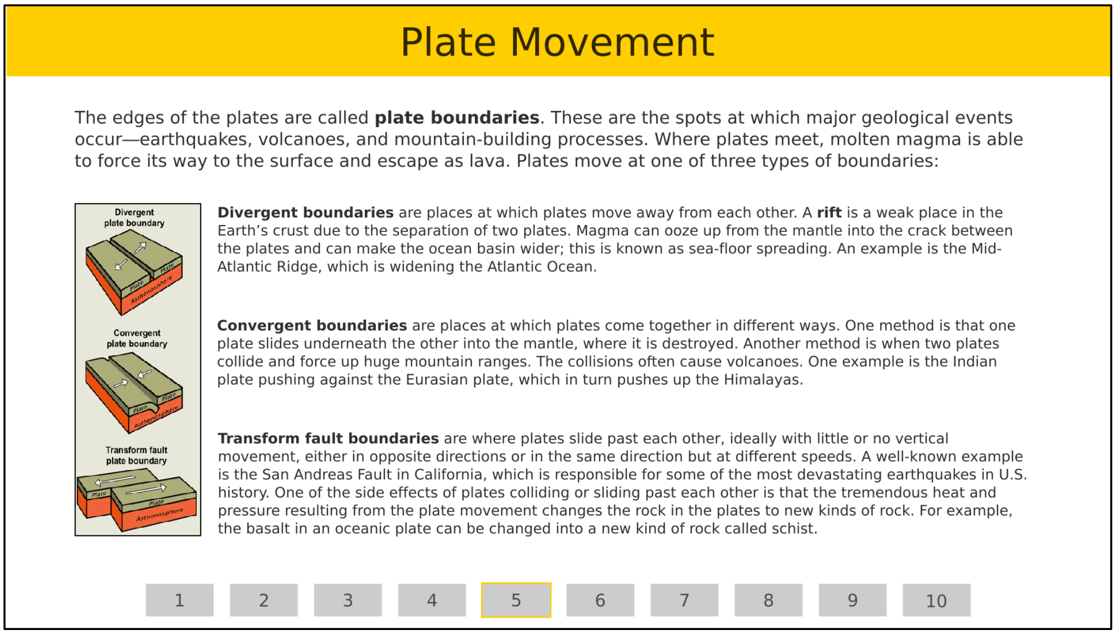


Figure B15. Low-interest detail screen from lesson, page 5.

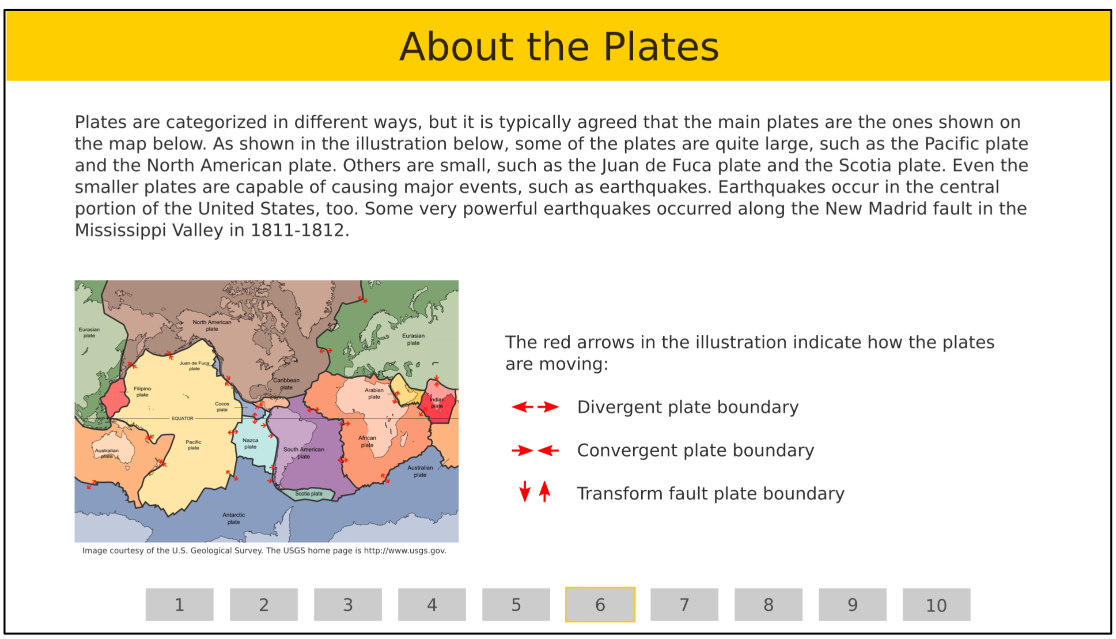


Figure B16. Low-interest detail screen from lesson, page 6.

About the Plates

The East African Rift (shown to the right) is an active continental rift zone in East Africa. This rift began developing about 25 million years ago when East Africa began separating from the rest of Africa and moving northeast. The basins that resulted from the geological uplifts filled with water.

The East African Rift is a divergent plate boundary. It is in the process of splitting the African Plate into two new plates (the Somalian Plate and the Nubian Plate shown on the map) at a rate of about .26 inches per year. Within 10 million years, the Somalian Plate will break off, and a new ocean basin will form.

The East African Rift area is unusual in that there are three plates moving apart: the Arabian Plate, the Nubian African Plate, and the Somolian African Plate.

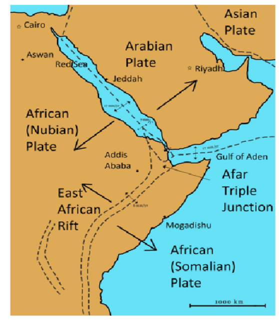


Figure B17. Low-interest detail screen from lesson, page 7.

About the Plates

The Cascadia subduction zone runs for seven hundred miles off the coast of the Pacific Northwest, as shown on the map at left. It is named after the Cascade Range, a chain of volcanic mountains that runs about a hundred miles inland.

The North American tectonic plate meets the Juan de Fuca Plate at the Cascadia subduction zone. Here, the Juan de Fuca Plate is sliding beneath the North American Plate. Pressure from the Juan de Fuca Plate is causing the North American Plate to bulge upward .12 to .16 inches per year and compress eastward 1.18 to 1.57 inches per year.

A craton is a large area of continental crust that is fairly rigid and has been stable for millions of years. The North American Craton covers most of the United States and Canada and limits how far the North American Plate can bulge and compress.

Sooner or later, North America will rebound like a spring. The resulting earthquake will range from 8.0 to 9.2 in magnitude, depending on which area of the subduction zone gives way.

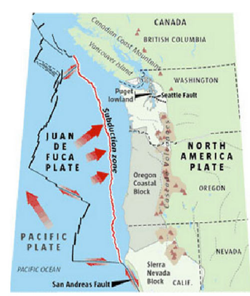


Image courtesy of the U.S. Geological Survey.
The USGS home page is http://www.usgs.gov.

Figure B18. Low-interest detail screen from lesson, page 8.

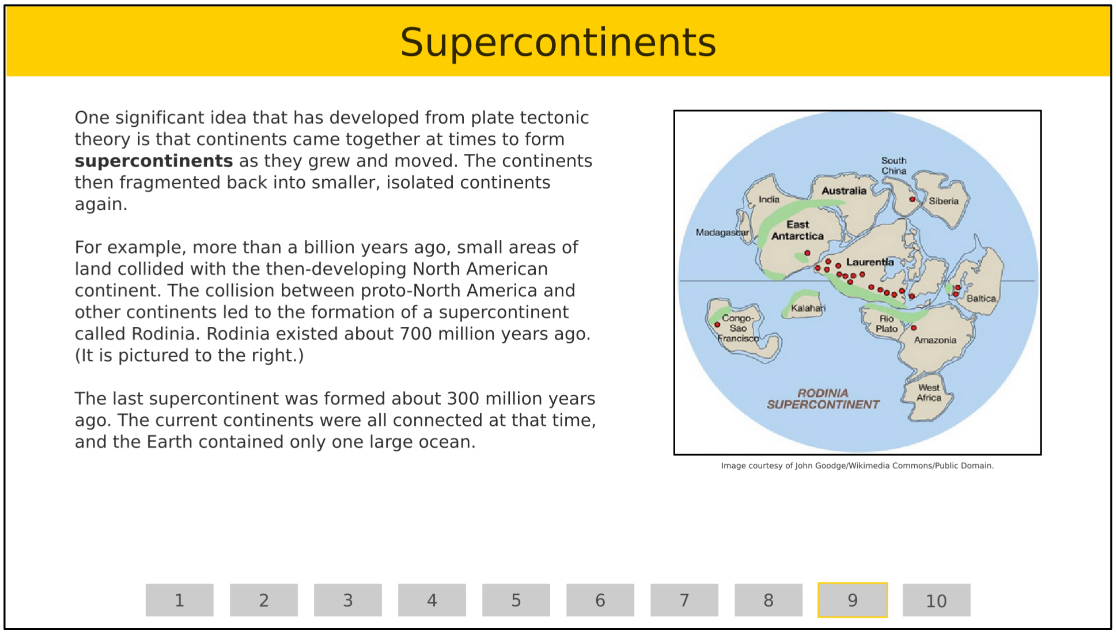


Figure B19. Low-interest detail screen from lesson, page 9.

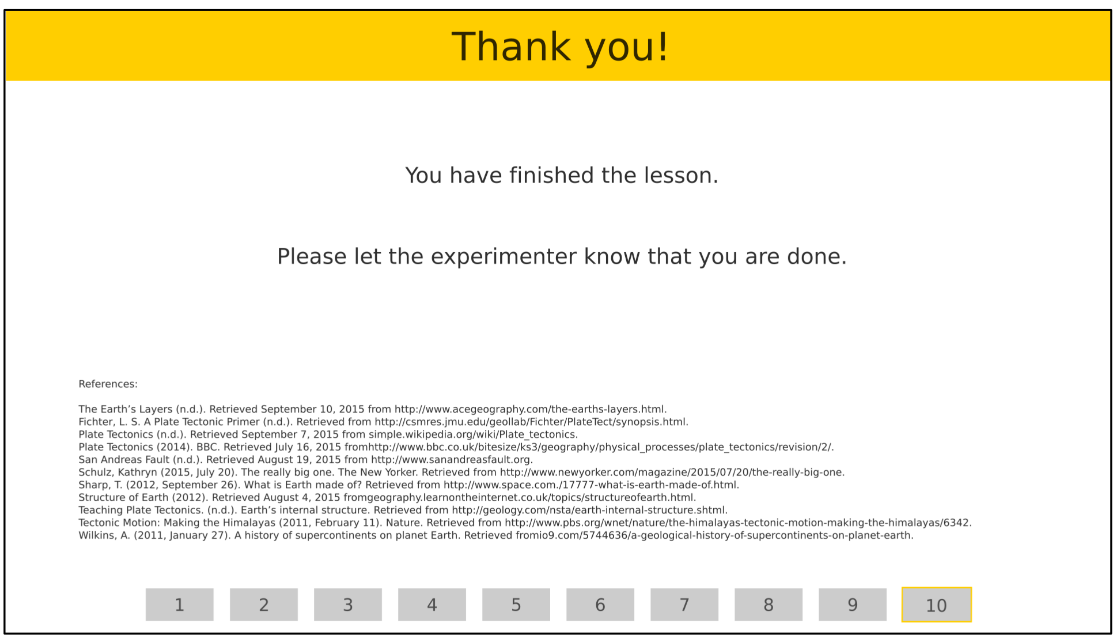
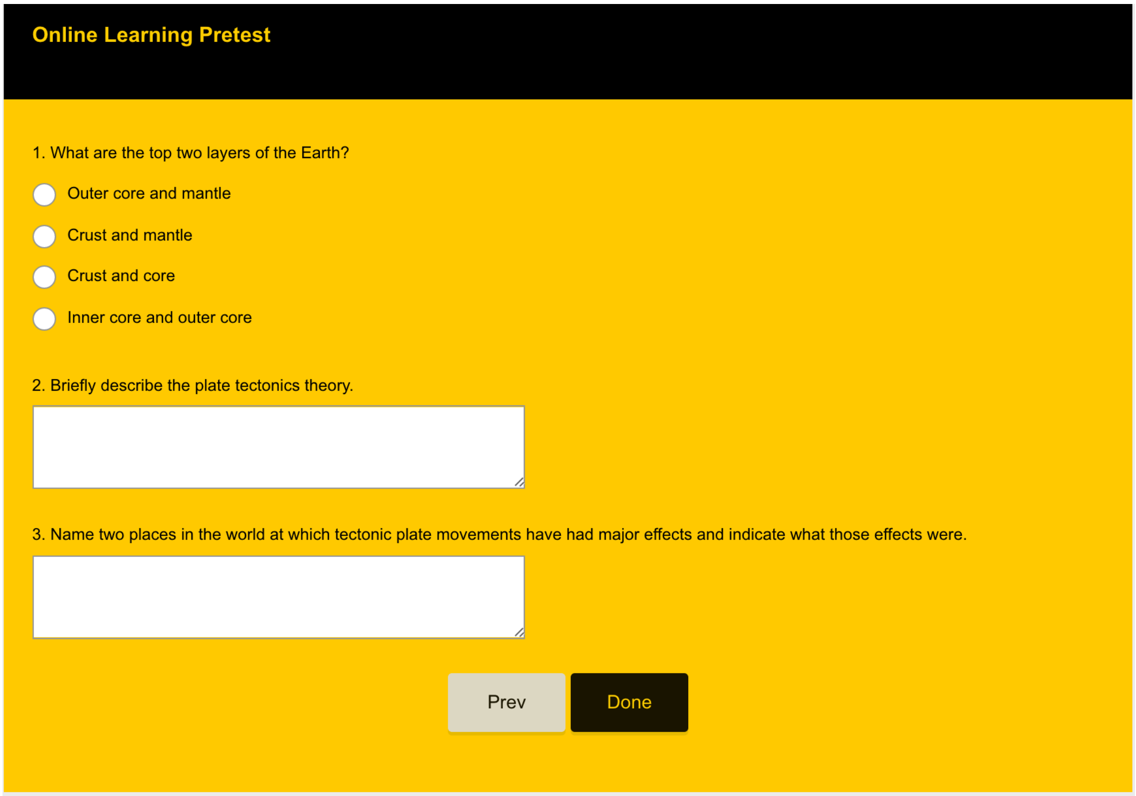


Figure B20. Low-interest detail screen from lesson, page 10.

