Chapter 16

Enhancing the Effectiveness of Educational Hypermedia: A Cognitive Load Approach

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ABSTRACT

With advancement in technology, hypermedia learning environments are becoming more common in education. Such environments present the multiple representations of information in a non-linear and non-sequential format, allowing the learners to enhance their retention and transfer of knowledge by selecting and sequencing their learning paths. Research into expert-novice differences has suggested that learner prior knowledge has major implications for learning. This chapter considers the role of learner prior knowledge in enhancing the effectiveness of hypermedia learning from a cognitive load perspective. Cognitive load theory is an instructional theory that investigates instructional means of managing limitations of human cognitive system, primarily processing limitations of working memory. The chapter reviews recent studies of cognitive load theory-generated techniques for learners with different levels of prior knowledge and relevant research in hypermedia learning. The chapter concludes with evidence-based recommendations for enhancing the effectiveness of educational hypermedia.

INTRODUCTION

The fundamental characteristics of human cognitive architecture have profound implications for processing information involved in learning from multimedia (e.g., learning from both words and pictures rather than words alone), hypertext (e.g., learning from online documents in a non-linear format, navigated by hyperlinks), and hypermedia environments (e.g., learning from computer based multimedia in a non-linear format, navigated by hyperlinks). Cognitive load theory (see Sweller, Ayres, & Kalyuga, 2011 for a recent overview) and cognitive theory of multimedia learning (see Mayer, 2014 for a recent

DOI: 10.4018/978-1-5225-0125-1.ch016
overview) place emphasis on the idea that the design of instructional materials should be aligned with human cognition. Considering the similarities in basic assumptions and major instructional principles generated by these cognitive instructional theories, cognitive load theory will be used as a point of reference throughout this chapter.

Many of the instructional methods and techniques developed within the above theories could be implemented in hypermedia learning thus fostering learning or eliminating situations which impede learning. For example, research within a cognitive load theory framework has found that presenting identical information in different mediums and modes can result in different learning outcomes (e.g., Florax & Ploetzner, 2010; Hoogerheide, Loyens, & van Gog, 2014; Schmidt-Weigand, Kohnert, & Glowalla, 2010). Therefore the selected method of presentation may play a fundamental role in the way learners process, integrate and understand information. For instance, under some conditions, the cognitive processes involved in listening to a spoken text rather than reading an identical written text may overload learner cognitive system, thus making it an ineffective way to present information (e.g., Singh, Marcus & Ayres, 2012). In order to describe cognitive processes involved in such instructional situations, the next section introduces the major characteristics and processing limitations of human cognitive architecture. It will be followed by the principles of cognitive load theory relevant to hypermedia learning environments, reviews of recent studies of cognitive load theory-generated techniques and relevant previous research in hypermedia learning. The chapter will conclude with evidence-based recommendations for enhancing the effectiveness of educational hypermedia.

BACKGROUND

Understanding human cognitive architecture is essential to cognitive load theory and other instructional theories, as it provides a theoretical framework for explaining how learners acquire, organize and automate information. Without such knowledge, educational designers and facilitators may have little understanding of why some methods of instruction result in superior learning, while other methods fail. Human cognitive architecture includes two major components that are essential for explaining how information is processed — working memory in which we consciously process information and construct mental representation and long-term memory as our knowledge base in which we store the constructed representations.

When dealing with novel information, working memory is severely limited in capacity and duration. Humans are able to consciously process no more than a few chunks of information for no longer than a few seconds (e.g., Baddeley, 1986; Miller 1956; Cowan 2001; Peterson & Peterson, 1959). Chunks of information are determined by the available task-relevant knowledge structures the learner holds in long-term memory. They are also referred to as schemas stored in long-term memory (Thorndyke & Hayes-Roth, 1979). A schema is an organized knowledge structure that is used to categorize information and thus guide our behavior. If available, schemas allow encapsulating many elements of information into larger units that could then be treated as single elements in working memory. Therefore the effective capacity of working memory always depends on the available relevant knowledge base in long-term memory.

Unlike working memory, long-term memory can hold information for an unlimited period of time without it being subject to interference effects (Atkinson & Shiffrin, 1968). The information processing