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Abstract

With the proliferation of free and easy-to-use tools to make online tutorials, many libraries have been creating online tutorials for their users. These cover everything from showing users how to navigate the databases to covering issues like copyright and evaluation. While the tutorials range from entertaining to rather dry, many of them, regardless of their entertainment value, do not employ the methods that can lead to deeper learning. Mayer (2014) has explored the concepts and research around online tutorials in *The Cambridge Handbook of Multimedia Learning*. The principles covered in the handbook and in the related research can be quite counterintuitive for those of us who create online tutorials. This paper explores these principles as they relate to tutorials created for library instruction. Additional research to expand on and support Mayer's principles will be discussed to provide evidence-based strategies for deepening learning and reducing elements that detract from learning.

Introduction

With all the time, effort, and money libraries put into creating interactive and original tutorials for their users, wouldn't it be unfortunate if all that work did not lead to learning? Unfortunately, many libraries make tutorials without using evidence-based research to drive their design. These tutorials distract and overload viewers, which, in turn, leads to decreased learning or no learning. Mayer (2014a) has explored the concepts and research around online tutorials and other forms of multimedia learning in *The Cambridge Handbook of Multimedia Learning*. The principles covered in the handbook and in the related research can be quite counterintuitive for those who create online tutorials without the proper educational background in instructional design. This paper will explore some of those principles and the research that supports them, and will provide strategies to improve multimedia instruction. By better understanding the design elements that assist rather than impair learning, librarians can create dynamic multimedia instructional materials that engage and educate users.

Dr. Richard Mayer's handbook, published first in 2005 and revised in 2014, provides research-based methods on how to best design multimedia instructional materials. Though multimedia does not necessarily refer to computer-based formats, the focus of the handbook remains on computer multimedia, though even a textbook could contain multimedia. The book incorporates empirical research and often meta-analyses that provide evidence-based strategies for those interested in instructional design. Mayer himself is a professor of psychology at UC who has conducted over one hundred experiments on effective online learning practices.

Recognizing Learning

Understanding how people learn is the first step toward creating effective learning. According to Mayer (2014b), individuals learn by selecting relevant pieces of information, organizing it in the mind, and integrating that information with previous knowledge (p. 47). The organization occurs in the working memory, and for that information to have permanence, it must move into long-term memory. Information moves from the working memory to long-term memory when a learner links information in the working memory to information in the long-term memory. As students are learning, they are moving through this process, and their cognitive capacity may be strained, depending on if instructional material is well made or not.

To indicate that learning has occurred, many studies focus on both recall and transfer skills. Improved recall means that students are able to retrieve and supply information stored in their memory. This is not the same as recognition, which means that students are able to select the correct information from a multiple choice or similar setting, rather than recalling it in a short answer or other scenario where information must be retrieved from their memories (Clariana & Lee, 2001). Transfer skills refers to the ability of students to apply skills to various situations and domains. Transfer skills, while an essential component of education, are not always automatic (Perkins & Salomon, 1988). Among various strategies for teaching to transfer, reducing cognitive load and providing instruction in various formats are effective methods of improving student transfer of skills learned (Billing, 2007), and are also strategies supported by multimedia learning.

Principles for Multimedia Learning

Multimedia, Animation, and Cognitive Load

According to the multimedia principle, which is supported with several research studies, more learning occurs when both pictures and words are used for instruction (Mayer & Anderson, 1991, 1992). This is because of the dual-channel theory, which shows that words and pictures are processed separately, though humans have the ability to cross-process (converting images to words and vice versa) (Baddeley, 1992; Pavio, 1986). In their instructional design role, librarians should create learning materials that reduce cognitive load by removing "inappropriate instructional procedures" (Paas & Sweller, 2014, p. 38). Though instructional designers may be tempted to add images or sounds to increase engagement, this can have a negative impact on learning. Even when using a PowerPoint, distracting transitions and animations can lead to a decrease in learning. Choosing the appropriate amount of multimedia effects is more important than many librarians may believe, but the research supports making prudent decisions in instructional design.