Appendix C

Pretest Questions



Online Learning Pretest

1. What are the top two layers of the Earth?

- Outer core and mantle
- Crust and mantle
- Crust and core
- Inner core and outer core

2. Briefly describe the plate tectonics theory.

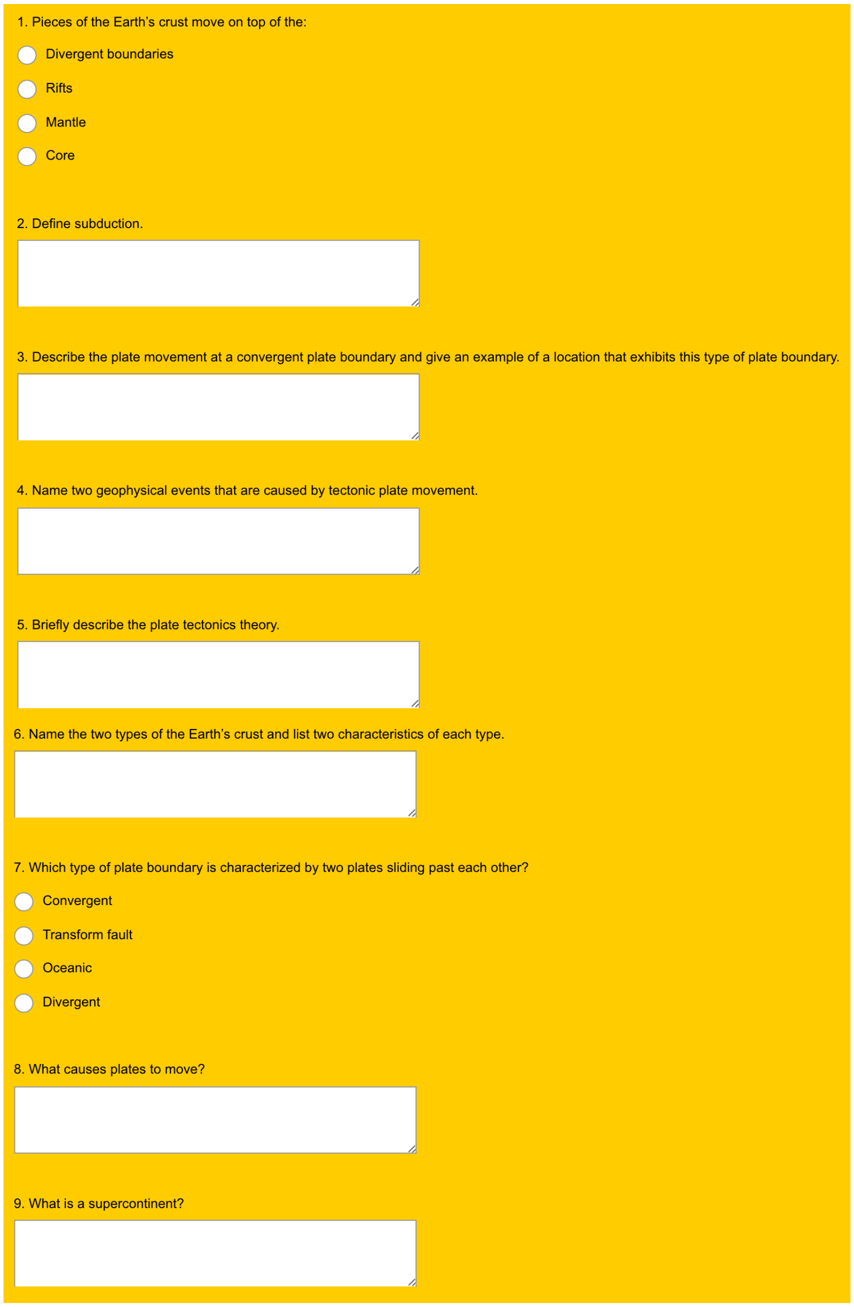
3. Name two places in the world at which tectonic plate movements have had major effects and indicate what those effects were.

Prev Done

Figure C1. Pretest, Study 1.

Appendix D

Recall/Recognition Test Questions



1. Pieces of the Earth's crust move on top of the:

- Divergent boundaries
- Rifts
- Mantle
- Core

2. Define subduction.

3. Describe the plate movement at a convergent plate boundary and give an example of a location that exhibits this type of plate boundary.

4. Name two geophysical events that are caused by tectonic plate movement.

5. Briefly describe the plate tectonics theory.

6. Name the two types of the Earth's crust and list two characteristics of each type.

7. Which type of plate boundary is characterized by two plates sliding past each other?

- Convergent
- Transform fault
- Oceanic
- Divergent

8. What causes plates to move?

9. What is a supercontinent?

Figure D1. Recall/recognition test, core content questions, Study 1.

10. The Rift Valley in Africa has provided a great deal of material for studying:

- Subduction zones
- Mountain-building activity
- Oceanic crust
- Evolution

11. California is the most earthquake-prone state in the U.S.

- True
- False

12. A chain of volcanoes formed at a subduction zone is called a:

- Rift
- Subduction arc
- Volcanic arc
- Divergent boundary

13. Drilling had to stop at the Kola Borehole due to:

- The fact that they drilled all the way into the Earth's core
- The extremely high temperature
- Government regulations
- The extremely low temperature

14. With the movement of the Pacific Plate, Los Angeles will end up in this location in 70 million years:

- Peru
- Alaska
- China
- Central America

15. What are the odds of a major earthquake occurring at the Cascadia subduction zone in the next 50 years?

- About one in three
- It's a virtual certainty.
- Approximately one in ten
- An earthquake could not occur there.

16. Marine fossils discovered in Antarctica tell us that Antarctica once was located:

- At the North Pole
- In what is now Europe
- Near the equator
- In central Russia

17. "The Big One" is an earthquake predicted to occur at which plate boundary in the U.S.?

- Juan de Fuca
- Mid-Atlantic Ridge
- Nazca
- San Andreas Fault

Figure D2. Recall/recognition test, high-interest detail questions, Study 1.

18. What is unique about the plates in the East African Rift area?

- ◯ There are three plates moving apart.
- ◯ The plate collisions are causing mountains to be formed.
- ◯ The plates are at transform fault boundaries.
- ◯ There are no plates in this area.

19. What is the dark, heavy rock that makes up most of the world's oceanic crust?

- ◯ Obsidian
- ◯ Basalt
- ◯ Schist
- ◯ Granite

20. A recent study showed that the North American tectonic plate moved at a rate of about 10 inches per year, 1.1 billion years ago. This is __________ plates typically moved at that time.

- ◯ The average speed at which
- ◯ Almost ten times as fast as
- ◯ Approximately twice as fast as
- ◯ About half as fast as

21. When the last supercontinent formed, how were the continents positioned?

- ◯ South America and Africa were connected; the others were positioned as they are today.
- ◯ None of the continents were connected.
- ◯ All of today's continents were connected except for North America.
- ◯ They were all connected.

22. Earthquakes cannot occur in the central U.S.

- ◯ True
- ◯ False

23. When plates collide, the resultant heat and pressure can cause:

- ◯ Changes to the type of rock in the plates
- ◯ A craton to form
- ◯ A rift
- ◯ Convection currents

24. Lava is the name for magma that has:

- ◯ Changed into a new kind of rock called schist.
- ◯ Caused sea-floor spreading.
- ◯ Been a rich source of hominid fossils.
- ◯ Erupted onto the Earth's surface.

25. A craton is:

- ◯ A large area of continental crust that is rigid and stable
- ◯ An area at which plates are pulling apart
- ◯ The top-most layer of the Earth
- ◯ A chain of volcanoes at a subduction zone

Figure D3. Recall/recognition test, low-interest detail questions, Study 1.

Appendix E: Transfer Test Questions

The map below shows the major plate boundaries, and the arrows indicate how the plates are currently moving. These questions may not necessarily have right and wrong answers; we are mainly interested in the reasoning you used to arrive at your answers.

1. The CEO of your company wants to set up a new division in one of these locations numbered on the map. [1:Seattle (Washington, U.S.), 2:Lima (Peru), 3:Asmara (Eritrea), 4:Helsinki (Finland)] Based ONLY on plate movements, which city would you recommend as the safest from a geophysical perspective?

- Seattle, Washington
- Lima, Peru
- Asmara, Eritrea
- Helsinki, Finland

2. Explain the reason(s) for your choice in question 1.

3. Using the information from question 1 again, explain your reasons for NOT selecting each of the other three locations.

4. Look at location number 5 on the map. Name the type(s) of geophysical events you think might occur in this area and give reasons for your answer.

Image courtesy of the U.S. Geological Survey. The USGS home page is http://www.usgs.gov.

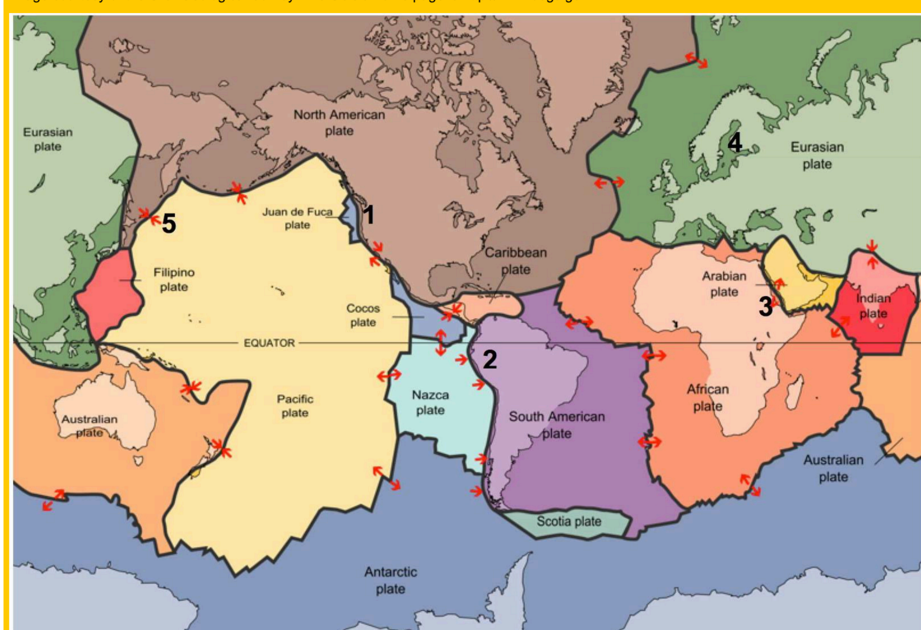


Figure E1. Transfer test questions, Study 1.

Appendix F

Potential Details for Study 2

Table F1

High- and low-interest extraneous details rated for Study 2.

1.	At night, it appears that electric-blue lava is flowing from the Kawah Ijen volcano in Indonesia. The color is caused by sulfuric gases that emerge with the lava; when the gases are exposed to oxygen and the lava causes them to burn, the flames are bright blue.
2.	Researchers can recreate magma using just a sliver of rock from a volcano, mixing it with other substances and placing it in a furnace. The recreated magma allows them to determine the temperature and pressure at which the lava was produced and to determine from how deep from inside the volcano the rock came.
3.	Russia's Kola Superdeep Borehole, the deepest hole in the world, led to a hoax in which people claimed that the drilling had extended all the way to hell. The story was that engineers had lowered a microphone down into the hole, where the temperature was 2000 °F, and that they could hear the screams of the damned.
4.	When the Earth formed, molten iron sank to its center to create the core. This process caused most of the planet's precious metals, such as gold and platinum, to sink as well. Scientists estimate that there are enough precious metals in the core to cover the entire surface of Earth with a layer about 13 feet thick.
5.	The deepest drilling that has ever been done into the Earth's crust is the Kola Superdeep Borehole, which is 7.5 miles deep. (The distance to the center of the Earth is 4,000 miles.) Digging had to stop at that depth because the temperature had already reached 356 °F.
6.	Lava is the name for magma that has erupted onto the Earth's surface—the red-hot material spilling from volcanoes. When a volcanic cone fills with lava but doesn't erupt, a lava lake is formed. You can see lakes made of lava at five places in the world, including Kilauea in Hawaii.
7.	The boundary between the Earth's continental crust and the mantle beneath it is called the Mohorovicic discontinuity, or Moho. In geology the word "**discontinuity**" is used for a surface at which seismic waves change velocity. At this discontinuity, seismic waves accelerate. One important scientific objective is to drill into the Moho.

8. The thin veneer of crust we live on makes up about one percent of Earth's volume. The inner and outer core occupy only 15 percent of the planet's volume. The mantle, between the outer core and the crust, makes up an estimated 68 percent of the planet's mass and 85 percent of its volume.
9. Magma near subduction zones contains ten times more gas, so the volcanic eruptions there are violent. The gas inside magma can expand hundreds of times in just a few seconds. One of the biggest eruptions ever occurred 2.2 million years ago and poured out enough magma to build six Mount Fujis.
10. The Mediterranean Ridge is the result of the African plate subducting underneath the Eurasian plate and other smaller microplates. As it moves, the African plate plows up the floor of the Mediterranean Sea, which is how Cyprus was formed. It may eventually form extremely high mountains in the Mediterranean.
11. Basalt is the dark, heavy, volcanic rock that makes up most of the world's oceanic crust. Compared to the familiar granite of the continents, basalt is darker, denser and finer grained. The first solid black crust of basalt on Earth formed 4.4 billion years ago.
12. A chain of volcanoes formed at a subduction zone is called a **volcanic arc**, and these volcanoes often form islands. The Pacific Ring of Fire is home to many of these groups of islands. The Indonesian Island Arc contains some of the most powerful volcanoes in the world.
13. Most of the world's ocean islands are volcanoes that may have originated as mantle plumes in the lowest part of the mantle. Hot rock that used to be part of the oceanic crust rose in columns from a depth of nearly 1,900 miles. Near the surface, where the pressure is reduced, the rock melted and formed volcanoes.
14. Mid-ocean ridges are peppered with vents of hot water, called black smokers. At these super-hot springs, the water hits the cold sea and turns black as the dissolved material in it—sulfur and metals and silica, mostly—precipitates out of solution. Many large ore deposits on land were formed at hydrothermal vents like these.
15. The rock at the bottom of the continental crust is lighter than the rock at the top, although the lighter material would be expected at the top. When an oceanic plate subducts beneath a continental plate, it drags lighter material such as sand and lava from the surface and deposits it underneath the continent.
16. When lava erupts under the sea, it cools into structures that resemble pillows. This dark rock is called pillow basalt, a volcanic, igneous rock. Pillow basalt typically forms at volcanoes at mid-ocean ridges or at oceanic hot-spot volcanoes, such as those that formed the Hawaiian Islands.

17. Recent research provides evidence for "true polar wander," in which the entire solid Earth slips about its liquid outer core over the course of five to ten million years, causing plates to shift completely. This research suggests that about 520 million years ago a shift of more than 60 degrees moved most continents from polar to tropical latitudes.
18. GPS is the most useful way to study crustal movement. Satellites in orbit about 12,000 miles above Earth continuously transmit radio signals. To determine its latitude, longitude, and elevation, each GPS ground site must simultaneously receive signals from four satellites. By measuring distances between points, geologists can determine if there has been movement along faults or between plates.
19. Until recently, it was thought that tectonic movements were present only on Earth. But geologists have found the first strong evidence for plate tectonics on Mars. The longest and deepest system of canyons in our solar system is on Mars and appears to be a plate boundary.
20. The Pacific Plate is moving to the northwest at approximately 1.8 inches per year. At this rate, Los Angeles and San Francisco will be next-door neighbors in about 15 million years; in an additional 70 million years, Los Angeles residents will find themselves with an Alaska zip code.
21. Alfred Wegener was a German scientist who first proposed the theory of continental drift, the movement of Earth's continents relative to each other. Wegener's ideas were initially rejected, but were proven to be generally true years after his death. A 2012 song about him called "The Posthumous Triumph of Alfred Wegener" by The Amoeba People is available on YouTube.
22. The deepest place on Earth is a trench near the Mariana Islands in the Pacific Ocean. The trench is 36,201 feet below sea level—if Mount Everest were placed in the trench, it would disappear. The trench was formed when the Pacific plate collided with the Philippine plate.
23. By studying the rock in West Greenland recently, a team of researchers concluded that modern plate tectonics—with subduction zones, earthquakes, and so on—started about 3.2 billion years ago. (The Earth is about 4.6 billion years old.) Before that, an entirely different set of processes shaped the Earth's surface.
24. The Pacific Plate is the largest tectonic plate and is the only large plate with no part of a continent situated on it. It represents more than one-third of the Earth's surface area. More than 80 percent of the world's earthquakes occur on the Pacific Plate.

