

Exploring Antecedents of Game-based Learning Effectiveness

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Abstract

The aim of this paper is to undertake a comprehensive review of literature in order to develop a conceptual framework that reflects the antecedents of an effective game-based learning environment for the Net generation; that is students who prefer to learn using games as a tool. The paper draws from theory on information systems effectiveness to conceptualise game-based learning effectiveness. Two key antecedents of effectiveness are identified – Game-Task Fit and Game Quality. Game-Task fit reflects the fit between the task that an instructor aims to teach and the game that will be used as the teaching tool. Game Quality is recognised through characteristics of Playability and Flow. The developed conceptual framework could be used as an evaluation tool for effective game learning environments for the Net generation.

Keywords

Games, Effectiveness, Fit, Quality, IS success.

INTRODUCTION

The Net generation are individuals born after 1982 who have lifestyles that depend on technology and who have a fascination for new technologies (Valtonen et al. 2011). There are arguments that the traits that define the Net generation do not solely depend on age, and that the traits are not common for all individuals born after 1982 (Gu et al. 2013). For the purpose of this paper, the Net generation will also include digital immigrants, who are people not born in a world driven by technology but who have become digitally fluent (Valtonen et al. 2010).

Students who fall under the Net generation are of interest because the manner in which they think and learn differs from other generations (So et al. 2012). These students prefer to learn by doing rather than listening (DeSilets and Dickerson 2011). This creates a problem for higher education institutions with regards to accommodating the Net generation who make up most of the student population (Worley 2011). A potential solution to this problem can be the use of games for learning. This is because the concept of learning with games is particularly interesting to today's students who incorporate technology into their daily lives (Girard et al. 2013).

Game-based learning environments make use of use educational games (Erhel and Jamet 2013). Simulation games are useful for imitating learning tasks that educators aim to teach (Sherry 2013). Although simulations

have proven to be as effective, in some instances, as traditional classroom methods (Chin et al. 2009) there are limited studies on the effectiveness of these games (Blanco et al. 2012; Girard et al. 2013).

Effectiveness pertains to achieving the desired outcome, which is synonymous with success (Ramezan 2011). Considering that the objective of educational games is to transfer skills and knowledge to a player (Brom et al. 2010; Girard et al. 2013), a lack of this knowledge transfer would defeat the purpose of game-based learning. The measuring of the effectiveness of games as learning tools is currently a problem because there is a lack of knowledge regarding what makes games effective as learning tools (Guillén-Nieto and Aleson-Carbonell 2012; Mayer et al. 2014).

The purpose of the study is to answer the question: *What are the antecedents of an effective game-based learning environment for the Net generation?* This will be achieved by conducting a comprehensive literature review to reveal the factors that lead to an effective learning environment using games as a tool that will meet the needs of the Net generation. The objective is to use the information to create a conceptual model that will allow for measuring the effectiveness of game-based learning environments for the Net generation.

The next section discusses the antecedents of an effective game-based learning environment. Thereafter effectiveness is discussed. The paper concludes with a conceptual framework that can be used to measure the effectiveness of game-based learning environments. The final sections discuss the research contribution and conclusions.

ANTECEDENTS OF GAME-BASED LEARNING EFFECTIVENESS

The research and development of games as educational tools can advance through documenting factors that make educational games effective (Wong et al. 2007). Considering that effectiveness is synonymous with success, the effectiveness of a system reflects the success of a system. Most IS effectiveness research focuses on the achievement of the goal of a system using the goal-centred approach (Grover and Jeong, 1996). This is the stance adopted in this paper, where antecedents that ensure the achievement of the goal of learning using an educational game will be explored. Educational games in game-based learning environments are typically designed to achieve a specific learning goal. It is however difficult to select one game that will reach the specific goal due to the wide variety of games available on the market (Liu and Lin 2009).

The game chosen has to match the task to complete the goal successfully (Cai et al. 2012, Gebauer and Ginsburg 2009; Ma et al. 2013). In learning environments, the fit between the task and technology leads to effectiveness (Lin 2012). Particular to games, the fit between the task and the game is important because tension between the goal of the game and the learning outcome decreases the effectiveness of learning (Brom et al. 2010).

In addition to this, in order to ensure that pedagogical foundations are met, the goal of the educational game needs to match the learning task (Blanco et al. 2012). The match between the game and task leads to better performance (Judith Gebauer et al. 2010; Hee-Dong Yang et al. 2013). A match between the task and the game is therefore an antecedent of an effective game-based learning environment. This antecedent can be named Game-Task Fit.

