Chapter 23
Supporting the Comprehension of Complex Systems with Video Narratives

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ABSTRACT

Complex systems are difficult to understand, and without extended training and experience, people tend to misperceive these systems. Although current simulation tools illustrate what is happening in complex systems, they lack the means to represent the narrative aspects of the exhibited behaviours, in order to provide an account for the behaviours. The goal of this research is to provide visualizations of complex dynamic system behaviours with multimedia, focusing on video narratives, and to study the implications and added values of the video clips. The target users are primarily university students in System Dynamics. The method could also be of value both to lower level school students as well as to policy makers and general population who must deal with challenging complex problems. A pilot study was conducted and the findings confirmed our prior expectations; namely, that providing the users with video clips facilitates their learning process.

INTRODUCTION

The world we live in is dynamic and complex. The complexity lies in interconnected components whose behaviour is not explained exclusively by their properties. Rather, the behaviour *emerges* from the interconnectedness of these components (Bar-Yam, 1997; Sabelli, 2006). According to the *Journal of Advanced Complex Systems*, a complex system is a system comprised of a (usually large) number of (usually strongly) interacting entities, processes, or agents, the understanding of which requires the development, or the use of, new scientific tools, nonlinear models, out-of equilibrium descriptions and computer simulations. For example, the housing prices might be influenced by the expenses of building new houses, the prices of land, the number of jobs, the availability of workers, and the number of new houses which are built. These factors interact with each other and the interactions contribute to

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the fluctuations of the housing prices. In fact examples of complex systems can be found in a wide variety of domains including climate, ecological networks, insect colonies, neural networks in the brain that produce intelligence and consciousness, social networks comprised of transportation, utilities, and telecommunication systems, as well as economies.

Understanding and reasoning about complex systems places a huge burden on working memory resources and is often counterintuitive or conflicts with commonly held beliefs (Casti, 1994; Feltovich, Coulson, & Spiro, 2001; Hmelo-Silver & Azevedo, 2006; Narayanan & Hegarty, 1998; Wilensky & Resnick, 1999). Computer simulations allow formal and experimental investigation of various complex systems. For example, simulations are designed to model the spread of infectious disease on social networks. Users can use the simulation to explore the effects of complex pharmaceutical interventions and non-pharmaceutical interventions on the spread of the disease (Barrett, Bisset, Eubank, Feng, & Marathe, 2008). Computer simulations are also used to model climate changes and interpret the changes in the past and predict the future (Hansen et al., 2007; West & Dowlatabadi, 1999). In Artificial life simulations are used to study the phenomena of living systems to understand the complex information processing that defines such systems (Bedau, 2003; Langton, 1995). In most of these simulations data visualization with charts and graphs is one of the most important aspects. Users can explore the simulations by manipulating parameters and observe the changes in the data visualization. However, it is not common to include videos in the visualization of simulations.

The current best understandings and analytical tools in the physical and social sciences (informed by complex systems) are continuing to expand beyond the reach of the working knowledge of professionals, policy makers, and citizens, who must deal with challenging social and global problems in the 21PstP century (Jacobson & Wilensky, 2006). Learning scientists have identified opportunities to help address the these challenges, calling for, among others, a systematic study focusing on what types of scaffolds or other learning aids are needed to support the understanding of complex systems (Sabelli, 2006). This involves both formal and informal learning as well as lifelong learning. The key issue is the teaching and learning of complex system knowledge and understanding of system thinking.

The development of advanced technology has resulted in interactive learning environments, including simulations, multimedia and other web-based learning environments, that may facilitate the understanding of complex systems. Simulation provides more experiential, explorative, and inquiry-based learning opportunities and has been widely used in various educational contexts from natural science to social study, from elementary school to high education, and from classroom to informal and lifelong learning. Studies have shown that simulation-based learning can be highly motivating and engaging and leading to deeper understanding of content and development of higher order thinking skills (Gredler, 2004; Hmelo & Day, 1999; Lee, 1999; Swaak & de Jong, 2001a; Veenman, Prins, & Elshout, 2002). Researchers have also studied learning mechanisms and reasoning skills that must be deployed to support learning about complex systems. For example, de Jong and colleagues (de Jong et al., 2005) identified and listed key factors necessary for effective discovery-based learning environments, to foster learning about particular complex systems, including generic knowledge about models, domain knowledge, general skills and scientific reasoning skills.

Visualization techniques have been adopted to support the uses of multiple representations of abstract concepts (Mayer, 2001). Multimedia learning theory focuses on how people integrate verbal and visual information in their learning processes. Video as a form of media have been widely used in learning in various disciplines such

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