12-2019

Applying principles for multimedia learning to eLearning modules to reduce extraneous processing

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Applying Principles for Multimedia Learning to eLearning Modules to

Reduce Extraneous Processing

by

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A Portfolio Paper

Submitted to the Graduate Faculty of

St. Cloud State University

in Partial Fulfillment of the Requirements

for the Degree of

Master of Science

in Information Media: Instructional Design and Training

December, 2019

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Chapter 1: Introduction

eLearning refers to any instruction that is computer-based where the computer is used as the delivery method, often accessible via the internet (Nichols, 2003). The use of eLearning as a training solution continues to grow rapidly (Clark, 2014). One reason for the growth is because of the Instructional Design tools available. eLearning authoring tools are a type of software created to make the development of eLearning more accessible for the typical computer user. The user does not need Flash, HTML, or any coding language knowledge. eLearning authoring tools often include audio tools, slide tools, animation tools, and visual tools. They are programmed to publish to a SCORM file, so the files can be uploaded to a Learning Management System or the web. Some examples of authoring tools are Lectora, Camtasia, Captivate, and Articulate Storyline (Nichols, 2003). With user-friendly eLearning authoring software available, anyone with basic PowerPoint knowledge can create eLearning (Pop, Pop, Bubatu, & Barbu, 2012; Nichols, 2003; Dagger, Wade & Conlan, 2005). With the accessibility of eLearning authoring tools, eLearning development is becoming easier for learning professionals to create, and it offers many benefits to businesses and to the learner.

eLearning helps businesses train consistently and efficiently with the flexibility of time and space and has long-term cost effectiveness (Dagger et. al., 2005; Oliveira Neto, Huang & Axevedo Melli, 2015). eLearning offers flexibility to today's learner as they participate in eLearning from anytime and anyplace (Pop et. al., 2012). Today's learner demands eLearning, and today's technology allows for the creation of dynamic, multi-media rich eLearning tutorials as it can be designed with explanations, examples, practice with feedback, scenario-based, project-based, simulations and even games (Clark, 2014).

As previously mentioned, technology is available to blend multimedia seamlessly together into eLearning modules (Nichols, 2003). One can easily conduct a simple internet search and find a plethora of tutorials on how to create eLearning using authoring software. Since augmented reality, virtual reality, and ubiquitous mobile devices are becoming common place, if a designer can dream it, technology can make it happen. However, one might wonder if there is a saturation point where the amount of media included in eLearning, or the way in which the media is presented, hinders rather than helps the learning effort.

With all the creative possibilities in developing eLearning, designers need to decide how to include and situate forms of media in their products and what elements to exclude and when. The way in which material or content is presented to a learner has a direct effect on how much the learner retains (Smith & Ragan, 2005). Just-in-time learning posted online makes it easy to find the "how" of designing and developing eLearning, but tactical resources built to support designing for the cognitive processes taking place in active learning are not as readily available (Paas & Sweller, 2014).

This portfolio proposal contains three chapters on the theme of designing eLearning using Cognitive Load Theory to reduce extraneous processing. The first chapter introduces the theme and sets the context for the portfolio proposal. The second chapter discusses literature on extraneous processing as it relates to eLearning. The third chapter introduces the proposed products for the portfolio based on the research findings.

Context and background of the portfolio theme

Effective training is important in business (Surijah, 2016). After a gap analysis, performance technologies may uncover the answer to a gap is training (Van Tiem & Moseley, 2004). Often, eLearning is the determined delivery method of a training intervention. Many organizations have incorporated eLearning tutorials into their training tool kits (Pop et. al., 2012; Nichols, 2003; Dagger et. al., 2005). eLearning typically involves a multi-media treatment of content which is delivered on a computer device anytime and anywhere. The learner typically has control, to some degree, over the pace of the content delivery (Clark, 2014).

eLearning has become a widely used instructional intervention because of the many benefits; including, but not limited to: the ability to reach broader audiences than in-person solutions, a higher learner engagement with a multimedia and edutainment component, cost-effectiveness, anytime-anywhere delivery, and consistent messaging (Brown, Murphy, & Wade, 2006; Dagger, Wade, & Conlan, 2005; Pop et. al., 2012). With many highly usable eLearning authoring tools available, speed to market can be added to the list. eLearning is so popular, in fact, that the increase of use continues to grow. For example, the amount of training available via eLearning for professionals increased four times from 2002-2012 (Clark, 2014).

eLearning helps businesses train consistently, efficiently, and cost-effectively (Clark, 2014). Modern eLearning authoring software makes developing eLearning accessible to businesses. Effective eLearning is online learning designed whereas the content is delivered in a way that allows for the learner to be observed meeting the objectives during evaluation (Smith & Ragan, 2005). Additionally, the learning was designed to reduce the likelihood of cognitive overload happening to the learner (Nichols, 2003; Kenny, Zhang, Schwier & Campbell, 2005). Professionals who are developing eLearning using authoring tools come from a wide variety of professional backgrounds. The depth and interactivity that the eLearning tutorials display can be categorized into four different levels, which are described in the Rationale section (Hirumi, 2013). Because these tools have a high usability, many subject matter experts can create level three, which is highly-interactive eLearning; as observed in the *Variables Made Easy with Articulate Storyline workshop* featuring Tom Kuhlmann hosted by Professional Association for Computer Training (PACT) on April 13, 2017 in Bloomington, MN.

eLearning authoring tools allow for creativity and individuality in design and development, which is great for developers who know how to design for effective learning. However, it is also very easy for eLearning developers to create eLearning that is more difficult to learn from than is necessary (Nichols, 2003). In such eLearning modules, the content may be meaningful, but the way in which it is presented is less than optimal for learning. Learners may not fully grasp content or may require an extra amount of effort put forward on their own will to learn the content. If the eLearning module is not designed to support efficient processing of the messages contained, learning is going to require a greater degree of effort. Ensuring a learner puts forth such concentration cannot be done through Instructional Design, as that is an intrinsic quality that learners must possess (Hirumi, 2013). When proficiency in the workplace affects the bottom line, lack of effective training makes an impact. It is the goal of all who are developing eLearning to produce effective eLearning (Brown et al., 2006).

Rationale

In business, eLearning developers have diverse professional backgrounds stemming from a variety of educational experiences and career tracks. Some have an academic background in Instructional Design, while others may be professionals who, though they have no formal Instructional Design knowledge, subject matter experts in various lines of work tasked with creating eLearning (Kenny, Zhang, Schwier & Campbell, 2005; Nichols, 2003). Some have graphic design and video editing backgrounds and found training to be a profession where they could leverage their creativity. Still others have specialty knowledge in a related area like organizational development. These are just a few examples of eLearning developers' backgrounds from personal observation. Diverse backgrounds add a wonderfully rich dynamic to the profession and are no doubt valuable. Although people from all backgrounds bring essential skills and knowledge to the training community, they often unknowingly develop eLearning that is less than effective. With the author pool expanding to include a broader base of developers, a gap exists between the authors who are responsible for the rapid development of eLearning tutorials and effective design based on theory (Van Tiem & Moseley, 2004).

eLearning tutorial products can be categorized into three levels (Hirumi, 2013). A fourth level has been identified, as well, when virtual reality is incorporated, as discussed by Kristen Carlson, Assistant Professor for Technology Integration, Secondary Education & edTPA Coordinator at St. Cloud State University in a 2017 graduate-level classroom discussion. Hirumi (2013) examined how eLearning authoring tools can be used to create dynamic and interactive eLearning tutorials. He described animation, drag and drop, fill in the blank, short answer, variables, triggers, matching, multiple choice questions, and immediate feedback as interactions that can be incorporated into eLearning tutorials (Hirumi, 2013). As Jeanne Anderson, Ed. D., Professor Emerita of Information Media St. Cloud State University said in a graduate level class in 2013, "Just because you can, doesn't mean that you should." What Anderson was alluding to is that interactions have their appropriate use as tools aiding in instructional strategies to enhance the transfer of knowledge, but they need to be used effectively. Pop-ups, highlights, and arrows are all examples of objects that can be animated using the software. This leaves the question of how much is too much.

Problem Statement

Armed with software and social media platform resources such as YouTube tutorials, anyone with a desire to create eLearning tutorials can do so with limited working knowledge of PowerPoint and other eLearning authoring tools regardless of their Instructional Design knowledge. However, the effectiveness of the product may suffer because of poor design (Paas & Sweller, 2014).

