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How Does Competition Help Future Learning in Serious Games? An Exploratory Study in Learning Search Engine Optimization

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ABSTRACT

Serious games, many of which are multi-player games, have been commonly used in information technology education and training. Competition can be intuitively associated with games; however, it is not always considered as a necessary attribute of serious games. Particularly, the learning impact results of competition are mixed. Challenge and control are two game attributes that are highly relevant to competition. With the use of a multi-player serious game, SEO War, this study aims to explore the relationships among competition, perceived control, perceived challenge, and self-efficacy in a game-based learning environment. Particularly, it investigates whether competition leads to self-efficacy. It also examines whether perceived challenge and perceived control mediate the relationship between competition and self-efficacy in serious games. This study contributes to the expanding literature on selecting important attributes for serious games, and it advances our understanding of the mechanism of how competition leads to self-efficacy. Moreover, it will help game designers decide on important game attributes through which games can be enhanced.

Keywords: Competition, Perceived control, Perceived challenge, Game-based learning

1. INTRODUCTION

Serious games have been commonly used in information technology (IT) education and training. They were developed for learning about different IT knowledge areas, such as computer programming (e.g., Muratet et al., 2009; Kazimoglu et al., 2012), IT project management (e.g., Carlos and Awad-Aubad, 2007; Chau et al., 2013; Lui, Lee, and Ng, 2015), project development methodology (e.g., Fernandes and Sousa, 2010), and software engineering (e.g., Baker, Navarro, and Van Der Hoek, 2005; Taran, 2007). Many of them are multi-player games. Several papers reviewing these serious games have also been published in recent years (Boyle et al., 2016; Baptista and Oliveira, 2018; Calderón, Ruiz, and O'Connor, 2018).

Competition is an interactive attribute that can be intuitively associated with games. However, not all scholars consider competition as an indispensable game attribute that leads to learning outcomes. Garris, Ahlers, and Driskell (2002) reviewed previous literature on games and proposed six essential game features leading to learning outcomes: fantasy, rules/goals, sensory stimuli, challenge, mystery, and control. Competition was not included. Wilson et al. (2009) expanded the list to 18 game attributes. The most comparable to competition seem to be interaction (interpersonal) and interaction (social). Interaction (interpersonal) refers to face-to-face interaction among players (Crawford, 1984), whereas interaction (social) means the interaction mediated by technology (Prensky, 2003). Competition was not explicitly mentioned in either list of attributes. One reason for not including competition may be the inconsistency among studies on the effect of competition on the learning experience.

No consensus has been reached among researchers on whether competition is conducive to learning. Some studies have supported that competition strengthens motivation (Yee, 2006; Muratet et al., 2009; Burguillo, 2010; Admiraal et al., 2011; Cagiltay, Ozcelik, and Ozcelik, 2015; Sepehr and Head, 2018). However, Deci et al. (1981) showed that students have lower intrinsic motivation when they are required to compete against their counterparts at solving puzzles. Losing the games at the end would reduce players' intrinsic motivation (Reeve and Deci, 1996). Van Eck and Dempsey (2002) proposed that competition is good only when students do not perform at their maximum potential. Stapel and Koomen (2005) stated that competition can help expose students to social comparison so that they focus on their differences from their counterparts. Losing the game can 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 their perception of the environment. Students who consider themselves to be playing the game in a gaming environment instead of a learning environment gain better learning experience during competition. Santhanam, Liu, and Shen (2016) showed that high competition among players reduces their self-efficacy.

The inconsistency among studies may be rooted in an inadequate understanding of how competition derives learning outcomes in the game-based learning environment (Song et al., 2013; Santhanam, Liu, and Shen, 2016). Challenge and control are among the earliest established game attributes (Malone and Lepper, 1987), and they are highly relevant to competition. Our study explores the intercorrelation 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? The study contributes to the expanding literature on selecting important attributes for serious games. It advances our understanding of the mechanism whereby competition leads to self-efficacy. Moreover, it will help game designers decide on important game attributes, whereby game enhancements can be made.

2. THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

2.1 Self-efficacy

Self-efficacy refers to 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. 1,175). People who possess stronger self-efficacy for a task are more willing to spend time and effort on that task (Bandura, 1989). Self-efficacy helps predict learners' future behavior. It has been commonly used as a measure to indicate the success of serious games as well as other more traditional training programs (Marcolin et al., 2000; Santhanam, Liu, and Shen, 2016).

According to theories on achievement motivation, people develop their perceptions 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 expect that players might develop confidence in their ability through competition against others and posit the first hypothesis:

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

2.2 Challenge

Challenge is among the most important attributes of serious games (Sweetser and Wyeth, 2005). It refers to the appropriate level of difficulty that matches players' skill. A number of researchers have 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 appropriate obstacles that players have to overcome in the game. They prompt interaction between players and the game. There are four kinds of conflicts: direct, indirect, violent, and non-violent. Crawford noted that the agent with whom players have conflicts can be a human individual 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" (Crawford, 1984, p. 12). The variety of conflicts, e.g., interpersonal competition among players, perhaps facilitates the matching between the level of difficulty and the players' skill. Thus, competition should be positively correlated with challenge (Sepehr and Head, 2018). This leads to the second hypothesis:

H2: Competition has a positive direct effect on challenge.

