

TEACHER ATTITUDES REGARDING THE USE OF GAME-BASED PROGRAMMING TOOLS IN K-12 EDUCATION

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ABSTRACT

In recent years, game-based programming tools (GBPTs) such as Code.org, Lightbot, and Cargo-Bot have been developed to help children worldwide better understand programming concepts through an interesting, enjoyable and visualizable programming learning experience. However, in-service teachers' perceptions regarding the use of these game-based programming tools in K-12 instruction have received little attention. To understand the perceptions of teachers, this study integrated perceived enjoyment into the Technology Acceptance Model (TAM) to explore the factors that influence the intentions of K-12 in-service teachers to use game-based programming tools in their instructional tasks. Thirty Chinese teachers in elementary and secondary schools were invited to finish at least one hour of code tutorial at the code.org site, and then undertake a paper-and-pencil questionnaire. We applied the partial least squares structural equation modeling technique to analyze the extended TAM model. Results demonstrated that teachers' behavioral intention was determined by their attitudes toward using GBPTs. Perceived usefulness and perceived ease of use had a significant and positive influence on teachers' attitude. In addition, the results also indicated that perceived enjoyment has a significant influence on perceived usefulness and perceived ease of use, but no significant effect on the attitude of teachers regarding the use of GBPTs.

KEYWORDS

Game-based Programming Tools, Technology Acceptance Model, Perceived Enjoyment, K-12 Teachers

1. INTRODUCTION

There is sufficient evidence to show that "learning to program" could benefit children's development of skills in general planning, problem-solving, creativity and cooperation, as well as skills of computational thinking in other settings (Ching et al. 2018; Topalli and Cagiltay, 2018; Wing, 2006). Nowadays, some emerging game-based programming tools (e.g., Code.org, Lightbot, and Cargo-Bot) have been designed to provide an easy-to-use, interactive, challenging and enjoyable learning environment to engage children and motivate them to learn programming. For example, Kalelioglu (2015) used Code.org (<https://code.org/>) to teach 32 fourth-grade primary school students programming concepts and found that students developed a positive attitude toward programming and improved their programming, mathematical and geometrical knowledge. Lopez et al. (2016) applied an educational programming game called Lightbot (<https://lightbot.com/flash.html>) to teach university students programming concepts. They observed that students seemed to enjoy learning with Lightbot and attained a better understanding of programming concepts. Similarly, Tessler et al. (2013) examined the effects of teaching programming concepts on high school students by playing Cargo-Bot (<http://twolivesleft.com/CargoBot>). They discovered that playing Cargo-Bot is indeed an enjoyable and effective way to learn programming.

These GBPTs can make programming learning more enjoyable and may facilitate programming instruction applications in existing K-12 education strategies (Rajeev et al., 2018). While some attention has been paid in the past to researching issues related to GBPTs, little is known about in-service teachers' perceptions of using GBPTs in K-12 education. This study presents an empirical investigation using TAM as a framework to explore K-12 in-service teachers' perceptions of utilizing GBPTs to reinforce their instruction. The technology acceptance model (TAM) (Davis et al., 1989) has been broadly applied to

explore users' perceptions in the application of a particular learning system and its tools. However, the existing constructs of TAM are not adequate enough to fully reflect the enjoyment of the user experience when operating these game-based programming tools. Therefore, one determinant variable—perceived enjoyment—was added to enhance the understanding of perceptions of teachers with regard to utilizing GBPTs.

2. THEORETICAL BACKGROUND

2.1 Technology Acceptance Model

The technology acceptance model (TAM) (Davis, 1989) is a well-recognized framework developed to explore user attitudes and behavioral intentions toward the use of different technology systems/tools. TAM was proposed by Davis in 1989, emphasizing that perceived usefulness and perceived ease of use are important for users who are deciding whether to accept or reject specific information technologies. Perceived usefulness is considered to be “the degree to which a person believes that using a particular system would enhance his or her job performance,” and perceived ease of use is defined as “the degree to which a person believes that using a particular system would be free from effort” (Davis, 1989; Davis et al., 1989). Specifically, behavioral intention is determined by user attitudes toward, a particular technology system or tool, which in turn is determined by its perceived usefulness and perceived ease of use. In addition, perceived ease of use has a direct and significant influence on perceived usefulness.

TAM has been widely applied and modified to explore attitudes and intentions of teachers to utilize different e-learning systems/tools. For example, Chiu (2017) used TAM to investigate external factors such as anxiety, computer self-efficacy, voluntariness, and institutional support to determine how these factors affected in-service secondary school teachers' adoption of electronic textbooks. Liu et al. (2017) revised TAM by adding the pedagogical beliefs of teachers to investigate the acceptance of information and communication technology (ICT) for university teachers of English as a Foreign Language (EFL) in China. Su et al. (2018) extended TAM by additionally considering external factors such as management support, computer anxiety, intrinsic motivation, and job relevance to explore in-service teachers' attitudes and behavioral intentions to use ICT in primary and secondary school education in China. However, little attention has been focused on the attitudes and behavioral intentions of teachers with respect to the usage of GBPTs in K-12 education.

