

PREMIER REFERENCE SOURCE

Cognitive Effects of Multimedia Learning



ROBERT Z. ZHENG

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This chapter describes human cognitive architecture within an evolutionary framework. The framework can be used as a base for cognitive load theory that uses human cognitive architecture to provide testable hypotheses concerning instructional design issues. Human cognition can be characterized as a natural information processing system. The core of such systems can be described using five principles: (a) information store principle, (b) borrowing principle and reorganizing principle, (c) randomness as genesis principle, (d) narrow limits of change principle, and (e) environment organizing and linking principle. These five principles lead directly to the instructional effects generated by cognitive load theory. Some of these effects are concerned with multimedia learning. The particular ones discussed in the chapter are the split-attention, modality, redundancy, element interactivity, and expertise reversal effects.

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This chapter addresses the role that working memory capacity (WMC) plays in learning in multimedia environments. It focuses on how individual differences in attentional control, affect cognitive performance in general, and cognitive performance in multimedia environments, in particular. The authors conducted a study that examined the effects of WMC on learning in a multimedia environment. Results

of this study indicated students with high WMC recalled and transferred significantly more information than students with low WMC. Ultimately, the chapter provides evidence that individual differences in working memory capacity should be taken into account when creating and implementing multimedia instructional environments.

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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 three 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.

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Manipulating Multimedia Materials 51

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The chapter discusses a theoretical framework for designing multimedia in which manipulation, rather than perception, of objects plays the predominant role. The framework is based on research by cognitive psychologists and on Engelkamp's (1998) multimodal model of action-based learning. Although the assumptions of Engelkamp's model should be helpful for instructional design, they are not complete enough to include the additional demands of multimedia learning. These additional demands can result in unintended actions, involve sequences of related actions, and require reflection about domain-specific knowledge. Actions can be performed on either physical or virtual manipulatives, but virtual manipulatives exist in idealized environments, support continuous transformations of objects, and allow for dynamic linking to other objects, symbols, and data displays. *The use of manipulatives in the Building Blocks and Animation Tutor projects provide illustrations.*

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The chapter uses a semiotics approach to provide a definition of visualizations as a specific form of external representation. It then discusses the differences between verbal and visual representations in how they represent information, and finally, how meaning is achieved when learning with them. Also

included in the chapter is the discussion of basic perceptual and cognitive processes relevant to learning with visualizations. This background is used to specify the instructional functions that visualizations have either as self-contained instructional messages or as text adjuncts. Moreover, the role of individual differences in processing visualizations is highlighted. The chapter ends with methodological suggestions concerning the important role of interdisciplinary research and assessment methods in this area.

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<i>Florian Schmidt-Weigand, University of Kassel, Germany</i>	

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<i>Tali Ditman, Tufts University, USA & Massachusetts General Hospital, USA</i>	
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Multiformat and modality interfaces have become popular and effective tools for presenting information in training and instructional systems. Technological innovation, however, has far surpassed researchers' understanding of how and under what circumstances these technologies are useful towards information gathering. Some recent research has begun to characterize the cognitive mechanisms that may be responsible for the comprehension and memory advantages typically seen with multimedia learning as well as the role of individual differences in this process. Other work has defined effective pedagogical practices, such as instructional content and organization, for producing engaging and effective learning experiences. This chapter attempts to bridge these two research areas, provides concrete design recommendations for current instructional practice, and directions for future research.

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The Web is emerging as a quintessential multimedia environment for complex learning, particularly in ill-structured domains. This chapter explores the cognitive load considerations associated with several constructs of deep and extended learning on the Web. Also examined, is how adjunct online tools and the role of learner motivation may help ameliorate cognitive load concerns when immersed in Web environments. The need for a reconceptualization of Cognitive Load Theory is proposed for more ill-structured conceptual arenas. The reconceptualization emphasizes support for the development of flexible knowledge assembly skills through processes of organic, reciprocal, and deep Web learning.

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<i>Putai Jin, University of New South Wales, Australia</i>	

Although research on cognitive effects and their implications for instructional design is rich, research on the effects of motivation in a multimedia learning context is surprisingly scarce. Since one of the major goals of providing multimedia instruction is to motivate students, there is a need to examine motivational elements. This chapter focuses on four major motivation theories—expectancy-value theory, self-efficacy, goal-setting and task motivation, and self-determination theory—and two motivation models—ARCS model and the integrated model of cognitive-motivational processes—that are derived from multimedia research, and reviews the literature on motivation in multimedia learning contexts. Suggestions are made with respect to motivation features and how they can be incorporated in multimedia learning resources to optimize learners' experience.

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This study investigates students' engagement with a multimedia enhanced problem-based learning (PBL) environment, Alien Rescue. Alien Rescue is a PBL environment for students to learn science. Fifty-seven sixth-grade students were interviewed. Analysis of the interviews, using the constant comparative method, showed that students were intrinsically motivated and that there were 11 key elements

of Alien Rescue that helped evoke students' motivation: authenticity, challenge, cognitive engagement, competence, choice, fantasy, identity, interactivity, novelty, sensory engagement, and social relations. These elements can be grouped into five perspectives of the sources of intrinsic motivation for students using the PBL environment: problem solving, playing, socializing, information processing, and voluntary acting; with problem solving and playing contributing the highest level of intrinsic motivation. The findings are discussed with respect to designing multimedia learning environments.