According to flow model theory (Csikszentmihalyi, 1975), people can gain the optimal experience of an activity if their skills match the task's level of 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 and Lepper, 1987). The appropriate level of difficulty generates motivating pressure for learning (Driskell and Dwyer, 1984). Self-efficacy is a commonly used construct to predict motivation to learn (Bandura, 1991). This theoretical background leads to the following hypotheses:

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

H4: The effect of competition on self-efficacy is partially mediated by challenge.

2.3 Control

Control has been considered as an elementary feature of a serious game (Malone, 1981; Kiili, 2005; Sweetser and Wyeth, 2005). It is players' sense of control over their own actions in the game (Sweestser and Wyeth, 2005). Garris et al. (2002, p. 451) referred to control as "the exercise of authority or the ability to regulate, direct, or command something." According to Malone and Lepper (1987), control means the degrees to which the game's outcomes depend on players' actions, the choices of action in the game are numerous, and the outcomes are apparent and salient. Several researchers have proposed that control is an interactive attribute of games (Vogel et al., 2006; Marlow et al., 2016). Prensky (2003) identified the difference between social interaction and equipment interaction. At first glance, control is more of an equipment interaction in Prensky's view. However, when it comes to competition against virtual players in the games, the line between the two kinds of interaction becomes blurred. 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 a situation through their skills. The actual situation, however, can be a chance situation in which people's actions have no effect on final outcomes. We therefore posit the following hypothesis:

H5: Competition has a positive direct effect on control.

Literature from various research areas has considered the desire for control as a human basic need (Fiske and Dépret, 1996). According to Csikszentmihalyi's (1996) flow theory, people gain a sense of control over actions through the optimal experience of an activity. The sense of control is especially crucial for military simulation serious games (Fong, 2006). Empirical findings have also suggested that a greater sense of control leads to a better game experience (Kim et al., 2015). 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 and Fiske, 1993). In other words, people who have a greater sense of control perceive themselves as more competent. This theoretical background leads to the research model (Figure 1) and hypotheses:

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

H7: The effect of competition on self-efficacy is partially mediated by control.

3. METHODS

3.1 Game Overview

SEO War is a multi-player serious game that is used for learning search engine optimization knowledge. It is a face-to-face board game. In the game, players act as digital marketing managers at four different universities. 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. Figures 2 and 3 show the main board and some game cards of SEO War. The player with the highest number of student admissions after six rounds wins the game. The game cards represent different SEO tactics commonly adopted by different websites. The players should use the cards of on-page optimization as well as off-page optimization to increase the number of website visitors. They should also use the cards to create unique content to attract backlinks to their websites. Furthermore, in order to increase student admissions, the players can use the cards of conversion optimization to improve the conversion rate of the websites. More details of SEO War are shown in Lui and Au (2018).

3.2 The Exploratory Study

Around 70 university students who were enrolled in a computer science course participated in the study. They played the serious game, SEO War, during their lecture hours. During the lecture, the instructors first introduced background information on the game and briefly demonstrated how to play the game. The students subsequently played the game in groups of four. Immediately after the game, the students completed online questionnaires. They were informed that their responses would be used for research purposes and

