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THE RELATIONSHIP OF LEARNER CHARACTERISTICS OF GAMING WITH MATH ENGAGEMENT

Abstract:

The main purpose of the study was to examine the effects of student's gaming behaviors and perceptions of games on the engagement in the mathematics classrooms. For the study, the research team recruited 299 sixth grade students from two schools located in rural areas of Virginia in the United States and collected data. For the analytical tool, we employed Structural Equation Modeling (SEM) to examine the relationship of gaming behaviors with the engagement mediated by perceptions of instructional games. We found that student's mathematics engagement was associated with student's perceptions of games and gaming behaviors. The game hours drew a significant path to student's perceptions of game learning while the game frequencies had a significant path to student's perceptions of game utility. The student's perceptions made significant paths to mathematics engagement. This study provided empirical information on student's mathematics engagement connecting student's perceptions of game learning and games utility.

Keywords:

instructional games, gaming behavior, perception of gaming, engagement, middle grades

JEL Classification: I21, O39

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Introduction

During last decades, several educational researchers have adopted instructional games to improve students' engagement in mathematics and help their school success (Gee, 2010; Oblinger, 2006). Despite the continued effort of the researchers who implement instructional games as educational interventions, the study findings have not consistently supported the benefits of instructional games (Kebritchi, Hirumi, & Bai, 2010). While some studies showed positive outcomes from the use of instructional games (Bottino et al., 2007; Chang, Wu, Weng, & Sung, 2012; Gillispie, Martin, & Parker, 2010) and others did not find significant outcomes (Ke, 2008a, 2008b; Ritzhaupt, Higgins, & Allred, 2011).

One major reason for the mixed results of the studies on instructional games can be due to methodological limitations (Hays, 2005). The most of the studies did not pay attention to the student' gaming behaviors and their perception of instructional games that are important precursors of the effects of instructional games on student's academic outcomes. However, there is a dearth of research examining the effects of student's characteristics of gaming behavior on the students' school outcomes. In this study, our research team examined the effects of students' gaming behaviors and student's perceptions on instructional games on the students' mathematics engagement using Structural Equation Modeling (SEM). In the analytical model, we included student's game hours and game frequencies as influencing factors to student's perceptions of instructional games. The student's perceptions of games, in turn, made paths as influencing factors to students' engagement.

Literature Review

Mathematics Engagement

The major outcome variables of the study were three types of engagement of behavioral, emotional, and cognitive engagement mirroring prior researchers' findings (Fredricks, Blumenfeld, & Paris, 2004; Kong, Wong, & Lam, 2003) who emphasized the conceptualization of three components of mathematical engagement. Behavioral engagement in our study was defined as students' demonstrations of concentrating and showing persistence for mathematics learning. The emotional engagement was students' feelings about learning mathematics, such as joy, interest and satisfaction (Barkatsasa, Kasimatisb, and Gialamas, 2009). The cognitive engagement was essentially defined as a psychological investment in learning, a desire to go beyond the requirements, and a preference for a challenge (Newmann, 1992).

Amount of Gaming

According to Willoughby (2008), the effects of instructional games depended on the gaming times of students and highlighted the importance of the proper amount of time for computer games for students. Moreover, Gentile (2011) exhorted that the amount of game play should be included in the studies of instructional games by presenting comprehensive literature review on instructional games. However, prior research on gaming hours have focused on the effect of the amount of game play of non-educational games, particularly violent games. Those study results reported that long hours of game

play were associated with game addiction, aggression and health issues (Anderson, Shibuya, Ihori, Swing, Bushman, Sakamoto, et al., 2010; Vandewater, Shim, & Caplovitz, 2004).

In contrast with the negative effects of long hours of playing non-educational games, Hoffman and Nadelson (2010) found the positive influence of the amount of playing educational games. In their study on engagement in games, Hoffman and Nadelson showed that the longer hours of educational games were related to higher engagement because educational games required strategies and problem-solving skills. According to Sherry (2001), when players played the game for a short time, they became frustrated as they could not get accustomed to the games due to the lack of the time.

