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Chapter XVI

Cognition Research Basis for Intructional Multimedia

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INTRODUCTION

The work described in this chapter is a synthesis of recent instructional cognition research implications for fundamental educational multimedia theory. Most of the research described here has been conducted in the Cognitive Load Theory context. The leading research group in this area is located at the University of New South Wales, in Sydney, Australia, and a complementary cognition research program is based at the Open University of Netherlands. The work emanating from these groups and allied efforts elsewhere has significant implications for multimedia use in various educational contexts.

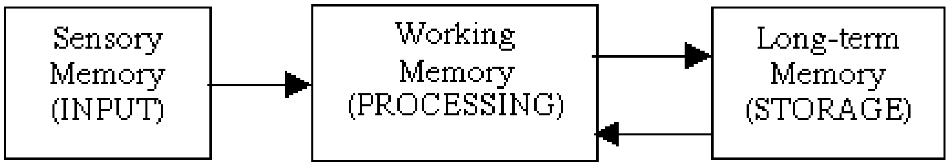
In this chapter the structure of human cognitive architecture will be described from an information processing perspective. Then the cognitive load theory will be introduced. The implications of multimodal experiments for multimedia instruction will be derived in the cognitive load theory context. The interaction of multimodal instruction and material complexity or element interactivity plus prior knowledge will be considered. Then the research on the instructional effects of moving images and sound will be discussed from a cognitive perspective. Methods for alleviating the visual search on complex multimedia screens employing focusing or linking strategies will be described. Guidelines for the effective design and use of educational multimedia in a global context will be noted in each section. Finally general issues of future research interest will be discussed.

The objectives of this chapter are to suggest a theoretical foundation for multimodal multimedia instruction, and to distil from the relevant cognition research a number of practical implications for educational multimedia planning, design and use.

COGNITIVE ARCHITECTURE

The research discussed in this chapter views the human mind as an information processing system. The architecture of the human mind is thought to consist of three basic components: sensory memory, working memory and long-term memory (Atkinson & Shiffrin, 1968), which roughly correspond to the input, processing and storage component stages of computers. This view has provided a useful basis for developing theories with significant learning and teaching implications.

Figure 1. Three component model of the human information processing system



The human mind receives information from the outside world through the senses (input stage) which are decoded in the sensory memory. The information from the sensory memory is then processed in the working memory (processing stage) and stored in the long-term memory (storage). Of course the previous information stored in the long-term memory can also be accessed, or activated, to help deal with the processing in working memory (Logie, 1996). The processing in the working memory is what we commonly call conscious thought (Baddeley, 1993).

One of the most interesting and significant aspects of the human mind is the very small capacity of the working memory. In 1956 G. A. Miller coined the famous term, "the magical number seven plus or minus two" to describe the number of distinct items he thought humans could hold in the working memory at any time (Miller, 1956). Since then the exact number of items has been shown to depend on a number of factors, ranging from age, health, level of fatigue, the type of item, familiarity with the content, training, etc. (Baddeley, 1994; Shiffrin & Nosofsky, 1994; Stoltzfus, Hasher & Zacks, 1996). However, without doubt the capacity of the working memory to deal with distinct items is quite limited, whereas the capacity of the long-term memory is very large; in fact, no clear boundary has been established for it (Simon & Gilmartin, 1973).

There are two main mental mechanisms that help to overcome the working memory limitations. They are schema formation (Chi, Glaser & Rees, 1982) and automation (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). If the items of information are grouped together in a meaningful way, e.g., 29011981 vs. 29.01.1981 (my daughter's birthday in the Australian dd.mm.yyyy format), they become easier to remember and use as one item, called a chunk (Chase & Simon, 1973; Miller, 1956; Zhang & Simon, 1985). Instead of eight separate items, they can be treated as a single entity by working memory.

The second mechanism is automation, i.e., processing that is so familiar that one does not have to think about the components of the processing consciously. This is the type of processing fluent readers use when reading text, where they do not try to make out individual letters, but process larger groups, words or groups of words, without attending to individual letters or even words separately. As one develops better schemas and automation, one gains expertise in a given field. Then one is able to select and use more elaborate schemas and automated processes to avoid the bottleneck of processing in the working memory, with too many individual separate items of information leading to confusion and poor processing due to a mental overload.

COGNITIVE LOAD THEORY

A major theory of learning and problem-solving, called the Cognitive Load Theory, is based on the above view of the mind (Sweller, 1988; 1999; Sweller, van Merriënboer & Paas, 1998). A number of significant advances in learning have been developed in this

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