To maximize effectiveness, eLearning should be designed for how people learn (Smith & Ragan, 2005). Therefore, theory takes an inherent and important role in the Instructional Design of eLearning tutorials. “Theories and models for course and curriculum design prescribe how to develop educational programs, which contain a mix of educational media, including texts, images, speech, manipulative materials, and network systems” (Kester & van Merriënboer, 2014, p. 105). eLearning tutorials can have many types of media incorporated into one module, including, but not limited to, narration, text on screen, images, graphic organizers and audio (Schnotz, 2014). An Instructional Designer decides the way in which to arrange and present content using multimedia to facilitate learning. To do this, it can be helpful to understand what arrangements can hinder learning. A resource aiding Instructional Designers in identifying concrete examples of how to arrange audio, animation, still and moving images and text in relation to one another may be useful.

Significance

The speed in which a worker can perform and the quality of their work directly relates to their job performance. The faster an employee becomes job proficient, the faster their work is adding optimal value (Clark, 1999). It is in a business’ best interest to efficiently and effectively train their employees to proficiency as fast as possible. A solution to help employees become proficient is to provide them with effective training. The more effective the training, the faster the employee can reach proficiency. In the business world, where time is money and where getting learners “up to speed” has a real bottom line benefit; designing effective training makes a difference (Surijah, 2016).

Level three eLearning tutorials are defined as highly interactive modules which require significant design and development; without knowing, practitioners can develop eLearning that is less effective because it increases extraneous processing (Chapman, 2010). A common example of this type of deliverable is an eLearning module that has been created for new hires with the goal of teaching them the software necessary for their function at a given company. While certain aspects of an eLearning module may be well done, if the design of multimedia is not supported in Cognitive Load Theory to reduces extraneous processing, the resultant learning is not as effective in terms of moving the learner to proficiency as quickly as possible. With the goal in mind to create training that is as effective as possible, and eLearning being a widely used training intervention, and with a gap in learning theory amongst eLearning developers, a tangible example of what to do and what not to do would be beneficial to the industry. One area of expertise that needs to be better represented in the community of eLearning professionals is Cognitive Load Theory.

Definition of Terms

Cognitive Load Theory. This addresses how many bits of information are being processed and are interacting in the working memory (Mayer, 2014). There are three categories of cognitive load: intrinsic, extraneous, and germane (Paas & Sweller, 2014; Veronikas & Shaughnessy, 2005).

Cognitive Processes (Paas & Sweller, 2014)**:**

a. Selecting relevant words from presented text or narration

b. Selecting relevant images from presented illustrations

c. Organizing and selecting words into a coherent verbal representation

d. Organizing and selecting images into a coherent pictorial and verbal representation

e. Integrating the pictorial and verbal representations and prior knowledge

eLearning. eLearning refers to any instruction that is computer-based where the computer is used as the delivery method, often accessible via the internet (Clark, 2014; Nichols, 2003). It is typically a form of multimedia learning that combines several media elements.

Effective eLearning. Effective eLearning is instruction delivered electronically where the likelihood of cognitive overload happening to the learner is reduced via deliberate design methods, and results in both schema construction and schema automation (Paas & Sweller, 2014; Kenny, Zhang, Schwier & Campbell, 2005; Nichols, 2003). It is the goal of all who are developing eLearning to produce effective eLearning (Brown et al., 2006).

Extraneous cognitive load. This refers to the effort a learner devotes to making sense of the Instructional Design method, rather than the relevant information. It takes up working memory space and obstructs the transfer of knowledge (Paas & Sweller, 2014).

Extraneous overload. This occurs when essential cognitive processing (required to understand the essential material in a multimedia message) and extraneous cognitive processing (required to process extraneous material or to overcome confusing layout in a multimedia message) exceeds the learner's cognitive capacity (Mayer, 2009).

Extraneous processing. This is mental energy that is devoted to the thought process of material outside of the learning content (Mayer, 2009).

Instructional Design. Instructional Design, or ID, is the professional practice of organizing and planning effective instruction that results in deeper learning based on current theory, research and practice in the field (Smith & Ragan, 2005).

Intrinsic cognitive load. This refers to the space and energy in a learner's cognitive processes taken up by the information itself (Mayer, 2009).

Mayer's principles for multimedia learning that reduce extraneous processing. When the principles defined below are put into practice, it results in more effective eLearning. These principles have been studied and proven to reduce cognitive load by reducing extraneous processing (Mayer, 2014).

Coherence principle. People learn better from a multimedia message when extraneous material is left out rather than included (Mayer, 2014).

Redundancy principle. People learn better from just graphics and narration together on a screen, rather than from graphics, narration and text all together on a screen (Mayer, 2014). This means that if there is an image and narration on a screen, according to solid Instructional Design, the practitioner should exclude text of the narration. Also, it is better to communicate the information using narration and an image rather than an image and text.

Signaling principle. People learn better from multimedia when signals are added to highlight and help visually show the organization of the material (Mayer, 2014).

Spatial contiguity principle. People learn better when related words and pictures are arranged near to rather than far from each other on the page or screen (Mayer, 2014). According to solid Instructional Design, the text on a slide needs to be very close to its associated image.

Temporal contiguity principle. Learning is more effective when animation and narration are presented simultaneously instead of successively (Mayer, 2014).

Multimedia learning theory. The study of multimedia learning theory asks if and how individuals achieve deeper learning from various combinations of media elements (Mayer, 2014).

Summary

The scope of this portfolio proposal is discussed followed by aspects of effective eLearning. The modality discussed will be eLearning. Specifically, eLearning tutorials created using authoring software for a business audience. This portfolio's scope includes examples of ways to design content for lowering the learner's cognitive load by reducing extraneous processing. As previously mentioned, developers can unknowingly design in ways that are less efficient for learning. This portfolio will provide examples and non-examples of media elements arranged in various ways in an eLearning module that communicates the message of how to design to maximize efficient learning. It will lay out instances of when to include audio, animation and text on slides and how to incorporate them together to maximize learning efficiency. The portfolio proposal will explore best practices for arranging objects on a slide in relation to one another. It will showcase how to use prompts for the learner to help them learn the content efficiently and without technical frustration. When these design considerations are in harmony, the eLearning is more effective, and the eLearning module renders a better learning solution. The questions posed in this portfolio proposal are not generally known or understood without an academic background. The tactical resources for designers are technology centered, and not necessary theory supported.

Chapter 2 discusses the literature reviewed on arranging multimedia elements in eLearning to maximize effective learning by reducing extraneous processing. Chapter 3 discusses the proposed products in detail. Ultimately, the products would contain design elements illustrating how learning objects can be incorporated on slides in a way that contributes to deeper learning. The intent is to create a guide that eLearning developers can refer to as they author. When following the principles discussed and illustrated in the portfolio products, developers will consistently create eLearning modules that facilitate cleaner and faster information processing in the learner. This is a positive contributing factor toward categorizing an eLearning module as “good” training. The products proposed in chapter 3 will offer a tangible and concrete reference guide as a solution to that knowledge gap in the eLearning developer community. Chapter 4 provides a complete description of the product of the portfolio. The product will be thoroughly described. Chapter 5 is a reflection on the portfolio and the product.

Chapter 2: Literature Review

The purpose of the portfolio is to illustrate tangible examples of effective eLearning design, and to explain why they are effective. Effective eLearning results in both schema construction and schema automation (Paas & Sweller, 2014). The way that information is presented affects how a learner processes the information (Smith & Ragan, 2005). Poor design causes an increase in the learner's cognitive load, and at times overwhelms the learner. Cognitive Load Theory is important to consider when working to understand how people learn.

Mayer (2005) identified five principles to describe how instruction can be designed and developed to reduce extraneous processing. This chapter thoroughly reviews literature related to Mayer's principles (2014) for multimedia learning which reduce extraneous processing. More specifically, this portfolio looks at how to design eLearning tutorials in a way that reduces extraneous cognitive load (Mayer, 2014; Paas & Sweller, 2014).

Chapter 2 first describes research methods and selection criteria used in the review of literature related to existing knowledge of Cognitive Load Theory and Mayer's (2014) principles for multimedia learning that reduce extraneous processing. The methodology for literature review, a qualitative approach to collect data, is described; specifically, evidence-based research on the effective application of Mayer's (2014) principles of multimedia learning that reduce extraneous processing to eLearning tutorials are included. Finally, research results are synthesized and gaps in research are discussed.