Students' Perceptions of Games

Student's perceptions of game learning and usefulness of games can be a critical factor for student's adoption of instructional games (Davis, 1989). According to Ha, Yoon and Choi (2007), the perceived ease of instructional games was an important factor influencing players' intentions to play instructional games while the perceived usefulness did not play a significant role in players' decision. Similarly, Hsu and Lu (2004) incorporated students' perceptions of the ease of use and usefulness using non-educational games. The study by Bourgonjon, Valcke, Soetaert and Schellens (2010) on learners' perceptions of the ease of use and usefulness of games also verified Davis' theory and suggested practical implications of educational games. The researchers chose students' preference of instructional games and students' support for the use of the games in class as dependent variables for the study. The researchers found that both the ease of use and usefulness had a significant association with students' preference for instructional games for learning.

Method

Participants and Survey

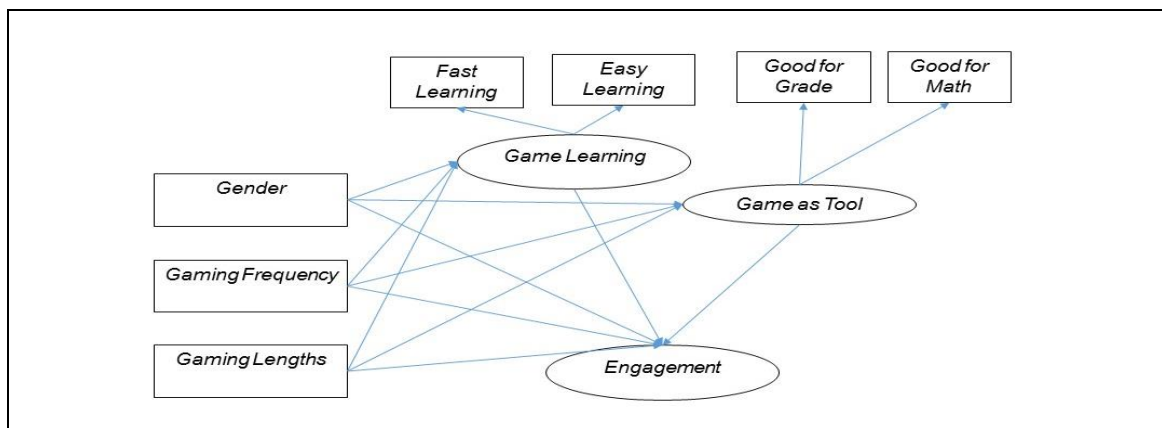
For this study, our research team recruited 299 sixth grade students from two schools in a rural school district in Virginia. The researchers visited the schools and collected data on students' mathematics engagement, gaming behaviors and attitudes, and demographics. The outcome measures of the study were of behavioral, emotional, and cognitive engagement. After conducting several iterations of piloting and validations, we had the engagement survey defensible internal consistency. The behavioral engagement had Cronbach Alpha of .753 with seven items, the emotional engagement had Cronbach Alpha of .792 with six items, and the cognitive engagement had Cronbach Alpha of .776 with 12 items. Each item had four options (1=strongly disagree; 4=strongly agree) in response to each statement.

The student's gaming behaviors were measured by self-reports on the hours and frequencies of gaming. Game hours were measured by the question, "How long do you usually play when you play digital games? (5 = longer than 2 hours, 4 = longer than 1 hour but less than 2 hours, 3 = Longer than 30 minutes but less than 1 hour, 2 = Longer than 15 minutes but less than 30 minutes, 1 = Less than 15 minutes). Game frequencies were was measured by the question, "How often do you play digital games? (5 = every day, 4 = 2-3 times a week, 3 = once a week, 2 = once a month, 1 = once or twice a year)."

The study also included four items of student's perceptions of game learning and the game utility with four options (4 = I strongly agree, 3 = I somewhat agree, 2 = I somewhat disagree, 1 = strongly disagree). The four items were "I learn math digital games fast." "It is easy for me to learn math digital games." "If I use digital games to learn math, I can get a better math grade." and "Digital games are good educational tools to help me to learn math." The four items in the analytical model built two latent variables, making the first two items the first latent variable of "game learning" and the last two items the second latent variable of "game utility." The student's gender was also included in the model.