25.	The Volcanic Explosivity Index (VEI) was developed in 1982. It is a relative scale that enables eruptions to be compared, whether they are recent eruptions or eruptions from millions of years ago. The primary characteristic used to determine the VEI is the volume of material—such as ash—ejected by the volcano.
26.	In 2011 scientists discovered a new transform fault, which they named Polaris, near Truckee, California (about 35 miles from Reno). Because this fault is connected to several other faults and is located near a dam, it could cause significant damage if it ruptured.
27.	The Earth's continents are currently moving away from the Mid-Atlantic Ridge toward the middle of the Pacific Ocean, where they will eventually collide in about 80 million years.
28.	When Mount Vesuvius erupted in 79 A.D., many citizens were killed. The heat would have boiled their brain tissue, which would then have burst out in small, scalding explosions that left blue-black burn marks on the bone. Moisture from vaporized flesh and blood combined with volcanic ash to create a plaster-like material that preserved the bones.
29.	The Mid-Atlantic Ridge appears above sea level at Iceland. In 1783 an eruption in this segment of the ridge released scorching lava and 50 million tons of sulfur dioxide. This ruined crops and killed more than 10,000 Icelanders, a fourth of the country's population at the time.
30.	One of the side effects of plates colliding or sliding past each other is that the tremendous heat and pressure resulting from the plate movement changes the rock in the plates to new kinds of rock. For example, the basalt in an oceanic plate can be changed into a new kind of rock called schist.
31.	"The Big One" is a hypothetical earthquake of magnitude approximately 8 or greater that is expected to happen along the San Andreas Fault. Such a quake will produce devastation to human civilization within about 50 to 100 miles of the quake zone, especially in urban areas like San Francisco.
32.	Some people believe that, when the "Big One" hits, California will suddenly "break off" and fall into the Pacific Ocean. There is no scientific basis for this. However, Catalina Island, south of Los Angeles, is falling into the sea at a rate of eight inches every thousand years and is tilting as it descends.
33.	The Pavlof volcano that erupted in Alaska recently is a stratovolcano—a steep, layered, cone-shaped volcano that looks beautiful but is also quite deadly. Other stratovolcanoes include Mount Rainier and Mount Etna. These volcanoes can produce ash plumes up to 49,000 feet high.

34. A pyroclastic surge is a boiling cloud of debris that shoots out sideways from the slopes of a volcano and can travel for miles. Few people have seen a surge up close, but many of us carry an image of it in memory: it resembles the clouds of powder and ash produced when the World Trade Center towers collapsed.
35. Volcanic ash can be disastrous for airplanes. Made of up tiny glass particles and pulverized rock, ash can spew tens of thousands of feet into the air, reaching jet cruising altitude. Ash that gets into the combustion chamber can melt, producing a substance like molten glass. That substance solidifies on turbine blades, blocking airflow and potentially stalling the engine.
36. More than 143 million Americans living in the 48 contiguous states are exposed to potentially damaging ground shaking from earthquakes. When people living in the earthquake-prone areas of Alaska, Hawaii and the U.S. territories are added, this number rises to nearly half of all Americans.
37. The moment magnitude scale (MMS) replaced the 1930s-era Richter scale in the 1970s as the method of measuring the size of earthquakes in terms of energy released. A quake is considered major when it registers more than 7.0 on the moment magnitude scale. A magnitude of 3.0 or lower is nearly imperceptible.
38. Earthquakes occur in the central portion of the United States, too. Some very powerful earthquakes occurred along the New Madrid fault in the Mississippi Valley in 1811-1812. The New Madrid fault line is about 20 times larger than the San Andreas fault and has triggered some small earthquakes in recent years.
39. Alaska is the most earthquake-prone state and one of the most seismically active regions in the world. Alaska experiences a magnitude 7 earthquake almost every year, and a magnitude 8 or greater earthquake on average every 14 years. Activity occurs at the boundary between the North American Plate and the North Pacific Plate.
40. The place where three tectonic plates meet, as in East Africa, is called a triple junction. A meeting of three plates is also a meeting of three boundaries, each with its own motion. Where three plates meet, all three could be divergent or convergent, but it is physically impossible for all three to be transform faults.
41. The East African Rift consists of a western and an eastern branch. The Western Rift contains some of the deepest lakes in the world, the Rift Valley Lakes. These fresh-water lakes are home to great biodiversity. For example, about 1,500 cichlid fish species live in the lakes. Cichlids are perch-like fish that appear only in tropical and subtropical freshwaters.

42. The East African Rift System (EARS) is a complex set of rifts considered to be one of the geologic wonders of the world. The area is unusual in that there are three plates moving apart: the Arabian Plate, the Nubian African Plate, and the Somalian African Plate.

43. The Rift Valley has been a rich source of hominid fossils that allow the study of human evolution. One of the most well-known fossils from this region is "Lucy," a hominid skeleton dating back over 3 million years. Environmental changes here may have driven our ancestors to become bipedal and to become more intelligent in order to adapt.

44. The volcanic and tectonic activity occurring in the East African Rift Valley makes it a potent power source. The United Nations Environment Program is developing a geothermal energy program to convert the heat created by the rift valley's underground activity into electricity through a series of steam wells. One of these wells in Kenya generates power for 5,700 homes.

45. Well-preserved dinosaur remains unearthed in Australia belong to species that had keen night vision and were warm-blooded, enabling them to forage for food during long, sub-freezing winter nights. This evidence demonstrates that Australia has drifted toward the equator during the last 100 million years. When these dinosaurs thrived, their habitat was much farther south, well within the Antarctic Circle.

46. Crater Lake in Oregon formed after the eruption and collapse of Mount Mazama, one of the volcanoes in the Cascade Mountain Range. About 6,000 years ago, rain and snow filled the caldera (volcanic crater) that was formed. It took about 250 years for the caldera to fill to its present-day lake level, which is nearly 2,000 feet deep.

47. Liquefaction occurs when the strength and stiffness of soil is reduced by earthquake shaking and has been responsible for much earthquake damage. Liquefaction occurs in saturated soils—soils in which the space between individual particles is completely filled with water. Construction on liquefaction-susceptible soils should be avoided.

48. Juan de Fuca is the Spanish-translated name of a Greek mariner who sailed for Spain in the 1500s. He claimed to discover a strait in the Pacific Northwest that led him to lands rich in gold, silver, and pearls. Historians doubt that he sailed the strait bearing his name, and for a time they doubted that he even existed.

49. Subduction zone, or megathrust, earthquakes are the largest types of earthquakes in the world and reach magnitudes above 9.0. These earthquakes are extremely powerful and destructive. The Pacific Northwest experiences a megathrust earthquake approximately every 500 years, and the last one occurred in 1700.

50. In 1700, an earthquake near the Cascadia Subduction Zone produced a tsunami that hit Japan. Tsunamis are seismic sea waves that cause the sea floor to move by many feet. An enormous amount of water is set into motion and sloshes back and forth for several hours, resulting in waves that travel at more than 500 miles per hour.

51. Regular earthquakes take place rapidly, while slow earthquakes occur over many months. Every 12 to 15 months, slow earthquakes occur in the Cascadia Subduction Zone. One of these events is happening now and is possibly connected to the earthquake that occurred northeast of Victoria, Canada on December 29, 2015. Slow earthquakes do not produce high-frequency seismic energy.

52. A craton is a large area of continental crust that is fairly rigid and has been stable for millions of years. The North American craton covers most of the United States and Canada and limits how far the North American Plate can bulge and compress.

53. The odds are approximately one in three that a big earthquake—similar in strength to Japan's 2011 earthquake—will occur at the Cascadia subduction zone in the next fifty years. One government agency predicts that this earthquake could kill as many as 13,000 people.

54. Scientists predict that the next supercontinent will form between 50 and 200 million years from now. It has already been named Amasia. One theory suggests that it will form when the Americas and Asia drift northward to merge and close off the Arctic Ocean.

55. Cynognathus is an extinct mammal-like reptile. The name means "dog jaw." Cynognathus was as large as a modern wolf and lived 250 to 240 million years ago. It is found as fossils only in South Africa and South America, which suggests that those plates were connected at one time.

56. Orogeny is the building of continental mountains by convergent plate tectonics processes. The Alleghanian Orogeny (325 million years ago) was the most recent of several major orogenies to help form the Appalachian Mountains. It was the result of a collision between ancestral North America and Africa and resulted in the supercontinent of Pangaea.

57. Geophysicists have developed a model to propose where future supercontinents will form. After a supercontinent breaks up, the continents initially drift apart but become trapped within a north-south band of subduction. The new supercontinent forms in this band, a quarter of the way around the globe (90°) from the center of its predecessor.

58. Unlike later supercontinents, Rodinia was entirely barren; it existed before life colonized dry land. It was before the formation of the ozone layer, so it was too exposed to the ultraviolet radiation in sunlight for any organism (except perhaps bacteria) to live on it.

59. Supercontinents break up because most of the rocks that make up continents are insulators and reluctant to transfer thermal energy. Eventually, heat builds up beneath a continent. The continental crust swells, stretches, and finally ruptures. New ocean floor builds within the rupture zones. Fragments of the supercontinent spread as the ocean plate grows along a new sea-floor spreading center.

60. Fossils provide evidence of previous plate locations. For example, remains of one crocodile-like reptile are found only in South America and Africa; it would have been physiologically impossible for the reptile to swim between continents, suggesting that the continents were connected. Marine fossils in Antarctica indicate that Antarctica was once located near the equator and had a tropical climate.

61. The last supercontinent, Pangaea, was formed about 300 million years ago. The current continents were all connected at that time, and much of the landmass was in the southern hemisphere. The Earth contained only one large ocean. Pangaea began to break apart about 175 million years ago.

62. Yellowstone National Park formed in a series of eruptions during the past two million years, including a powerful explosion 640,000 years that that created a giant crater and spewed ash as far as New York. Recent research conducted on the eruptions in Idaho and other nearby areas suggests that earlier eruptions in the area were fewer, but much larger, than previously thought.

63. Research conducted in a major oil- and natural gas-producing region in Western Canada suggests a link between hydraulic fracturing, or fracking, and induced earthquakes in the region. The fracking process uses high-pressure injections of fluid to break apart rock and release trapped oil and natural gas. Fracking can increase the fluid pressure in the natural pores and fractures in rock, or change the state of stress on existing faults, to produce earthquakes.

64. Since the Himalayas are the world's youngest mountains, little erosion has occurred, so the highest mountains are only getting higher. The word Himalaya means "abode of snow." In the Hindu religion, the Himalayas are known as the Giri-raj, which means "King of the Mountains."

65. The southernmost active volcano on Earth is Mount Erebus in Antarctica, which features a 1700° F lava lake that may be many miles deep. One thing that makes Erebus unique is that it is one of the few consistently **active** volcanoes in the world. Mount Erebus is always on, bubbling, releasing gas and flinging ten-feet wide volcanic bombs—hunks of molten rock that sometimes explode on landing.

Appendix G

High- and Low-Interest Details, Study 2

Table G1

Pairs of high- and low-interest extraneous details used in Study 2.

	High-Interest	Low-Interest
Page 2	The deepest drilling that has ever been done into the Earth's crust is the Kola Superdeep Borehole, which is 7.5 miles deep. (The distance to the center of the Earth is 4,000 miles.) Digging had to be stopped at that depth because the temperature had already reached 356 °F.	Lava is the name for magma that has erupted onto the Earth's surface—the red-hot material spilling from volcanoes. When a volcanic cone fills with lava but doesn't erupt, a lava lake forms. You can see lakes made of lava at five places in the world, including Kilauea in Hawaii.
Page 3	Magma near subduction zones contains ten times more gas, so volcanic eruptions there are violent. The gas inside magma can expand hundreds of times in a few seconds. One of the biggest eruptions ever occurred 2.2 million years ago. It released enough magma to build six Mount Fujis.	Basalt is the dark, heavy, volcanic rock that makes up most of the world's oceanic crust. Compared to the familiar granite of the continents, basalt is darker, denser and more finely grained. The first solid black crust of basalt on Earth formed about 4.4 billion years ago.
Page 4	The deepest natural place on Earth is a trench near the Mariana Islands in the western Pacific Ocean. The trench is 36,201 feet below sea level and 1580 miles long—if Mount Everest were placed in the trench, it would disappear. The trench was formed when the Pacific Plate collided with the Philippine Plate.	Alfred Wegener first proposed the idea of continental drift. This theory described the movement of Earth's continents relative to each other. Wegener's ideas were initially rejected. However, they were proven to be mostly true years after his death. The Amoeba People recorded a song about him called "The Posthumous Triumph of Alfred Wegener."

Page 5	When Mount Vesuvius erupted in 79 A.D., destroying Pompeii, thousands of citizens were killed. The volcano's heat boiled their brain tissue, which then burst out in small, scalding explosions that left blue-black burn marks on the bone. Moisture from vaporized flesh and blood combined with volcanic ash to create a plaster-like material, which preserved the bones.	The Volcanic Explosivity Index (VEI) was developed in 1982. This is a relative scale that allows scientists to compare how explosive eruptions are. They can be either recent eruptions or eruptions from millions of years ago. The VEI is mainly determined by the volume of the material ejected by the volcano, such as ash.
Page 6	A pyroclastic surge is a boiling cloud of debris that shoots out sideways from the slopes of a volcano and can travel for miles. Few people have seen a surge up close, but many of us carry an image of it in memory: it resembles the clouds of powder and ash produced when the World Trade Center towers collapsed.	The moment magnitude scale (MMS) replaced the 1930s-era Richter scale in the 1970s as the method of measuring the size of earthquakes in terms of energy released. Like the Richter scale, it is logarithmic. A quake is considered major when it registers more than 7.0 on the moment magnitude scale, while a magnitude of 3.0 or lower is nearly imperceptible.
Page 7	The volcanic and tectonic activity occurring in the East African Rift Valley makes it a potent power source. The United Nations Environment Program is developing a geothermal energy program to convert the heat created by the valley's underground activity into electricity. This is done through a series of steam wells. One of these wells in Kenya generates power for 5,700 homes. This program could provide a sustainable energy source for millions of people.	The East African Rift consists of a western and an eastern branch, and these are often grouped with the Ethiopian Rift to create the East African Rift System (EARS). This is a complex set of rifts considered to be one of the geologic wonders of the world. The EARS area is unusual in that three plates—the Arabian, the Nubian, and the Somalian—are moving in different directions, as shown on the map.

Page 8	In 1700, a magnitude 9 earthquake near the Cascadia Subduction Zone produced a tsunami that hit Japan. Tsunamis are seismic sea waves that cause the sea floor to move by many feet. An enormous amount of water is set into motion and sloshes back and forth for several hours. This results in waves that travel faster than 500 miles per hour.	Juan de Fuca is the Spanish-translated name of a Greek mariner who sailed for Spain in the 1500s. He claimed to discover a strait in the Pacific Northwest that led him to lands rich in gold, silver, and pearls. Historians doubt that he sailed the strait bearing his name, and for a time they doubted that he even existed.
Page 9	Fossils provide evidence of previous plate locations. For example, remains of one crocodile-like reptile are found only in South America and Africa; since it would have been physiologically impossible for the reptile to swim between continents, this suggests that the continents were connected. Marine fossils in Antarctica indicate that Antarctica was once located near the equator and had a tropical climate.	Orogeny is the building of continental mountains by convergent plate tectonics processes involving folding and faulting of the Earth's crust. The Alleghanian Orogeny (325 million years ago) was the most recent of several major orogenies to help form the Appalachian Mountains. It was the result of a collision between ancestral North America and Africa and resulted in the supercontinent of Pangaea.

