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Multimedia Influence on Learning

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ABSTRACT

This paper draws on past research to identify factors that might affect the efficacy of computer-based multimedia as a learning tool. These factors are incorporated into the cognitive theory of multimedia learning to develop an extended theoretical framework. The factors include: first: the match of information and channel. The nature of the information determines the best sensory channel; Second: multimedia will be effective only if it is properly designed. Design guidelines that reduce cognitive load as well as graphic design issues should be taken into consideration. Third: learners with high spatial abilities get the most out of multimedia presentations. Instructors need to foster spatial skills in their students so they will be able to take a greater advantage of multimedia presentations.

INTRODUCTION

Multimedia has been defined in different ways. Mayer (2001) classifies multimedia definitions depending on the factors stressed in each definition. The first definition emphasizes the concurrent use of multiple communication media (Mayer, 2001). Communication media can be speakers, video recorders, and so on. Some authors underline that true multimedia has to be computer-based (Gaytan & Slate, 2003; Hofstetter, 1993). The second definition focuses on how material is presented (Mayer, 2001). Multimedia refers, therefore, to the concurrent use of different material presentations. Presentations can be either verbal (written text or audio) or pictorial (animation pictures. The third definition stresses the sensory channels people use to acquire information (Mayer, 2001). Multimedia refers, in this definition, to the concurrent use of different sensory channels.

Each definition has an underlying theoretical perspective that defines how multimedia research should be conducted. Definitions stressing the use of multiple physical media is a technology-centered approach (Mayer, 2001). Research based on this approach seeks to determine the effect of a particular technology on learning outcomes. Findings from studies comparing different delivery media show conflicting results (Clark, 1994; Mayer, 2001). Research using this approach is not productive from the theoretical, conceptual and methodological point of view (Clark, 1994; Mayer, 2001).

The second (material presentation) and third (sensory channel) definitions are learner-centered approaches based on theories of how people learn (Mayer, 2001). Research based on this approach seeks to identify how multimedia can enhance people's cognitive capabilities (Mayer, 2001). These learner-centered approaches were reconciled under the Cognitive Theory of Multimedia Learning (CTML) developed by Mayer (2001). In this paper we use Mayer's definition of multimedia and its underlying cognitive theory. According to Mayer (2001) multimedia is "the presentation of material using both words and pictures" (p. 2).

The CTML is used as the base theoretical framework because it explains how humans process material presented in different forms. As mentioned above, debating on whether the use of multimedia per se enhances learning outcomes is as useless as debating on whether the use of books enhances learning outcomes. It is evident that the usefulness of books as support materials depends on several factors. How do students process the material? Does the book language match students' language skills? Is the scope of the book adequate to the task? Do students have the required background to understand the book? Is the material appealing? Similarly, the factors affecting the efficacy of computer-based multimedia, as a learning tool, must be assessed. Multimedia has the potential to enhance people's cognitive capabilities (Mayer, 2001). Understanding these factors will maximize the probability of success when using multimedia. In short, this paper draws on past research to identify the factors that might affect the efficacy of computer-based multimedia as a learning tool. These factors are incorporated into the CTML to develop an extended theoretical framework.

LITERATURE REVIEW

The objective of multimedia research for educational purposes is to determine the factors that enhance the information cognitive processing. The final goal is to improve learning outcomes (Mayer, 2001). Learning can be assessed by how much students recall the information presented (remembering) and by how much students can apply the information acquired to novel situations (Mayer, 2001).

The cognitive theory of multimedia learning explains how people learn from two material presentations: words and pictures. Words can be delivered through speech or through printed text. Pictures can be still or dynamic images (animation). The CTML is based on three premises, (1) dual channels for processing visual and auditory information, (2) limited capacity to process information in each channel, (3) and the learners' active processing of information. The dual-code premise states that humans have two information processing systems that can be used simultaneously (Paivio, 1986). The verbal (words) and the visual (pictures) channels can complement each other but are qualitatively different (Paivio, 1986). Since the two channels are not equivalent, it is important to identify the match between the delivery channel and the material (Andres, 2004; Mayer, 2001). Therefore, the material-channel match is a variable affecting learning outcomes.

