Chapter III
Measurement of Cognitive Load During Multimedia Learning Activities

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ABSTRACT

This chapter focuses on issues dealing with the definition and measurement of cognitive load in multimedia and other complex learning activities. The chapter is broken into 3 main sections: defining multimedia learning and describing its effects on cognitive load; describing theoretical definitions of cognitive load; and mapping definitions of cognitive load onto commonly used measurement techniques. The chapter concludes with a discussion of how research on multimedia learning and cognitive load could be advanced by carefully considering issues of construct validity, and by including the use of convergent measurement techniques.

INTRODUCTION

Over the last thirty years, there has been considerable interest in the areas of cognition and instruction (Ayres, 2006; Brunken, Plass, & Leutner, 2003; Sweller & Chandler, 1991, 1994; van Merrriënboer & Sweller, 2005). Specifically, researchers are interested in understanding learners' mental processes, as well as the instructional procedures and designs that best facilitate those processes, especially when learning involves multimedia, where information is processed through multiple sensory channels (Mayer & Moreno, 2003; Michas & Berry, 2000; Moreno & Mayer, 1999). One of the most studied topics in this domain has been cognitive load and modality in learning (Mayer, 2001; Mayer & Moreno, 2003; Sweller & Chandler, 1991). Based on the assumptions of working memory theory (Baddeley, 1986, 1999), the concept of cognitive load refers to learners' ability to process information given the current demands placed on working memory. As learning tasks become more complex, they demand more working memory resources, thereby increasing cognitive load. When the demand for working memory resources exceeds availability, cognitive "overload" occurs, and individuals' ability to learn and process information decreases.

Although there is a plethora of evidence concerning the effects of cognitive load on learning from multimedia and ways to effectively reduce cognitive load (Mayer, 2001; Mayer & Moreno, 2003), the central question pertaining to the study of cognitive load still remains unanswered: When, how, and at what level do we know the learner is cognitively overloaded? In other words, how do we define cognitive load, and how do we measure it, particularly in multimedia learning tasks? This chapter discusses: (1) multimedia learning and its cognitive consequences with regard to learners' information processes; (2) definitions of cognitive load; and (3) approaches to measuring cognitive load in multimedia and complex learning environments.

MULTIMEDIA LEARNING

What is Multimedia Learning?

Multimedia instruction involves presenting educational content through multiple media, primarily through visual and auditory presentations. Mayer (2001) proposed a theory of multimedia learning which relies on three major assumptions drawn from theories in cognitive psychology. First, working memory involves two distinct systems for encoding and processing visual and auditory information (Baddeley, 1986, 1999; Paivio, 1986). Second, the processing resources devoted to each of these channels are limited, such that when demand exceeds availability, cognitive "overload" can occur (Baddeley, 1986, 1999). Third, meaningful learning occurs when individuals actively and simultaneously process information from the visual and auditory channels, and attempt to select, organize, and integrate that information in conjunction with existing mental schemas (Anderson, 1996; Kozma, 1991; Mayer & Sims, 1994; Michas & Berry, 2000; Wittrock, 1989). Because well-designed multimedia presentations organize and integrate visual and auditory information, learners are able to devote more resources to mapping this incoming information onto content retrieved from long-term memory.

A number of studies on multimedia learning have demonstrated that the appropriate use of multimedia presentations can result in the reduction of cognitive load (e.g., Mayer & Anderson, 1991, 1992; Mayer & Moreno, 2003; Mayer, Moreno, Boire, & Vagge, 1999; Mayer & Sims, 1994). For example, Tarmizi and Sweller (1988) found that when learners were required to mentally integrate two sources of information (diagrams and texts) from worked geometry examples, cognitive resources were overloaded due to learners having to split their attention between the two sources of information. However, Chandler & Sweller (1991) found that when diagrams were embedded with text (i.e., the diagram and text were integrated), learning increased. Although cognitive benefits of multimedia learning have been recognized by researchers across a wide spectrum of disciplines (see Kozma, 1994; Lee, Plass, & Homer, 2006; Mayer & Moreno, 2003), there is a concurred view among researchers that multimedia may also impede learning and increase cognitive load if not appropriately designed.

The issue of how to appropriately measure multimedia effects on cognitive load is complex,

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