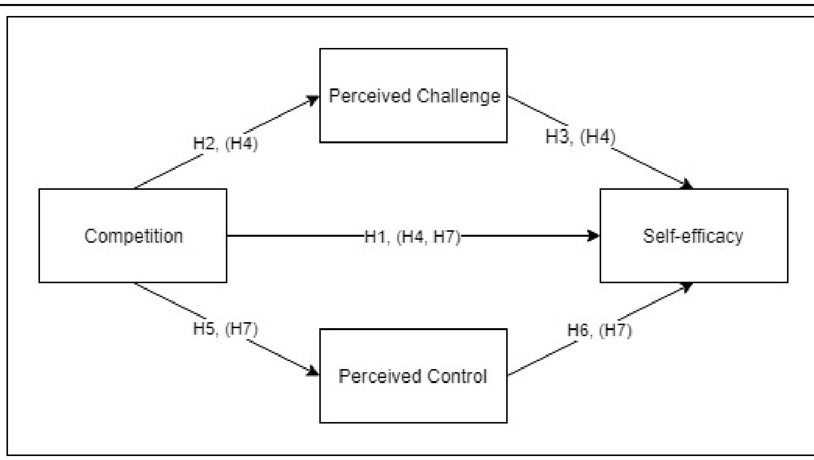

Figure 1. Research Model

Figure 2. Main Board of SEO War

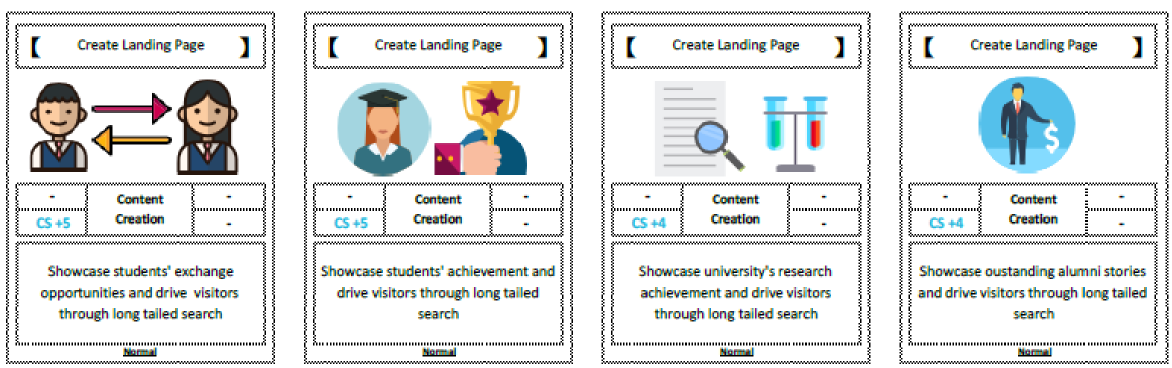

Figure 3. Cards of SEO War

would be anonymized. The questionnaires were designed based on questions from several relevant studies, including Hsu et al. (2009), Tan et al. (2013), and Hamari et al. (2016). The responses were collected using a five-point Likert scale (i.e., strongly agree, slightly agree, neutral, slightly disagree, and strongly disagree). The questions are shown in Appendix A. A total of 69 students successfully completed the questionnaires.

4. DATA ANALYSIS AND RESULTS

4.1 Analysis

The PLS-SEM (partial least squares structural equation modeling) approach was used to conduct a mediation analysis of the data (Nitzl, Roldan, and Cepeda, 2016; Hair et al., 201). We chose PLS-SEM because (1) the size of our dataset is small, (2) our model is prediction-oriented, and (3) our research focus is not to seek for the best model among the constructs. These reasons align with Wong's (2013) conditions for adopting PLS-SEM. We used the analytic tool SmartPLS 2.0 M3 (Ringle, Wende, and Will, 2005) for our analysis.

	AVE	Sqrt(AVE)	Correlation among Constructs			
			Competition	Perceived Challenge	Perceived Control	Self-efficacy
Competition	0.7794	0.8828	1.0000			
Perceived Challenge	0.8009	0.8949	0.4635	1.0000		
Perceived Control	0.6650	0.8155	0.6203	0.6993	1.0000	
Self-efficacy	0.9212	0.9598	0.5583	0.6407	0.7384	1.0000

Table 1. Details of the Average Variance Extracted, Square of the AVE, and Correlation among the Constructs

	CR
Competition	0.9137
Perceived Challenge	0.9234
Perceived Control	0.8559
Self-efficacy	0.9590

Table 2. Details of the Composite Reliability of the Constructs

	Competition	Perceived Challenge	Perceived Control	Self-efficacy
Competition (IC1)	**0.9226**	0.4341	0.5557	0.5158
Competition (IC2)	**0.8520**	0.3717	0.5173	0.4528
Competition (IC3)	**0.8724**	0.4188	0.5680	0.5070
Perceived Challenge (C1)	0.4140	**0.8768**	0.6507	0.6016
Perceived Challenge (C2)	0.4177	**0.8984**	0.6406	0.5560
Perceived Challenge (C3)	0.4122	**0.9092**	0.5841	0.5602
Perceived Control (AC1)	0.5506	0.6170	**0.8693**	0.6029
Perceived Control (AC2)	0.4605	0.6023	**0.7984**	0.5930
Perceived Control (AC3)	0.5025	0.4913	**0.7757**	0.6098
Self-efficacy (S1)	0.5550	0.6641	0.7207	**0.9628**
Self-efficacy (S2)	0.5154	0.5621	0.6960	**0.9567**

Table 3. Details of the Loadings and Cross-Loadings for the Items

Three criteria – sample size, convergent validity, and discriminant validity – were checked to justify the adoption of PLS-SEM. For a typical research study that has a 5% significance level, a statistical power of 80% and an R^2 value of more than 0.25, according to Wong (2013), the minimum sample size is 59 for a research model that has no more than three arrows pointing to any latent variables. Chin (1998) proposed that the required sample size should be at least 10 times larger than the block that possesses the largest number of formative indicators and 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. Our dataset is larger than both recommended requirements.

