Chapter 11
Computer Simulation in Higher Education:
Affordances, Opportunities, and Outcomes

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ABSTRACT

Computer simulation as both an instructional strategy and technology holds great potential to transform teaching and learning. However, there have been terminological ambiguity and typological inconsistency when the term computer simulation is used in the education setting. This chapter identifies three core components of computer simulation, and develops a learning outcome-based categorization, linking together computer simulation's technical affordances, learning opportunities, and learning outcomes. Exemplary computer simulations in higher education are identified to illustrate the unique affordances, opportunities, and outcomes of each type of computer simulation.

INTRODUCTION

Along with gaming, gamification, 3-D virtual reality, and 3-D modeling, computer simulation has recently become a buzzword in higher education and e-learning. In 2012, the New Media Consortium Horizon Report projected that games and simulations are on the two to three-year adoption horizon (New Media Consortium, 2012). Enabled by rapid advances in computer and Internet technologies and coupled with decreasing costs, simulation technology is widely incorporated into the science, technology, engineering, and mathematics curricula in higher education (D'Angelo et al., 2013). Healthcare and medical education, in particular, have made extensive use of computer simulation as routine instructional activities and tools across the curricula (Damassa & Sitko, 2010). There has also been growing interest in social sciences and humanities to use computer simulation to help college students understand and explore the complex systems and processes of social- and human-related disciplines (Gilbert & Troitzsch, 2005; Porter, Riley, & Ruffer, 2004).

Computer simulation, both as an instructional strategy and technology, holds great potential to transform teaching and learning. The educational basis of simulation are the notions of "real-world problems," "contextual learning," "situated learning," "active learning," and "deep learning." A large body of literature condemns one-way lecture-based education as inefficient and ineffective in promoting higher levels of learning and helping learners transfer and apply knowledge and skills in real-world contexts (see for example, Clark, 2004; Jonassen, 1999; Wilson, 1996). In simulation, however, students are situated in real-life scenarios, encounter real-life problems or challenges, and are required to act, think, and solve problems like an expert. Simulation is a viable tool to engage students in "deep learning" that empowers higher-order thinking (such as analysis and creation) as opposed to "surface learning" that requires only memorization and comprehension. Indeed, computer simulation has demonstrated great effectiveness in engaging and motivating learners, in facilitating higher levels of learning that help learners transfer and apply knowledge and skills in real-world contexts (Damassa & Sitko, 2010; Tennyson & Jorczak, 2008), and most notably, in promoting 21st-century skills, including decision-making, critical thinking, problem solving, collaboration, effective communication, persistence, and learning to learn (Binkley et al., 2011).

However, there has been terminological ambiguity regarding "game-based learning," "3-D modeling," "computer simulation" in education, causing confusion and difficulty in differentiating one from the other in terms of their distinct educational affordances and instructional benefits. Similarly, categorizations of computer simulations vary significantly across disciplines and the efforts to identify a learning outcome-based typology are scarce. At the same time, there has been limited research on exploring the unique learning opportunities enabled by computer simulation and its impact on learning outcomes in affective, cognitive, and social domains. The purposes of this chapter, therefore, are to differentiate computer simulation from other similar technologies, identify its core attributes, categorize it based on learning outcomes, and explore the distinctive learning opportunities and benefits enabled by computer simulation.

Background

Computer simulation has been used interchangeably with other similar instructional technologies, such as "computer/digital games," "augmented reality/virtual reality," and "computer modeling." These terms are often lumped together under "digital game-based learning" for convenient naming and classification purpose, but with apparent shifts in distinctive and essential attributes of each. Computer game, used most frequently with simulation, differs greatly in a number of essential attributes from those of simulation. A computer game is characterized by a set of clearly stated goals, rules, and rewards, in which users need to reach higher levels in order to progress. In simulation, on the other hand, learners are more focused on a phenomenon, system, process, or activity, with the ultimate goal to solve a real world problem (D'Angelo et al., 2013). As Prensky (2001) clarified, "simulations are not, in and of themselves games. In order to become games, they need additional structural elements - fun, play, rules, a goal, winning, competition, etc." (p. 212). Similarly, augmented reality/virtual reality technology, which is mostly akin to simulation as to replication of real worlds, is characterized by an immersive and enhanced virtual environment, blended with reality (e.g., real-world spaces) and digital objects (e.g., images, videos, audios) (New Media Consortium, 2016). The distinction between augmented reality/virtual reality and simulation hinges on the underlying model. While an underlying model is not essential to an augmented reality/virtual reality, a simulation must be structured to reveal or embed a model of a real world phenomenon, environment, or activity, such as the biological evolutionary model and an organization-operating model.

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