Chapter VIII
Managing Cognitive Load in Dynamic Visual Representations

INTRODUCTION

According to dual-coding theory, when learning concrete concepts, adding pictorial representations could be superior to verbal-only descriptions (Clark & Paivio, 1991; Sadoski & Paivio, 2001). This theory assumes existence of two additive sub-systems in human cognitive architecture that process verbal and pictorial information. Accordingly, people learn better when information is encoded verbally and visually rather than in one mode only. Information that has been encoded using two different modes can also be retrieved from memory more easily.

The cognitive theory of multimedia learning provides detailed theoretical arguments that effectively support this view and also apply it to dynamic visualizations such as instructional animations. According to cognitive theory of multimedia learning, different mental representations are constructed from verbal and pictorial information, and meaningful learning occurs only when learner actively establishes connections between these representations (Mayer, 2001; Mayer, & Moreno, 2003; Mayer & Sims, 1994).

This chapter discusses the strengths and weaknesses of dynamic visualizations and the relationship between instructional effectiveness of dynamic and static diagrams and levels of learner task-specific expertise. It has been mentioned previously that instructional formats that are effective for low-knowledge learners could be ineffective, or even deleterious, for high-knowledge learners and vice versa (the expertise reversal effect). Significant interactions between levels of learner expertise

and instructional procedures have been found in many situations. Such an interaction may also exist between dynamic and static visualizations. For example, novice learners may benefit more from traditional static diagrams than from dynamic visual representations (e.g., animated diagrams), while more knowledgeable learners may benefit more from animated rather than static diagrams.

This assumption has a viable theoretical rationale. According to cognitive load theory, continuous animations and video may be too cognitively demanding for novice learners. Associated processing difficulties could be due to a high degree of transitivity in such visualizations, on the one hand, and limited capacity and duration of working memory, on the other hand. Less knowledgeable learners, therefore, may benefit more from a set of equivalent static diagrams. However, animations could be superior to static diagrams for more knowledgeable learners who have already acquired a sufficient knowledge base for dealing with issues of transitivity and limited working memory capacity. The chapter also briefly describes a specific empirical study that was designed to investigate the relation between levels of learner expertise and instructional effectiveness of dynamic and static visualizations (Kalyuga, 2007). The rapid diagnostic method discussed in Chapter IV, was used in this study for measuring levels of learner prior knowledge.

ADVANTAGES AND WEAKNESSES OF INSTRUCTIONAL ANIMATIONS

Instructional animations and video have been around for long time as an important part of educational technologies. There are some significant theory-based arguments in favor of greater effectiveness of animated rather than static images, and corresponding principles have been suggested for designing and using animation in instruction (e.g., Mayer & Anderson, 1992; Mayer & Moreno, 2002; Reed, 2005; Rieber, 1990; Weiss, Knowlton, & Morrison, 2002). Some empirical evidence was also obtained to support instructional effectiveness of animations. For example, Rieber, Smith, Al-Ghafry, Strickland, Chu, and Spahi, (1996) found that animated graphical feedback improved learner performance, reduced solution time and learner frustration in a computer-based simulation on the laws of motion in comparison with simple textual feedback. In the area of learning electronic troubleshooting skills, Park and Gittelman (1992) demonstrated that animated visual feedback was more effective than static visual feedback.

On the one side, since animations belong to visual representations in general, cognitively-based principles for designing and using visual representations apply to animations as well (Rieber, 1990). On the other side, animations represent dynamic visualizations that are capable of representing movements and trajectories.

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