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This chapter examines the cognitive demands of student-centered learning, from and with, Web-based multimedia. In contrast to externally-structured directed learning, during student-centered learning the individual assumes responsibility for determining learning goals, monitoring progress toward meeting goals, adjusting or adapting approaches as warranted, and determining when individual goals have been adequately addressed. These tasks can be particularly challenging in learning from the World Wide Web, where billions of resources address a variety of needs. The individual, in effect, must identify which tools and resources are available and appropriate, how to assemble them, and how to manage the process to support unique learning goals. The chapter focuses on the applicability of current cognitive principles to Web-based multimedia learning and implications for research.

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<i>Lloyd P. Rieber, The University of Georgia, USA</i>	

This chapter presents a review of research on the use and role of interactive simulations for learning. Contemporary theories of learning, instruction, and media, suggest that learning involves a complex relationship and dependency between a learner's prior knowledge, a learner's motivation, the context, the task, and the resources (e.g., simulations) provided to and used by the learner to support or enable the task. Given this perspective, and data from an evolving research program, simulations are best used to help learners construct knowledge and make meaning by giving them control over phenomena modeled by the simulation. Several theoretical frameworks have guided this research program: dual coding theory, mental models, and constructivist learning theory. An overall result of this research is that learning should be based on experience, such as that derived from interacting with a simulation, and supported with explanations. This is counter to traditional educational wisdom where explanations rule instructional strategies.

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The role and promotion of transfer in multimedia instructional environments is an oft-neglected concept in instructional multimedia research. However, while most instructional multimedia research does not focus specifically on transfer, the majority of basic multimedia research conducted uses retention and transfer as dependent measures. The purposes of this chapter are to (a) provide a review of the current state of the transfer literature, (b) provide a synthesis of the existing literature on the evidence for transfer in multimedia instructional environments, and (c) provide a series of strategies for constructing and using multimedia for the purpose of fostering transfer. The significance of proactively creating multimedia instructional environments that fosters transfer, lays in the benefits of creating knowledge that may be generalized and applied in the “real world.” Specifically, knowledge that may be generalized, applied, or transferred broadly, facilitates the learner’s ability to solve problems of all types. In addition, and unfortunately even under the best of conditions, fostering transfer is challenging; thus, a proactive stance in fostering transfer is necessary to increase the likelihood of generating knowledge transfer.

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This chapter discusses an emerging theme in supporting effective multimedia learning: developing scalable, cognitively-grounded tools that customize learning interactions for individual students. The theoretical foundation for expected benefits of customization and current approaches in educational technology that leverage learner prior knowledge is discussed. Followed by a description of the development of a customized tool for science learning, called CLICK, that uses automatic techniques to create knowledge models that can be fed into cognitively-informed pedagogical tools. CLICK leverages existing multimedia resources in educational digital libraries for two purposes. To generate rich representations of domain content relevant for learner modeling that are easily scaled to new domains and disciplines, and also to serve as a repository of instructional resources that support customized pedagogical interactions. The potential of the CLICK system is discussed along with initial comparisons of knowledge models created by CLICK and human experts. Finally, the chapter discusses remaining challenges and relevant future extensions for effective customization tools in educational technology.

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Multimedia environments can benefit learning as well as offer significant capacity to serve research purposes. The authors reviewed current hypermedia learning models, specifically focusing on how they integrate motivational elements into their frameworks. The goal-tracing methodology was proposed to identify traces of learners' use of cognitive tools that reflect their goal orientations. By applying data mining techniques to these data, the authors show how it is possible to identify goal patterns together with study tactic patterns. The authors propose that future research could benefit substantially by merging trace methodologies with other methods for gathering data about motivation and learning.

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<i>Alan D. Koenig, University of California–Los Angeles, USA</i>	
<i>Robert K. Atkinson, Arizona State University, USA</i>	

The first part of this chapter explores how narrative can be used as a cognitive aid in educational video games. It discusses how narrative is currently used in games, and how that modality of presentation, when combined with instruction, is complimentary to the way we comprehend, store, and retrieve information. The second part of the chapter reviews the cognitive prerequisites needed in the minds of players to adequately attend to, and leverage, the instructional aspects of games. To this end, it offers suggestions for how to instill a functional game-schema in the minds of novice players so that they can be productive in the game environment. The focus on the interplay of narrative and game schema construction in this chapter is also meant to serve as a model for a holistic approach to games research in which a game's cognitive prerequisites are explicitly studied alongside the more traditional pedagogical measures.

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Advanced digital storybooks offer, in addition to an oral rendition of text, the possibility of enhancing story content through the use of video. In three experiments effects of added video with accompanying music and sound on language comprehension and language acquisition were tested in a group of second language learners from low educated families. Three questions were posed. Do video additions positively influence young children's story understanding over and above still images when listening to a storybook? How does video add to language acquisition; through added information or through the appraisal of helpfulness of the added information? Do these extra information sources benefit all young children to the same extent or especially children with insufficient prior knowledge?

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To learn by means of analogies, students have to see surface and deep structures in both source and target domains. Educators generally assume that students, presented with images, texts, video, or demonstrations, see what the curriculum designer intends them to see, that is, pick out and integrate information into their existing understanding. There is however, evidence that students do not see what they are supposed to see, which precisely inhibits them to learn what they are supposed to learn. In this extended case study, which exemplifies a successful multimedia application, three classroom episodes are used (a) to show how students in an advanced physics course do not see relevant information on the computer monitor, (b) to exemplify teaching strategies designed to allow relevant structures to become salient in students' perception allowing them to generate analogies and thereby learn, and (c) to exemplify how a teacher might assist students in bridging from the multimedia context to the real world.

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