Methodology for Literature Review

This section discusses the search criteria for selecting articles and studies for review. The selected articles contain data on working memory, Instructional Design principles for eLearning, Cognitive Load Theory, Mayer's principles for multimedia learning, effective eLearning and the eLearning industry related to design and multimedia. The literature search was conducted through St. Cloud State’s student library portal using the following databases: Academic Search Premier, Business Source Premier, JSTOR, ScienceDirect, ERIC, and LexisNexis Academic. Various search terms are used for each database, including “eLearning and Cognitive Load Theory”, “Mayer’s principles for multimedia learning”, “effective eLearning”, “Signaling principle”, “Coherence principle”, “Redundancy principle”, “Spatial Contiguity principle”, “Temporal Contiguity principle”, “Instructional Design for eLearning”, “applying Mayer’s principles for multimedia learning”, and “how to create effective eLearning”. Journals used include *Human Resource Development International*, *Journal of Computer Assisted Learning*, *Journal of Educational Technology & Society*, *Educational Technology Research & Development*, *Quarterly Review of Distance Education*, *Canadian Journal of Learning and Technology*, *Training and Development*, *Educational Psychology Review*. A hard copy of *The Cambridge Handbook of Multimedia Learning*, edited by Mayer, 2014 was also used. Only peer-reviewed articles published in a scholarly journal are included in the search. The findings of the literature review are then synthesized and analyzed in a literature review.

The Review and Analysis on Theme section of this paper reports the findings during the literature review related to the problem statement around how best to design for Cognitive Load Theory given a multimedia treatment.

Review and Analysis on Theme

Good Instructional Design is adapted from the understanding of how people learn. With effective learning being the goal of instruction, and the understanding that “people learn more deeply from words and pictures than from words alone” (Mayer, 2014, p. 43), multimedia treatment of content is considered more effective than text alone at producing deeper learning.

To learn something means that the message is stored in long-term memory. “To function, natural information processing systems require a very large store of information.” Long-term memory provides this storage in human cognition (Paas & Sweller, 2014, p. 29). There are different types of messages that can be retained. When considering how multimedia messages are stored, Paas & Sweller (2014) state that knowledge is retained in the long-term memory no matter the form of media. The process of transferring information or messages is dynamic. Cognitive Load Theory involves the working memory and the long-term memory. The data in long-term memory is already learned. Schema construction occurs (Paas & Ayres, 2014). If the goal of Instructional Design is to move information into the long-term memory, the way in which it is coded in the process happens in the working memory. The working memory is where incoming elements of information are processed, and it has limited capacity (Paas & Sweller, 2014).

Active learning takes place in the working memory, which sorts out relevant information from irrelevant information. The capacity of this process is termed cognitive load. The goal of effective Instructional Design is to reduce extraneous cognitive load (Paas & Sweller, 2014). There are three categories of cognitive load: intrinsic, extraneous, and germane (Paas & Sweller, 2014).

Mayer (2014) is a leading researcher on Cognitive Load Theory and multimedia principles for learning. A primary source for this portfolio proposal is a book edited by Mayer called *The Cambridge Handbook of Multimedia Learning*. The first book of its kind, it defines Multimedia Principles for online learning based on Sweller’s (2014) Cognitive Load Theory. Cognitive Load Theory is a learning theory that Instructional Designers use to design for how the human brain learns so that a maximum amount of learning can take place.

Cognitive Load Theory takes an inherent and important role in the Instructional Design of eLearning tutorials because "theories and models for course and curriculum design prescribe how to develop educational programs, which contain of mix of educational media, including texts, images, speech, manipulative materials, and networked systems" (Kester & van Merriënboer, 2014, p. 105). Cognitive Load Theory can be used as a theoretical framework for designing eLearning tutorials. Cognitive Load Theory explains the capacity of one's mind during active learning. The theory explains where space and effort are consumed by information during the learning process. Cognitive load refers to the volume of information that the mind is processing. It includes three types. First, there is intrinsic, task-inherent cognitive load. Second, there is extraneous cognitive load. Third, there is instruction-based germane cognitive load (Veronikas, & Shaughnessy, 2005). When multimedia is arranged and presented in a way that reduces extraneous processing, the designed instruction is more effective in facilitating learning because it increases germane cognitive load (the effort used to process relevant information). Thus, a thorough understanding of the theory must be demonstrated before it is effectively applied (Mayer, 2005).

The Cognitive Theory of Multimedia Learning is based on Cognitive Load Theory and addresses the principles discussed later in this section (Clark, 2014; Fiorella & Meyer, 2014). For example, three assumptions of cognitive theory of multimedia learning are supported, as they are in Cognitive Load Theory. These assumptions are as follows: 1) learners take information through dual channels; 2) the working memory has a limited capacity; and 3) active processing occurs (Fiorella & Mayer, 2014; Kester & van Merriënboer, 2014; Schnotz, 2014). The following paragraph explains the three assumptions in more detail and as they relate to one another in cognitive learning theory.

Active learning requires the cognitive processes of selecting, organizing and integrating. The cognitive theory of multimedia learning contains five processes that must happen for learning to occur: selecting words, selecting images, organizing words, organizing images and integrating (Fiorella & Mayer, 2014; Mayer, 2014). Learners take information in through dual channels: auditory and visual. Sensory information is stored visually for a very short amount of time before it is transferred to the working memory. Similarly, auditory information is stored briefly and is then transferred to the working memory (Schnotz, 2014). The second assumption in Cognitive Load Theory and Cognitive Theory of Multimedia Learning is that the working memory has a limited capacity. Thus, “Instructional Designers should be sensitive to the limitations of working memory by being careful about the amount and layout of the information that is presented to learners” (Fiorella & Mayer, 2014, p. 307). Several factors can contribute to a learner’s cognitive load, but this paper examines and addresses the extraneous processing factor. If cognitive load is too high due to extraneous processing, cognitive overload results.

Cognitive overload is a mental event where the working memory is full and cannot take in new information, resulting in shallower or non-existent learning. It happens when the essential cognitive processing is in total use. The principles demonstrated in this portfolio limit the extent that extraneous processing increases cognitive load. “A major challenge for Instructional Designers is to create instructional messages that are sensitive to the characteristics of the human information processing system, so that the amount of processing required in each channel of working memory does not exceed the learner’s cognitive capacity” (Fiorella & Mayer, 2014, p. 281). Knowing that cognitive overload needed to be diminished for effective learning to take place, Mayer worked to answer the question of how to reduce cognitive load.

Mayer (2014) used four criteria to guide his work on the cognitive theory of multimedia learning. The first criterion is theoretical plausibility. This means that principles uncovered align with principles of learning. The second criterion used considers the degree to which the principle can be tested using scientific processes. The third criterion considers the empirical plausibility, meaning uncovered principles align with empirical findings. Finally, the fourth criterion considers the applicability of the principle. This criterion involves looking at the practicality of putting the principle into practice (Mayer, 2014). With these criteria, Mayer (2014) identified and defined principles for multimedia learning.

Mayer's principles are discussed in *The Cambridge Handbook of Multimedia Learning* (2014). Five of these principles directly relate to extraneous processing. As review, cognitive load refers to the volume of information being processed at one time in the working memory (Mayer, 2014). There are three categories of cognitive load: intrinsic, extraneous, and germane (Paas & Sweller, 2014; Veronikas & Shaughnessy, 2005). Intrinsic cognitive load refers to the space and energy one's cognitive processes take up by the information itself. Extraneous cognitive load refers to the effort a learner devotes to making sense of the Instructional Design method, rather than the relevant information. It takes up working memory space and obstructs the transfer of knowledge (Paas & Sweller, 2014). Germane cognitive load can be described as the amount of cognitive load devoted to intrinsic cognitive load processes (Paas & Sweller, 2014). Extraneous processing is the mental effort that the learner exhibits when separating important information from extra information or relevant content from non-relevant content. A learner's two information intake channels, audio and visual, are involved. When a person's extraneous cognitive load is high, learning is more difficult because processing resources are devoted to the irrelevant information. Reducing extraneous processing is used as a rationale for much of Mayer's principles for multimedia learning (Paas & Sweller, 2014; Mayer, 2014).