Appendix H

Lesson Content Screens, Study 2

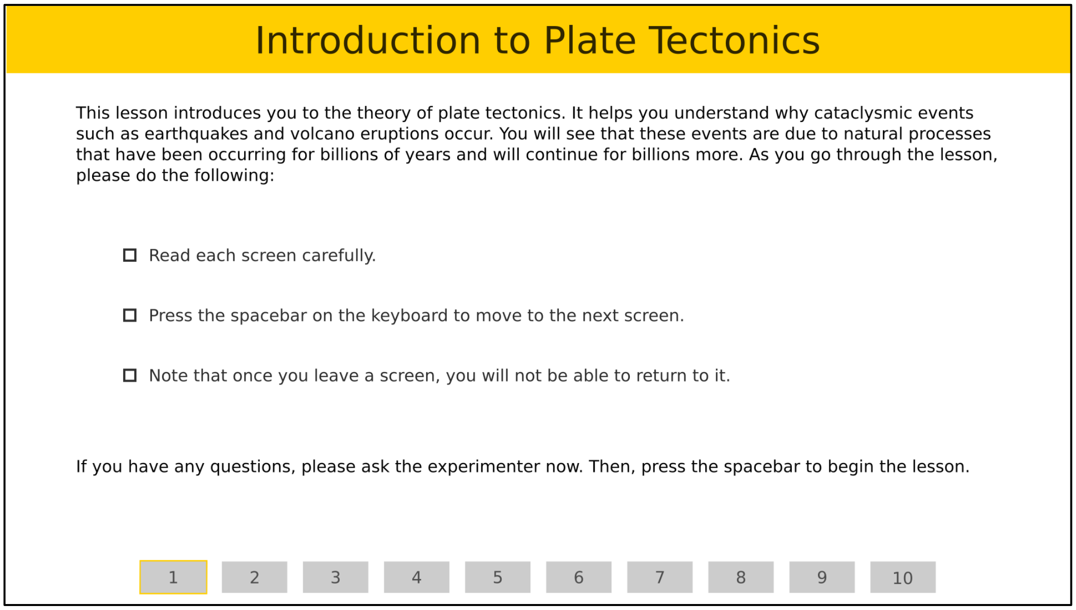


Figure H1. High-interest detail screen from lesson, page 1.

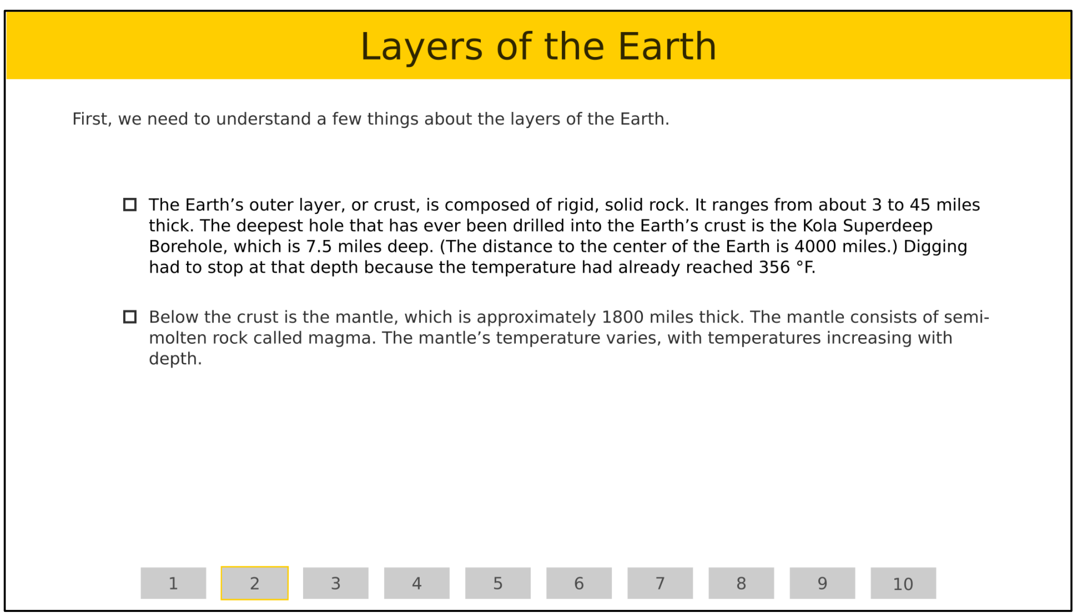


Figure H2. High-interest detail screen from lesson, page 2.

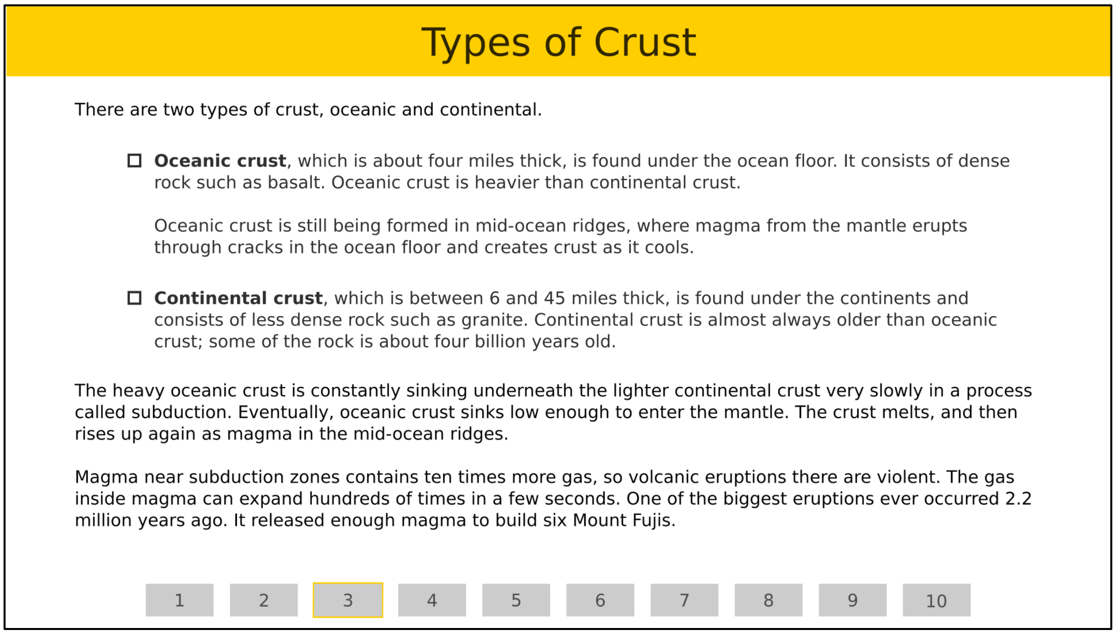


Figure H3. High-interest detail screen from lesson, page 3.

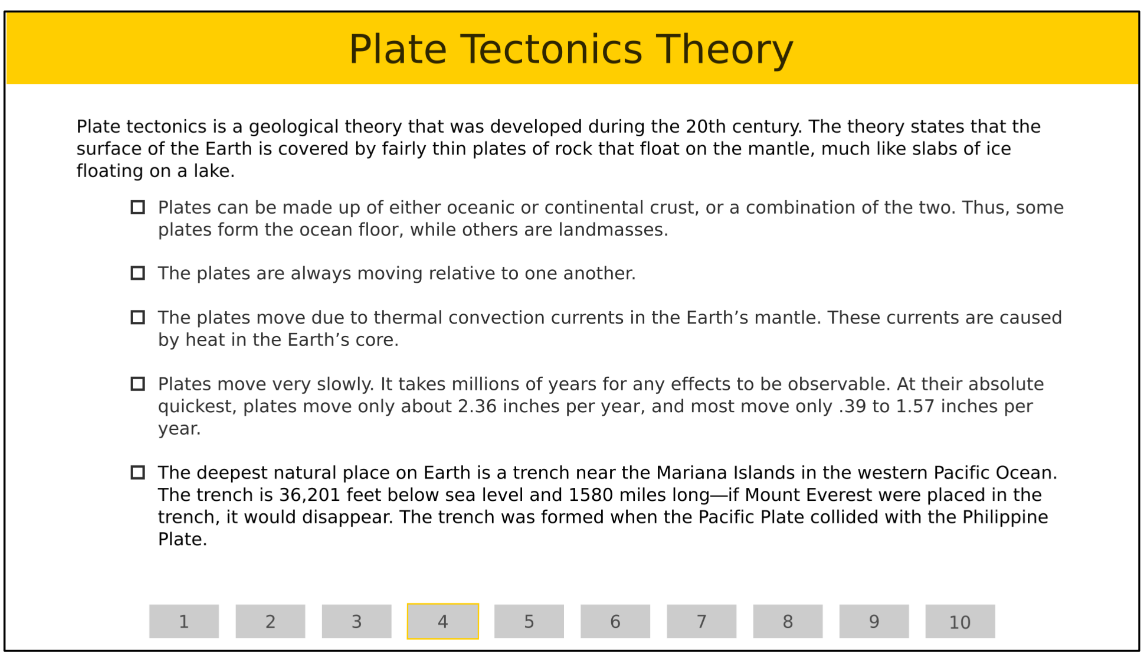


Figure H4. High-interest detail screen from lesson, page 4.

Plate Movement

The edges of the plates are called plate boundaries. These are the spots at which major geological events occur—earthquakes, volcanoes, and mountain-building processes. Where plates meet, molten magma is able to force its way to the surface and escape as lava. Plates move at one of three types of boundaries:

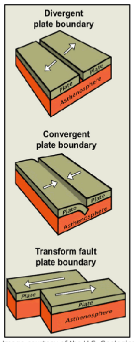


Image courtesy of the U.S. Geological Survey. The USGS home page is http://www.usgs.gov.

Divergent boundaries are places at which plates move away from each other. A rift is a weak place in the Earth's crust due to the separation of two plates. Magma can ooze up from the mantle into the crack between the plates and can make the ocean basin wider; this is known as sea-floor spreading. An example is the Mid-Atlantic Ridge, which is widening the Atlantic Ocean.

Convergent boundaries are places at which plates come together in different ways. One method is that one plate slides underneath the other into the mantle, where it is destroyed. Another method is when two plates collide and force up huge mountain ranges. One example is the Indian plate pushing against the Eurasian plate, which in turn pushes up the Himalayas. The collisions often cause volcanoes. When Mount Vesuvius erupted in 79 A.D., destroying Pompeii, thousands of citizens were killed. The volcano's heat boiled their brain tissue, which then burst out in small, scalding explosions that left blue-black burn marks on the bone. Moisture from vaporized flesh and blood combined with volcanic ash to create a plaster-like material, which preserved the bones.

Transform fault boundaries are where plates slide past each other, ideally with little or no vertical movement, either in opposite directions or in the same direction but at different speeds. A well-known example is the San Andreas Fault in California, which is responsible for some of the most devastating earthquakes in U.S. history.

1 2 3 4 5 6 7 8 9 10

Figure H5. High-interest detail screen from lesson, page 5.

About the Plates

Plates are categorized in different ways, but it is typically agreed that the main plates are the ones shown on the map below. As shown, some of the plates are quite large, such as the Pacific Plate and the North American Plate. Others are small, such as the Juan de Fuca Plate and the Scotia Plate. Even the smaller plates are capable of causing major events, such as earthquakes and volcanoes. A pyroclastic surge is a boiling cloud of debris that shoots out sideways from the slopes of a volcano and can travel for miles. Few people have seen a surge up close, but many of us carry an image of it in memory: it resembles the clouds of powder and ash produced when the World Trade Center towers collapsed.

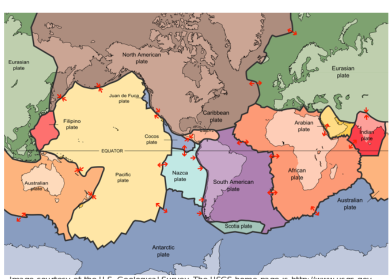


Image courtesy of the U.S. Geological Survey. The USGS home page is http://www.usgs.gov.

The red arrows in the illustration indicate how the plates are moving:

- Divergent plate boundary
- Convergent plate boundary
- Transform fault plate boundary

1 2 3 4 5 6 7 8 9 10

Figure H6. High-interest detail screen from lesson, page 6.

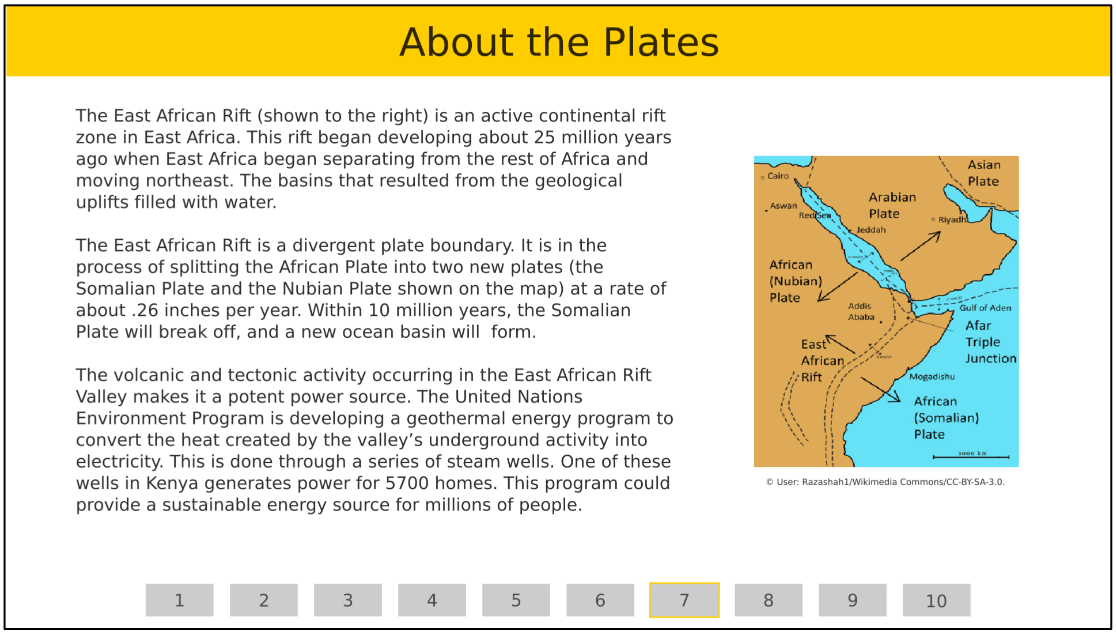


Figure H7. High-interest detail screen from lesson, page 7.

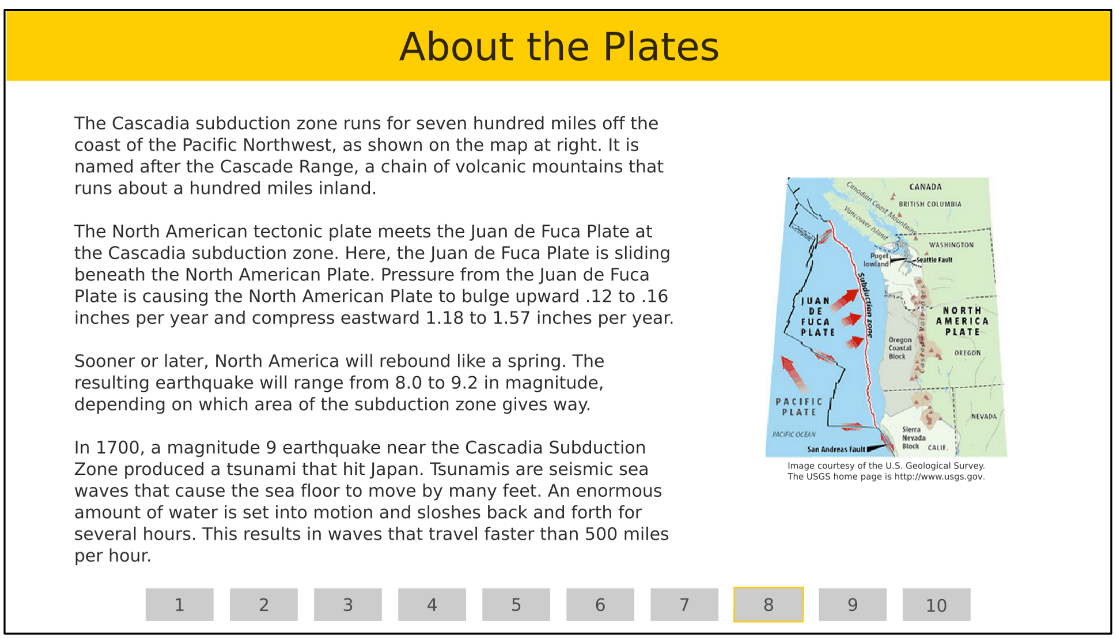


Figure H8. High-interest detail screen from lesson, page 8.

