Chapter 44
Sustain City:
Effective Serious Game Design in Promoting Science and Engineering Education

Ying Tang
Rowan University, USA

Kauser Jahan
Rowan University, USA

Christopher Franzwa
Rowan University, USA

Marzieh S. Saeedi-Hosseiny
Rowan University, USA

Talbot Bielefeldt
Independent Researcher, USA

Nathan Lamb
Rowan University, USA

Shengtao Sun
Rowan University, USA

ABSTRACT

Recent years have witnessed a growing interest in interactive narrative-based serious games for education and training. A key challenge posed by educational serious games is the balance of fun and learning, so that players are motivated enough to unfold the narrative stories on their own pace while getting sufficient learning materials across. In this chapter, various design strategies that aim to tackle this challenge are presented through the development of Sustain City, an educational serious game system that engages students, particularly prospective and beginning science and engineering students, in a series of engineering design. Besides narrative-learning synthesis, supplementing the player's actions with feedback, and the development of a sufficient guidance system, the chapter also discusses the integration of rigorous assessment and personalized scaffolding. The evaluation of Sustain City deployment confirms the values of the serious games in promoting students' interests and learning in science, technology, engineering, and mathematics (STEM) fields.

DOI: 10.4018/978-1-6684-7589-8.ch044

INTRODUCTION

Play and technology have been combined in various interesting ways to synthesize elements of environment and story with simulations in providing real-time visualized responses (Entertainment Software Association, 2013); and to embody real world situations in which players explore, learn and solve problems (Barab, Gresalfi, & Arici, 2009). The consideration of games in education is made evident by recent and growing development in "serious games," defined by design that takes into account "(i) serious aspects that determine the pedagogical objectives such as the transmission and/or acquisition of knowledge, know-how, or information; (ii) and fun aspects which focus on the motivation and the management of end users' frustration." (Cheng, Chen, Chu, & Chen, 2015; Hocine & Gouaich, 2011). Serious games offer several strong learning-enhancement capabilities, allowing for the realization of virtual worlds that can assist students in ways that the typical classroom environment cannot (Torrente, Blanco, Moreno-Ger, & Fernandez-Manjon, 2012). In standard textbook-driven lecturing and study, visual or hands-on learners are left to find their own ways of perceiving the ever more complex concepts as they wade through a course. Currently, even hands-on approaches to learning, such as lab experiments, are limited by budgetary and safety constraints. Serious games, on the other hand, make difficult abstract concepts and large data sets accessible in ways that are more visual, interactive, and concrete, providing an opportunity to gain the attention of students who are not otherwise engaged with the content (Bosch, 2016; Callaghan, Savin-Baden, McShane, & Eguíluz, 2015; Di Mascio & Daiton, 2017; Franzwa, Tang, & Johnson, 2013; Rhodes et al., 2017). The game format provides students with a learning structure and an incentive to develop their skills at their own pace in a non-judgmental but competitive and often fun environment (Habgood & Ainsworth, 2011; Terzidou, Tsiatsos, Miliou, & Sourvinou, 2016). Vivid examples can be found in many domains, such as science and engineering discovery (Barab et al., 2009; Ma, Oikonomou, & Jain, 2011; Mavromihales & Holmes, 2016; Mott & Lester, 2006), military training (Smith, 2009; Zielke et al., 2009) and healthcare training (Menzies, 2017; Tong, Chignell, Tierney, & Lee, 2016; Wattanasoontorn, Hernandez, & Sbert, 2012).

Echoing general concerns with the current state of the US school systems, many educational groups have begun advocating curricular changes for Science, Technology, Engineering, and Mathematics (STEM) subjects. In a report of the President's Council of Advisors on Science and Technology (PCAST, 2012), higher performing students cite "uninspiring" introductory courses as a factor in choosing different majors while lower performing students struggle with mathematics due to insufficient assistance. Issues such as student interests and instructional feedback should be considered when developing any STEM serious game. While the educational value of games has long been recognized, there is significant resistance to their adoption in formal education. One problem is the amount of instructional time that must be devoted to training and practice to allow games to have a significant effect on student learning. There is a tendency for serious games to develop an all-inclusive learning system that largely leaves the instructors without the flexibility needed to create their own curriculum. Arnab et al. (2012) and Wilson (2009) argued that considerable benefit would be gained from aligning games with standards and curricula. An effective serious game relies on an instructor for focus and guidance (Egenfeldt-Nielsen, 2010). Best practices for using games in the classroom promote a strong interconnection between instructors and software, where instructors remain the driving force behind education (Wilson, 2009). A set of serious-game-based educational experiments carried out in three European countries support those research propositions (Earp, Ott, Popescu, Romero, & Usart, 2014). In particular, the study revealed the importance of tutor in guiding the learning experience although the game was tailored for self-regulated