Does competition help learning? An exploratory study on competition, challenge, control, and self-efficacy in digital serious games

Research-in-Progress

Philip Tin Yun Lee
Faculty of Business and Economics
The University of Hong Kong
phil0127@hku.hk

Richard Wing Cheung Lui
Department of Computing
The Hong Kong Polytechnic University
cswclui@comp.polyu.edu.hk

Michael Chau
Faculty of Business and Economics
The University of Hong Kong
mchau@business.hku.hk

Abstract

Serious games have been commonly used in information technology education and training. Many of them are multi-player games. Competition can be intuitively associated with games. However, research results of the learning impact of competition are mixed. Challenge and control are two game attributes which are highly relevant to competition. With the use of a multi-player serious game, SEO War Online, this study aims to explore the relationships among perceived competition, perceived control, perceived challenge, and self-efficacy in a serious gaming environment. Particularly, it examines whether competition helps learning in a serious gaming environment and whether challenge and control are two major mechanisms through which competition generates learning effects. The study advances our understanding of whether and how competition derives self-efficacy. It contributes to expanding literature on selection of important game attributes. It helps game designers determine whether competition is an important game attributes through which game optimization can be achieved.

Keywords: Competition, Control, Challenge, Serious Games

Introduction

Serious games have been commonly used in Information Technology (IT) education and training. They were developed for learning different IT knowledge areas such as computer programming (e.g. Muratet et al., 2009; Kazimoglu et al., 2012), IT project management (e.g. Carlos et al., 2007; Chau et al., 2013; Lui et al., 2015), project development methodology (e.g. Fernandes & Sousa, 2010), and software engineering (e.g. Baker et al., 2005; Taran, 2007). Many of them are multi-player games.

Competition is an interactive attribute that can be intuitively associated with multi-player games. Some previous empirical studies have focused solely on how face-to-face competition improves learning outcomes (e.g. Chang et al., 2007; Wu et al., 2007). Competition through computer games is particularly interesting, given that it is different from face-to-face competition because of the mediation effect of digital interfaces (Prensky, 2003). Particularly, unlike face-to-face competition, competing through video games lacks eye contact, facial expressions and gestures among players.

No consensus has been reached among researchers on whether competition is conducive to learning. Some studies have supported that competition strengthened motivation (Yee, 2006; Muratet et al., 2009; Burguillo, 2010, Admiraal et al., 2011). However, Deci et al. (1981) showed that students have lower intrinsic motivation when they are required to compete against their counterparts on solving puzzles. Losing the games at last would reduce players' intrinsic motivation (Reeve & Deci, 1996). Van Eck and Dempsy's (2002) proposed that competition is good only when students do not perform at their maximum levels. Stapel and Koomen (2005) stated that competition exposes students to social comparison so that the students focus on their difference to their counterparts. Losing the game may therefore adversely affect students' confidence. Cheng et al. (2009) found that students who have low self-efficacy feel discouraged and frustrated in competitions against those who have stronger self-efficacy. Vandercruysse et al. (2013) proposed that the impact of competition in a gaming environment on students' learning and motivation depends on the students' perception of the environment. The students who consider themselves as playing the game in a gaming environment instead of a learning environment gain better learning experience during competition. Santhanam et al. (2016) showed that high competition among players reduces their self-efficacy.

The inconsistency among studies may be rooted in inadequate understanding how competition derives learning outcomes in the game-based learning environment (Song et al., 2013; Santhanam et al., 2016). Challenge and control are among the earliest established game attributes (Malone & Lepper, 1987). They are highly relevant to competition. Self-efficacy, on the other hand, is a critical learning outcome (Marcolin et al., 2000; Santhanam et al., 2016). Our study explores the inter-correlation among competition, perceived challenge, perceived control and self-efficacy. Our study aims to answer two research questions: (1) does competition lead to an increase in self-efficacy; and (2) do perceived challenge and perceived control mediate the relationship between competition and self-efficacy. In other words, we examine whether competition helps learning in a serious gaming environment and whether challenge and control are two major mechanisms through which competition generates learning effects. The study advances our understanding of whether and how competition derives an important learning outcome, namely self-efficacy. It contributes to the expanding literature on selection of important attributes of serious games. It helps game designers determine whether competition is an important game attributes through which game optimization can be achieved.