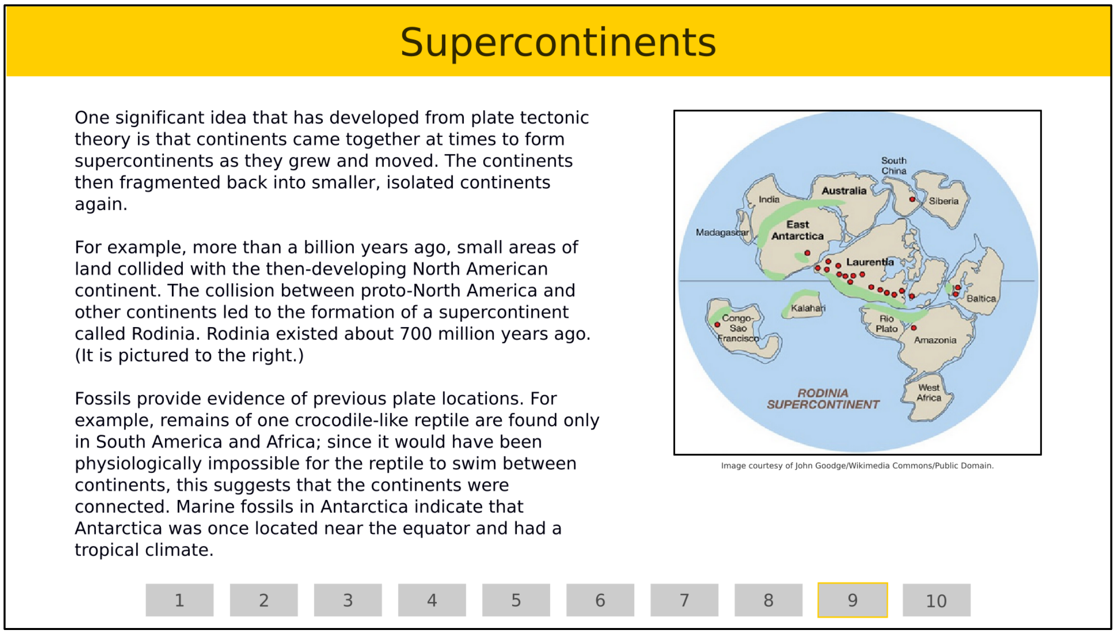


Figure H9. High-interest detail screen from lesson, page 9.

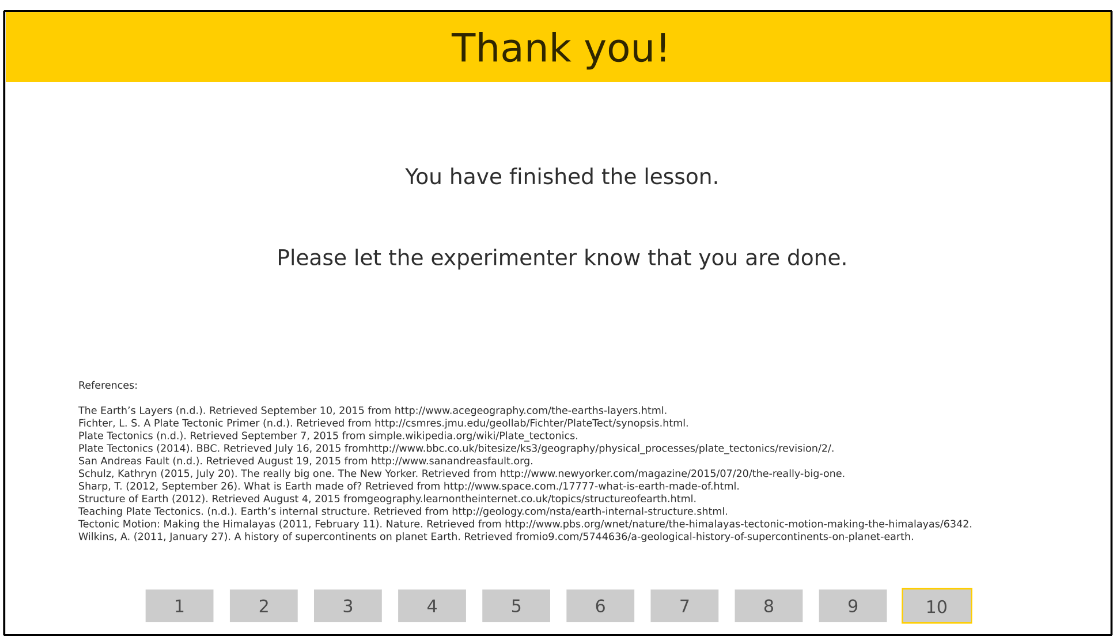


Figure H10. High-interest detail screen from lesson, page 10.

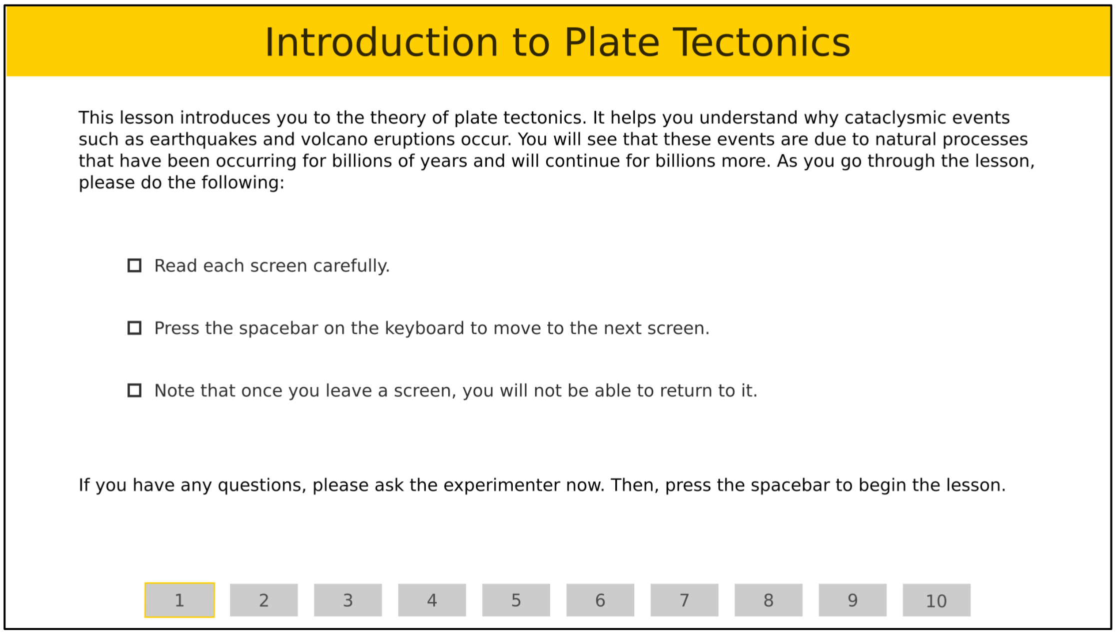


Figure H11. Low-interest detail screen from lesson, page 1.

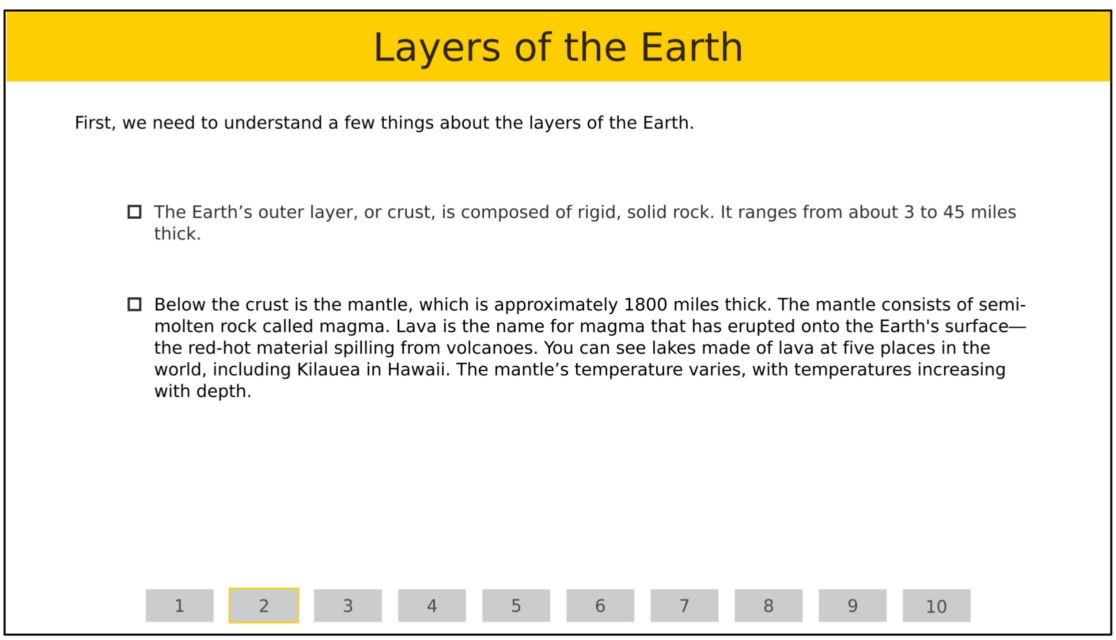


Figure H12. Low-interest detail screen from lesson, page 2.

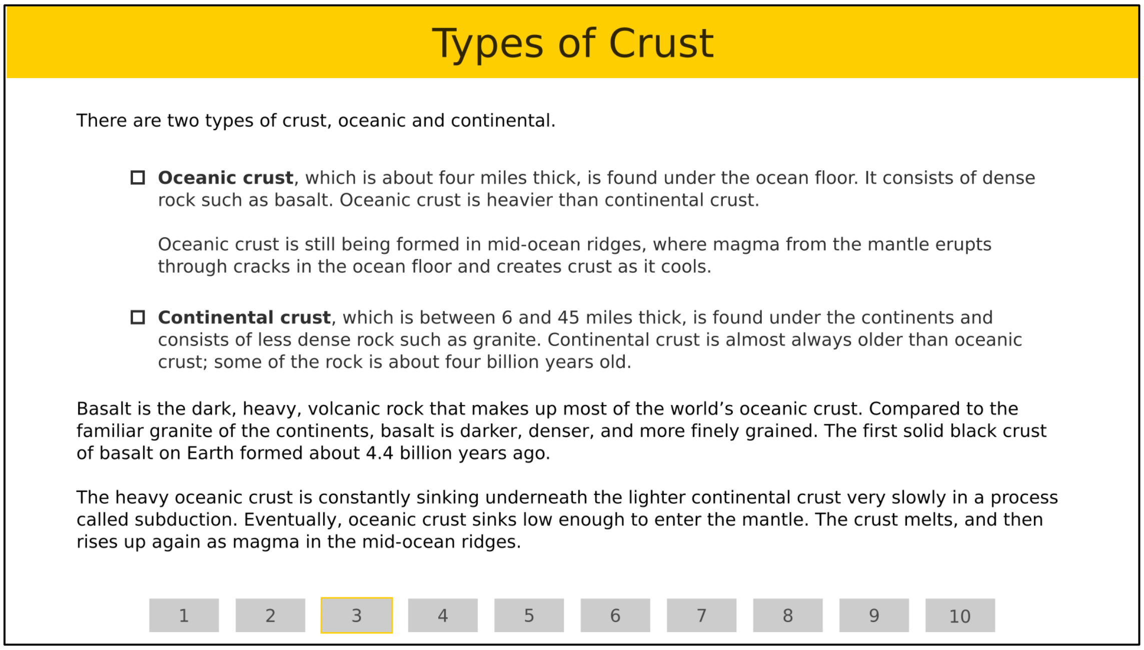


Figure H13. Low-interest detail screen from lesson, page 3.

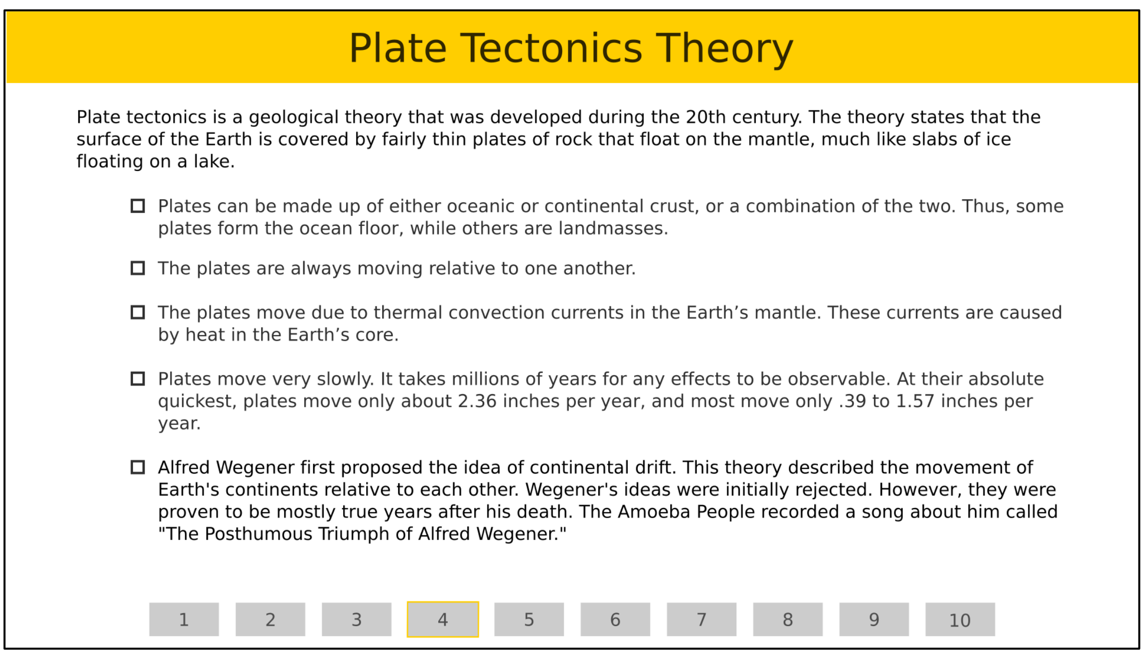


Figure H14. Low-interest detail screen from lesson, page 4.