Analysis

The research team first conducted several preliminary analyses using descriptive statistics, correlation analyses. The SEM as the main analytical tool was employed to analyze separate behavioral, emotional, and cognitive engagement models. The paths of SEM began with student's gender, game hours, and game frequencies as exogenous variables and ended with each of engagement as an endogenous variable. As mediator variables, game learning and game utility were also included.



Results

The three engagement models revealed similar results, showing the same significant paths although the coefficients showed minor differences in numeric values as shown in Table.

In the measurement model, indicator variables had significant paths to latent variables as we hypothesized. Specifically, the fast game learning and easy game learning variables were loaded significantly on the game learning latent variable. The game as good for grade and the game as good for math items were significantly loaded on the game utility latent variable.

In the structural models, game hours showed a significant path to game learning while game frequencies made a significant path to game utility. Gender made a significant path to game learning. Game learning and game utility made significant paths to

engagement in behavioral and emotional engagement models, but not in the cognitive model.

The fit statistics also showed similar results across the three models showing all good fits to data. Specifically, the behavioral model showed a good fit of the model to the data with the results of $\chi^2 = 13.629$, $df = 10$, $p > 0.05$, NFI = .971, CFI = .992, RMSEA = .0348. The emotional model showed a good fit to the model to the data with $\chi^2 = 10.907$, $df = 11$, $p > 0.05$, NFI = .974, CFI = 1.000, RMSEA = .000. The cognitive model also showed a good fit to the model to the data with $\chi^2 = 14.864$, $df = 12$, $p > 0.05$, NFI = .965, CFI = .993, RMSEA = .0283.

Table. Significant Path Outcomes of Behavioral, Emotional, and Cognitive Engagement Models.

		Behavioral		Emotional		Cognitive	
		B	T	B	T	B	T
Game Frequency	→ Game Learning	---		---		---	
Game Duration	→ Game Learning	0.083	3.083**	0.087	3.142**	0.094	3.306**
Gender	→ Game Learning	---		---		---	
Game Frequency	→ Game as Tool	0.140	2.790**	0.096	2.587**	0.085	2.359*
Game Duration	→ Game as Tool	---		---		---	
Gender	→ Game as Tool	0.246	3.332**	0.219	2.682**	0.190	2.498**
Game Learning	→ Engagement	0.145	2.489*	0.133	1.562	---	
Game as Tool	→ Engagement	0.357	5.327**	0.186	2.316*	0.350	4.591**

Note: * $p < .05$; ** $p < .01$

Note. The dotted lines reflect unspecified paths in the model.

Summary and Conclusion

In this study, we examined the effects of student's game hours and frequencies on their perceptions of game learning and game utility that made another significant paths mathematics engagement. In the analysis, we also considered student's gender.

The important contribution of this study to the field is the in-depth exploration of mathematics engagement paying attention to three sub-domains of behavioral, emotional and cognitive engagement. The major predictor variables of this study were student's perceptions of game learning and game utility.

In the structural models, we found that game hours showed a significant path to game learning, indicating that when students played games for a long time, they felt they could learn instructional games fast and easily. The structural model also showed that game frequencies made a significant path to game utility indicating that when students played games frequently, they perceived games as a good educational tool. In turn, game learning and game utility made significant paths to engagement in behavioral and emotional engagement models, but not in the cognitive model. Gender made a significant path to game learning.

Our research findings suggest that to improve mathematics engagement, educators and game developers need to take efforts to promote student's perceptions of game learning and game utility by providing enough preparatory sessions to help students get familiar with game rules and structures. In addition, explanations of the purpose and usefulness of instructional games before the implementation of the educational game would be a help for students to get the best benefits from instructional games. In addition, the future study needs to identify the optimal amount of playing games, which is enough to help a student get familiar with the games but not too long to cause students' boredom. In conclusion, this study provided empirical information on student's mathematics engagement connecting student's perceptions of game learning and games utility. The study findings would be particularly useful for researchers who study educational games and the specific ways to help students get engaged in educational games for their learning.