Theoretical Background and Hypothesis Development

Self-efficacy

Self-efficacy addresses people's confidence in their ability to master a task. A more precise definition is "people's beliefs in their capabilities to mobilize the motivation, cognitive resources, and courses of action needed to exercise control over events in their lives" (Bandura, 1989, p.1175). People who possess stronger self-efficacy of a task are more willing to spend time and efforts on that task (Bandura, 1989). Self-efficacy has been commonly used as an important learning outcome of serious games and also many other more traditional training programs (Marcolin et al., 2000; Li et al., 2013; Santhanam et al., 2016).

According to theories on achievement motivation, people develop their perception of competence with reference to the abilities and efforts of other members in a normative reference group (Nicholls, 1984). Game players recognize their own achievement through interpersonal interaction in games (Crawford, 1984). We expected that players develop their confidence in their ability through competition against others, and posit the first hypothesis:

H1: Competition has a positive direct effect on self-efficacy.

Challenge

Challenge is among the most important attributes of serious games (Sweetser & Wyeth, 2005). It refers to the appropriate level of challenge that matches players' skill. A number of researchers used the term *conflict/challenge* instead of *challenge* (e.g. Prensky, 2003; Pavlas et al., 2009; Wilson et al., 2009; Marlow et al., 2016). According to Crawford (1984), conflicts are the obstacles that players have to overcome in the game. The conflicts prompt interaction between players and the game. There are four kinds of conflicts, including direct, indirect, violent and non-violent. Crowford noted that the agent whom players have conflicts with can be an individual human or a computer simulated player.

More conflicts generate more interaction among players. The interaction "transforms the challenge of the game from a technical one to an interpersonal one" (Crowford, 1984, p. 12). More conflicts imply more intensive challenges in the game among competing players. Thus, we expected that competition is positively correlated with challenge. This leads to the second hypothesis:

H2: Competition has a positive direct effect on challenge.

According to flow theory (Csikszentmihalyi, 1975), people can gain the optimal experience of activities if their skills match the level of task difficulty. An activity that is too easy or too hard cannot generate much intrinsic interest. In the context of serious games, perceived challenge enhances intrinsic motivation to learn. An optimal level of challenge is the amount of challenge that stimulates people to gain the greatest intrinsic motivation (Malone & Lepper, 1987). The appropriate level of difficulty generates motivating pressure for learning (Driskell & Dwyer, 1984). Self-efficacy is a commonly used construct to measure motivation to learn (Bandura, 1991).This theoretical background leads to the following hypothesis:

H3: Challenge has a positive direct effect on self-efficacy.

We further hypothesized that challenge is one of the mechanisms through which competition generate learning effects but not the only mechanism. We therefore posit that:

H4: The effect of competition on self-efficacy is partially mediated by challenge (both mediated effect and direct effect exist).

Control

Control has been considered as an elementary feature of a serious game (Malone, 1981; Kiili, 2005; Sweetser & Wyeth, 2005). It is a sense of control over players' actions in the game (Sweestser & Wyeth, 2005). Garris (2002, p.451) referred control to "the excise of authority or the ability to regulate, direct, or command something". According to Malone and Lepper (1987), control means the degrees that outcomes of the game depend on players' action, that choices of action in the game are large, and that the outcomes are apparent and salient. Several researchers proposed that control is an interactive attribute of games (Vogel et al., 2006; Marlow et al., 2016). Prensky (2003) identified the difference in social interaction and equipment interaction. At first glance, control is more of equipment interaction in Prensky's viewpoint. However, when it comes to competition against virtual players in the games, the line between the two kinds of interaction becomes blurred. Particularly, these virtual players, according to Crowford (1984), can generate conflicts against real players. Langer (1975) suggested that competition can lead to a perception of skill situation. People perceive an illusion of control, since they think that they can affect the situation by their skills. The actual situation, however, can be a chance situation in which people's actions have no effect on final outcomes. We predicted that players perceive a sense of control during competition, regardless of competing against real players or virtual players. We therefore posit the following hypothesis:

H5: Competition has a positive direct effect on control.

