Human Memory and Multi-media Instructional Design

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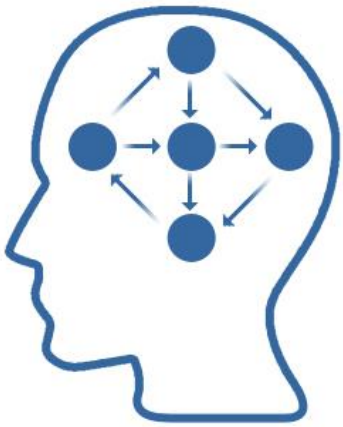


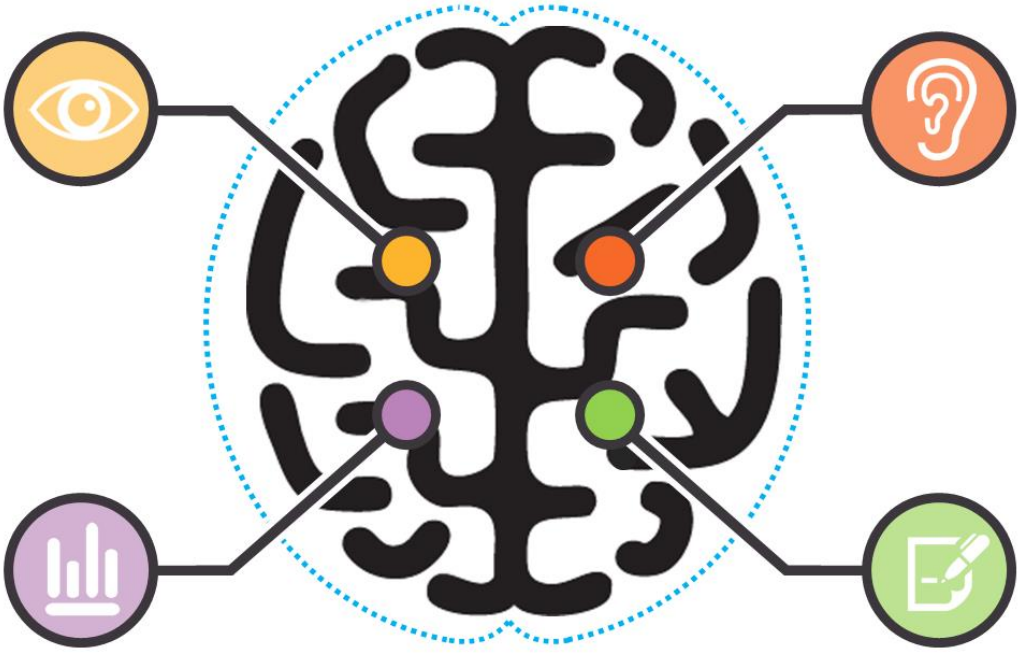
The science of instruction applies learning theory to the design of instructional materials. The science is founded on research that explores the instructional strategies that have the greatest impact on learning (Mayer, 2010). In order to fully understand which instructional strategies will most likely be effective, it is important to understand human learning and memory processes. Multimedia rich designs have been presented as one of the instructional strategies that can maximize the capabilities of the human memory in learning (Mayer, 2014). eLearning in particular is an incredibly powerful tool for implementing various forms of multimedia and interactivity in learning, thus opening up a variety new opportunities and potential to optimize learner retention. Therefore, this paper will explore the human memory systems and the use of multimedia design in order to fully exploit the capabilities of human memory. In addition, we will examine research documenting the impact of utilizing multimedia design within varying populations.

Human Memory Systems

Early theories suggested that human memory systems consist of three primary components: a sensory store, a short-term memory, and a long-term memory (Broadbent, 1958). The sensory memory holds information for a fraction of a second so that relevant information can be selected and then processed by the short-term memory (Broadbent, 1958). From the short-term memory, information can then be selected and transferred into long-term memory (Broadbent, 1958). More recent theories have suggested that the short-term component is actually more of a complex "working memory," that processes both visual and auditory information (Baddeley, 1992).

The working memory consists of a "visuospatial sketch pad" and a "phonological loop" (Baddeley, 1992). What does this mean? Essentially, the working memory is comprised of a visual and auditory component. The visual component holds and manipulates pictures within

the working memory (Baddeley, 1992). The verbal component can process both auditory information and written word information that can be vocalized within the person's brain (Baddeley, 1992). The input from both the verbal and visual parts of working memory can then be processed by the central executive center of the brain (Kawasaki, Kitajo, & Yamaguchi, 2010). This is further substantiated by research utilizing EEG technology has shown the engagement of the executive center in the frontal lobe when people are manipulating both verbal and visual information (Kawasaki et al., 2010). This confirms that when learners are presented both visual and verbal information to process, the executive center coordinates and organizes the information.



