Multimedia Learning: Empirical Results and Practical Applications

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ABSTRACT: *Web-based multimedia represents the presentation of instruction that involves more than one delivery media, presentation mode, and/or sensory modality. The basis for the use of multimedia is the assumption that when the user interacts within these various methods they learn more meaningfully. Recently, there has been an increase in the amount of multimedia research that is grounded in cognitive psychology. This research has begun to identify various design principles that are both theoretically grounded and educationally applicable. This session is designed to examine and provide examples of principles of effective multimedia design that are grounded in cognitive psychology.*

Defining Multimedia:

Multimedia may be defined in multiple way, depending upon one's perspective. Typical definitions include the following:

- Multimedia is the "use of multiple forms of media in a presentation" (Schwartz & Beichner, 1999, p. 8).
- Multimedia is the "combined use of several media, such as movies, slides, music, and lighting, especially for the purpose of education or entertainment" (Brooks, 1997, p. 17).
- Multimedia is "information in the form of graphics, audio, video, or movies. A multimedia document contains a media element other than plain text" (Greenlaw & Hepp, 1999, p. 44).
- Multimedia comprises a computer program that includes "text along with at least one of the following: audio or sophisticated sound, music, video, photographs, 3-D graphics, animation, or high-resolution graphics" (Maddux, Johnson, & Willis, 2001, p. 253).

The commonality among these definitions "involves the integration of more than one medium into some form of communication….Most commonly, though, this term now refers to the integration of media such as text, sound, graphics, animation, video, imaging, and spatial modeling into a computer system (von Wodtke, 1993)" (Jonassen, 2000, p. 207).

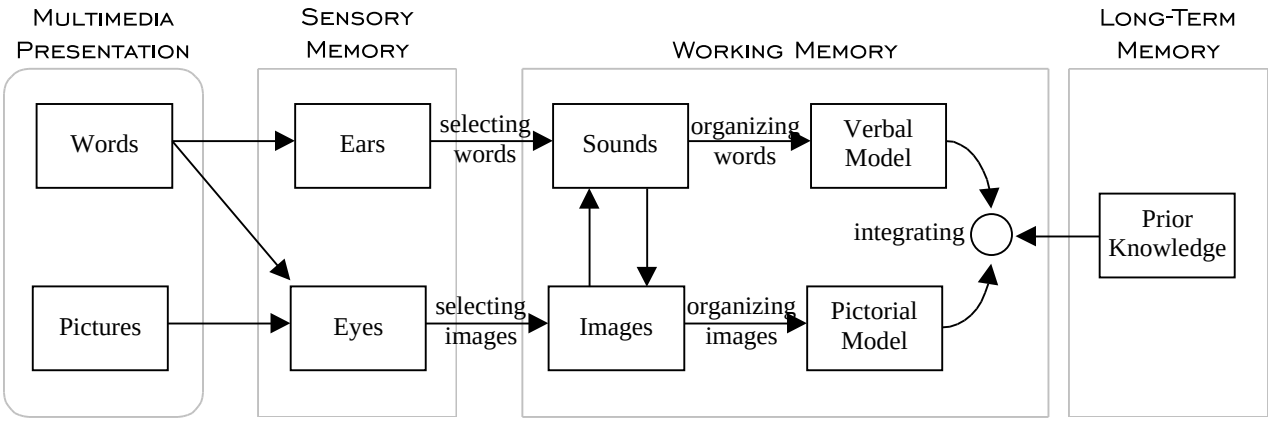
A Multimedia Framework:

Investigating the effects of multimedia on learning and performance requires a solid foundation in learning theory. A theoretically-grounded investigation of multimedia allows one to draw conclusions relative to the learner, rather than attempting the slippery slope of a media comparison (see Clark, 1994; Lockee, Burton, & Cross, 1999). Bishop and Cates (2001) effectively synthesize information processing theory and communication theory as a foundation for the investigation of the use of sound in multimedia instruction. Another example of multimedia investigations that are grounded in cognitive theory includes the work of Richard Mayer (see Mayer, 1997, 1999; Mayer & Anderson, 1991, 1992; Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Mayer & Gallini, 1990; Mayer & Heiser, & Lonn, 2001; Mayer & Moreno, 1998; Mayer, Moreno, Boire, & Vagge, 19999; Mayer, & Sims, 1994; Moreno & Mayer, 1999; Moreno, & Mayer, 2000; Moreno & Mayer 2001).