Average variance extracted (AVE) and composite reliability (CR) were used to verify the convergent validity. The AVE of each construct should be larger than 0.5 (Fornell and Larcker, 1981). Composite reliability (CR) should be greater than 0.7, unless the study is exploratory in nature (Bagozzi and Yi, 1988; Wong, 2013). Tables 1 and 2 show that our dataset fulfills these requirements.

We followed 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 with its own items. Table 3 shows that our dataset fulfills Chin's recommendations. In addition, the square root of the AVE of each construct should also be greater than the correlation of the construct with the other remaining constructs (Fornell and Larcker, 1981). Table 1 shows that our data are in line with these requirements.

Table 4 shows the *t*-statistics of the *outer* loadings. All the *t*-statistics are larger than 2.58. The outer model loadings are significant at $p = 0.01$.

4.2 Results

The results show that competition accounted for 21.5% of the variance of perceived challenge and 38.5% of the variance of perceived control. Competition, together with perceived challenge and perceived control, contributed to 59.0% of the variance of self-efficacy (see Table 5). The variance is slightly lower than the substantial level (67%) and much larger than the moderate level (33%) proposed by Chin (1998). It shows that the structural fit of the proposed model is reasonably good.

	Competition	Perceived Challenge	Perceived Control	Self-efficacy
Competition (IC1)	**12.0191**			
Competition (IC2)	**11.9881**			
Competition (IC3)	**13.4802**			
Perceived Challenge (C1)		**10.8791**		
Perceived Challenge (C2)		**10.8318**		
Perceived Challenge (C3)		**9.6448**		
Perceived Control (AC1)			**12.9837**	
Perceived Control (AC2)			**11.3026**	
Perceived Control (AC3)			**9.8322**	
Self-efficacy (S1)				**28.6445**
Self-efficacy (S2)				**31.9344**

Table 4. The *t*-Statistics of the Outer Loading

	R^2
Perceived Challenge	0.2148
Perceived Control	0.3848
Self-efficacy	0.5896

Table 5. Details of the Coefficients of Determination of the Dependent Variables

Path	Direct Effect	*t*-statistics	Total Effect	*t*-statistics
Competition → Self-efficacy	0.1517	1.5572*	0.5583	6.2261***
Competition → Perceived Challenge	0.4635	3.8867***	N/A	N/A
Competition → Perceived Control	0.6203	7.8631***	N/A	N/A
Perceived Challenge → Self-efficacy	0.2345	2.4198***	N/A	N/A
Perceived Control → Self-efficacy	0.4803	3.7817***	N/A	N/A
* = p < 0.1, ** = p < 0.05, *** = p < 0.01				

Table 6. The Path Coefficients and the *t*-Statistics of the Direct Effect and the Total Effect

Table 6 presents the direct and total effects on self-efficacy with a bootstrapping sample size of 5,000. The total effect of competition means the sum of the direct effect and the indirect effect of competition to self-efficacy. It is equivalent to the direct effect of competition on self-efficacy without the mediators, i.e. perceived challenge and perceived control (Barron and Kenny, 1986; Wong, 2016; Hair et al., 2017). It is equal to the results of the first stage of the two-step approach (Becker, Klein, and Wetzels, 2012). All path coefficients are significant at $p < 0.01$ except the path coefficient between competition and self-efficacy. Thus, H2, H3, H5, and H6 are supported. The path coefficient between competition and self-efficacy is significant only at $p < 0.1$, and its value is 0.152, which is rather small. Still, we can consider that H1 is marginally supported. Given that both a mediated effect and a direct effect of competition on self-efficacy exist, H4 and H7 are also supported.

5. DISCUSSION

Our study aimed to explore the interrelationships among competition, perceived challenge, perceived control, and self-efficacy in the environment of a serious game. The results show that competition significantly influences perceived challenge and perceived control. The players felt a sense of control through competition against others. They concurrently considered competition as an interpersonal challenge.

In addition, competition has a strong total effect on self-efficacy in the game-based learning environment. However, the direct effect of competition on self-efficacy is largely mediated by perceived challenge and perceived control. The direct effect on self-efficacy is weak and only marginally significant. The size and significance of the direct effect do not justify competition as a fundamental dimension of a serious game, particularly when it is compared to perceived control and perceived challenge. Our results respond to Vorderer, Hartmann, and Klimmt's (2003) conjecture that competition's effect on enjoyment in leisure games is mediated by Malone's (1981) game attributes, namely, challenge, control, and fantasy. We have identified two main mechanisms (i.e., perceived challenge and perceived control) through which competition leads to self-efficacy, an important indicator of future willingness to spend time and effort on the academic subject (Bandura, 1989). A better understanding of the mechanisms will help us resolve the inconsistency among studies on competition (Song et al., 2013; Santhanam, Liu, and Shen, 2016). Inadequate understanding of the mechanisms may be a reason for the inconsistency among studies on competition.