Game-Task Fit

Fit is “the degree to which a technology assists an individual in performing his or her portfolio of tasks” (Robles-Flores and Roussinov 2012, p.441). In game-based learning environments, fit refers to the degree that a game assists an individual in performing a learning task. Goodhue (1995) developed a model to measure the fit between technology and task, aptly named the Task-Technology Fit (TTF) model (Goodhue and Thompson 1995). The TTF framework has four constructs with the dependent variable in the framework being the degree of Task Technology Fit (Goodhue 1995). Task-Technology Fit will be renamed Game-Task Fit in order to particularise the TTF framework within the context of game-based learning environments. The other three constructs in TTF are the independent constructs, namely (1) the task that the user aims to complete with the technology, (2) the characteristics of the technology and (3) the individual abilities of the users (Goodhue, 1995).

Tasks are abstract and/or specific actions that vary in scope and difficulty (Aljukhadar et al. 2014). Since the educator designs the instructional goals (McGill et al. 2011), the task pertains to the instructional task that the educator aims to teach with the game. The task can incorporate three dimensions. The first dimension is interdependence, which is the extent to which users depend on each other to complete tasks (Goodhue 1995, Lembach and Lane 2013). Interdependence is not a requirement in this paper because the focus is on individual learning. The second dimension is variation in the task, which is often a feature of learning environments in order to assess various skill levels. The third dimension relates to task difficulty (Goodhue 1995). Task difficulty depends on the skill level of the person performing the task, or the conditions that the task is completed under (Pollock et al. 2014). Task difficulty hence may vary for users based on their individual abilities (Goodhue 1995).

Individual Ability may depend on training, competencies, knowledge and skills (Goodhue and Thompson 1995, Liu et al. 2011b). This is why it is important to consider the characteristics of the individual learner and their abilities.

Game Characteristics - According to TTF theory, technology characteristics ought to positively contribute towards the performance of the user so as to increase the fit perception (Goodhue 1995). In the game-based learning context the technology characteristics are the game characteristics. The characteristics of the game should promote game quality (Hamam and Saddik 2013). If a game is well-designed, it is more likely to contribute towards learning effectiveness (Mwangi et al. 2011).

It is difficult to design an educational game that conforms to the requirements and idiosyncrasies of all learners, but there can be some degree of conformance by ensuring the quality of the basic elements of the game are met (Hwang et al. 2014). The basic structure of any game includes elements such as mechanics, story, aesthetics, and technology (Schell 2008). *Mechanics* refers to the rules and procedures that describe how the player achieves the goal of the game. *Story* refers to the linear or complex sequence of events of a game. *Aesthetics* refers to the sights, sounds, smells, and feels experienced by the player. *Technology* refers to the definition of what can be done in the game. *Usability* is another important game characteristic, and is “the extent to which a product can be used by specified users to achieve specified goals with effectiveness (Moreno-Ger et al. 2012, p2). *Enjoyment* is “the pleasurable aspects of the interaction described as being fun and enjoyable rather than boring” (Lowry et al. 2013, p622). The quality of the above characteristics is important to the Net generation who are visually oriented and technologically proficient (Walter 2013). Although games provide an enjoyable experience (Fu-Hsing Tsai et al. 2012), educational games have both a hedonic and a utilitarian purpose. Hedonic systems are systems that are purely for entertainment purposes and utilitarian systems are systems that are purely for productivity (Wu and Lu 2013). Since the utilitarian purpose of educational games is for knowledge transfer or learning (Chen et al. 2012; Jovanovic et al. 2011), the design of an educational game has to consider the design elements as well as the educational elements (Bellotti et al. 2013). The incorporation of educational theory in educational games will ensure that the effectiveness of the game is significant (Hwang et al. 2013).

Playing games in itself leads to learning (Sedano et al. 2013), however there are six characteristics listed by Norman (as cited in Pivec, 2007, p267) required for an effective game-based learning environment. These are the *goal orientation* of the game (Jovanovic et al. 2011), the instant *feedback* the game provides (Erhel and Jamet 2013), the *motivation* that the player has to complete the game (Liu et al. 2011a), the level of *challenge* that the game provides (Sedano et al. 2013), the level of *interactivity* that the game allows (Khanlarian and Singh 2014) and the level of *immersion* that the game creates (Eric Zhi Feng 2011). These characteristics are advantageous for the Net generation, as these type of students are typically goal-oriented, get bored easily, are curious, prefer exploration, possess a short attention span and demand real-time fast processing (Walter 2013).