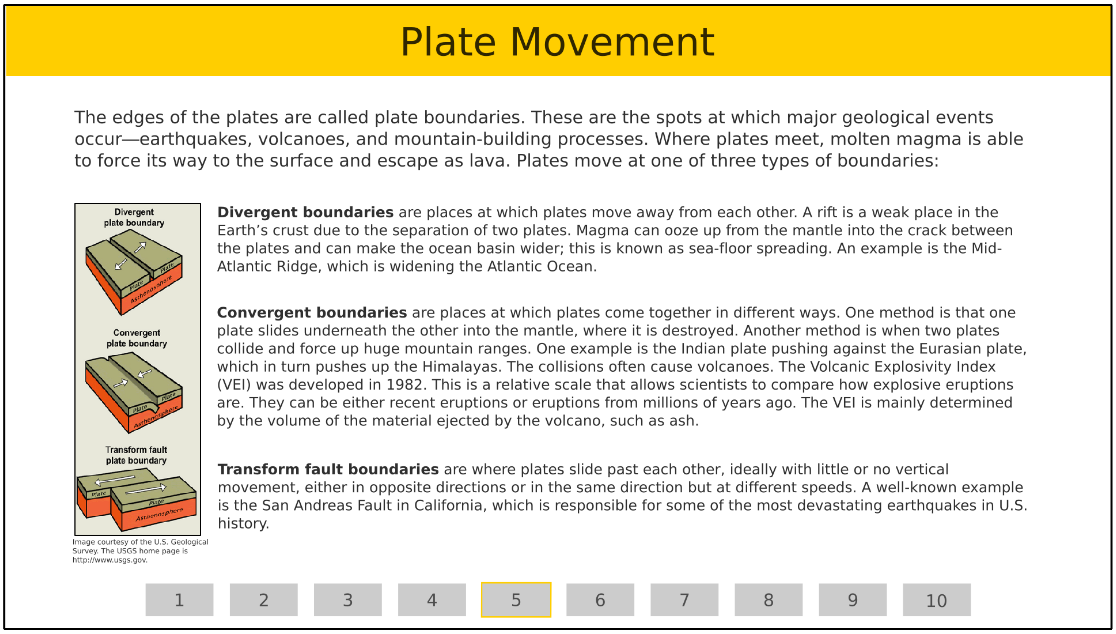


Figure H15. Low-interest detail screen from lesson, page 5.

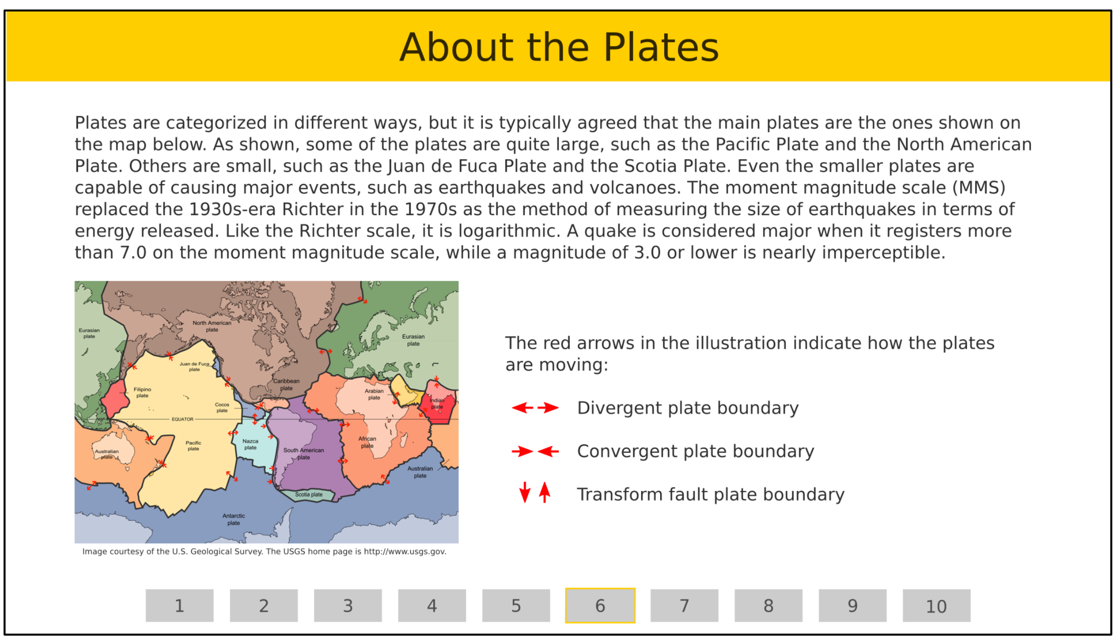


Figure H16. Low-interest detail screen from lesson, page 6.

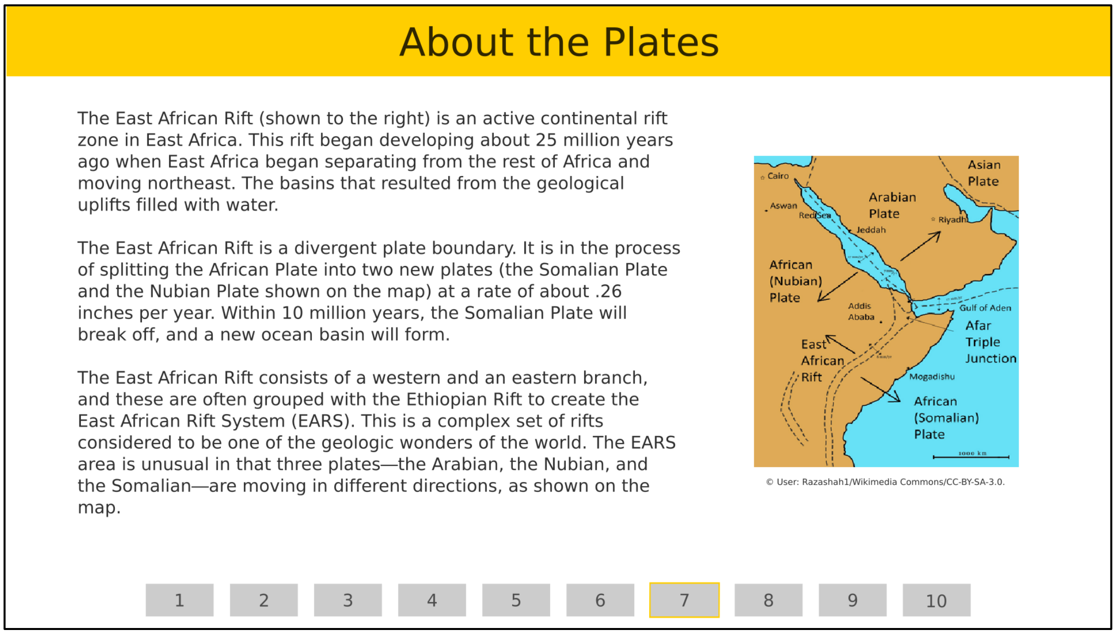


Figure H17. Low-interest detail screen from lesson, page 7.

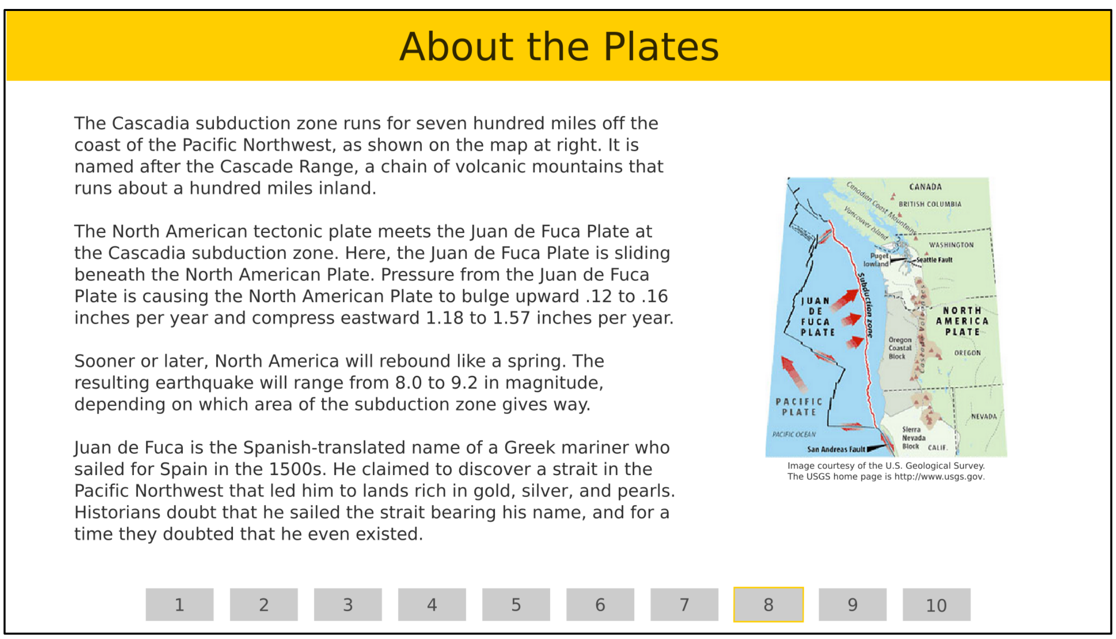


Figure H18. Low-interest detail screen from lesson, page 8.

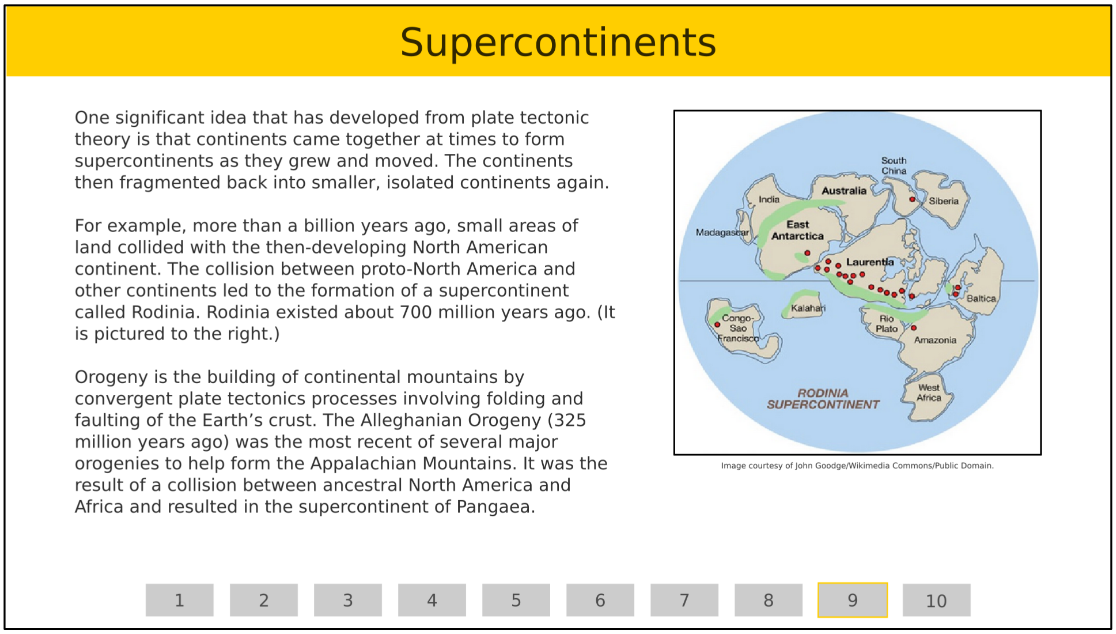


Figure H19. Low-interest detail screen from lesson, page 9.

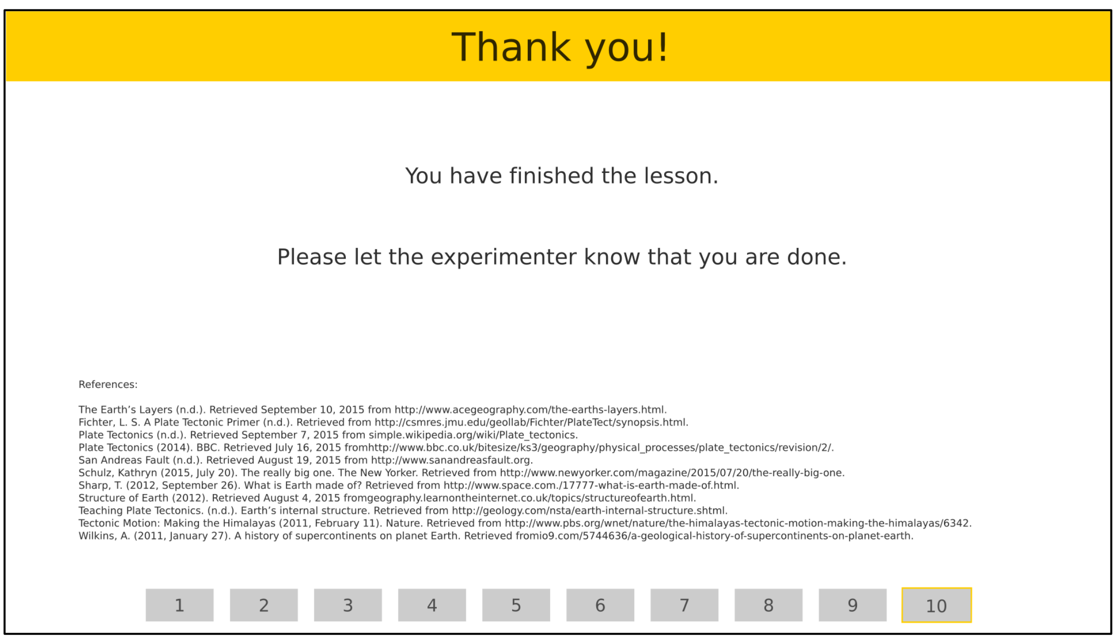


Figure H20. Low-interest detail screen from lesson, page 10.

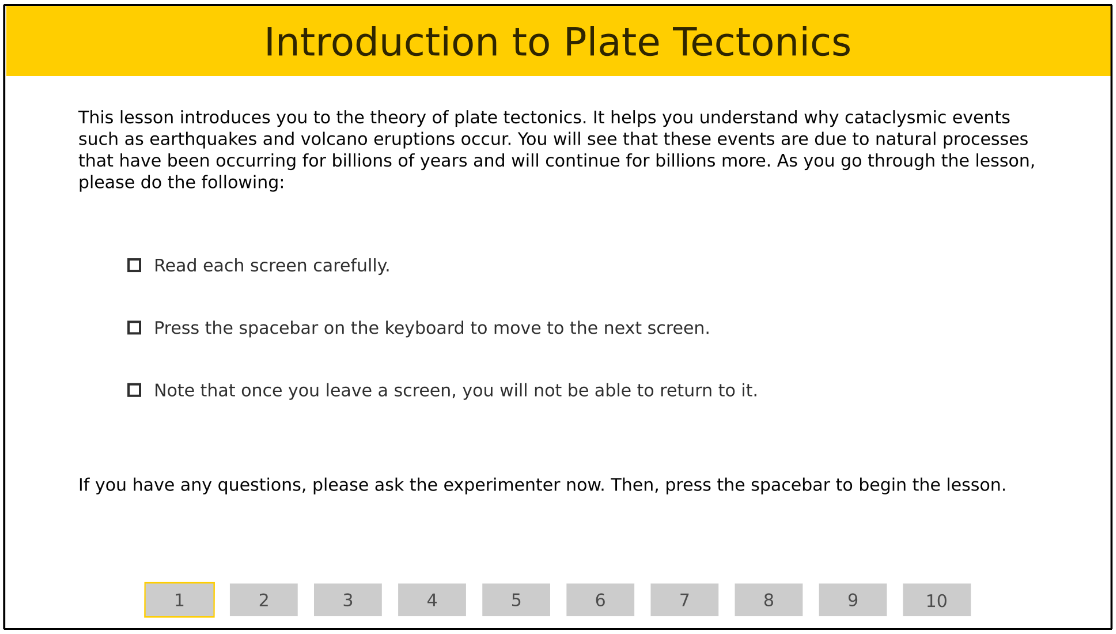


Figure H21. No-detail screen from lesson, page 1.