Understanding that "people learn more deeply from words and pictures than from words alone" means that multimedia treatment of content is more effective than other methods at producing deeper learning (Mayer, 2014, p. 43). Mayer's (2014) principles for multimedia learning are tactics for Instructional Designers to apply to content. Coherence, Signaling, Redundancy, Spatial Contiguity and Temporal Contiguity principles arrange multimedia objects in a way that reduces extraneous processing (Mayer, 2014). "The theoretical foundations that underlie these design principles build on work in information processing theory that explains how information is stored, retrieved, and transformed" (Lajoie, 2014, p. 625). Having defined the principles, Mayer continued to research and test these theories.

Supporting research on these principles has more than doubled since 2005. For example, the number of studies on principles related to reducing extraneous processing went from 40 to 99 between 2005 and 2014. There has been "strong growth in what we know about how to design effective multimedia instruction" (Mayer, 2014, p. 11). Designing effective multimedia instruction regarding the principles for multimedia learning that reduce extraneous processing is further discussed below with each principle.

Coherence principle. This principle states that people learn better from a multimedia message when extraneous material is left out rather than included (Mayer, 2014). This means the Instructional Designer should only focus on including content that directly relates to the strategy and objective (Smith & Ragan, 2005). For example, music should not be included along with narration. Another example of this is an image with a completely unrelated caption included with narration that explains far too much detail than the learner needs to perform the task at hand

(Fiorella & Mayer, 2014). Further still, considering that people learn best from words and pictures together (multimedia principle), the pictures must relate to the words and not simply be for vanity (Schnotz, 2014). Stories and visuals heighten learner engagement, but explanations should be brief. The most effective design talks about the images or goes through the content with a short audio clip (Clark, 2014).

The Coherence principle, along with Signaling, Redundancy, Spatial Contiguity and temporal continuity were suggested for reducing extraneous cognitive load with the use of characters in eLearning authoring software. In one study, Sanghoon Park (2015) examined the use of avatars in eLearning tutorials and how they affect cognitive load. Park (2015) suggested that avatars not be used as they create extraneous processing explained by the Coherence principle. However, Park (2015) does not describe how to apply these strategies or alternatives of using avatars in eLearning tutorials. Other relevant research includes Mayer and Moreno (2002) who conducted a study regarding animation and principles. They provide concrete examples of seven principles relating to animation (Mayer & Moreno, 2002).

Another practical example is shared by Kester and van Merriënboer (2014), who describe a hypermedia environment where people need to learn about an event in history. They found that, although the environment can play music for a dramatic effect, it would detract from the instructional message. Therefore, as a general rule, do not include music with narration for learning-engagement purposes as this disrupts the dual-channel intake. Also, irrelevant pictures to soften the content should be avoided.

Signaling principle. People learn better from multimedia when signals are added to highlight and help visually demonstrate the organization of the material (Mayer, 2014). Signals directly relate to calling a learner's attention to an area of the screen. In eLearning tutorials, this could be highlighting hot spots on the screen, disabling and strategically enabling a navigational button, or calling attention to interaction with animation. Pop-ups, highlights, and arrows are all examples of objects that can be animated. These can be a great representation and application of the Signaling principle, but according to the Coherence principle, they should be used only when it is necessary to call the learner's attention to something (Mayer, 2014). The Instructional Designer must consider how much Signaling is necessary to appropriately call the learner's attention without being too distracting.

Kester and van Merriënboer (2014) described a practical example of the Signaling principle. They say that for auto-mechanic students who are discovering how to take apart an engine, it is an effective technique to animate the disassembling process one step at a time. During that animation, highlight the specific pieces that are being taken apart.

Redundancy principle. People learn better from graphics and narration together on a screen (modality principle) than from graphics, narration and text all together on a screen (Mayer, 2014). Presentation is important. "According to the Redundancy principle, students will learn more deeply from the non-redundant presentation than the redundant presentation because the redundant presentation requires more extraneous processing" (Fiorella & Mayer, 2014, p. 287). When text is narrated, the audio and visual channels are processing the same information which is redundant; thus how the principle gets its name. "Extraneous cognitive load is minimized when both the visual and auditory subcomponents of working memory are used, rather than when the learner is asked to devote limited working memory capacity to process two visual inputs" (Clark, 2014, p. 851). If there is an image and narration on a screen, according to solid Instructional Design, the practitioner should exclude text of the narration. Images should only be explained through one mode, auditory or visual, but not both or it violates the Redundancy principle and creates extraneous processing (Clark, 2014).

In their eLearning tutorials, practitioners often include slides with text that is then also narrated (Clark, 2014). This is because practitioners intuitively assume that the practice of narrating text aids in the transfer of knowledge. This practice ads to extraneous processing and therefore, hinders learning. Also, it is more effective to communicate the information using narration and an image rather than an image and text. However, "when there are no visuals present, on-screen text will not overload the visual center of working memory. Furthermore, when sentences are long or complex, written text allows the learner to review words at their own rate " (Clark, 2014, p. 852).

As the principles were designed to be tested based on the criteria previously mentioned, experiments have revealed the following degrees of applicability. If narration is used to elaborate on short text phrases, extraneous processing is not increased. A common practical example of this in eLearning tutorials is to use an image accompanied by brief text that is then further explained with narration (Clark, 2014). In this case, learning is not diminished (Mayer & Johnson, 2008). Similarly, if there is a very basic image, or if there is no image, the content is simplistic and the narration is brief and segmented, extraneous processing is not overloaded (Clark, 2014; Fiorella & Mayer, 2014). Additionally, if learners are not fluent in the language narrated, they should have access to text so that they can read at their own pace (Clark, 2014). An example from Kester and van Merriënboer’s research (2014) illustrates the Redundancy principle. Econometric students, who are learning to understand times of economic growth, should first be given a qualitative model so they can take an educated guess as to whether there will be any economic growth. Then, the students can receive a more detailed quantitative model, so they can calculate the economic growth but without repeating the qualitative information.

The Redundancy principle has some conflicting research. Mayer (2014) claims that graphics and narration result in deeper learning when text is left off a slide. However, the Badeley theory suggests that written text does not interfere with working memory when situated next to images unless the text is describing something of visual-spatial significance (Schuler, Scheiter & van Genuchten, 2011).

Spatial Contiguity principle. People retain more content when related words and pictures are arranged near to rather than far from each other on the page or screen (Mayer, 2014; Schnotz, 2014). This means the text on a slide needs to be very close to its associated image. Spatial Contiguity is associated with the split attention principle because it avoids split attention. Split attention can be even further avoided, however, with narration; and thus, the Temporal Contiguity principle.

Temporal Contiguity principle. Instruction is more effective when animation and narration are presented simultaneously instead of successively (Mayer, 2014). Not only do images and narration, or text, need to be relevant to the content (Coherence principle), they need to be situated and presented together at the same time (Schnotz, 2014). When content is presented in an image, or animation, and narration is directly presented simultaneously, split attention is avoided because the learner’s dual channels are both being utilized in the most efficient way possible (Mousavi, Low, & Sweller, 1995). The Temporal Contiguity principle is especially effective when presenting a process. If the narration and animation correlate in real-time, it is the most effective way to train a process (Clark, 2014).

Gaps in Research

Literature supporting Mayer's (2014) principles for multimedia learning and Cognitive Load Theory and how they relate is prevalent. Articles cited in this portfolio lead to further evidence that Mayer's (2014) principles for multimedia learning which reduce extraneous processing result in efficient Instructional Design. There is much more research to be done however to illustrate their application.

To start, practitioner research is needed to record the most effective method of delivering, documenting and evaluating learning with technology (Kirkpatrick, 1996; Lajoie, 2014). Learner research is needed to determine the effect of a principle on a variety of audiences, including secondary education students and professional training programs (Fiorella & Mayer, 2014). Research on the available features offered in eLearning tutorial authoring software is lacking; specifically, on the unique features and interactions available. More research about how to design for multimedia which coordinates Signaling, feedback, interactions, and other scaffolding are incorporated is needed (Fiorella & Mayer, 2014; Graesser, Hu, & Nye, 2014). More research is needed to tell what degree verbal and visual forms of Signaling is helpful. More research is needed on the conditions where the Redundancy principle is useful; on the Spatial Contiguity principle regarding the treatment beyond pages in a book; and to define the temporal limits of the principles: how far is too far, or how much of an exception is still effective (Fiorella & Mayer, 2014). A study on the modality principle in eLearning was found and would be an excellent model for replication with additional principles (Fiorella, Vogel-Walcutt, Schatz, 2012). The products developed for this portfolio can be used in such studies.