Game Quality

Two attributes of game quality are playability and flow. *Playability* is determined by characteristics such as the game mechanics, the story, usability and game play (Sánchez et al. 2012, Desurvire and El-Nasr 2013, Desurvire et al. 2004). *Flow* refers to the “process of optimal experience” (Jin 2012, p169). An individual experiencing flow has self-direction in behaviour (motivation), a balance of challenge and skill (challenge), concentration

(immersion), perceived control (interactivity) and a perception that there are clear goals and feedback (Eric Zhi Feng 2011; Jin 2012). Jackson and Eklund (1996) provide a scale that is appropriate for the measurement of flow in games (Procci et al. 2012).

To summarise, the first antecedent to effectiveness is that there should be a fit between a game and the task it hopes to achieve based on the abilities of the user. The second antecedent to effectiveness is that the game should be high in quality. To achieve high quality, the game should be playable in terms of its rules, mechanics, story, usability and game play capabilities. Additionally, to ensure that games are useful for learning the game should have clear goals, provide feedback, be motivational, challenging, and interactive and cause immersion. The next section discusses the notion of effectiveness.

EFFECTIVENESS

As a point of departure, a number of researchers use the IS Success Model, by DeLone and McLean (1992) to measure effectiveness of systems (Khayun et al. 2012). The model is appropriate to a wide variety of contexts as it provides a synthesis of literature on the dimensions of system effectiveness. It identifies six major concepts associated with IS success, namely System Quality, Information Quality, Use, User Satisfaction, Individual Impact and Organisational Impact (Ramezan 2011). DeLone and McLean (2003) reviewed the 1992 framework and made three key modifications. The first was the addition of a concept named Service Quality. Secondly, the Use concept was complemented with an Intention to Use concept. Thirdly Individual Impact and Organisational Impact were replaced with the Net Benefit concept. These concepts from the updated model will be discussed as they relate to game-based learning.

System Quality takes cognisance of issues such as usability, availability, reliability, adaptability and response time of a system (DeLone and McLean 2003). In the context of game-based learning *Game Quality* is the equivalent concept of interest, and has been discussed in the previous section.

Information Quality is reflected by the precision, relevance, sufficiency, timeliness and currency of information (Brown and Jayakody, 2008; Rai et al., 2002). It is sometimes referred to as content quality in the e-commerce context (Brown and Jayakody; 2008; Molla and Licker, 2001). In game-based learning, the quality of information or content is important so as to ensure effective learning takes place, and hence should be a key consideration.

Service Quality relates to the support that a manufacturer, vendor or help desk may provide to the end user of an IS (DeLone and McLean 2003). Service quality is beyond the scope of this study and will therefore not be included in the model for game –based learning.

Perceived Usefulness has been included as an additional dimension in some modified IS success models (Brown and Jayakody, 2008; Rai et al., 2002). It is defined as the belief by a user that “using the system will improve his or her performance” (Lee and Lehto 2013, p194). For learners employing game-based learning tools, this belief is important to consider.

Satisfaction measures are used to evaluate the user experience with a system (De Oliveira et al. 2013). User experience is “a person’s perceptions and responses resulting from the use or anticipated use of a product” (Takatalo et al. 2011, p657). Satisfaction is not easy to measure due to the fact that it is a perception (Sánchez et al. 2012). The perception that a game provides a good user experience is important. Learning is more likely to occur if a user perceives a game as satisfactory. Satisfaction has a relationship with the use of a system in that they positively affect each other (Khayun et al. 2012).

Use of a system can be measured by the actual utilisation of the system or by the *Intention to Use* a system (DeLone and McLean 2003). Playing a game is a system use behaviour (Kuss et al. 2012), but in order for human beings to carry out a particular behaviour, they should intend on carrying out the behaviour (Park et al. 2009). The Use construct in this context will therefore measure the actual utilisation of a game, provided that the user intends to use the game.