Santhanam, Liu, and Shen (2016) showed that only players' engagement increases with competition in a gamified training environment. In their studies, players' self-efficacy decreased when competition was high. They argued that the difference in competitive structure is a possible reason for the inconsistent findings among studies on whether competition leads to learning outcomes. Based on our results, we propose that competition may not be a good focal point on which to examine a serious game. Rather, perceived challenge and perceived control are better evaluation dimensions of serious games, given their significant direct effects on self-efficacy.

The results show that both perceived challenge and perceived control have positive effects on self-efficacy. This aligns with the relevant theories and the empirical findings (Csikszentmihalyi, 1975; Dépret and Fiske, 1993; Csikszentmihalyi, 1996; Kim et al., 2015). The direct effect of competition on perceived control is slightly larger than that on perceived challenge. That is, the players related competition to perceived control more than to perceived challenge. The results lean toward the view that competition leads to social comparison and are complementary to the conclusions of Stapel and Koomen (2005), Cheng et al. (2009), and Song et al. (2013). On the other hand, our results are not contradictory to Van Eck and Dempsy's (2002) view that competition causes players to judge the difference between the task's difficulty and their own abilities. However, this effect is less than that which leads to social comparison in our study.

Players with comparable game skills should be put into the same group so they can achieve better self-efficacy. The conflicts in the game can then concurrently match the similar game skills of the players. In practice, however, it is sometimes difficult to ensure that players in the same group have comparable game skills. For example, teachers may not have the opportunity to recognize their students' academic proficiency from previous teaching or survey the students' game experience and familiarity in advance of the gameplay. Under this circumstance, some students will inevitably be deprived of perceived challenge.

Putting more effort into game design, especially into the game actions, can help compensate for the grouping problem in practice in order to achieve the full potential of serious games. Game designers should develop serious games that provide players with a multitude of game actions. These game actions are not limited to those that affect other players' game performance. Customization of in-game characters, for example, can also increase perceived control (Kim et al., 2015). Players can gain a sense of control through these game actions. The number and the diversity of game actions facilitate the development of self-efficacy.

6. LIMITATIONS AND FUTURE STUDIES

Several directions for future studies have been identified. Our current study is limited to face-to-face competition, and therefore we did not encounter the mediation effect of digital interfaces on relationships among players mentioned by Prensky (2003). Some empirical studies have focused particularly on how face-to-face competition improves learning outcomes (e.g., Chang et al., 2007; Wu et al., 2007). Future studies can expand the current scope of research by including the mediation effect of digital interfaces. The mediated environment limits the impacts of facial expressions, verbal cues, and body language. If only the board and the cards are digitalized, then the learning effects of the game will be limited. Communication features should be added for player interaction in order to achieve similar learning effects to those of face-to-face serious games. A good digital serious game should also include game features (e.g., leaderboards, badges) and channels (e.g., chat rooms) through which players can interact with other players.

The current study investigated competition among real people. Competition between real players and virtual, simulated players had not been examined. Crawford (1984) defined both kinds of competition as conflicts that prompt interaction. Williams and Clippinger (2002) showed that players feel stronger aggression after competing against the computer than after competing against a stranger face-to-face. However, Anderson and Carnagey (2009) found contradictory results. Future studies can investigate how players perceive these two kinds of competition differently and the difference in their perception between a real and a virtual gaming environment.

In addition, there are other interactive attributes beside competition, e.g., collaboration and cooperation. Future research can focus on how these different kinds of interaction lead to an improvement in learning outcomes. Different modes of play can also be examined. Muratet et al. (2009) used the individual mode against the computer and the multiplayer mode against friends to demonstrate the effectiveness of real-time strategy, a popular game genre. They argued that the individual mode can improve players' skills, whereas the multiplayer mode can encourage players to tackle new challenges. Moreover, the perception of the interaction may also matter. Vandercruysse et al. (2013) proposed that the perception of the game environment may impact the effect of competition on learning outcomes. It is perhaps not the nature of the game interactivity among players but how the players perceive the interactivity that matters. The interaction among players in the game can be a mix of various interactive attributes.

Lastly, we did not explore the best model for competition, perceived challenge, perceived control, and learning outcomes. The study is prediction-oriented as it focuses mainly on the two research questions, i.e. whether competition lead to better learning outcomes, and whether perceived challenge and perceived control mediate the relationship between competition and learning outcomes. Future studies may seek for the most appropriate model for these constructs.

7. CONCLUSION

Our study shows that competition significantly leads to an increase in self-efficacy. The relationship between competition and self-efficacy, however, is strongly mediated by perceived challenge and perceived control. Therefore, competition may not be a good dimension on which to evaluate the learning impacts of serious games. Game designers and education practitioners should focus more on enhancing the challenge and control provided in serious games to improve learners' experiences.

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9. REFERENCES

Admiraal, W., Huizenga, J., Akkerman, S., & Ten Dam, G. (2011). The Concept of Flow in Collaborative Game-Based Learning. *Computers in Human Behavior*, 27(3), 1,185–1,194.

