Chapter IX
Optimizing Cognitive Load in Instructional Simulations and Games

INTRODUCTION

Instructional simulation and games are usually used as substitutes for actual equipment, processes, real-life problems, and social situations. They allow observing outcomes of different learner actions and steps without involving actual hardware and people. They also provide environments for practicing important skills in an efficient (in terms of cost and time) way. From a cognitive load perspective, using actual equipment or human actors may not necessarily lead to the acquisition of expected knowledge and skills. High cognitive load involved in operating the equipment itself, performing required procedures, interacting with other people, especially when allowed time is constrained, may inhibit learning. In such high load situations, limited cognitive resources would be left for actual learning. Instructional simulations and games allow modeling such processes without time limitations and other cognitive constrains. Instructional simulations may also allow representing abstract knowledge structures and processes that are difficult to observe in real conditions. They may enhance the development of abstract thinking and problem-solving skills by offering environments for exploring and testing hypotheses.

Many available instructional simulations and games represent mostly exploratory learning environments with limited guidance for learners. From a cognitive load perspective, any random exploratory or search procedures may impose excessive levels of working memory load thus interfering with meaningful learning

(see Chapter II for more details about basic principles of cognitive load theory). Therefore, optimizing levels of instructional guidance represents the most important means of managing cognitive load and enhancing learning outcomes in such environments.

This chapter starts with examining the role of simulations as instructional technology tools and describes means of enhancing instructional effectiveness of simulations and games. Then the chapter discusses how to evaluate cognitive load in simulations using concurrent verbal reports. Some issues of cognitive load associated with instructional applications of mobile technologies are considered at the end.

SIMULATIONS AS TOOLS OF INSTRUCTIONAL TECHNOLOGY

Practical use of software products and physical equipment often does not lead to understanding of theoretical principles they try to convey because high cognitive demands of familiarization with equipment and procedures, taking measurements, interpreting data, etc. Limited (if any) cognitive resources may remain available for generalizations required for understanding the theory. In such high-load situations, learners may adopt a "recipe approach" by following step-by-step directions without clearly understanding reasons behind these steps (McFarlane & Sakellariou, 2002). Instructional simulations may help to partially avert these problems because they may eliminate the need for handling apparatus and represent simultaneously observable and theoretically predicted behaviors of the system under investigation (Hennesy, Deaney, & Ruthven, 2006).

Interactive visualizations of abstract knowledge structures by manipulating familiar objects are important benefits of simulations that enhance the development of abstract thinking and problem-solving skills (Boyle, 2004). Simulations may provide a framework for visualization of complex problems that could be encountered in real settings outside the simulation, offer environments for exploring hypotheses and receiving immediate feedback (Baggott & Nichol, 1998; Monaghan & Clement (1999). In science education, computer simulations allow many naturally occurring invisible processes, especially at molecular or atomic levels, to be made transparent and accessible to learner experimentations by manipulating (compressing or extending) natural time intervals. Such interactive manipulations of experimental situations may enhance learner abilities to apply scientific knowledge to complex real-life situations. A number of studies reported successful use of instructional simulations in educational settings, especially for teaching science classes.