References

- ANDERSON, C., SHIBUYA, A., IHORI, N., SWING, E. L., BUSHMAN, B. J., SAKAMOTO, A., et al. (2010) Violent video game effects on aggression, empathy, and prosocial behavior in Eastern and Western countries: A meta-analytic review. *Psychological Bulletin*, 136 (2), 151-173
- BARKATSASA, A. T., KASIMATISB, K., & GIALAMAS, V. (2009) Learning secondary mathematics with technology: Exploring the complex interrelationship between students' attitudes, engagement, gender and achievement. *Computers & Education*, 52 (3), 562-570.
- BOTTINO, R.M., FERLINO, L., OTT, M., & TAVELLA, M. (2007) Developing strategic and reasoning abilities with computer games at primary school level. *Computers & Education*, 49, 1272-1286.
- BOURGONJON, J., VALCKE, M., SOETAERT, R., & SCHELLENS, T. (2010) Students' perceptions about the use of video games in the classroom. *Computers & Education*, 54, 1145-1156.
- CHANG, K., WU, L., WENG, S., & SUNG, Y. (2012) Embedding game-based problem-solving phase into problem-posing system for mathematics learning. *Computers & Education*, 58, 775-786.

- DAVIS, F. D. (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.
- FREDRICKS, J. A., BLUMENFELD, P. C., & PARIS, A. H. (2004) School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74 (1), 59-109.
- GEE, J. (2010) Video Games: What they can teach us about audience engagement. *Nieman Reports*, 64 (2), 52-54. Retrieved from Communication & Mass Media Complete database.
- GENTILE, D. A. (2011) The multiple dimensions of video game effects. *Child Development Perspectives*, 5 (2), 75-81.
- GILLISPIE, L., MARTIN, F., & PARKER, M. A. (2010) Effects of a 3-D video game on middle school student achievement and attitude in mathematics. *Electronic Journal of Mathematics & Technology*, 4 (1), 68-80.
- HA, I., YOON, Y., & CHOI, M. (2007) Determinants of adoption of mobile games under mobile broadband wireless access environment. *Information & Management*, 44 (3), 276-286.
- HAYS, R. T. (2005) The effectiveness of instructional games: a literature review and discussion. Naval Air Warfare Center Training System Division (No. 2005-004). Retrieved 08.11.10 from <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA441935&Location=U2&doc=GetTRDoc.pdf>.
- HOFFMAN, B., & NADELSON, L. (2010) Motivational engagement and video gaming: a mixed methods study. *Educational Technology Research and Development*, 58 (3), 245-270.
- HSU, C., & LU, H. (2004) Why do people play on-line games? An extended TAM with social influences and flow experience. *Information & Management*, 41 (7), 853-868.
- KE, F. (2008a) A case study of computer gaming for math: Engaged learning from gameplay? *Computers & Education*, 51, 1609-1620. doi:10.1016/j.compedu.2008.03.003
- KE, F. (2008b) Alternative goal structures for computer game-based learning. *International Journal of Computer-Supported Collaborative Learning*, 3 (4), 429-445.
- KONG, Q., WONG, N., & LAM, C. (2003) Student engagement in mathematics: Development of instrument and validation of construct. *Mathematics Education Research Journal*, 15 (1), 4-21.
- NEWMANN, F. (1992) Higher-order thinking and prospects for classroom thoughtfulness. In F. Newmann (Ed.) *Student engagement and achievement in American secondary schools* (pp. 62-91). New York: Teachers College Press.
- RITZHAUPT, A., HIGGINS, H., & ALLRED, B. (2011) Effects of modern educational game play on attitudes towards mathematics, mathematics self-efficacy, and mathematics achievement. *Journal of Interactive Learning Research*, 22 (2), 277-297.
- SHERRY, J. (2001) The effects of violent video games on aggression. *Human Communication Research*, 27 (3), 409-431.
- VANDEWATER, E., SHIM, M.-S., & CAPLOVITZ, A. G. (2004) Linking obesity and activity level with children's television and video game use. *Journal of Adolescence*, 27 (1), 71-85.
- WILLOUGHBY, T. (2008) A short-term longitudinal study of Internet and computer game use by adolescent boys and girls: Prevalence, frequency of use, and psychosocial predictors. *Developmental Psychology*, 44 (1), 195-204.