

Understanding the Cognitive Theory of Multimedia Learning

*Dr.S.Mercy Gnana Gandhi

Sathyabama University

Corresponding author: Dr.S.Mercy Gnana Gandhi

ABSTRACT

A cognitive theory of multimedia learning details the human information processing system that includes dual channels for visual/pictorial and auditory/verbal processing. Each channel has limited capacity for processing. Such active learning entails carrying out a coordinated set of cognitive processes during learning. Processing of pictures occurs mainly in the visual/pictorial channel and processing of spoken words occurs mainly in the auditory/verbal channel. But processing of printed words takes place initially in the visual/pictorial channel and then moves to the auditory/verbal channel. The present paper clearly discusses the five steps in multimedia learning which are selecting relevant words from the presented text or narration, selecting relevant images from the presented illustrations, organizing the selected words into a coherent verbal representation, organizing selected images into a coherent visual representation and integrating the visual and verbal representations and prior knowledge.

Keywords: Learning, Multimedia, Cognitive theory, Representation, Processing

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I. THREE ASSUMPTIONS OF A COGNITIVE THEORY OF MULTIMEDIA LEARNING

Paivio, 1986; Baddeley, 1992 assumed that humans possess separate channel for processing visual and auditory information thus have dual channels. Baddeley, 1992; Chandler & Sweller, 1991 stated that humans are limited in the amount of information that they can process in each channel at one time and thus have limited capacity to do anything. Mayer, 1999c and Wittrock, 1989 of the view that humans engage in active learning by attending to relevant incoming information, organizing selected information into coherent mental representations, and integrating mental representations with other knowledge and thus they can process anything actively.

II. THREE PROCESSES FOR ACTIVE LEARNING

Selecting: In this process, the learner pays attention to relevant words and pictures in a multimedia message to create a word base and an image base. Eg: In viewing a narrated animation on lightning formation, learner pays attention to words and pictures describing each of the main steps.

Organizing: Here the learner builds internal connections among selected words to create a coherent verbal model and among pictures to create a coherent pictorial model. Eg: Learner organizes the

steps into a cause-and-effect chain for the words and for the pictures.

Integrating: Learner builds external connections between the verbal and pictorial models and with prior knowledge. Eg: Learner makes connections between corresponding steps in the verbal chain in the pictorial chain and justifies the steps on the basis of knowledge of electricity.

III. FIVE STEPS IN A COGNITIVE THEORY OF MULTIMEDIA LEARNING

Building on the three assumptions described earlier, a multimedia environment has been presented in more than one format, such as in words and pictures. For meaningful learning to occur in a multimedia environment the learner must engage in five cognitive processes: (1) selecting relevant words for processing in verbal working memory (2) selecting relevant images for processing in visual working memory (3) organizing selected words into a verbal mental model (4) organizing selected images into a visual mental model and (5) integrating verbal and visual representations as well as prior knowledge. Although these processes are presented as a list, they do not necessarily occur in linear order, so a learner might move from process to process in many different ways. Successful multimedia learning requires learner coordination and monitoring of these five processes.

IV. SELECTING RELEVANT WORDS

The first step involves a change in *knowledge representation* from a sensory representation of spoken sounds entering the ears to an internal representation of word sounds in working memory. The input for this step is a spoken verbal message that is received in the learner's ears. The output for this step is a word sound base - a mental representation in the learner's verbal working memory of selected words or phrases. The cognitive process mediating this change is called *selecting relevant words* and involves paying attention to some of the words that are presented in the multimedia message. The need for selecting only part of the presented message occurs because of capacity limitations in each channel of the cognitive system. If the capacity was unlimited, there would be no need to focus attention on only part of the verbal message. Finally, the selection of words is not arbitrary; the learner must determine which words are most relevant - an activity that is consistent with the view of the learner as an active sense maker.

V. SELECTING RELEVANT IMAGES

The second step involves a change in *knowledge representation* from a sensory representation from a sensory representation of unanalyzed visual stimulation entering the eyes to an internal representation of visual images in working memory. The input for this step is a pictorial portion of a multimedia message that is held briefly in visual sensory memory. The output for this step is a visual image base - a mental representation in the learner's working memory of selected images. The cognitive process underlying this change is called selecting relevant images and involves paying attention to part of the animation or illustrations presented in the multimedia message. This process begins in the visual channel, but it is possible to convert part of it to the auditory channel. It is not possible to process all parts of a complex illustration or animation segment, so learners must focus on only part of the incoming pictorial material. Finally, the selection process for images - like the selection process for words - is not arbitrary because the learner must judge which images are most relevant for making sense of the multimedia presentation.