Multimedia Instructional Design

The goal of multimedia instructional design is to engage both input systems of the working memory (Mayer, 2014). Multimedia instruction is simply the presentation of both words and images to support student learning of a concept (Mayer, 2011). The instruction gives the learner a visual input with a corresponding verbal input (Mayer, 2014). The information is processed by the two systems of working memory and can then be integrated by the executive center. The result is a complete representation of the concept, which can then be

incorporated into the long-term memory. Utilizing multimedia to simultaneously engage students on both visual and auditory levels, enables learners to build a more complete picture of the concepts and content presented. The successful integration of the information into long-term memory allows the learner to retrieve the information when applicable. Therefore, the learner is more likely to be successful in organizing and later retrieving information when it is presented in both the visual and verbal formats simultaneously.

The active cognitive process that results from multimedia instructional design facilitates "meaningful learning" (Mayer, 2014). Meaningful learning typically refers to a learner-centered approach that allows the learner to build their own significant connections and draw conclusions about their environment (Wightman, 2013). As a result, the learner is more cognitively active in building representations and linking them to previous information (Clark & Mayer, 2011). Therefore, the use of multimedia can enhance the learning process and maximize the impact of a training program.

Research Support for Multimedia Instructional Design Practices

A review of the research on multimedia instructional practices supports the effectiveness of the design strategy with diverse instructional content and populations. For example: early research with college students showed that they recalled and applied more information on bicycle tire pumps when they were presented information on the workings of the pumps through corresponding visual and verbal information (Mayer & Anderson, 1991). The students were shown animated images of the bicycle pump in action with verbal narrations of the animations (Mayer & Anderson, 1991). They were then able to apply their learning to new problems related to pumps (Mayer & Anderson, 1991). The use of both modalities allows learners to build higher-level problem solving abilities through the integration of the images

and sounds. This active learning process maximizes the use of the working memory to improve learning.

In more recent years, multimedia instructional design has been shown to apply to a wide range of instructional topics. Research supports its effectiveness in teaching geometry (Milovanovic, Obradovic, & Milajic, 2013), algebra (Malik, 2011), health science (Ercan, 2014), chemistry (Eskandari & Ebrahimi, 2013), and medical practices (Chang & Hsu, 2010; Genucheten, Hooijdonk, Schuler, & Scheiter, 2014; Yu-Ling & Yu-Hsiu, 2014). In all of these studies the use of images and words together corresponded with improved performance over the use of one instructional modality. The variety of instructional topics among these studies supports the use of multimedia design to enhance learning across training content.

Additionally, multimedia practices have been determined to be effective in working with diverse populations. Research on multimedia instructional design is not limited to the United States. Learners from a diverse pool of cultures and nations have been shown to benefit from multimedia instructional design, compared to single modality designs (Eskandari & Ebrahimi, 2013; Yu-Ling & Yu-Hsu, 2014). Multimedia research also supports the use of the design with various age groups from high school students (Eskandari & Ebrahimi, 2013; Malik, 2011), to college students (Mayer and Anderson, 1992), and beyond (Chang & Hsu, 2010); Yu-Ling & Yu-Hsiu, 2014). This research suggests that multimedia design has a universal effectiveness that can support the learning of diverse groups of individuals.

In addition, there have been multiple studies to explore the use of multimedia instruction with students with diverse learning needs. Students with learning disabilities have been shown to benefit from multimedia instructional design as well (Azimi & Mousavipour, 2014; Magnan, Ecalle, Veuillet, & Collet, 2004; Magnan & Ecalle, 2006). The use of multimedia in learning has offered a more robust technique that can even circumvent challenges that apply to learners differing learning styles, strengths and weaknesses. Some learners may be stronger at processing visual information and others may be stronger at processing auditory information, however, multimedia instructional design builds on both of these strengths within the same lesson. Therefore, regardless of the differences among learners, they are all likely to benefit from a design that successfully integrates multimedia.

Conclusions

The purpose of this paper is to highlight the science behind instruction through the use of multimedia and effective principles of instructional design to incorporate multimedia within the context of learning. This research illustrates the potential impact instructional designers and eLearning developers can have to provide quality learning solutions that make use of the full cognitive capacity of the learner, building meaningful representations and connections through effective multimedia design. The use of both visual and verbal information for instruction allows the learner to build a more comprehensive representation of learning concepts (Mayer, 2014) and enhances the integration of information into existing knowledge.

In combination with substantial evidence indicating the positive impact multimedia has on learner retention, the research also supports the use of multimedia instruction and subsequent learning potential across a wide range of learners from varying demographics. Multimedia design practices ensure that instruction is based not only on a solid understanding of how people learn, but also on sound research (Clark & Mayer, 2011). The research presented showed a universal benefit in utilizing multimedia design with diverse populations of learners and various topics of instruction. In general, learners recall and are able to apply more information when it is presented through corresponding verbal and visual inputs, compared to one-modality designs. Therefore, to support the ultimate goal of maximizing learning outcomes, both the human memory system and research identifying the impact of corresponding visual and verbal information, point to the use of multimedia as a vital tool in instructional design.

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