Mayer has based the majority of his multimedia work on an integration of Sweller's *cognitive load theory* (Chandler & Sweller, 1991; Sweller, 1999), Pavio's *dual-coding theory* (Clark & Paivio, 1991; Paivio, 1986), and Baddeley's *working memory model* (1986, 1992, 1999). Mayer focuses on the auditory/verbal channel and visual pictorial channel, stating,

> I define multimedia as the presentation of material using both words and pictures….thus the definition of multimedia I use…is narrower than some other definitions….I have opted to limited the definition to just two forms – verbal and pictorial – because the research base in cognitive psychology is most relevant to this distinction."

Mayer bases his *cognitive theory of multimedia learning* on the following model.



This model is based upon three primary assumptions (Mayer, 2001):

1. Visual and auditory experiences/information are processed through separate and distinct information processing "channels."
2. Each information processing channel is limited in its ability to process experience/information.
3. Processing experience/information in channels is an active cognitive process designed to construct coherent mental representations.

Further, this model is activated through five steps: "(a) selecting relevant words for processing in verbal working memory, (b) selecting relevant images for processing in visual working memory, (c) organization selected words into a verbal mental model, (d) organizing selected images into a visual mental model, and (e) integrating verbal and visual representations as well as prior knowledge" (Mayer, 2001, p. 54).

Empirical Multimedia Results and Applications

Mayer and his colleagues have conducted a decade's worth of research investigating the nature and effects of multimedia presentations on human learning. These effects are summarized below with relative practical applications.

Empirical Results	Practical Applications
Multimedia Principle: Students learn better from words and pictures than from words alone.	On screen animation, slide shows, and narratives should involve both written or oral text and still or moving pictures. Simple blocks of text or auditory only links are less effect than when this text or narration is coupled with visual images. (Sample example)
Spatial Contiguity Principle: Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.	When presenting coupled text and images, the text should be close to or embedded within the images. Placing text under an image (i.e., a caption) is sufficient, but placing the text within the image is more effective. (Sample example)
Temporal Contiguity Principle: Students learn better when corresponding words and pictures are presented simultaneously rather than successively.	When presenting coupled text and images, the text and images should be presented simultaneously. When animation and narration are both used, the animation and narration should coincide meaningfully. (Sample example)

Coherence Principle: Students learn better when extraneous words, pictures, and sounds are excluded rather than included.	Multimedia presentations should focus on clear and concise presentations. Presentations that add "bells and whistles" or extraneous information (e.g. to increase interest) impede student learning. (Sample example).
Modality Principle: Students learn better from animation and narration than from animation and on-screen text.	Multimedia presentations involving both words and pictures should be created using auditory or spoken words, rather than written text to accompany the pictures. (Sample example)
Redundancy Principle: Student learn better from animation and narration than from animation, narration, and on-screen text.	Multimedia presentations involving both words and pictures should present text either in written form, or in auditory form, but not in both. (Sample example)
Individual Differences Principles: Design effects are stronger for low-knowledge learners than for high-knowledge learns and for high spatial learners rather than from low spatial learners.	The aforementioned strategies are most effective for novices (e.g., low-knowledge learners) and visual learners (e.g., high-spatial learners). Well structured multimedia presentations should be created for they are most likely to help.

Conclusion

Multimedia and its effects on learning are slowly being teased out. This teasing, or investigation, is best endeavored from a well-grounded foundation, such as cognitive psychology. The work of Mayer, and others, provides an example of well-grounded multimedia research that is yielding interesting and robust findings.

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