VI. ORGANIZING SELECTED WORDS

Once the learner has formed a word sound base from the incoming words of a segment of the multimedia message, the next step is to organize the words into a coherent representation - a knowledge structure that is called a *verbal model*. The input for this step is the word sound base - the words and phrases selected from the incoming verbal message - and the output for this step is a verbal model - a coherent (or structured) representation in the

learner's working memory of the selected words or phrases. The cognitive process involved in this change is *organizing selected words*, in which the learner builds connections among pieces of verbal knowledge. It is represented by the arrow from Sounds to Verbal Model. This process is most likely to occur in the auditory channel and is subject to the same capacity limitations that affect the selection process. Learners do not have unlimited capacity to build all possible connections, so they must focus on building a simple structure. The organizing process is not arbitrary but rather reflects an effort at sense making - such as the construction of a cause - and - effect chain.

VII. ORGANIZING SELECTED IMAGES

The process for organizing images parallels that for selecting words. Once the learner has formed an image base from the incoming pictures of a segment of the multimedia message, the next step is to organize the images into a coherent representation - a knowledge structure that is called a *pictorial model*. This change from images to a pictorial model requires the application of a cognitive process that is called *organizing selected images*. In this process, the learner builds connections among pieces of pictorial knowledge. This process occurs in the visual channel, which is subject to the same capacity limitations that affect the selection process. Learners lack the capacity to build all possible connections among images in their image base and rather must focus on building a simple set of connections.

VIII. INTEGRATING WORD-BASED AND IMAGE-BASED REPRESENTATIONS

The most crucial step in multimedia learning involves making connections between word-based and image-based representations. This step involves a change from having two separate representations - a visual model and a verbal model - to having an integrated representation in which corresponding elements and relations from one model are mapped onto the other. The input for this step is the visual model and the verbal model that the learner has constructed so far, and the output is an integrated model, which is based on connecting the two representations. In addition, the integrated model includes connections with prior knowledge.

IX. INTEGRATING PROCESS

It involves building connections between corresponding portions of the pictorial and verbal models as well as relevant existing knowledge from long term memory. This process occurs in visual and verbal working memory and involves the coordination between them. It is represented from **Long-Term Memory** by the arrows from the Verbal model and the Pictorial Model as well as the arrow.

This is an extremely demanding process that requires the efficient use of cognitive capacity. The process reflects the epitome of sense making because the learner must focus on the underlying structure of the visual and verbal representations. The learner can use prior knowledge to help coordinate the integration process.

X. LONG-TERM MEMORY TO WORKING MEMORY.

Each of the five steps in multimedia learning is likely to occur many times throughout a multimedia presentation. The steps are applied segment by segment, not to the entire message as a whole. For example, in processing the lightning lesson, learners do not first select all relevant words and images from the entire passage, then organize them into verbal and visual models of the entire passage, and then connect the completed models with one another at the very end. Rather, learners carry out this procedure on small segments: They select relevant words and images from the first sentence of the narration and the first few seconds of the animation; they organize and integrate them; and then this set of processes is repeated for the next segment, and so on.

XI. SERIOUS LIMITATIONS

In short, multimedia learning takes place within the learner's information processing system - a system with serious limitations on the capacity of each channel, and a system that requires coordinated cognitive processing in each channel for active learning to occur. In particular, multimedia learning is a demanding process that requires selecting relevant words and images, organizing them into coherent verbal and pictorial representations, and integrating the verbal and pictorial representations. The theme of this paper is that multimedia

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messages should be designed to facilitate multimedia learning processes. Multimedia messages that are designed in light of how the human mind works are more likely to lead to meaningful learning than those that are not.

XII. PROCESSING OF PRINTED WORDS

So far, cognitive processing of pictures takes place mainly in the bottom channel of that is, in the visual / pictorial channel - whereas the cognitive processing of spoken words takes place mainly in the top channel - that is, in the auditory / verbal channel. Once the words are represented in the auditory / verbal channel, they are processed like the spoken words. When verbal material enters through the visual channel, the words must take a complex route through the visual channel. The words must take a complex route through the system and must also compete for attention with the illustration.

XIII. CONCLUSION

The theme of this paper is that the design of multimedia messages for a classroom teaching should be based on a satisfactory theory of how people learn and in particular, on a cognitive theory of multimedia learning. A cognitive theory of multimedia learning based on three well-established ideas in cognitive science have been discussed - what we call the dual-channel, limited-capacity, and active processing assumptions. The author shows how multimedia learning occurs when the learner engages in five kinds of processing - selecting words, selecting images, organizing words, organizing images, and integrating. Thus, we understand how pictures, spoken words, and printed words are processed according to the cognitive theory of multimedia learning.

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