One way to reduce extraneous load is to avoid animation unless it is essential to the understanding of a process. In some research studies, static images have been found to generate better learning (Butcher, 2014). Thus, screenshots may be better to use than screencasting, especially if the learners have little prior knowledge, or if the skills being learned are very complicated (Butcher, 2014). Though librarians may think that it is necessary to have a screencast of using the databases, often times a series of screenshots should be sufficient in instructing students. Additionally, the distraction of extraneous movement or information is removed when librarians use screenshots alone. However, it is important to note that a meta-analysis discovered that animation had a greater impact on learning than static pictures (Höffler & Leutner, 2007). This was particularly true when the animation itself represented movement or a process using motion that needed to be learned (Höffler & Leutner, 2007). The meta-analysis did find that unnecessary, entertaining animation was not advantageous over static images (Höffler & Leutner, 2007). As Lowe and Schnotz (2014) state, deciding whether or not animation may be better than static images requires "more careful analysis of the nature of the learning task than would normally be undertaken by instructional designers" (p. 524). Therefore, animations should only be used when they are demonstrating something that needs to be learned.

Used appropriately, transitions and animations can benefit learning, as supported in the signaling principle. Some screenshot and screencasting software allow creators to highlight certain words or images through the use of arrows or other attention-attracting mechanisms. Using this to direct learners to the most important aspects of a lesson can increase learning (van Gog, 2014). Students do not have to put as much cognitive effort into discerning which pieces of information they should select, and they can focus on moving this information into their working memory and then their long-term memory. Using a particular tone of voice when explaining a vital piece of information for students can help them select the most important information to organize and integrate for learning. In an experiment using voice signaling, students showed improved retention and transfer skills over those students who did not receive instruction with verbal signaling (Mautone & Mayer, 2001). Even in face-to-face instruction that does not use multimedia, signaling verbally can be beneficial to students.

Showing an image or screenshot and then explaining it on another slide or in a handout negatively impacts learning (Ayres & Sweller, 2014). When designing instructional materials, librarians should create lessons that integrate information together for the learners where possible. If the information is not integrated, students have to hold information in their working memory while selecting information to be integrated with it, and this causes an extraneous cognitive load. Thus, spoken words and pictures should be shown at the same time to improve learning and problem-solving ability, which is supported by the temporal contiguity principle (Mayer, 2001). Additionally, related materials need to be physically located next to each other to increase learning, as seen with the spatial contiguity principle (Mayer & Fiorella, 2014). This includes feedback in tutorials. For example, if learners are asked to apply knowledge through an interactive testing feature, feedback on the performance should appear next to the question itself (Clark & Mayer, 2003). Otherwise, students will have to flip between the feedback and the question, and this can add to cognitive load (Clark & Mayer, 2003).

To improve learning, librarians should break up lessons into shorter learning modules. When students are viewing long tutorials or attending long webinars without a break, they may experience cognitive overload (Mayer & Pilegard, 2014). One of the benefits of online learning

is allowing for user control. Segmenting the instruction and allowing learners to repeat material and pace themselves improves both recall and transfer in students (Mayer & Pilegard, 2014). Learners should have access to a forward and back button in online tutorials, and a pause button in videos. It is important to note that being able to sequence their own learning only benefits students with a high level of prior knowledge (Clark & Feldon, 2014). Thus, lessons that require students to move through a linear lesson, while also allowing students to repeat and pause material, appear to be the most effective. Though a navigation page may be useful to students who cannot complete a learning module all at one time, librarians should consider whether or not they want to encourage learner control of the multimedia elements. According to an analysis of the research, instructional designers should allow learners to control the order of the selection and sequencing of their learning if the learners have a strong, prior understanding of the topic, and if they will receive appropriate scaffolding and additional instruction (Scheiter, 2014). Thus, providing a clear, linear order for learning will be the most efficient for most distance learners.