Literatures from various research areas have considered the desire for control as a human basic need (Fiske & Dépret, 1996). According to Csikszentmihalyi's (1996) flow theory, people gain a sense of control over actions through the optimal experience of an activity. Empirical findings also suggested that a greater sense of control leads to better game experience (Kim et al., 2015). Particularly, the sense of control is crucial for military simulation serious games (Fong, 2006). In the context of serious games, better gaming experience leads to better learning outcomes. In addition, power and control are two closely related constructs in the psychology literature. More control can generate the feeling of being in power (Dépret & Fiske, 1993). In other words, people who have more sense of control perceive stronger competence. This theoretical background leads to the following hypotheses:

H6: Control has a positive direct effect on self-efficacy.

Furthermore, we hypothesized that control is another major mechanism through which competition generates learning effects. However, we predict that control and challenge are not the only two mechanisms. Competition may have its own influence on self-efficacy which is not generated through these two major mechanisms. Competition is expected to have its direct effect on self-efficacy. Hence, we posit that:

H7: The effect of competition on self-efficacy is partially mediated by control (both mediated effect and direct effect exist).

Figure 1 shows the research model of our study:

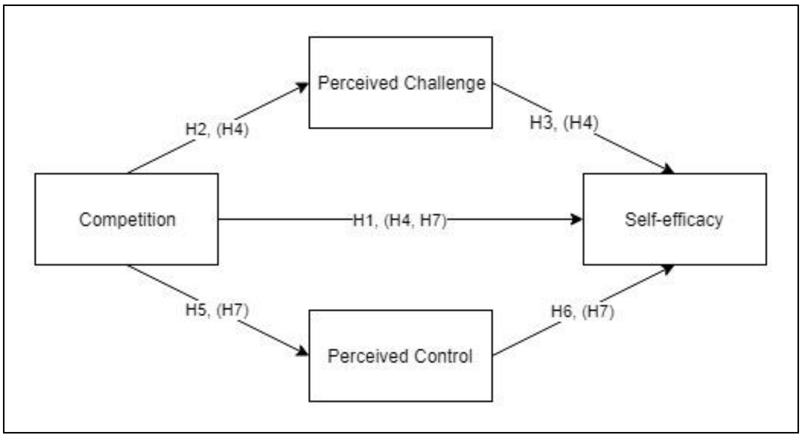

Figure 1: Research Model

Methods

Game Overview

SEO War Online is a multi-player serious game that is used for learning search engine optimization knowledge. The game is a digitalized version of the face-to-face board game SEO War. Figure 2 shows the main board and some cards of SEO War. More details of SEO War are shown in (Lui & Au, 2018). In the game, players act as a digital marketing manager in four different universities respectively. They have to compete against each other in the game to promote their universities through online marketing campaigns with the use of their search engine optimization knowledge.

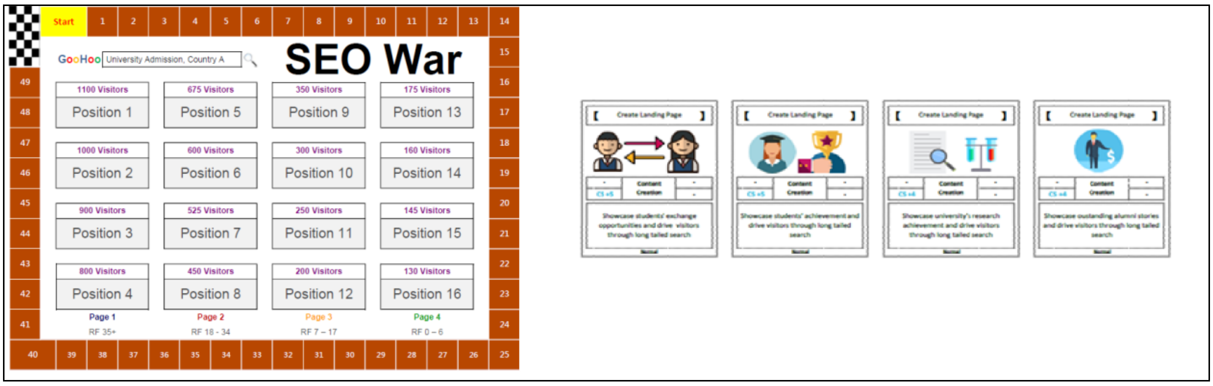

Figure 2: Main Board and Cards of SEO War

Experiment

University students who take a computer science course will be recruited to participate in the study. They will play the serious game, SEO War Online, during their lecture hours. During the lecture, the instructors will first introduce background information of the game and briefly demonstrate how to play the game. The students will subsequently play the game in groups of four. Immediately after the game, the students will be required to fill in online questionnaires. They will be informed that their responses would be used for research purposes. The questionnaires were designed on the basis of questions from several relevant studies including Hsu et al. (2009), Tan et al. (2013) and Hamari et al. (2016). The responses are collected using a 5-point Likert scale (i.e., Strongly Agree, Slightly Agree, Neutral, Slightly Disagree, and Strongly Disagree). Some of the main questions to measure the constructs in the research model are shown in Table 1. These questions have been validated before by tests of convergent validity and discriminant validity in a pilot study using SEO War. The pilot study was conducted similarly as the aforementioned procedures.