Contradictory findings by research also requires further study. As previously discussed, avatars were discovered to increase cognitive load (Park, 2015). According to Mayer (2014), avatars decrease cognitive load. These conclusions are contradictory, and more research needs to be done to clarify and define effective application. Another contradictory finding is regarding whether text and graphics can be situated together with narration on a slide without increasing extraneous processing. Mayer's (2014) studies show that the text should be left off the slide, whereas the Badley theory states that the text can be situated near the graphic if it does not distract from the image's message. This leaves room for further study and clarification.

Overall, research is available about how to arrange audio, narration, graphics, animation, video and text on slides in combination with one another to reduce extraneous processing. However, as a general statement, more support is better support. Therefore, a gap exists in research that bridges educational psychology and concrete examples of multimedia principles being applied using eLearning authoring tools (Dagger et. al., 2005). More research needs to be done around making eLearning tutorials interesting and effective (Caballé et al., 2014), and more studies about applying the Coherence, Signaling, Redundancy, Spatial Contiguity and Temporal Contiguity principles to eLearning tutorials would fill a research gap regarding effective application.

Summary

There is much research on how people learn. Sweller's (2014) Cognitive Load Theory has been examined and adopted in educational psychology. How information is taken in, processed, and effectively learned is adequately tested and accepted. Mayer (2014) built his principles for multimedia learning on Cognitive Load Theory. The literature review examines Mayer's (2014) Principles of Multimedia Learning which reduce extraneous processing. The overarching research question is: how can the principles be applied to eLearning tutorials resulting in efficient learning? The research on their application in eLearning tutorials leaves room for further study.

Much research is done regarding educational psychology and the effectiveness of the principles. However, there is a gap in research regarding practical application of the principles using eLearning authoring software for creating eLearning tutorials. The products in the portfolio will answer the gap in research and demonstrate concrete examples of applying Mayer's (2014) principles for multimedia learning that reduce extraneous processing. This portfolio looks at how Instructional Designers can create informational messages that support rather than detract from the learning process. The purpose of this portfolio is to demonstrate how Mayer's (2014) principles for multimedia learning, which reduce extraneous processing, can be applied to level three eLearning tutorials using eLearning authoring tools. The idea is to share the products of this portfolio with practitioners in the eLearning community. When developers use the portfolio's product as an example, practitioners can create eLearning grounded in sound Instructional Design based on Cognitive Load Theory (Paas & Sweller, 2014).

Chapter 3 discusses the product that demonstrates the application of Mayer's (2014) principles for multimedia learning to examples of eLearning to reduce extraneous. The portfolio answers the research gap by providing tangible examples of eLearning tutorials that incorporate the principles.

Chapter 3: Proposed Portfolio Products

The goal of the portfolio is to provide tangible examples of how to incorporate multimedia in eLearning in a way that reduces extraneous processing. The following product would be included in the portfolio to demonstrate a thorough understanding of how to apply Mayer's (2014) principles of multimedia learning that reduce extraneous processing to eLearning tutorials using eLearning authoring tools. The created work would include examples and non-examples of what the principles look like when applied to content in eLearning modules. It would include a guide for Instructional Designers that explains how a given principle is or is not applied to the corresponding example. A brief description of the guide and examples is included in this chapter. The portfolio's timeline and IRB are discussed as well. Finally, the application of the product is proposed.

Brief Description of Products

The examples included in this portfolio were created using slides from previously created eLearning modules that were created using the Analysis, Design, Development, Implementation, Evaluation (ADDIE) model. This is an industry-recognized, circular process where the Instructional Designer analyzes, designs, develops, implements, and evaluates (Smith & Ragan, 2005).

The product is a self-paced, interactive eLearning module that has branching interactivity organized around the principles. The content is designed to support effective Instructional Design beyond the five principles discussed in chapter 2. The product is rich in multimedia and interaction. It tests the software limitations and provide a multitude of examples of the five principles that reduce extraneous processing.

It was created using Articulate Storyline 360 as the authoring software. The product itself-functions as an online, interactive-guide to applying Mayer's principles of multimedia learning to content. The content itself varies by example. It is built with an interactive menu and branching functionality. The menu is organized by principles. Each menu item, or principle, contains three examples and or non-examples of applying that principle.

The product was published to SCORM 2004 standards. It is available in its published form, and fully functional for viewing and exploration online. It is stored on Amazon S3, which is a simple storage service offered by Amazon Web Services. It was uploaded to Amazon S3 using Cloudberry Explorer. This way, the self-paced eLearning module will have its own web address and can be accessed anywhere by anyone. Log in credentials are not needed. It is embedded into a website.

The second part of the product is a user guide for explaining the use of the five principles. It is be an interactive element contained within a layer on each of the example slides.

- Coherence principle-Examples of content that applies and does not apply to the objectives
- Redundancy principle-Examples of how to include audio and text on screen effectively as well as examples of how it is ineffective
- Spatial Contiguity-Examples of various arrangements of images and text on a screen
- Signaling principle-Various examples of how Signaling can be used
- Temporal Contiguity principle-Various examples of combining animation and narration

Context for Implementation. This product is available on a webpage free to the public. Product one can be explored on the webpage. The link will be posted on LinkedIn as well as shared in eLearning Heroes, a professional blog for eLearning designers and developers.

Institutional Review Board Approval

International Review Board (IRB) Training for Graduate Students was completed on March 18, 2017. IRB approval is not needed for this portfolio because the data collected is end users' observations.

Application of Products

The products can be used by anyone who wants to learn more about applying Mayer's five principles for reducing extraneous processing. The multimedia used can be duplicated by other practitioners as it is not copyrighted. It could be used in the classroom as an activity for students, or in professional development initiatives.

Timeline

March 2019

- Draft of proposal submitted to advisor

March 2019

- Committee members agree to participate, sign, and submit form

April 2019

- Culminating project preliminary meeting with committee members

Fall 2019

- Project projection and completion
- Remain in contact with committee members about project completion

- Culminating project completed
- Final meeting with committee members
- Oral and written exit interview with the Teacher Development Department
- Graduation

Summary

The proposed portfolio features a product created from an Instructional Design perspective using Articulate Storyline 360 and includes a user guide. The products collectively demonstrate an understanding of Mayer's (2014) principles of multimedia learning (Coherence principle, Signaling principle, Redundancy principle, Spatial Contiguity principle, Spatial Contiguity principle and Temporal Contiguity principle) and mastery of how to apply the principles to eLearning modules as they pertain to reducing cognitive load. This portfolio answers a gap found in the available resources for communicating to practitioners via tangible examples on how to model effective eLearning using Mayer's (2014) principles for multimedia learning that reduce extraneous processing. The products are uploaded to social media platforms, including LinkedIn and eLearning Heroes so they can be shared and used as examples for developers.

Chapter 4: Complete Description of Product

The purpose of the portfolio is to illustrate tangible examples of effective eLearning design and to explain why they are effective. In this chapter, the products of the portfolio will be thoroughly described. How the products are implemented in the Instructional Design community is then described and explained. The goal of these products is to help the professional Instructional Design community by offering a comprehensive resource showing best practices based on principles to reduce extraneous processing.

The products of the portfolio, as described in chapter three are two separate items that are now combined into one deliverable. This overall deliverable is an eLearning module created with Articulate Storyline 360. It has intuitive navigation, branching navigation and self-paced learner-led options to explore the content. The module starts with a main menu page, which has an interactive design. There is a title here and five tabs, one for each principle. As the learner hovers over each of the five tabs, they move on a motion path and reveal the names of the principles. Once the tabs are expanded, they remain that way throughout the whole interaction, no matter how many times the learner navigates from and back to the main menu. The learner can access and return to any of the menu options as frequently or infrequently and in any order in which they desire. This unlocked navigation is purposeful and done so because the implementation of the module is to be a resource. Each button when clicked, brings the learner to the corresponding branching scene. Each scene has a landing slide with the name and brief definition of the principle, as well as three buttons. The learner can click on one button at a time to lightbox a new slide with content that is either an example or a non-example of the principle in action. Each principle has a total of three different examples and/or non-examples. Similar to the free navigation of the main menu, once a learner accesses a lightbox they can close out of it by clicking the X in the upper right corner. They can visit and revisit as many times as they wish. The button to access the lightbox has a responsive design so that once accessed, a checkmark is revealed to signal it has been visited.

Each lightboxed slide has a layer on it. The main base layer of the slide displays the featured content. However, to view the explanation of how the example represents the principle, there is an icon in the upper left corner that can be clicked to reveal a layer with an explanation. This layer can be opened and closed as many times as the user wants and can be left in either state without it distracting from the main content of the slide.