The nature of the information determines which representation is best. The verbal channel might be appropriate for abstract information that needs to be presented in discrete units in a linear sequence (Mayer, 2001). On the other hand, the visual channel can be used to present holistic non-linear representations of material close to our sensory experience, such as simulation or illustration of phenomena behavior (Andres, 2004; Browell, 1996; Mayer, 2001; Mousavi, Low, & Sweller, 1995). A study by Zhang (2000) testing the use of multimedia when searching for information found deteriorated students' performance (Zhang, 2000). When students need to focus their attention on abstract information the use of pictures or animation creates an external stimulus competing for cognitive resources (Mayer, 2001). In this case, pictures or animation distract students rather than help them (Mayer, 2001; Rieh, 2002). Another factor affecting the material-channel match is the required pace of exposure. Pace of exposure refers to the control that a person has over the speed of material presentation. Written information is self-paced, as opposed to audio and video, which are forced-paced. Pace of exposure is particularly important when considering the complexity of a message. People have less opportunity to process complex messages when pace of exposure is forced (Petty & Cacioppo, 1986).

A second factor influencing multimedia effectiveness is the layout design (Mayer, 2001). Based on extensive research, Mayer (2001) identified five principles to develop effective multimedia presentations. The spatial contiguity principle states that pictures and their related words must be placed nearby. The temporal contiguity principle states

that words and pictures must be presented simultaneously. The coherence principle indicates that extraneous materials should be avoided. The modality principle indicates that for animation it is better to use audio rather than written text. The redundancy principle indicates that when using animation and audio, additional text should not be included.

These principles explain how information representation must be presented. However, they do not address the influence of graphic design issues on learning outcomes. For instance, is a color picture better than a black and white picture? Does the tone of the voice matter? Studies on persuasion show that the perceived attractiveness of the message has an impact on the persuasive effect of the communication (Chaiken, 1987; Pallak, 1983; Slater & Rouner, 1996; Williams & Tollett, 2000). Attractiveness refers to the perceived pleasantness of the layout. The perceived attractiveness applies to images and sounds presented. For instance, presenting a picture of a communicator enhances persuasion only when the communicator is perceived as attractive (Eagly & Chaiken, 1984). For written information, characteristics such as organization, balance (Slater & Rouner, 1996) and colors influence the perceived attractiveness of a message (Williams & Tollett, 2000). Similarly, including audio might be effective only if the sound or voice is pleasant. Speech could be pleasant with appropriate vocal intonations; otherwise it can be dull or annoying. Also, the tone of voice and speed of speech influence the perceived attractiveness of a message (Chaiken, 1987). Therefore, the attractiveness of the message is a third factor influencing multimedia outcomes.

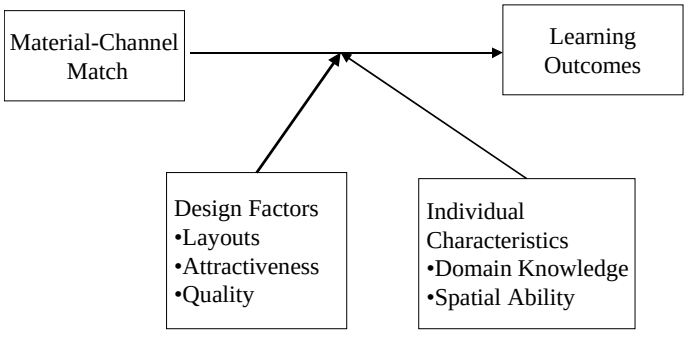
Attractiveness needs to be discussed also in terms of the cognitive process. Due to the limited processing capabilities of the human brain, learners must select the relevant words and images to be processed. That is, the images and words processed on the working memory are already filtered. Therefore, the audio and pictures must be pleasant enough not to annoy, disturb or bore the learner. However, it can be speculated that the attractiveness should not be overdone because the most important feature is to present learners with relevant information to construct knowledge and not to distract them. Do images need to be a fully animated video with real colors? Or can a simple drawing be enough? Probably, for visual aids that do not need to show the real texture or colors to be understood a simple but relevant picture will suffice. It is possible that attractiveness has a threshold level. Above that level, any increase in attractiveness might not have an effect on learning outcomes. Another possibility is that a very attractive picture might get too much attention from learners distracting them from the main objective. All in all, the effects of attractiveness on multimedia learning needs to be further explored.

A fourth factor influencing learning outcomes is quality. Quality refers to the physical specifications of the information displayed. For instance, the quality of graphic information is usually stated in terms of its resolution and number of colors used. The higher the resolution and the number of colors displayed the higher the quality. Quality has an impact on the persuasive effect of the communication. For instance, presenting a high quality color photograph of a communicator has a more persuasive impact than a photocopy of the same photograph (Pallak, 1983). However, the quality of audio and images on the Web is constrained by the technical limitations of computers and the Internet. For instance, the final quality of an image that users see on their screens depends on both the quality of the source image (i.e., the bit depth of the image) and the resolutions of the users' monitors. In addition, quality affects download speeds; the higher the quality, the larger the amount of information that must be transmitted and the slower the download speed.

