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Serious games on environmental management

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ABSTRACT

Serious environmental management games can improve understanding of practical environmental sustainability challenges by offering opportunities to obtain first-hand experiences that may be otherwise too costly, difficult or dangerous to reproduce in reality. Game-based learning (GBL) has been found to increase soft skills, such as critical thinking, creative problem solving and teamwork, as well as to improve cognitive development, learning retention and social learning, which are important for future environmental researchers and professionals. Environmental management games can be applied in educational settings to promote awareness about sustainable resource planning and management among citizens who are increasingly exposed to products of the information age. This paper provides an overview of game-based learning and the state of serious games (SG) for environmental management, offering insight into their potential as effective tools in facilitating environmental education. SGs have been shown to possess numerous qualities that have been connected with improved learning experiences and cognitive development, but research must continue to study the SGs' efficacy. Shortcomings found with games reviewed are that few evaluate or explain pedagogical foundation, and many are hard to implement or not accessible. Methods employed in determining the effectiveness of SGs vary greatly among environmental studies, necessitating a standardized methodology to reduce disparities in testing procedures. Furthermore, a centralized source, effectively an online database for SGs, is needed for locating and obtaining information pertaining to the available environmental games and their most appropriate applications.

Contents

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1. Introduction

Environmental management has long recognized the importance of interdisciplinary collaboration and a systems perspective (Hoekstra 2012; Rusca, Huen, & Schwartz, 2012), providing a suitable context for application of game based learning (GBL). Games can be applied in educational settings to promote awareness about environmental and sustainability challenges among citizens who are increasingly exposed to products of the information age. Computer graphics and realistic simulations allow learners to role-play in environments that would otherwise be difficult to replicate (Kirriemuir & McFarlane, 2004). This capability is essential for environmental management education because of the need to make important decisions about "wicked" environmental planning and management problems (e.g., climate change and extreme weather events, ocean acidification, desertification, and biodiversity loss, among others) as opposed to well-defined, end-in-view "tame problems" (Rittel & Webber, 1973).

The youth who were the first generation to grow up with digital technology including internet, computers, video games, MP3 players, and smartphones, have been dubbed the net-generation, digital-generation or digital natives (Prensky 2001). Prensky (2001) maintains that digital natives think and process information differently than previous generations because of the pervasiveness of exposure to technology that is a key characteristic of today's youth who spend their time differently than former generations. In 2009, it was estimated that total daily media exposure among American youth ages 8–18 was 10:45 h on average; an increase from 8:33 h in 2004 and 7:29 h in 1999 (Rideout, Foehr, & Roberts, 2010). Video gaming, specifically, increased to an average of 73 min per day in 2009, a marked increase from 49 min in 2004 and 26 min in 1999 (Rideout et al., 2010). This popularity is, in part, because video games provide a practical medium for personal and social gratification as gamers enjoy the challenge of beating the game and other players in an engaging, indiscriminate "level playing field" as compared to the real world (Sherry, Lucas, Greenberg, & Lachlan, 2006). The demographic of gamers includes more than just young children and teenage boys. The gender distribution of games is 47% female and 53% male and the average age of gamers is 30 years (Entertainment Software Association, 2012).

"Serious games" (SG) developed for educational purposes have experienced increased attention in the past decade (Young et al., 2012) as advances in technology has made electronic media more accessible and digital games more ubiquitous. Areas where SGs are thought to have a particularly high potential for overcoming deficiencies of traditional lecture-driven classes are in science, technology, engineering and math (STEM) curricula (Levine, 2011; Mayo, 2007). Reasons that students claim to leave STEM programs include either loss of interest in the curriculum, loss of academic self-confidence resulting from a competitive environment (Seymour and Hewitt, 1997), or incompatible personal learning styles (Bernold, Spurlin, & Anson, 2007). It is suggested that loss of interest in engineering programs may be associated with the dominance of lecture formatted classes (Blickenstaff, 2005), which account for more than 95% of engineering courses (Deshpande & Huang, 2011). Mayo (2007) describes five reasons that SGs can improve interest and retention of STEM majors: massive reach, effective learning paradigms, enhanced brain chemistry, increased time on task and better learning outcomes. Implementing games in K-12 can also expose students to STEM professions in a manner that is fun and engaging, which could increase recruitment and the retainment of college-bound students in STEM majors.

With so much interest in technology and specifically, gaming, more and more focus outside of the research world is being placed on the potential that games may have as an educational tool. The NMC Horizon Report: 2013 Higher Education was developed to inform education leaders, policy makers, and faculty about new and emerging technology and its potential impact on teaching, learning, and research (Johnson et al., 2013). A key trend noted in the report is the evolution of teaching in higher education to incorporate more informal learning such as online learning, hybrid learning, and collaborative models. Programs such as The National STEM Video Game Challenge promoted by the US government are on the rise. Established by President Obama in 2010, the Video Game Challenge calls for middle and high school students to design STEM related games to promote learner independence (Robertson & Howells, 2008), systems thinking, and higher-order skills that are fundamental to STEM learning (Resnick, 2012). The US Congress has also launched the E-TECH Caucus for the purpose of educating policymakers and the public about the benefits that the gaming industry can have on education and the economy (Levine, 2011). Additionally, in 2012 the first national policy initiative on digital gaming's role in education, health, civic engagement, and numerous other areas was introduced (Toppo, 2012).

This paper provides an overview of GBL and serious environmental management games and their potential to improve cognitive development, professional skills and the learning experience in regard to environmental management. GBL has been found to enchance soft skills such as critical thinking, creative problem solving and teamwork (Gee, 2004; Johnson et al., 2013) as well as improve learning retention, cognitive development and socialization, among others (Squire, 2008; Van Eck, 2006). It caters to different learning styles, providing a supplement to the traditional methods in order to accommodate a greater proportion of learning orientations. The review describes the state of SGs in the environmental management field, and provides insight into their variation pertaining to theme, objective, intended participants, game type and availability, among others.

2. Game-based learning (GBL)

GBL is a pedagogical method of learning that utilizes role-plays, board games, card games or video games to promote retention of learned material and cognitive development. For traditional lecture-driven classes, learning occurs in an environment (the classroom) outside the context of the material being taught. On the other hand, the learning environment in a game is relevant to the subject and allows players to apply and practice what they have learned within an authentic context; this style of learning has been shown to be more effective than purely lecture-driven learning (Van Eck, 2006). At the foundation of GBL methods are key mechanisms (fundamental aspects) and principles (underlying concepts) that have been identified as important elements for learning (Perrotta, Featherstone, Aston, & Houghton, 2013). The most commonly supported mechanisms for a successful GBL experience include rules, goals, fictional settings, progressively difficult goals, interactivity and user control, uncertainty, immediate and constructive feedback, situated cognition, and social elements (Annetta, 2010; Perrotta et al., 2013; Squire, 2008). These elements are implemented differently depending on the type of media, e.g. board game versus video game, but follow similar themes nonetheless.

Based on the work of Caillois (1962), Frasca (1999) introduced a classification system in which games are categorized into two groups: paidea and ludus. Ludus games are those that result in winners and losers (e.g. chess or Pac-man) and are more complex. Paidea games, on the other hand, have no true winners or losers (e.g. merry-go-round), providing a different means of GBL that is not driven by competition. The distinction is important because ludus games can create an element of competition, which serves to instill a sense of motivation and drive to perform at a higher level