

Serious Games for Sustainable Development

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Sustainable Development (SD) is the development that meets the needs of the present without compromising the ability of the subsequent generations to cater to their future needs (Brundtland, 1987). An ecologically balanced environment, long-term economic wellbeing, and social equity are commonly regarded as the triple bottom line (TBL) of sustainable development. Effective management of the triple bottom line requires the adoption of SD practices (Pope, Annandale, & Morrison-Saunders, 2004). The concepts of sustainable development and the triple bottom line have emerged as a major focus for the society because of factors such as: the depletion of natural resources, changes in demographics and a push toward a more equitable society. To achieve the goals of TBL, we will need the right attitude and managerial skills to examine these challenges holistically (Savitz, 2006) and the adoption of courses and degrees focusing on SD will play an important role in the curriculum of intermediate and higher education (Cotton, Warren, Maiboroda, & Bailey, 2007). The focus of this review is the use of serious games (SG), designed with a primary purpose other than pure entertainment, as a tool to teach sustainable development.

Serious Games for Teaching Sustainable Development

In this paper we critically review three leading serious games in the field of sustainable development. We chose to focus on these three games after an analysis of

35 leading serious games based on their popularity, availability, quality, developer's credibility, duration of play and topic (e.g., triple bottom line). The three serious games we have chosen to review are *Climate Challenge*, *EnerCities*, and *Shortfall*.

A Short Introduction to the Games

Climate Challenge (www.bbc.co.uk/sn/hottopics/climatechange/climate_challenge) is played by a single player from the perspective of the president of the European Nations. The president must tackle climate change and stay popular enough with the voters to remain in Office. The president must maintain four resources—money, energy, food and water—and achieve the carbon dioxide emissions target consented with the other nations by selecting in each turn of the game amongst a list of policies appertaining to trade (e.g. export food, import water supplies), agriculture and industry (e.g. switch from coal to gas, subsidise aviation) along with policies related to national (e.g. introduce fuel tax, privatise electricity, plant forests), local (e.g. improve building regulation, invest in water infrastructure, promote wind farms) and household issues (e.g. promote recycling). There are descriptions of each policy and public opinion statements “for” and/or “against”. Additionally, in each turn catastrophic, natural and manmade events take place, caused by climate change, which may affect the selected policies. According to the chosen policies and their final effect on the four resources the popularity of the president increases or falls. The game starts at year 1990 and goes on for 10 rounds each one played in the next decade. As time passes new, more technologically advanced, policies become applicable. The game is played freely online with no registration requirement and the game's duration is around an hour. The game supports 3D graphics with no animation features.

The goal of EnerCities (www.energycities.eu) is to build a sustainable metropolis. The player serves as the city's mayor and decides on residential building types (suburban, urban, towers) to be developed, the business and industries that are needed (light-heavy industry, commercial), environmental actions (develop parks, forests, wildlife reserves), citizens' well-being through services offerings (create markets, public services, entertainment activities), and the source for generating energy to support city needs (coal, hydro, solar, nuclear plant, windmills). Every decision taken by the mayor has its implications, for example, the investment required, its potential for generating revenue, its effect on the environment, energy consumption and production, and citizens' wellbeing. The aim is to keep the city sustainable by having a good score in economy (city's wealth), the environment (low pollution and maintenance of natural resources), and wellbeing (happy citizens!). The clock ticks from year 2021 to 2110 and during this period the player should manage to reach the target population (200 inhabitants) by building houses. As the population increases and/or time passes more options/policies become available. The game is over either when the population reaches 200 or when the clock is at year 2110. EnerCities allows gamers to post their gaming scores online which enhances the gaming experience and increases the likelihood that gamers will return by creating an element of competition. EnerCities has a more advanced game engine for visualizing 3D perspectives with animations as well as music and sound effects that react to player's actions. It is a "sandbox game" wherein a player can roam freely through a virtual world having autonomy with regard to when and how game objectives are to be realized and player is given controls that are basic, yet expandable for advanced options. The players can easily turn the game on and off, and save it in different states. The game is played by a single player, online with free registration, and the

game's duration is around 1.5 hours. EnerCities is also available in 6 languages and is embedded in social media (Facebook) and is available for alternative platform play and word of mouth advertisement.