Audio

Because of the dual-channel processing ability of humans, the modality principle states that learners can process more when both audio and visual modes are used for instruction (Lowe & Sweller, 2014). However, if the process being described has a high level of complexity, having only one mode can engender more learning (Kalyuga & Sweller, 2014). For most library instruction, though, having dual-mode instruction should be an efficient way to teach research skills. Many online tutorials libraries create include both audio and visual elements, which allows users to hear a process described, like searching a discovery system, while they are watching this process. This allows for the verbal information to be easily integrated with the visual information, which can lead to deeper learning because the information is more likely to be organized into working models in long-term memory (Mayer & Sims, 1994).

Multimedia instruction with audio in online tutorials can become ineffective in unexpected ways. For example, if words are displayed on a screen and read by a narrator, learning decreases (Kalyuga & Sweller, 2014). This is referred to as the redundancy principle. Though it may seem like reading information provided textually to students re-emphasizes concepts, this is not as effective for learning. If the material itself is simple, then typically the redundancy principle does not impact learning to a large degree (Kalyuga & Sweller, 2014). Because many librarians create online instructional tools that have applications for a variety of audiences, limiting redundancy will benefit all learners. Even when giving a presentation, librarians should avoid reading their presentation slides, not only because this is not a sophisticated presentation practice, but because listeners will retain less from the presentation.

Not only should redundant text be removed, but truly any information or content that is not necessary for learning should not be included in tutorials. This includes music, related anecdotes, or even providing too much of an explanation (Clark & Mayer, 2003). Though these tools may seem to increase student interest, they instead make learning more difficult by distracting the learner and making it difficult for the learner to understand the connections between the important content being presented (Clark & Mayer, 2003). Research has shown that additional sounds, music, pictures, and words all detract from learning (Clark & Mayer, 2003). This does not mean that a video promoting the library that has entertaining elements would be

ineffective because the purpose is to only pique the interest of the viewer. For tutorials on important concepts, however, entertaining features would be ineffective.

Personalization and Characters

When librarians create instructional materials online, they should keep in mind the personalization principle. Personalization means that a conversational tone should be used to increase learning (Mayer, 2014c). Instead of using third-person pronouns, librarians should use first- and second-person pronouns, especially when making materials for lower-achieving students and for shorter lessons (Mayer, 2014c). In a study of college students, students rated higher in both retention and transfer skills when receiving multimedia instruction with a personalized, informal explanatory text than with formal instruction (Kartal, 2010). Regardless of whether the instruction is provided via text or audio, the instruction should not be overly stiff, formal, or academic. This may seem contrary to some goals of library instruction teams, who wish to appear more rigorous if they are in an academic setting. A conversational tone, however, can still convey expertise and knowledge without placing more cognitive strain on students as they navigate difficult language or processes that seem too theoretical because they are not personalized.

Students learn more from audio lessons that use a human voice without an accent, even when the same material is covered (Mayer, 2014c). Though software exists that creates animation with text-to-speech features, like Voki, students will not learn as much from this as they will from a human voice. Additionally, a character that looks very cartoonish or does not have human-like movements will not positively impact learning (Mayer, 2014c). Having a human-like character on the screen with a human voice is not only preferred by students, but can increase learning (Moreno, Mayer, Spires, & Lester, 2001). However, several studies indicate that while a character (often called a pedagogical agent) does not negatively impact learning through the split-attention principle, it typically does not have a positive impact above and beyond other multimedia learning (Clark & Feldon, 2014; Craig, Gholson, & Drisdol, 2002; Gulz, 2004). In fact, Clark and Feldon (2014) call the advantages of pedagogical agents a "questionable principle" that does not require further research (p. 156). Therefore, libraries should not feel compelled to employ characters, cartoons, or even their own talking head in their instructional materials because research does not support their use.

Content to Improve Learning

While some content in multimedia learning, like extraneous information, can be damaging to the learning experience, research has shown that some content across multimedia learning can be very beneficial. For example, exposing students to the concepts covered in a lesson before beginning the lesson (pre-training) can allow for deeper learning (Mayer & Pilegard, 2014). So, for example, before a librarian shows how Boolean operators can be used in a database, she or he could explain what they are and how they function. The cognitive load of explaining the function of a Boolean operator as they are used in a particular database could strain a student's ability to learn. Pre-training allows students to work through a concept and store it in their long-term memory prior to a more complicated lesson. Once the have this in their long-term memory, they have a schema into which they can integrate new information about this concept as they work through the lesson.