The experiment, nonetheless, involves limitations. First, given that the game requires some basic knowledge in search engine optimization, only computer science students are recruited. Second, all data collected are self-reported.

Table 1. Main Survey Questions

Constructs	Questions	Constructs	Questions
Competition (IC1)	I competed with other game players during the game.	Perceived Control (AC1)	I can control my status and performance in the game
Competition (IC2)	I enjoyed competing with other players.	Perceived Control (AC2)	I can play the game using various strategies
Competition (IC3)	The game facilitates me to compete with other players.	Perceived Control (AC3)	I felt I influenced other players in the game.
Perceived Challenge (C1)	The game provides an appropriate test of my skills.	Self-efficacy (S1)	I am more confident in SEO knowledge.
Perceived Challenge (C2)	The game challenges me to perform to the best of my ability.	Self-efficacy (S2)	I am more confident in learning social media and its applications.
Perceived Challenge (C3)	When playing the game, I experienced the level of challenge that matches my skill level.		

Data Analysis

The PLS-SEM (partial least squares structural equation modeling) approach will be used to analyze the data. We choose PLS-SEM because: (1) the size of our data set is not large, and (2) our model is prediction-oriented. These reasons align with Wong’s (2013) conditions for adopting PLS-SEM. We use the analytic tool SmartPLS 2.0 M3 (Ringle et al., 2005) for our analysis. Three criteria, including sample size, convergent validity, and discriminant validity, will be checked to justify the adoption of PLS-SEM.

For a typical research study that has a 5% significant level, a 80% statistical power and more than 0.25 R^2 value, according to Wong (2013), the minimum sample size for a research model which has no more than 3 arrows pointing to any latent variables is 59. Chin (1998) proposed that the sample size requirement should be at least 10 times larger than the block that possesses the largest number of formative indicators, and also at least 10 times larger than the construct that has the most constructs influencing it. Based on Chin’s suggestion, the minimum sample size is 30 in our case. Average variance extracted (AVE) and composite reliability (CR) will be used to verify the convergent validity. AVE of each construct should be larger than 0.5 (Fornell & Larcker, 1981). Composite reliability (CR) should be greater than 0.7, unless the study is exploratory in nature (Bagozzi & Yi, 1988; Wong, 2013). We will follow Chin’s (2010) recommendations to verify the discriminant validity. First, the loadings for each item should be larger on its own construct than its cross-loadings on other unintended constructs. Also, each construct should not have higher variance with other unintended items than its own items. In addition, the square root of the AVE of each construct should also be greater than the correlation of the construct to other remaining constructs (Fornell & Larcker, 1981).

Ongoing Work

We expected to demonstrate two major mechanisms through which competition significantly leads to an increase in self-efficacy in a serious gaming environment. One is through challenge, and another is through control. The relationship between competition and self-efficacy is expected to be strongly and significantly mediated by perceived challenge and perceived control. The players will feel a sense of control through competition against others. They will also consider competition as an interpersonal challenge. In addition, competition is expected to have a strong total effect on self-efficacy in the serious gaming environment. This will demonstrate the significance of competition in deriving learning outcomes.

Moreover, we predicted that the learning effect of competition is partially, but not totally, mediated by perceived challenge and perceived control. The direct effect of competition on self-efficacy is expected to be strong and significant. This will support that competition is an important game attribute to which game designers should pay attention. The learning effects of competition are not simply a combined effect of challenge and control. Game designers can optimize the level of competition among players to optimize their serious gaming experience. However, if the direct effect of competition on self-efficacy is not significant, that competition is a critical game attribute for consideration of game designers will not be supported in our study. In such case, game designers might optimize the levels of challenge and control instead for the best serious gaming experience.

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