Coherence principle

When the learner accesses the Coherence principle scene, they see a back arrow that they can click to return to the main menu. In the center of the slide is the name of the principle followed by a brief definition. The Coherence principle scene includes one example and two non-examples. When the learner clicks on the first example button, a slide is lightboxed and a video tutorial for printing a document created in Word starts automatically. The first non-example contains the same learning objective as the example described above and was created using the same software as the example. The second non-example contains a video tutorial with the learning objective of how to resize an image using Paint.

Signaling principle

When the learner accesses the Signaling principle scene, they see a back arrow that they can click to return to the main menu. In the center of the slide is the name of the principle followed by a brief definition. The Signaling principle scene includes three examples of the principle in practice. When the learner clicks on the first example button a slide is lightboxed and a video starts automatically. The video is of an interactive menu in an eLearning tutorial created with Articulate Storyline 360. The second example is a screenshot of a slide used in an eLearning tutorial that is designed to teach the learner how to complete tasks using a specific piece of software. The third example is a video tutorial showing how to print a document in Word.

Redundancy principle

When the learner accesses the Redundancy principle scene, they see a back arrow in which they can click to return to the main menu. In the center of the slide is the name of the principle followed by a brief definition. The Redundancy principle scene includes two examples and one non-example. When the learner clicks on the first example button, a slide is lightboxed and a video discussing how to print a document from Word starts automatically. The second example is a video tutorial showing how to resize an image using Paint, the same subject matter used as a non-example for the Coherence principle. The non-example shows the video tutorial used previously instructing learners how to print a document from Word.

Spatial Contiguity principle

When the learner accesses the Spatial Contiguity principle scene, they see a back arrow that they can click to return to the main menu. In the center of the slide is the name of the principle followed by a brief definition. The Spatial Contiguity principle scene includes one example and two non-examples. When the learner clicks on the first example button a slide with an image of a cat and the text, “What are the safe petting zones of a cat? Click each ‘?’” is lightboxed. Eight flashing question marks overlay the cat image. This is an interactive slide used in an eLearning tutorial. The learner clicks on a question mark and then receives an answer of whether that body part of a cat is considered a safe petting zone. The first non-example illustrates this concept with the same image and subject matter, but the interactive question marks are listed to the left of the image. The second non-example of the Spatial Contiguity principle provides learners with the steps to complete a task in a piece of software. This slide is used in an eLearning tutorial before the learner clicks Next to begin practicing the task.

Temporal Contiguity principle

When the learner accesses the Temporal Contiguity principle scene, they see a back arrow that they can click to return to the main menu. In the center of the slide is the name of the principle followed by a brief definition. The Temporal Contiguity principle scene includes three examples. When the learner clicks on an example button a slide is lightboxed. The first example is a video tutorial for completing an administrative task. The second example is an animated video that has very limited text being written live with the narration. It also is making an overall image that helps illustrate the message. The third example is a screencast tutorial with narration.

Implementation of products

The product will be shared with a private group of Instructional Designers with a short presentation on the paper. For the community at large, this will be posted to LinkedIn and shared on eLearning Heroes as a resource from which designers and developers can learn (Higdon, 2019).

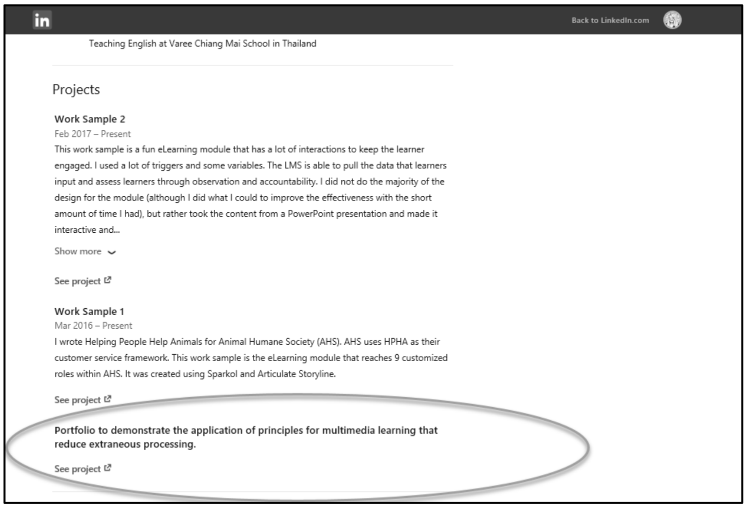

Figure 1. Screen shot of the portfolio posted to LinkedIn

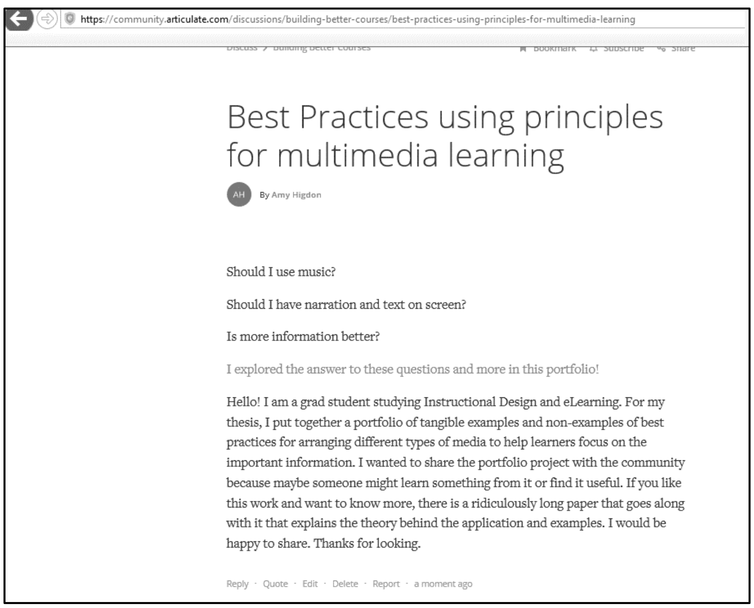

Figure 2. Screen shot of the portfolio shared on the eLearning Heroes blog

Summary

The product is a tool that can be accessed and shared with Instructional Designers. It is posted on social websites and can be shared and viewed for reference to best practices for ways to put Mayer's (2014) principles for multimedia learning that reduce extraneous processing into practice. Each of the five featured principles; Signaling, Redundancy, Spatial Contiguity, Temporal Contiguity, and Coherence are represented through examples or non-examples. Each example or non-example has a learner guide associated with it to provide the learner more information as to why something is relevant. Chapter 5 contains reflection on the product as it relates to Cognitive Load Theory and Mayer's (2014) principles of multimedia learning that reduce extraneous processing. Recommendations for application of the work and for additional products as well as conclusions and significance are discussed.

Chapter 5: Reflection of the Theme and Product

Much information can be found on Cognitive Learning Theory and principles for multimedia learning. The gap that exists between the theoretical information and practice exists because of a need for Instructional Designers, who do not have advanced degrees in Instructional Design, to quickly understand how to put the principles to practice in their work. The product of this portfolio is a means to fill that gap. Overall, the product is a tangible example of how to apply the principles discussed in the portfolio to eLearning modules. In this chapter, each principle will be discussed in terms of how the principles were applied to the product. Implementation of the product, recommendation for application and additional products will also be discussed. Finally, this chapter ends with a conclusion and significance statement.

Coherence principle.

There is an example and two non-examples provided. The example slide has a video tutorial for printing a document created in Word that starts automatically once the slide is accessed. The tutorial has clear, step-by-step narrated instructions that correspond with the animation of the screencast, which was created with a trial version of Camtasia. Because of the trial version, a watermark is visible on the screen. The video is less than one minute long. If the learner accessed this video looking for instructions on how to print from Word, they would find only that information and nothing more. Any extra subject matter is left out of the video. Therefore, this is an example of the Coherence principle in practice.