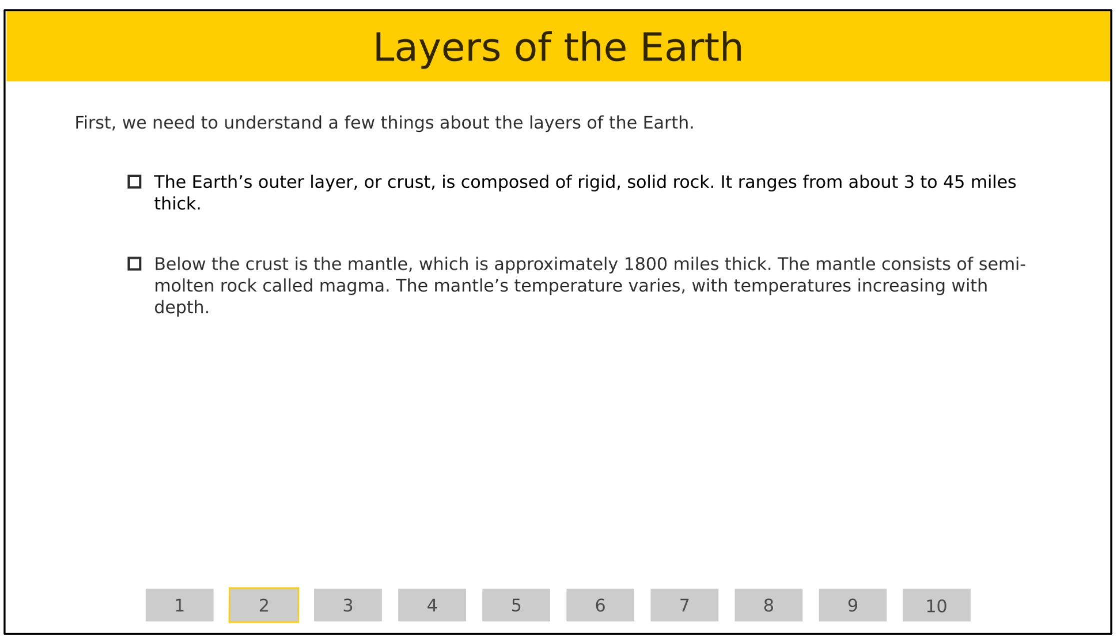


Figure H22. No-detail screen from lesson, page 2.

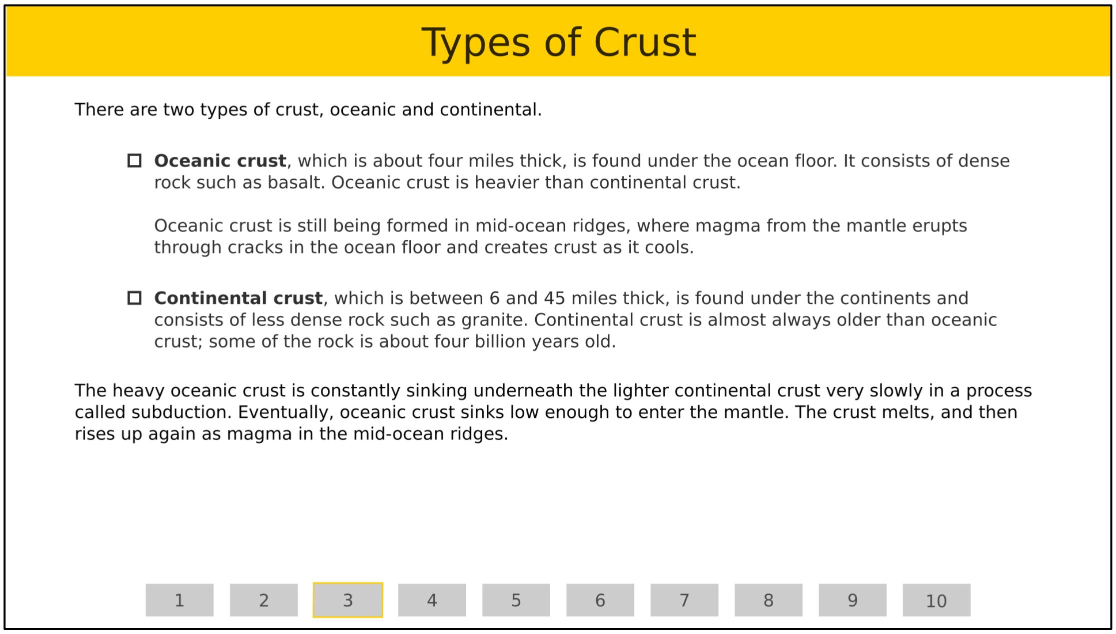


Figure H23. No-detail screen from lesson, page 3.

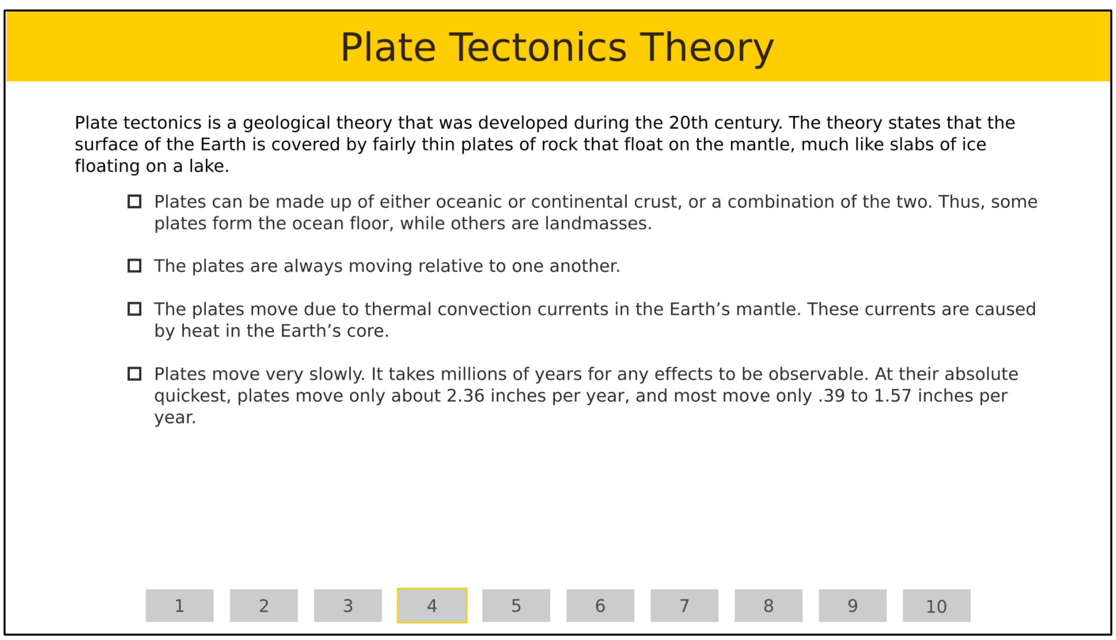


Figure H24. No-detail screen from lesson, page 4.

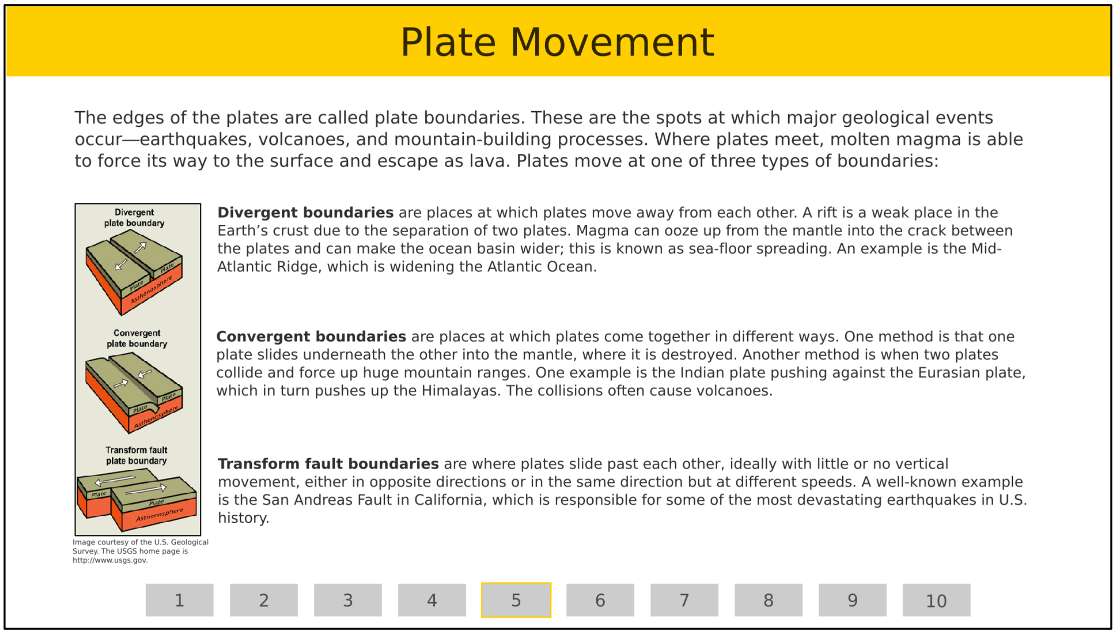


Figure H25. No-detail screen from lesson, page 5.

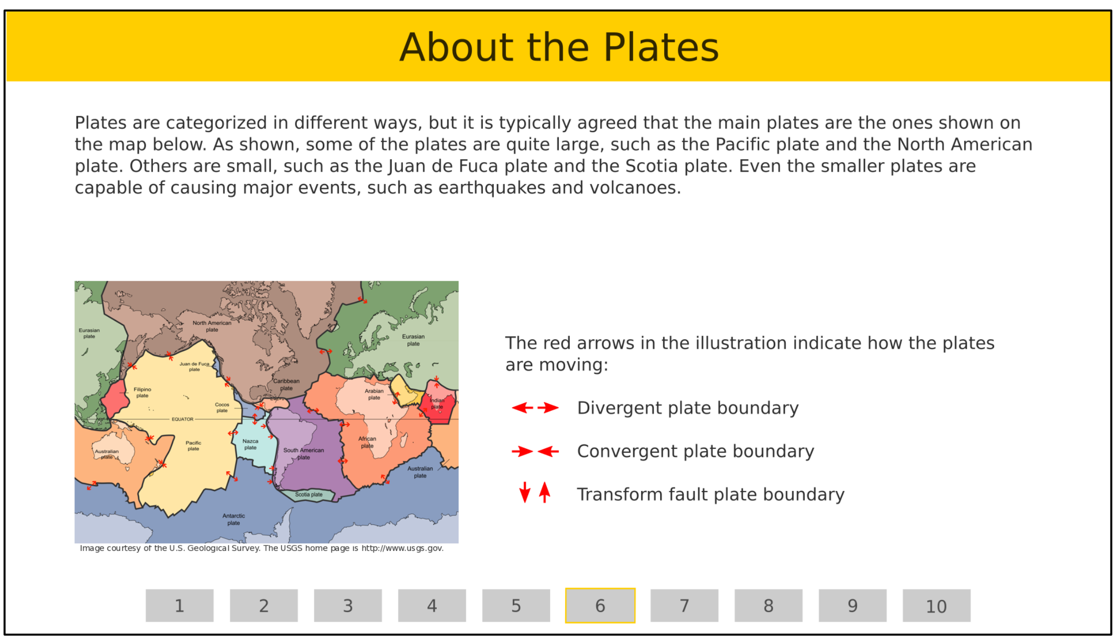


Figure H26. No-detail screen from lesson, page 6.

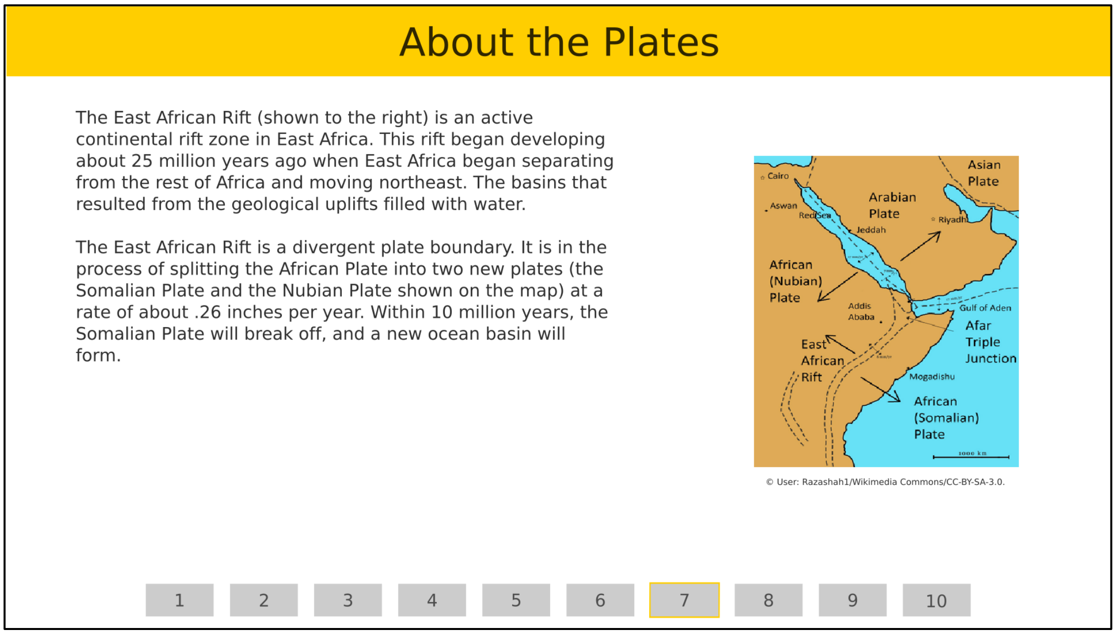


Figure H27. No-detail screen from lesson, page 7.

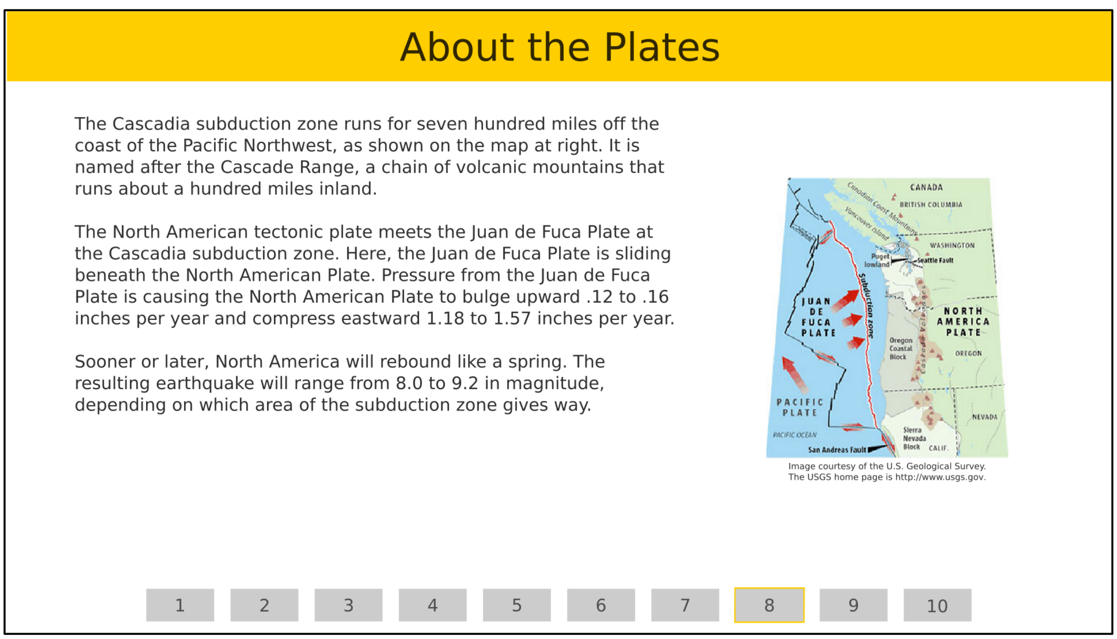


Figure H28. No-detail screen from lesson, page 8.

