Chapter 10
Using Concept Maps to Enhance Students' Prior Knowledge in Complex Learning

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ABSTRACT

As an instructional tool, concept map has been widely used to teach complex subjects in schools. Research suggests that concept mapping can help bridge learners' prior knowledge with new learning, reduce the cognitive load involved in learning and improve comprehension, content retention, and knowledge transfer. Existing literature focuses on cognitive features, cognitive styles and differences between instructor provided and student generated concepts. However, little is known about the effects of concept maps as a cognitive tool to influence learners' learning, specifically before and after the learning takes place. This chapter offers a discussion of general research in concept mapping and theories that support such instruction. Finally, an empirical study is presented with suggestions for future research in concept mapping.

INTRODUCTION

Like other types of learning, complex learning poses considerable challenges to learners due to its high demands on cognitive resources, prior knowledge and information processing (Grice, 1987; Schwartz & Bransford, 1998; Zheng, McAlack, Wilmes, Kohler-Evans, & Williamson, 2009). For many, prior knowledge activation resonates with meaningful learning (Surber & Schroeder, 2007; Winberg & Hedman, 2008). However, Schwartz and Bransford (1998) pointed out that learning can be "problematic if students do not have the relevant prior knowledge to begin with" (p. 475). Thus, how to effectively develop learners' prior knowledge becomes a focal point for many researchers who explore the issues from the perspectives of cognitive structures (Kinchin, Hay, & Adams, 2000) and memory related instructional pedagogies (Lee, Plass, & Homer, 2006). Par with the prior knowledge research is the focus on cognitive resources in complex learning. Since complex learning requires a high degree of

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element interactivity and there is a limitation to human capacity in dealing simultaneously with multiple elements (Baddeley & Hitch, 1974; Sweller & Chandler, 1991, 1994), it becomes critical that instruction address the issue of how to optimize learners' cognitive resources in complex learning, particularly using modern learning technologies such as multimedia and hypermedia. Recent studies have successfully proved that appropriately designed multimedia instruction can significantly reduce learners' cognitive load, hence enhance their abilities in complex learning (Mayer & Moreno, 2003; Zheng et al., 2009).

Among the efforts to improve learners' abilities in complex learning is the application of concept map which is used as a tool to facilitate prior knowledge construction and activation as well as to optimize cognitive resources for deep learning. For example, Puntambekar and Goldstein (2007) observed learners who applied concept maps to science learning and found that learners who learned with concept maps were able to navigate better through the content and engage in deep learning. In a separate study, Roberts and Joiner (2007) used the concept map as an educational strategy to help a group of autistic students learn science. Results showed that students with concept mapping condition outperformed those without. Despite the fact that concept mapping has displayed proven educational benefits for learners, its use in schools and classrooms does not seem to be widespread (Kinchin, 2001). Kinchin concluded that school ecology (i.e., the existing curricular structure and the underlying philosophy of curriculum) as well as teachers' epistemology may hinder the use of concept map in schools. Existing literature focuses on cognitive features, cognitive styles and differences between instructor provided and student generated concepts (Roberts & Joiner, 2007; Puntambekar & Goldstein, 2007; Shmaefsky, 2007). However, little is known about the effects of concept maps as a cognitive tool to influence learners' learning, specifically before and after the learning takes place. This chapter offers a discussion of general research in concept mapping and theories that support such instruction. The chapter starts with defining the concept map and describing the status of practices and research in concept mapping, followed by a discussion on complex learning and cognitive issues involved in complex learning. Review of cognitive learning theories will be made with emphases on working memory theory (Baddeley, 1986), dual-coding theory (Paivio, 1986) and cognitive load theory (Sweller, 1988). Finally, an empirical study will be presented with discussions and suggestions for future research in concept mapping.

DEFINITION OF CONCEPT MAP

What is a concept map? The answer varies depending on how one looks at the role of concept maps. For some, it is an outline for understanding the content covered/to be covered. For others, it represents a network of knowledge for learning. According to Wikipedia.org (2008), "concept mapping is a technique for visualizing the relationships among different concepts. A concept map is a diagram showing the relationships among concepts" (¶1). Wang and Dywer (2006) defined concept map as "graphic representations of knowledge of a domain. A concept map consists of a set of nodes representing concepts, objects, or actions connected by directional links that define the relationships between and among those nodes" (p. 136). Based on the above definitions, we define the concept map as:

Concept maps are graphical ways of working with ideas and presenting information. They reveal patterns and relationships and help students to clarify their thinking, and to process, organize and prioritize. The visual representation of information through word webs or diagrams enables learners to see how the ideas are connected and understand how to group or organize information effectively.