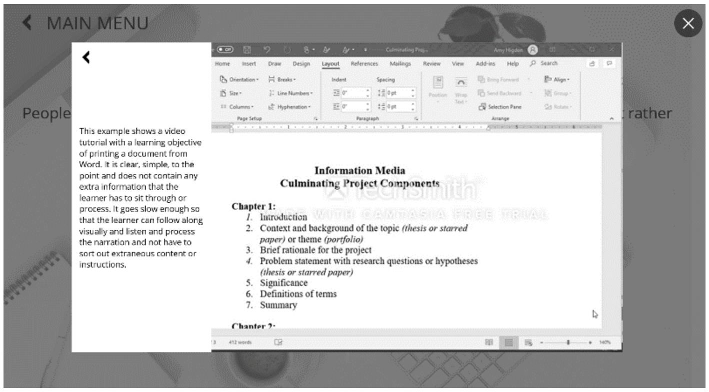

Figure 3. Screen shot of the first example of the Coherence principle in practice

The first non-example contains the same learning objective as the example described above and was created using the same software. However, it is about ten times as long, going into unnecessary detail about content unrelated to the learning objective. In addition to demonstrating the steps to printing a document, the instructor discusses a variety of features of the software. This causes the learner to employ additional effort to pull out the relevant information. It can also cause some frustration in the learner as they are looking for one thing, but they have to sit through a lot of irrelevant content. Some of the additional content is somewhat related to printing, but it isn’t necessary to the step-by-step process of how to print.

Figure 4. Screen shot of the first non-example of the Coherence principle in practice

The second non-example contains a video tutorial with the learning objective of how to resize an image using Paint. Instead of being clear and leaving irrelevant information out of the video, it is an example of an extemporaneously narrated tutorial. The narrator goes off onto tangents that lead the learner off task. Although small stories and asides can be entertaining, they do not support the Coherence principle, which calls for keeping all irrelevant content out of the material. Working memory is ultimately sorting out relevant information and connecting the content to what they already know. If the learner is experiencing the subject matter for the first time, the irrelevant information is extra challenging.

Figure 5. Screen shot of the second non-example of the Coherence principle in practice

An additional ubiquitous example is when searching for a tutorial video on how to cut an onion on the world wide web, we may come across a video that would otherwise be helpful, but the narrator takes many minutes before starting the demonstration. By that point, the viewer may have lost interest or has moved onto find a completely different resource altogether. If the point of the tutorial is to teach something, any extra information included is not helping meet the objective. The extra information can create extraneous processing and distract the learner.

Signaling principle

The first example slide has a video of a screen capture of an interactive menu in an eLearning tutorial created with Articulate Storyline 360, which starts automatically. The Learner Guide explains how the menu is a flow chart. Before this menu slide, there is video that explains the process to the learner. Once they access the menu slide, they can click on the highlighted boxes in the process. The green boxes are clickable and highlight as the learner hovers over them to signal that they are interactive. Additionally, the main menu is shown and highlighted in the menu tab on the left side to remind the learner of where they are in the tutorial. This expands as the learner goes through the course. This slide supports the Signaling principle because signals are programed in to help the learner identify where they are and where they can go in the self-paced eLearning tutorial.

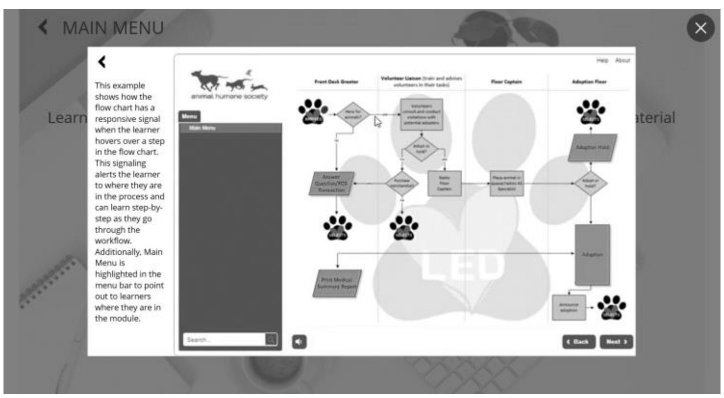

Figure 6. Screen shot of the first example of the Signaling principle in practice

The second example is a screenshot of a slide used in an eLearning tutorial designed to teach the learner how to complete tasks using a specific piece of software. The screenshot shows one step. There are instructions on the slide for what the learner should do, and the button that they need to click is highlighted. This helps the learner locate the button and signals to them what the next step is in completing the task. This is an example of the Signaling principle because the graphics on the screen signal to the learner to draw their attention.

Figure 7. Screen shot of the second example of the Signaling principle in practice

The third example is a video tutorial showing how to print a document in Word. This example is the same video tutorial given as an example of the Coherence principle, now enhanced to contain on screen signals that bring the learner's attention to relevant areas of the software. They signal what to focus on and when and where to click to perform a task. As you can see by this example, when applying more than one principle to the content enhances the quality and effectiveness of the eLearning module.

Figure 8. Screen shot of the third example of the Signaling principle in practice

Thinking about the principle in other context can help communicate its importance. For example, watching a virtual software demonstration on screen can be difficult to follow.

Virtually led demonstrations often feature highlighters and pointers to help signal portions of the screen. When a software demonstration is given in person, the facilitator is likely to point to the screen, or even wiggle the mouse around important navigational features which is an example of signaling. Signaling may seem intuitive, but it is also a very important feature to include in eLearning modules to decrease extraneous processing.

Redundancy principle

The first example is a video discussing how to print a document from Word that starts automatically. To show the Redundancy principle in practice, callout boxes point out the main steps to complete the task. Here, narration and animation are the primary modalities used to communicate the message, and text is used very sparingly. The text is not the exact same as the narration, but rather highlights the main points. The text is not enough to distract the learner by using up the dual channels for intake.

Figure 9. Screen shot of the first example of the Redundancy principle in practice

The second example is of a video tutorial showing how to resize an image using Paint. The same subject matter was used in a tutorial as a non-example for the Coherence principle. This example demonstrates the Redundancy principle because it does not contain both lengthy text and narration. Instead, it contains only narration and animation. There is not any

Redundancy present that would increase extraneous processing. Although the software provides developers with a very easy way to add text or closed captioning, if the text is going to be played along with the narration, it would violate the Redundancy principle. If the designer needs to add text features for accessibility purposes, it is suggested that this option be able to be turned off for learners who wish to only listen to the narration.

Figure 10. Screen shot of the second example of the Redundancy principle in practice

The non-example shows the video tutorial used previously instructing learners how to print a document from Word. The basic recording of the video was used as a positive example for the Coherence principle. It is clear, which reduces extraneous processing. However, when the text is added word for word to go along with the narration, extraneous processing is increased. Therefore, this is not recommended. As stated previously, if you wish to add text for accessibility, please do so as an option for learners to experience the content without audio, but do not have the text show on screen as default.

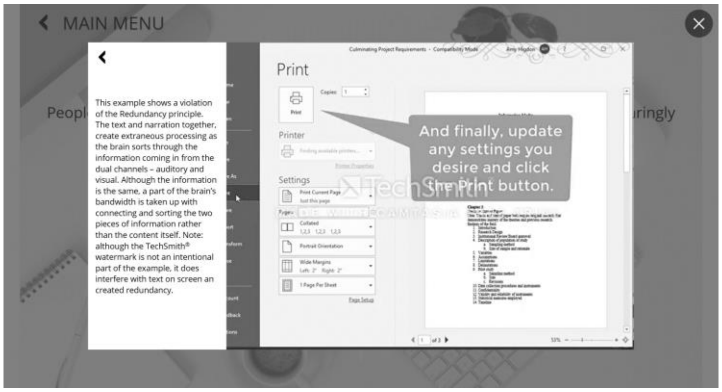

Figure 11. Screen shot of the first non-example of the Redundancy principle in practice

A ubiquitous non-example of the Redundancy principle will likely be familiar to anyone who has ever watched television or a movie with subtitles on. A film with subtitles is in violation of the Redundancy principle. Think about where a viewer's eyes may focus when subtitles are present. Reading subtitles makes it more difficult to experience the full potential of the cinematography. The viewer's experience is much more encompassing when audio is matched with the moving picture.

Spatial Contiguity principle

The first example displays an image of a cat with the text "What are the safe petting zones of a cat? Click each '?'" and eight flashing question marks on top of the cat image. This is an interactive slide used in an eLearning tutorial. The learner clicks on a question mark to receive an answer of whether that body part of a cat is considered a safe petting zone. This is an example of the Spatial Contiguity principle because the information identifying the areas of the cat is located directly on top of the corresponding area of the image. It reduces extraneous processing because the learner does not need to make a spatial connection from terms listed on one side of the slide to the image on the other side, for example. Another way that developers can unknowingly violate the Spatial Contiguity principle is to use reference numbers on an image but then have the corresponding definition listed away from the image. Although this may make sense for a formatting purpose, it increases extraneous processing. It is always best to have the labels as close to the identifier as possible to support the Spatial Contiguity principle.