Anderson, C. A. & Carnagey, N. L. (2009). Causal Effects of Violent Sports Video Games on Aggression: Is it Competitiveness or Violent Content? *Journal of Experimental Social Psychology*, *45*(4), 731-739.

Bagozzi, R. P. & Yi, Y. (1988). On the Evaluation of Structural Equation Models. *Journal of the Academy of Marketing Science*, 16(1), 74–94.

Baker, A., Navarro, E. O., & Van Der Hoek, A. (2005). An Experimental Card Game for Teaching Software Engineering Processes. *Journal of Systems and Software*, 75(1–2), 3–16.

Bandura, A. (1989). Human Agency in Social Cognitive Theory. *American Psychologist*, 44(9), 1,175–1,184.

Bandura, A. (1991). Human Agency: The Rhetoric and the Reality. *American Psychologist*, 46(2), 157–162.

Baptista, G. & Oliveira, T. (2018). Gamification and Serious Games: A Literature Meta-Analysis and Integrative Model. *Computers in Human Behavior*, 92, 306–315.

Baron, R. M. & Kenny, D. A. (1986). The Moderator–Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality and Social Psychology*, 51(6), 1173–1182.

Becker, J. M., Klein, K., & Wetzels, M. (2012). Hierarchical Latent Variable Models in PLS-SEM: Guidelines for using Reflective-Formative Type Models. *Long Range Planning*, 45(5-6), 359–394.

Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Pereira, J., & Riberio, C. (2016). An Update to the Systematic Literature Review of Empirical Evidence of the Impacts and Outcomes of Computer Games and Serious Games. *Computers & Education*, *94*, 178–192.

Burguillo, J. C. (2010). Using Game Theory and Competition-Based Learning to Stimulate Student Motivation and Performance. *Computers & Education*, 55(2), 566–575.

Cagiltay, N. E., Ozcelik, E., & Ozcelik, N. S. (2015). The Effect of Competition on Learning in Games. *Computers & Education*, *87*, 35–41.

Calderón, A., Ruiz, M., & O'Connor, R. V. (2018). A Multivocal Literature Review on Serious Games for Software Process Standards Education. *Computer Standards & Interfaces*, *57*, 36–48.

Carlos, M. Z. J. & Awad-Aubad, G. (2007). Requirements Game: Teaching Software Project Management. *CLEI Electronic Journal*, 10(1), 3–14.

Chang, S. B., Deng, Y. C., Cheng, H. N., Liao, H. C., Yu, F. Y., & Chan, T. W. (2007). Implementation and Evaluation of EduBingo for Arithmetic Drill. In T. W. Chen (ed.), *The First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning* (pp. 99–103). Jhongli City, Taiwan: IEEE.

Chau, M., Wong, A., Wang, M., Lai, S., Chan, K. W. Y., Li, T. M. H., Chu, D., Chan, I. K. W., & Sung, W. K. (2013). Using 3D Virtual Environments to Facilitate Students in Constructivist Learning. *Decision Support Systems*, 56, 115–121.

Cheng, H. N., Wu, W. M., Liao, C. C., & Chan, T. W. (2009). Equal Opportunity Tactic: Redesigning and Applying Competition Games in Classrooms. *Computers & Education*, 53(3), 866–876.

Chin, W. W. (1998). The Partial Least Squares Approach to Structural Equation Modeling. In G. A. Marcoulides (ed.), *Modern Methods for Business Research* (pp. 295–336). New York: Psychology Press.

Chin, W. W. (2010). How to Write Up and Report PLS Analyses. In V. E. Vinzi, W. W. Chin, J. Henseler, & H. Wang (eds), *Handbook of Partial Least Squares* (pp. 655–690). Berlin and Heidelberg: Springer.

Crawford, C. (1984). *The Art of Computer Game Design*. New York: McGraw-Hill Osborne Media.

Csikszentmihalyi, M. (1975). *Beyond Boredom and Anxiety*. San Francisco: Jossey-Bass.

Csikszentmihalyi, M. (1996). *Flow and the Psychology of Discovery and Invention*. New York: Harper Collins.

Deci, E. L., Betley, G., Kahle, J., Abrams, L., & Porac, J. (1981). When Trying to Win: Competition and Intrinsic Motivation. *Personality and Social Psychology Bulletin*, 7(1), 79–83.

Dépret, E. & Fiske, S. T. (1993). Social Cognition and Power: Some Cognitive Consequences of Social Structure as a Source of Control Deprivation. In G. Weary, F. Gleicher, & K. L. Marsh (eds.), *Control Motivation and Social Cognition* (pp. 176–202). New York: Springer.

Driskell, J. E. & Dwyer, D. J. (1984). Microcomputer Videogame Based Training. *Educational Technology*, 24(2), 11–17.