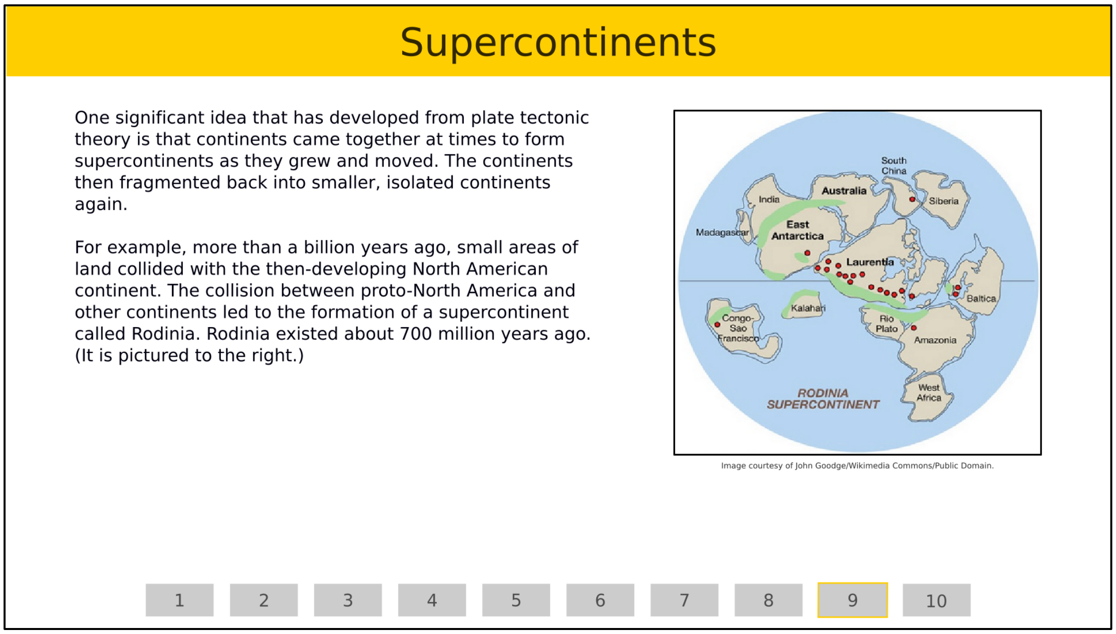


Figure H29. No-detail screen from lesson, page 9.

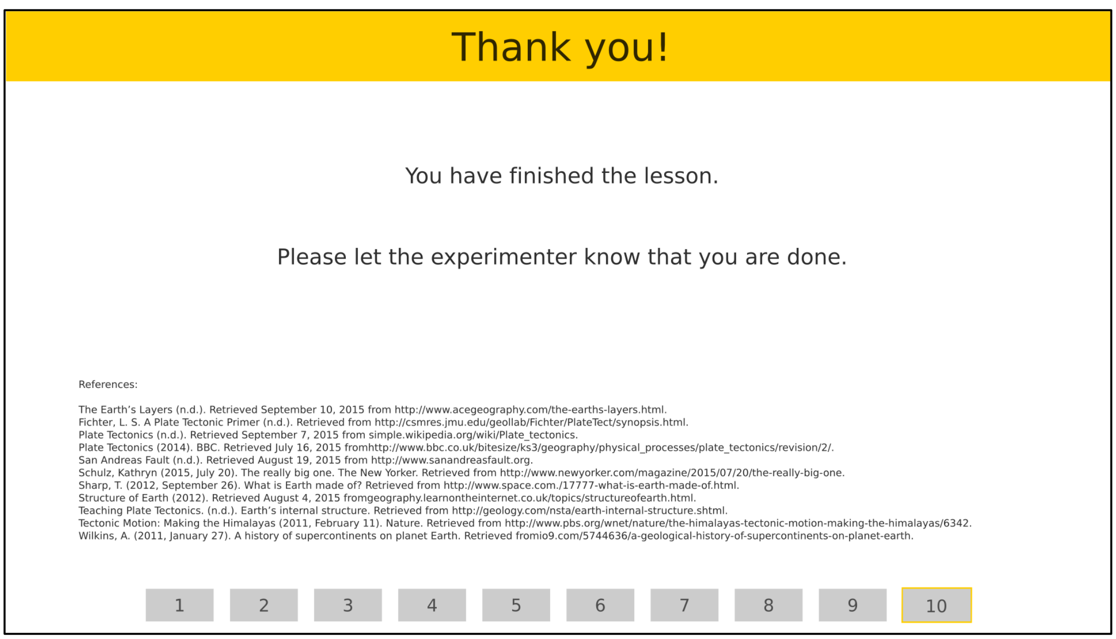


Figure H30. No-detail screen from lesson, page 10.

Appendix I

Core Content Test Questions, Study 2

Online Learning Quiz #1

1. The Indian plate pushes against the Eurasian plate at which type of plate boundary?

- Convergent
- Transform fault
- Rift zone
- Divergent

2. The San Andreas fault in California is a transform fault boundary, which is an area at which plates:

- Slide past each other
- Crash into each other
- Overlap
- Pull apart

3. Which of the following statements does NOT apply to plate tectonics theory?

- The surface of the Earth is covered by fairly thin plates of rock.
- Plates may move a couple of inches per year.
- Plates consist of either oceanic crust, continental crust, or a combination.
- All plates move in the same direction.

4. Pieces of the Earth’s crust move on top of the:

- Rifts
- Hydrosphere
- Mantle
- Outer core

Figure I1. Core content test questions 1-4, Study 2.

5. The process of oceanic crust sinking beneath continental crust is called:

- ◯ Condensation
- ◯ Sea-floor spreading
- ◯ Convection
- ◯ Subduction

6. Which type of plate boundary is characterized by two plates moving away from each other?

- ◯ Convergent
- ◯ Transform fault
- ◯ Oceanic
- ◯ Divergent

7. What is a supercontinent?

- ◯ A continent that encompasses multiple countries
- ◯ A continent consisting of countries with a common language and culture
- ◯ Australia
- ◯ A set of separate continents that merged into one large continent

8. What causes plates to move?

- ◯ Gravity
- ◯ Convection currents in the Earth's mantle
- ◯ The Earth's rotation
- ◯ Conduction currents in the Earth's core

9. Which of the following geophysical events is NOT directly caused by tectonic plate movement?

- ◯ Volcanoes
- ◯ Mountain-building processes
- ◯ Earthquakes
- ◯ Tsunamis

10. Which of the following is a characteristic of continental crust?

- ◯ It mainly consists of dense rock such as basalt.
- ◯ Some of the rock is about four billion years old.
- ◯ It slowly sinks below the oceanic crust.
- ◯ It is typically six to 12 feet thick.

Figure I2. Core content test questions 5-10, Study 2.

Appendix J

Detail Test Questions, Study 2

Online Learning Quiz #2

1. "Juan de Fuca" refers to all of the following except:

- A former president of Mexico
- A strait through which the border between the U.S. and Canada lies
- A tectonic plate in the Pacific Northwest in the U.S.
- A Greek mariner who sailed for Spain

2. Which of the following statements is NOT true of a pyroclastic surge?

- It resembles the clouds of powder and ash produced when the World Trade Center towers collapsed.
- It can travel for miles.
- It is defined as a boiling cloud of debris shooting out sideways from a volcano.
- It is another term for "storm surge," which is a change in water level over and above the astronomical tide.

3. Marine fossils discovered in Antarctica tell us that Antarctica was once located:

- At the North Pole
- In what is now Europe
- Near the equator
- In central Russia

4. The theory of continental drift was first proposed by this man, whose ideas were initially rejected.

- Abraham Werner
- James D. Dana
- Juan de Fuca
- Alfred Wegener

5. After the eruption of Mount Vesuvius in 79 A.D., some citizens were killed as a result of:

- Stampedes
- Falling into a massive rift that opened up in the city
- Drowning due to a tsunami
- Volcanic heat boiling their brain tissue

Figure J1. Detail test questions 1-5, Study 2.

6. What is the Volcanic Explosivity Index?

- ○ A measure of the strength of earthquakes.
- ○ A scale that allows scientists to compare the explosiveness of volcanic eruptions
- ○ A gas detector used to measure the amount of combustible gases present in a sample
- ○ A scale that allows scientists to determine the strength of explosives.

7. Where can lakes made of lava be seen?

- ○ In the Upper Peninsula, where they are solidified (also known as frozen lava lakes)
- ○ You cannot see them because they are underground.
- ○ Kilauea in Hawaii
- ○ In the Cascadia Range in the northwestern U.S.

8. Which of the following describes the moment magnitude scale?

- ○ It is a linear scale.
- ○ It was replaced by the Richter scale in the 1970s.
- ○ A major quake measures more than 7.0 on the scale.
- ○ It measures the exact time that an earthquake occurred.

9. Which of the following is NOT a characteristic of tsunamis?

- ○ They have never been generated via the Cascadia Subduction Zone.
- ○ They cause the ocean floor to move by many feet.
- ○ They are most often caused by earthquakes.
- ○ They cause waves that travel more than 500 miles per hour.

10. Which of the following is considered to be one of the geologic wonders of the world?

- ○ East African Rift System
- ○ Cascadia subduction zone
- ○ Mid-Atlantic Ridge
- ○ San Andreas fault

Figure J2. Detail test questions 6-10, Study 2.

11. Which of the following is a characteristic of basalt?

- ◯ It is very colorful, light-weight rock.
- ◯ It is volcanic rock.
- ◯ The first crust of basalt on Earth formed about a million years ago.
- ◯ None of the above.

12. Why are volcanoes near subduction zones so violent?

- ◯ Magma in subduction areas contains ten times the normal amount of gas, and the gas in magma expands quickly.
- ◯ The heavy oceanic crust collides with the continental crust very forcefully.
- ◯ Scientists are testing several hypotheses to explain why.
- ◯ The temperature of the magma in subduction zones is much higher than magma at other locations.

13. Two plates collided to form the deepest natural place on Earth, which is:

- ◯ The Kola Superdeep Borehole
- ◯ The Mariana Trench
- ◯ The Great Blue Hole in Belize
- ◯ Lake Baikal in Russia

14. Drilling had to stop at the Kola Borehole due to:

- ◯ The fact that they drilled all the way into the Earth’s core
- ◯ The extremely high temperature
- ◯ Government regulations
- ◯ The extreme density of the magma they had drilled into

15. A tectonic process by which a section of the Earth's crust is folded and forms a mountain range is referred to as:

- ◯ Epeirogeny
- ◯ A pyroclastic surge
- ◯ Orogeny
- ◯ Progeny

16. What innovative source of energy is being harnessed in the East African Rift Valley?

- ◯ Heat generated by volcanic and tectonic activity
- ◯ The force generated from tectonic plates that are pulling apart
- ◯ Wind generated by volcanic and tectonic activity
- ◯ Clean coal

Figure J3. Detail test questions 11-16, Study 2.

Appendix K

Transfer Test Questions, Study 2

Online Learning Quiz #3

The **map below** shows the major plate boundaries, and the arrows indicate how the plates are currently moving. Use this map to answer the following questions.

These questions may not necessarily have right or wrong answers; we are mainly interested in the reasoning you used to arrive at your answers.

1. The CEO of your company wants to set up a new division in one of these locations numbered on the map. [1:Seattle (Washington, U.S.), 2:Lima (Peru), 3:Asmara (Eritrea), 4:Helsinki (Finland)] Based ONLY on tectonic plate movements, which city would you recommend as the safest from a geophysical perspective?

- [1] Seattle, Washington
- [2] Lima, Peru
- [3] Asmara, Eritrea
- [4] Helsinki, Finland

2. Explain the reason(s) for your choice in question 1.

3. Using the information from question 1 again, explain your reasons for NOT selecting each of the other three locations.

4. Look at location number 5 on the map. Identify the type(s) of geophysical events caused by plate movement that you think might occur in this area.

5. Give reason(s) for your answer in question 4.

Figure K1. Transfer test questions, Study 2.

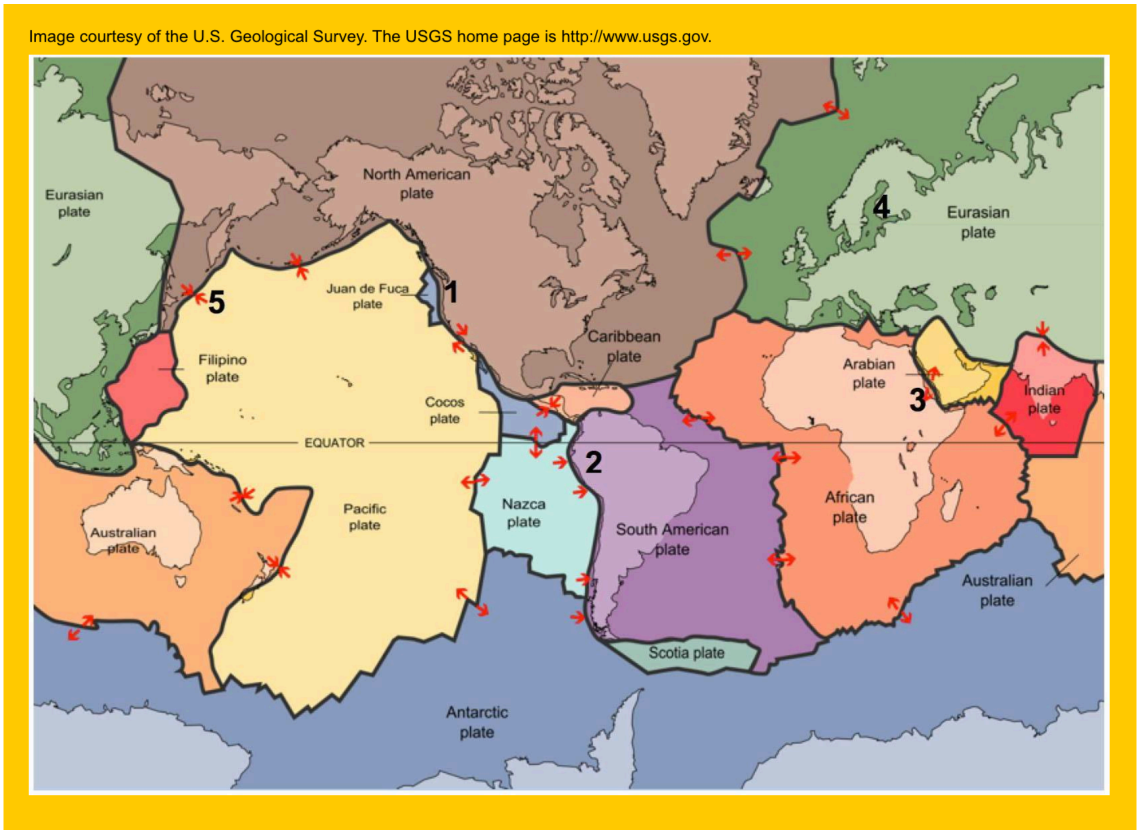


Figure K2. Transfer test diagram, Study 2.

Appendix L

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Figures B7, B17, H7, H17, H27

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Appendix L

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