Shortfall (<http://www.coe.neu.edu/Groups/shortfall/>) focuses on the supply chain management of an automotive plant that comprises 5 companies or echelons: (1) raw materials, (2) 2nd tier materials, (3) parts producer, (4) car producer, and (5) the consumer. Each player is the manager of one of the three intermediary companies in this serious game which buys from an upstream echelon and sells to a downstream echelon. The goal is to make a profitable and environmental benign SC. The game is played over 10 rounds. In each round the player is informed about the current market values regarding materials, parts, and cars purchase and selling prices as well as the maximum buy/sell amount. Each player needs to decide on two technological interventions in its factory each turn, which offer improvements in the areas of production (e.g. emission control, electrolytic cell), storage (e.g. cross-docking, reusable pallets), and waste (e.g. scrap segregation, reuse of rubber). These options may have an effect on cost, storage capacity, waste removal and the green score. As the player accumulates innovations more options become available. The player also needs to make four decisions regarding how much to buy from the previous echelon, how much to produce, what is possible to sell and how much waste to remove versus store. At each round, an event occurs (e.g. strike, material shortage) that affects the companies' capability to buy or sell. Scoring is based on 5 categories: profits, green score, waste removed, waste disposal expenses and cars sold. The SC players that score higher in most categories win the game. Shortfall is a team play game. Its team consists of 3 players that manage each of the intermediate SC echelons and play their part from a different computer on the same game determined by a seed number

provided in the beginning of the game. Different teams can compete with each other by comparing their scores. However, the game can also be played individually. In this case the single player selects a SC echelon and the computer plays the other echelons. The player's score is compared against the score of the other echelons of the same SC. In team play a coordinator is required in the class. The game is supported only by 2D graphics, which are text-driven and it is played over a 2 hour session.

Critical Evaluation of the Games

The three games are evaluated under three broad categories: (a) triple bottom line – the ability of the games to engage the players in the three facets of sustainability, (b) gaming experience (e.g., game play and game story), and (c) classroom pedagogy – an evaluation of “fitness for purpose” for classroom teaching.

Triple Bottom Line

The TBL of sustainability is present in all three games but with differing levels of importance. The environmental aspect is emphasized in Climate Challenge by keeping carbon dioxide (CO₂) emissions at the agreed national level. Failure to do so deteriorates one of the three performance measures that determine the player's score. In EnerCities, avoiding pollution and the depletion of natural resources represents the environmental aspect and is one of the five performance measures used in the game. Shortfall accounts for the environment with the application of technological interventions that avoid pollution and hazardous waste. The economic dimension of TBL is denoted in both Climate Challenge and EnerCities by trading-off favorable public policies within available budget and in Shortfall by making profits. Finally, the societal aspect of TBL is depicted in the Climate Challenge by the popularity of the president and in the EnerCities by achieving a score in citizens'

well-being. Shortfall lacks behind on this aspect by not explicitly measuring societal benefit although the green score implies that the industry's social face is considered.

Gaming Experience

Game play: In all three games, the player's fatigue is minimized by varying activities (e.g., available policies through time/rounds) and pacing during game play. All three games provide clear goals through scores and present short-term goals throughout play; however, EnerCities presents two sets of goals for achieving high scores and reaching the target population, which may disorient the player. Shortfall is the only team-oriented game. Climate Challenge is easy to learn, but hard to master; while Shortfall is difficult to learn, but easy to master. This may affect the desire to start playing and continue playing the game.

Game story: Climate Challenge has an interesting and straightforward storyline and the player knows how they are doing based on news bulletins which serve as a barometer that directly reflects the popularity of player's chosen policies. In EnerCities the player has many available options and in various categories (e.g. environment, industry, energy) and this make the plot interesting. In Shortfall, the story experience is realistic, however as it requires some basic knowledge of manufacturing management it is more likely to capture players' attention with relevance to the subject.

Classroom Pedagogy

The selected games approach sustainable development concepts at three levels: national (Climate Challenge); local (EnerCities); and enterprise (Shortfall). This challenges users to focus on different policies that each level may apply to explore sustainable development. Climate Challenge targets students in societal and political studies. EnerCities appeal to college students in societal studies as well as to

secondary students. Shortfall targets a smaller population, and appeals to higher education students of industrial management and engineering. Climate Challenge and EnerCities are quite popular games amongst teenagers who may have played the game outside of their school curriculum (Knol & De Vries, 2011). All three games offer an online tutorial before and while playing the game to assist in game play. Likewise, Climate Challenge and EnerCities offer scientific material on game concepts and provide an instructor's manual for class play. On the other hand, EnerCities and Shortfall provide reports that include the game debriefing, which reflect on the gameplay experience, and users' assessment results of the game.

Overall, all three games instil in the players an awareness of the many options available to consider the environment while caring for their economic and social wealth, a fundamental requirement of all future decision makers and managers. All three games can benefit courses related to environmental management and managing sustainable development. EnerCities and Climate Challenge are ideal for introductory courses to societal studies in higher education and the latter to political studies too but both can also be taught in secondary education courses for raising environmental awareness. Shortfall could be taught to graduate and postgraduate students in industrial engineering and production management or operations management courses.

The main goal of this study is to give a glimpse of serious games potentials as innovative approaches to teaching and learning. Serious games could be considered as tools which offer an alternative and fun way of educating and developing managers. They are mental contests played with a computer in accordance with specific rules that uses entertainment to educate, train, enhance decision making and communicate

strategic objectives (Zyda, 2005). Serious games bear the promise of an increasing presence in the school and higher education curriculum.

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