Fernandes, J. M. & Sousa, S. M. (2010). Playscrum: A Card Game to Learn the Scrum Agile Method. In K. Debattista (ed.), *Second International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)* (pp. 52–59). Braga, Portugal: IEEE.

Fiske, S. T. & Dépret, E. (1996). Control, Interdependence and Power: Understanding Social Cognition in Its Social Context. *European Review of Social Psychology*, 7(1), 31–61.

Fong, G. (2006). Adapting COTS Games for Military Experimentation. *Simulation & Gaming*, 37(4), 452–465.

Fornell, C. & Larcker, D. F. (1981). Structural Equation Models with Unobservable Variables and Measurement Error: Algebra and Statistics. *Journal of Marketing Research*, 18(3), 382–388.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, Motivation, and Learning: A Research and Practice Model. *Simulation & Gaming*, 33(4), 441–467.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 2ed., Thousand Oaks, CA: Sage.

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging Games Help Students Learn: An Empirical Study on Engagement, Flow and Immersion in Game-Based Learning. *Computers in Human Behavior*, 54, 170–179.

Hsu, S. H., Wen, M. H., & Wu, M. C. (2009). Exploring User Experiences as Predictors of MMORPG Addiction. *Computers & Education*, 53(3), 990–999.

Kazimoglu, C., Kiernan, M., Bacon, L., & Mackinnon, L. (2012). A Serious Game for Developing Computational Thinking and Learning Introductory Computer Programming. *Procedia-Social and Behavioral Sciences*, 47, 1,991–1,999.

Kiili, K. (2005). Digital Game-Based Learning: Towards an Experiential Gaming Model. *The Internet and Higher Education*, 8(1), 13–24.

Kim, K., Schmierbach, M. G., Chung, M. Y., Fraustino, J. D., Dardis, F., & Ahern, L. (2015). Is it a Sense of Autonomy, Control, or Attachment? Exploring the Effects of In-Game Customization on Game Enjoyment. *Computers in Human Behavior*, 48, 695–705.

Langer, E. J. (1975). The Illusion of Control. *Journal of Personality and Social Psychology*, 32(2), 311–328.

Lui, R. W. C., Lee, P. T. Y., & Ng, V. T. (2015). Design and Evaluation of PMS: A Computerized Simulation Game for Software Project Management. *The Computer Games Journal*, 4(1–2), 101–121.

Lui, R. W. C. & Au, C. H. (2018). Establishing an Educational Game Development Model: From the Experience of Teaching Search Engine Optimization. *International Journal of Game-Based Learning (IJGBL)*, 8(1), 52–73.

Malone, T. W. (1981). Toward a Theory of Intrinsically Motivating Instruction. *Cognitive Science*, 5(4), 333–369.

Malone, T. W. & Lepper, M. R. (1987). Making Learning Fun: A Taxonomy of Intrinsic Motivations for Learning. In R. E. Snow, P. A. Federico, & W. E. Montague (eds.), *Aptitude, Learning, and Instruction* (pp. 223–253). L. Erlbaum Associates.

Marcolin, B. L., Compeau, D. R., Munro, M. C., & Huff, S. L. (2000). Assessing User Competence: Conceptualization and Measurement. *Information Systems Research*, 11(1), 37–60.

Marlow, S. L., Salas, E., Landon, L. B., & Presnell, B. (2016). Eliciting Teamwork with Game Attributes: A Systematic Review and Research Agenda. *Computers in Human Behavior*, 55, 413–423.

Muratet, M., Torguet, P., Jessel, J. P., & Viallet, F. (2009). Towards a Serious Game to Help Students Learn Computer Programming. *International Journal of Computer Games Technology*, 3, 1–12.

Nicholls, J. G. (1984). Achievement Motivation: Conceptions of Ability, Subjective Experience, Task Choice, and Performance. *Psychological Review*, 9(3), 328–346.

Nitzl, C., Roldán, J. L., & Cepeda, G. (2016). Mediation Analysis in Partial Least Squares Path Modeling: Helping Researchers Discuss More Sophisticated Models, *Industrial Management & Data Systems*, 119 (9), 1849–1864.

Pavlas, D., Bedwell, W., Wooten, S. R., Heyne, K., & Salas, E. (2009). Investigating the Attributes in Serious Games that Contribute to Learning. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 53(27), 1,999–2,003.

Prensky, M. (2003). Digital Game-Based Learning. *Computers in Entertainment (CIE)*, 1(1), 21–24.

Reeve, J. & Deci, E. L. (1996). Elements of the Competitive Situation that Affect Intrinsic Motivation. *Personality and Social Psychology Bulletin*, 22(1), 24–33.

Ringle, C. M., Wende, S., & Will, A. (2005). SmartPLS 2.0 (beta). Hamburg. Available at http://www.smartpls.de.

Santhanam, R., Liu, D., & Shen, W. C. M. (2016). Research Note—Gamification of Technology-Mediated Training: Not All Competitions Are the Same. *Information Systems Research*, 27(2), 453–465.