Figure 12. Screen shot of the first example of the Spatial Contiguity principle in practice

The first non-example illustrates this exact concept. The same image and subject matter are used as in the first example, but the interactive question marks are listed to the left of the image. Because the text is located far from the image, it increases extraneous processing. The learner must make the cognitive leap of associating the location of the image with the content.

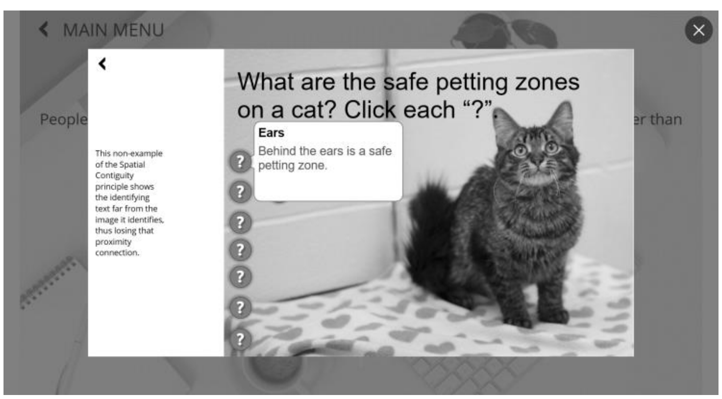

Figure 13. Screen shot of the first non-example of the Spatial Contiguity principle in practice

The second non-example of the Spatial Contiguity principle provides learners with the steps to complete a task in a piece of software. This slide is used in an eLearning tutorial before the learner clicks ‘Next’ to begin practicing the task. If this arrangement were to support the Spatial Contiguity principle, the steps would be situated very close to the screenshot of the software with a callout box, for example. Instead, all the instructions are on a separate slide. Not only does the learner have to remember these steps, they don’t have the visual reference to help them make the mental leap. Therefore, their extraneous processing is increased as they exert effort to remembering the steps or navigating to and from this slide to complete the task.

Figure 14. Screen shot of the second non-example of the Spatial Contiguity principle in practice

A ubiquitous example or non-example of the Spatial Continuity principle is manufacture instructions for assembling an item. Whether it be for assembling the Lego pirate castle, or this year’s trendy farmhouse-modern armoire straight from the Sweden boutique, if the labels and instructions are near the corresponding image, frustration is reduced during construction.

Temporal Contiguity principle

The first example is a video tutorial for completing an administrative task. The narration is in sync with the animation so that the demonstration is happening at the same time that the instructions are given. This is in support of the Temporal Contiguity principle and reduces extraneous processing.

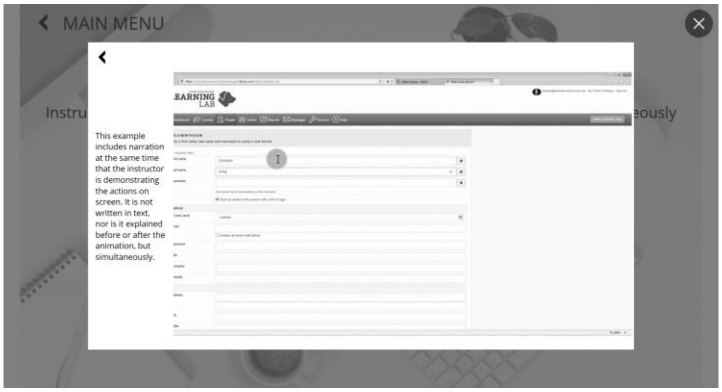

Figure 15. Screen shot of the first example of the Temporal Contiguity principle in practice

The second example is an animated video that has some very limited text that being written live with the narration. It also is making an overall image that helps illustrate the message. The animation, imagery, and narration helps reduce extraneous processing as the dual intake channels are being optimally stimulated. The imagery used allows the learner to relate the words to the pictures that are displayed rather than creating their own ideas.

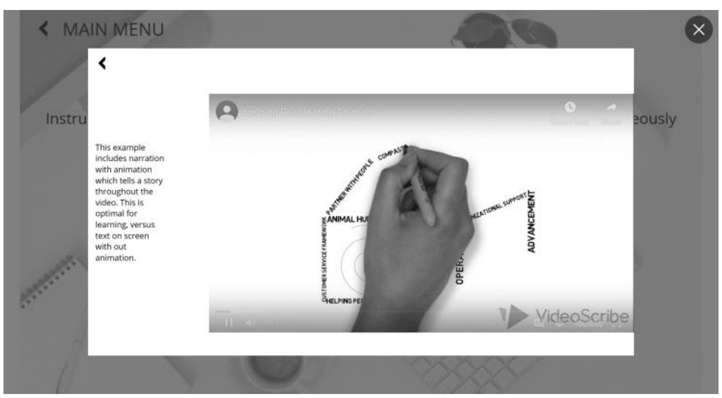

Figure 16. Screen shot of the second example of the Temporal Contiguity principle in practice

The third example is a screencast tutorial with narration. Like the first example, this video demonstrates the Temporal Contiguity principle in practice. Instead of using text either simultaneously or before or after the imagery, the narration is presented in tandem with the animation, thus reducing extraneous processing.

Figure 17. Screen shot of the third example of the Temporal Contiguity principle in practice

Imagine learning to cook a new dish by watching a tutorial. These types of tutorials are ubiquitous. They can be found on television and the internet. Now imagine if the recipe was first displayed in text form to read. Following that, the viewer watches only the video footage with no instructions. Likely, it would be difficult to recall if the video footage accurately represented the written instructions. The learner would need to flip back and forth between the two kinds of media to get an entire picture of the recipe. That creates extraneous processing.

Implementation of Products

The overall portfolio fills a definite gap in the Instructional Design community by bridging academic research and practice. There are many principles for multi-media learning identified by Mayer (2014); this portfolio only addresses five of them. There are additional ways to put the principles into practice or violate them, so this project could be expanded. More principles could be added, and more examples of correct and incorrect application could be added as well.

Recommendation for application

It is recommended that Instructional Designers share the product of the portfolio with peers. Professionals should practice the principles when designing eLearning tutorials as they are represented in the product.

Recommendation for additional Products

For any theory relating to multimedia learning, it is recommended that a collection of examples be created and shared in the Instructional Design and even academic community to increase the uptake of adopting the principles into practice.

Conclusions and significance

Having a quick-easily accessible reference tool and resource that can help Instructional Designers create more effective products. The principles can work together. They enhance each other. The Instructional Designer does not need to decide one over the other, but can instead, look at the types of media incorporated in their design and then design how the media elements can best relate to one another to aid in learning. Intuition can play a role in correctly using the principles. By observing how media has been used in past tutorial presentation, and by reflecting on one’s own experience and preference for ingesting multimedia messages, we can often create multimedia messages that support the principles.

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Appendix

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)
COMPLETION REPORT - PART 1 OF 2
COURSEWORK REQUIREMENTS*

* NOTE: Scores on this Requirements Report reflect quiz completions at the time all requirements for the course were met. See list below for details. See separate Transcript Report for more recent quiz scores, including those on optional (supplemental) course elements.

- **Name:** Amy Higdon (ID: 6168908)
- **Institution Affiliation:** St. Cloud State University (ID: 1328)
- **Institution Email:** hiam1301@stcloudstate.edu
- **Phone:** 763-432-4883

- **Curriculum Group:** Basic/Refresher Course - Human Subjects Research
- **Course Learner Group:** IRB Training for Graduate Students
- **Stage:** Stage 1 - Basic Course

- **Record ID:** 22326947
- **Completion Date:** 25-Feb-2017
- **Expiration Date:** 24-Feb-2022
- **Minimum Passing:** 70
- **Reported Score*:** 78

REQUIRED AND ELECTIVE MODULES ONLY	DATE COMPLETED	SCORE
Belmont Report and CITI Course Introduction (ID: 1127)	25-Feb-2017	2/3 (67%)
Students in Research (ID: 1321)	25-Feb-2017	3/5 (60%)
Informed Consent - SBE (ID: 504)	25-Feb-2017	4/5 (80%)
Internet-Based Research - SBE (ID: 510)	25-Feb-2017	5/5 (100%)

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid Independent Learner.

Verify at: www.citiprogram.org/verify/?k05c4a1ba-fd41-4811-b4ec-1098874b73d5-22326947

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