Net Benefits are a balance of positive and negative impacts (Khayun et al. 2012). DeLone and McLean (2003) raise three questions that require an answer before using net benefits, which are: ‘What qualifies as a “benefit”?’ For whom? At what level of analysis?’ To answer the first question, since the impact of game-based learning environments is knowledge transference or learning, net benefits will measure the balance between the positive and negative impacts of educational games on knowledge transference or learning. To answer the second question, considering that the evaluation of multimedia should focus on the user (Hamam and Saddik 2013) and that games are multimedia technologies, the net benefits will be that of the user. To answer the third question, since the unit of analysis is the learner (D’ambra et al. 2013), the level of analysis will be at an individual level since the focus is on the user and learning environments that use technology are unique to each user (Khanlarian and Singh 2014). It is useful to use pre and post-tests where instructors can identify whether students improved their knowledge after the game experience (Blanco et al. 2012; Girard et al. 2013; Bellotti et al. 2013). A useful theory to measure pre and post test results for any size sample is the Rasch model (Vogel and Engelhard, 2011). The Rasch model is appropriate because the model takes into account the ability of the student and the difficulty of the task when estimating the difference in the pre and post test results (Bond and Fox 2006).

In summary, a game succeeds if its use meets the objectives of the user by having a fit between the task and the game characteristics based on the abilities of the user, being of high quality and the user is satisfied with the system. According to the literature these success factors are beneficial to the Net generation. Figure 1 provides a graphical representation of the evaluation conceptual framework that summarises the results of this paper.

The framework also illustrates relationships such as Game Quality as an antecedent to Use and Satisfaction (DeLone and McLean 2003). The quality of the game is an antecedent to Perceived Usefulness (Zhu et al. 2012). Information Quality is an antecedent to Perceived Usefulness (Rai et al., 2002). There is also a relationship between Flow and Satisfaction (Klein et al. 2010).

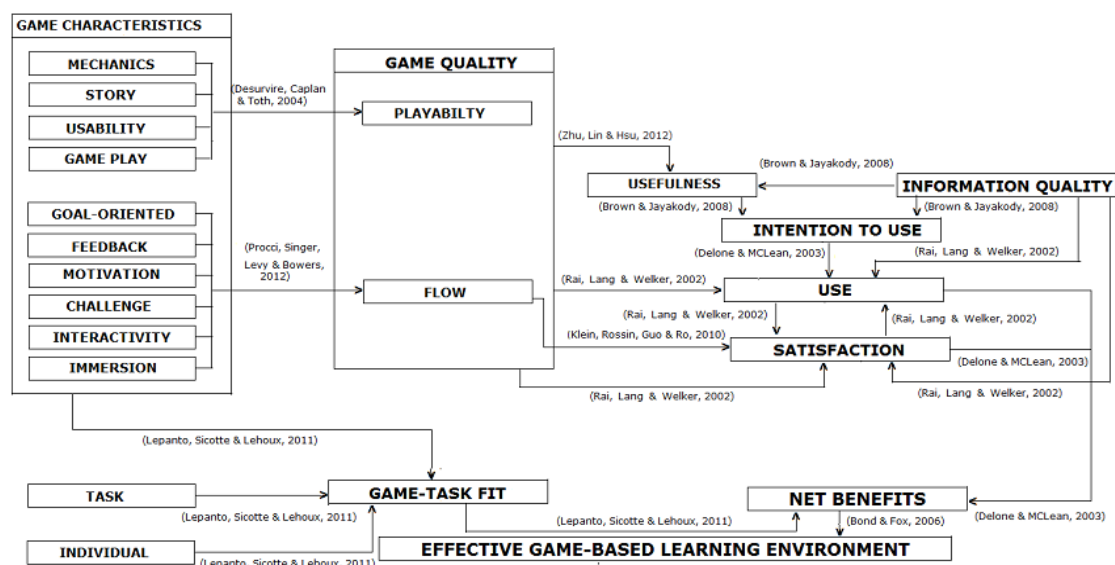


Figure 1: Conceptual Framework

CONCLUSION

The Net generation prefer gaming as a learning tool, but there is currently scarce research pertaining to the effectiveness of games as a learning tool - more specifically the antecedents to game-based learning effectiveness. Effectiveness is an important issue because it measures whether or not a game has successfully

taught a student the necessary concepts. This paper therefore investigates the antecedents to game based learning. The results of the literature review show that the first antecedent to effectiveness is Game-Task Fit. The second antecedent to effectiveness is Game Quality. Figure 1 contains the conceptual framework indicating all the relevant variables.

Future research will involve empirically testing the model through an appropriate approach. This will help educators in accepting the use of games in classrooms. The model will also provide educators with a tool to evaluate the appropriateness of games for teaching that will satisfy the needs of the Net generation. The model may also assist game designers in ensuring that salient elements are incorporated in educational games.

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