It is important to note that even though quality and attractiveness might be related they are different concepts. Quality refers to the physical condition of transmitted information and is measured objectively; while attractiveness is a perceived attribute of the information and each individual assesses it subjectively. It could be thought that the higher the quality, the higher the attractiveness, but this is not always the case. A black and white picture (low quality) might be perceived as more attractive than a color picture. An otherwise unattractive image might be of high quality.

Finally, individual characteristics influence learning outcomes. Empirical findings suggest that domain-specific knowledge and spatial ability affects learning outcomes (Mayer, 2001). Learners with a low level previous knowledge about the presentation benefit more from a well-designed multimedia presentation than do learners with high level of previous knowledge (Mayer, 2001). In terms of spatial ability, learners with high spatial ability benefit more from a well-designed multimedia presentation as compared to learners with low spatial ability (Mayer, 2001).

Figure 1 Extended multimedia learning model



EXTENDED MODEL

Based on previous research, the CTML can be extended to include the factors that might have an effect on learning outcomes when using computer-based multimedia. Figure 1 shows the relationship among the variables.A multimedia presentation that matches the information nature with the sensory channel will increase the learning outcomes. For instance, complex information that requires self-pace of exposure is not suited for animation. Using animation will not only waste useful resources but it might even hinder the learning process. An arrow between material-channel match and learning outcomes shows this direct relationship. However, a good match is not enough; the impact on learning outcomes is moderated by two main factors. Design factors and individual characteristics. Design factors refer to the appropriate layout, the attractiveness, and the quality of the material. The layout should minimize information processing load. A good design helps learners to construct knowledge. In terms of attractiveness, the material should be attractive to capture learners' attention. However, the final effect of attractiveness needs to be empirically tested. It might be possible that attractiveness might diminish students' learning by adding irrelevant information. In terms of quality, a person using computer-based multimedia must be aware of the relationship between quality and download time. The highest quality might not necessarily mean a better design. Finally, the relationship between material-channel match and learning outcomes is also moderated by individual characteristics. Learners' previous knowledge on the domain and spatial ability are the two factors supported by empirical evidence.

CONCLUSIONS AND FUTURE RESEARCH

As with any other learning resource, the adequacy of multimedia should be assessed. This assessment should include pedagogical and managerial concerns (Browell, 1996; Gaytan & Slate, 2003). Multimedia must be used for a specific pedagogical purpose. Issues such as learning objectives and modification of the learning process must be addressed before hand. The managerial assessment should include a cost-benefit analysis in terms of the resources needed (money, time, staff) and intended outcomes. Using multimedia for the sake of it, without a clear objective, wastes valuable resources. Previous research shows conflicting results on the outcomes of multimedia use as a learning tool. It is clear that

multimedia can be an effective learning tool depending on how it is used. Multimedia per se does not ensure improved students' performance and satisfaction. The proper use of multimedia should be assessed to increase the probabilities of an effective use. This presentation has aimed to provide guidance on the factors affecting computer-based multimedia learning. First, instructors must be aware that the match of information and channel is critical for multimedia success. Some material is suitable for multimedia and some is not. Second, multimedia will be effective only if it is properly designed. Third, learners with high spatial abilities get the most out of multimedia presentations. Instructors might need to foster spatial skills in their students so they will be able to take a greater advantage of multimedia presentations.

Based on the cognitive theory of multimedia learning, this model was designed to explore the impact of computer-based multimedia on learning outcomes. The model was built based on findings from previous empirical and theoretical research. However, the extended model has not been empirically tested.

The use of multimedia for purposes other than learning is outside of the scope of this model. The purpose of multimedia for educational purposes is to enhance a learner's cognitive skills. However, multimedia can also be used for marketing purposes. In that case, the main goal might be to capture peoples' attention.

Finally the cognitive theory of multimedia learning explains how verbal and visual information is processed. Currently, computers can display text (as written information), audio (as radio) and video (as TV). In the future, it is expected that the number of sensory capabilities that a computer will be able to handle will be extended to include, for instance, scent (Fox, 2000). The cognitive theory of multimedia learning should be then revised to incorporate the processing from information coming from other sensory channels.

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