Providing students with worked examples can also improve learning. Typically, a worked example refers to something like a math problem where a question is presented, and then the entire process that it takes to attain the solution is explored. An example of this relevant to libraries could be a tutorial that works through copyright problems, applying the four factors of fair use, and then determining whether a particular information use is a violation of copyright or not. Worked examples can deepen the learning of students (Renkl, 2014), but there are some important factors to consider if worked examples are included. One is the passivity of learners; when they do not internally or audibly explain the problems to themselves as they see and/or listen to the worked examples (self-explanation), they will not learn as much (Renkl, 2014). Therefore, the tutorial should include prompts that ask students to make comparisons, reflect on conclusions, or provide explanations of what they learned in their own words (Renkl, 2014). Additionally, the worked examples need to avoid providing too much extraneous information and should focus on the particular skills required so that students may problem-solve on their own. A worked example on fair use should not provide extraneous information about patent law or trademarks, but focus on how to apply the four factors well.

Moving from a worked example to application will allow learners to begin to create the structures in their long-term memory that allows them to remember the content of the lesson. While games may appear to be a fun manner of showing the retention of learning, application problems that represent authentic scenarios will generate better learning (Clark & Mayer, 2003). Tutorials that require students to drag and drop correct elements of a citation, to insert the appropriate keywords, or to make a decision regarding a plagiarism case allow them to retain and transfer knowledge relevant to the topic. If the test of skills does not represent the actual environment or context in which the learner will be using the skills in reality, then the learning is less likely to be transferred (Clark & Mayer, 2003).

Considering Audience

Particular audiences may require particular designs and content in multimedia learning. The expertise reversal principle in multimedia learning states that many of the principles that are effective for novices become ineffective or harmful for learning for those who have a significant amount of prior knowledge (Kalyuga & Sweller, 2014). Typically, the more prior knowledge someone has, the less structure they need in their learning environment (Kalyuga & Sweller, 2014). Less scaffolding, less worked examples, and less explanations are actually more effective for learning for knowledgeable students (Kalyuga & Sweller, 2014). Since these students have mental models already, they are integrating new information with these models, not creating new mental models. Too much information can cause cognitive overload as they work with their long-term memory and the new information.

While elderly adults may have slower processing abilities, multimedia learning proves to be an effective way to provide instruction. Naturally, if there is an extraneous cognitive load in learning how to use a system, that can negatively impact learning. Because of the modality effect, though, older adults learn more when there is a dual-channel method of learning (Van Gerven, Paas, & Tabbers, 2006). In fact, researchers of multimedia learning and elderly adults suggest that instructional designers do not need to create particular instruction for the elderly, but can use the principles described above to design effective instructional materials for most learners (Van Gerven, Paas, & Tabbers, 2006).

Conclusion

Though multimedia learning does provide a way to create effective instruction, there are some important research findings to keep in mind so that the beneficial effects of multimedia instruction is not exaggerated. Research does not indicate that multimedia instruction is more motivating or produces more learning than older media or face-to-face instruction strategies (Clark & Feldon, 2014). It can benefit learning, but that does not mean that older methods of instruction should be abandoned. Additionally, librarians should not attempt to use multimedia instruction to match "learning styles." Research on learning styles has indicated that attempting to match preferred learning style and instruction does not increase learning (Dembo & Howard, 2007). Instead, following the principles that benefit students as explored above will generate deeper, better learning.

This paper has demonstrated the evidence-based design principles that can be used to improve multimedia learning. Ultimately, tutorials should focus on elements relevant to the learning and should provide authentic scenarios and learner reflection. Though pictures of LOLcats and pop music may seem to generate more interest in library tutorials, if the goal of the tutorial is student learning, then librarians and instructional designers should remove extraneous content and focus on strategies that will increase rather than decrease student recall and transfer.

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