Sepehr, S. & Head, M. (2018). Understanding the Role of Competition in Video Gameplay Satisfaction. *Information & Management*, *55*(4), 407–421.

Song, H., Kim, J., Tenzek, K. E., & Lee, K. M. (2013). The Effects of Competition and Competitiveness upon Intrinsic Motivation in Exergames. *Computers in Human Behavior*, 29(4), 1,702–1,708.

Stapel, D. A. & Koomen, W. (2005). Competition, Cooperation, and the Effects of Others on Me. *Journal of Personality and Social Psychology*, 88(4), 1,029–1,038.

Sweetser, P. & Wyeth, P. (2005). GameFlow: A Model for Evaluating Player Enjoyment in Games. *Computers in Entertainment (CIE)*, 3(3), 1–24.

Tan, J. L., Goh, D. H. L., Ang, R. P., & Huan, V. S. (2013). Participatory Evaluation of an Educational Game for Social Skills Acquisition. *Computers & Education*, 64, 70–80.

Taran, G. (2007). Using Games in Software Engineering Education to Teach Risk Management. In Ceballos, S. (ed.), *The 20th Conference on Software Engineering Education & Training* (pp. 211–220), Dublin, Ireland: IEEE.

Van Eck, R. & Dempsey, J. (2002). The Effect of Competition and Contextualized Advisement on the Transfer of Mathematics Skills in a Computer-Based Instructional Simulation Game. *Educational Technology Research and Development*, 50(3), 23–41.

Vandercruysse, S., Vandewaetere, M., Cornillie, F., & Clarebout, G. (2013). Competition and Students' Perceptions in a Game-Based Language Learning Environment. *Educational Technology Research and Development*, 61(4), 927–950.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer Gaming and Interactive Simulations for Learning: A Meta-Analysis. *Journal of Educational Computing Research*, 34(3), 229–243.

Vorderer, P., Hartmann, T., & Klimmt, C. (2003). Explaining the Enjoyment of Playing Video Games: The Role of Competition. In D. Marinelli (ed.), *Proceedings of the Second International Conference on Entertainment Computing* (pp. 1–9). Pittsburgh: Carnegie Mellon University.

Williams, R. B. & Clippinger, C. A. (2002). Aggression, Competition and Computer Games: Computer and Human Opponents. *Computers in Human Behavior*, *18*(5), 495-506.

Wilson, K. A., Bedwell, W. L., Lazzara, E. H., Salas, E., Burke, C. S., Estock, J. L., Orvis, K. L., & Conkey, C. (2009). Relationships between Game Attributes and Learning Outcomes: Review and Research Proposals. *Simulation & Gaming*, 40(2), 217–266.

Wong, K. K. K. (2013). Partial Least Squares Structural Equation Modeling (PLS-SEM) Techniques Using SmartPLS. *Marketing Bulletin*, 24(1), 1–32.

Wong, K. K. K. (2016). Mediation Analysis, Categorical Moderation Analysis, and Higher-Order Constructs Modeling in Partial Least Squares Structural Equation Modeling (PLS-SEM): A B2B Example using SmartPLS. *Marketing Bulletin*, 26, 1–22.

Wu, W. M., Cheng, H. N., Chiang, M. C., Deng, Y. C., Chou, C. Y., Tsai, C. C., & Chan, T. W. (2007). AnswerMatching: A Competitive Learning Game with Uneven Chance Tactic. In T. W. Chen (ed.), *The First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning* (pp. 89–98). Jhongli City, Taiwan: IEEE.

Yee, N. (2006). Motivations for Play in Online Games. *CyberPsychology & Behavior*, 9(4), 772–775.

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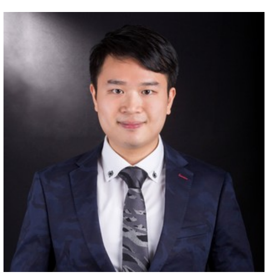

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Appendix A: Post-Game Questionnaire

	Questions	Strongly Agree	Slightly Agree	Neutral	Slightly Disagree	Strongly Disagree
		5	4	3	2	1
Competition (IC1)	I competed with other game players during the game.					
Competition (IC2)	I enjoyed competing with other players.					
Competition (IC3)	The game facilitates me to compete with other players.					
Perceived Challenge (C1)	The game provides an appropriate test of my skills.					
Perceived Challenge (C2)	The game challenges me to perform to the best of my ability.					
Perceived Challenge (C3)	When playing the game, I experienced the level of challenge that matches my skill level.					
Perceived Control (AC1)	I can control my status and performance in the game.					
Perceived Control (AC2)	I can play the game using various strategies.					
Perceived Control (AC3)	I felt I influenced other players in the game.					
Self-efficacy (S1)	I am more confident in SEO knowledge.					
Self-efficacy (S2)	I am more confident in learning social media and its applications.					

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