2.2 Perceived Enjoyment

Perceived enjoyment is at the core of the media entertainment experience (Vorderer et al., 2004), and is defined as “the extent to which the activity of using technology is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated” (Davis et al., 1989). Some studies emphasized that perceived enjoyment plays an important role, and as such have incorporated it to explain certain phenomena regarding teachers' perceptions of using an e-learning system/tool (Abdullah and Ward, 2016; Sun and Zhang, 2008). For example, Teo and Noyes (2011) incorporated perceived enjoyment into a TAM framework to explore pre-service teachers' intentions to use technology and found that perceived enjoyment had a significant impact on teachers' attitudes and intentions for computer usage. Elkaseh et al. (2015) extended TAM by incorporating perceived enjoyment and social influence to explore students' and university teachers' perceptions of e-learning tools for teaching and learning. This study showed that perceived enjoyment significantly affects perceived usefulness and perceived ease of use. Park and Kwon (2016) employed TAM, examining two external factors—perceived enjoyment and service quality—to forecast teachers' intentions in using teaching assistant robots. They demonstrated that perceived enjoyment and service quality were extremely significant influencing factors in which perceived enjoyment had a positive effect on perceived usefulness and perceived ease of use. Adukaite et al. (2017) conducted an empirical study to investigate South African tourism teachers' perceptions regarding acceptance of a gamified application in tourism instruction, and demonstrated that perceived enjoyment was one important determinant affecting teachers' behavioral intentions to use gamified applications for tourism education.

According to the relevant literature, perceived enjoyment seems to be a key influencing factor for teachers that may affect their perceived usefulness, perceived ease of use and attitude toward utilizing GBPTs in K-12 education.

3. RESEARCH MODEL AND HYPOTHESES

Based on the previous literature review, an extended technology acceptance model (TAM) was applied and integrated with perceived enjoyment to better investigate in-service teachers' perceptions regarding the use of game-based programming tools in K-12 instruction. Figure 1 shows the research model for this study.

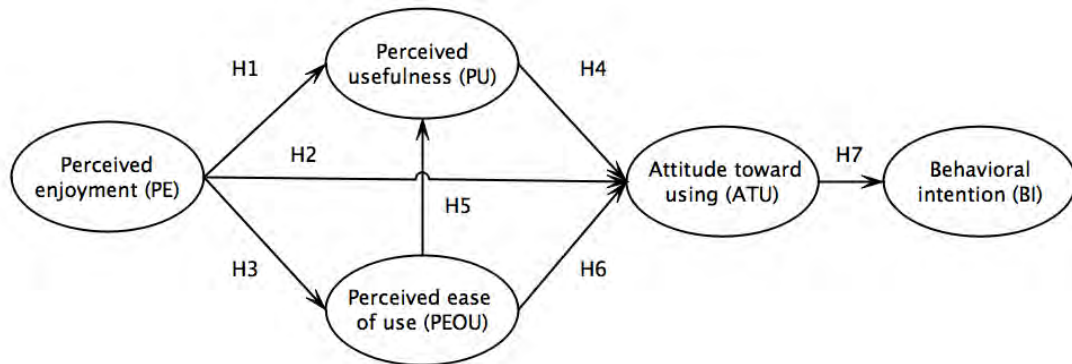


Figure 1. The hypothesis model

Specifically, this study attempts to answer the following research hypotheses:

H1. Perceived enjoyment will have a direct positive influence on K-12 in-service teachers' perceived usefulness.

H2. Perceived enjoyment will have a direct positive influence on K-12 in-service teachers' attitude toward using GBPTs.

H3. Perceived enjoyment will have a direct positive influence on K-12 in-service teachers' perceived ease of use.

H4. Perceived usefulness will have a direct positive influence on K-12 in-service teachers' attitude toward using GBPTs.

H5. Perceived ease of use will have a direct positive influence on K-12 in-service teachers' perceived usefulness.

H6. Perceived ease of use will have a direct positive influence on K-12 in-service teachers' attitude toward using GBPTs.

H7. Attitude toward using GBPTs will have a direct positive influence on K-12 in-service teachers' behavioral intention.

4. METHOD

4.1 Participants

A convenience sampling method was used, with 30 in-service teachers participating in this study hailing from elementary and secondary schools in Zhejiang Province, China. The participants totaled 28 females and 2 males, aged 26 to 40.

4.2 Instrument

A specific questionnaire containing 15 items was developed from the published items of previous studies (Rubio et al., 2015; Balog and Pribeanu, 2010; Ahn et al., 2004; Venkatesh, 2000; Davis, 1989; Taylor and Todd, 1995). Each item was measured on a 5-point Likert scale, with values ranging from 1 (strongly disagree) to 5 (strongly agree). To ensure the clarity and validity of the aforementioned items, the contents of the questionnaire were reviewed and revised several times by two educational technology experts.

4.3 Procedure and Data Analysis

The paper-and-pencil questionnaire was administered once the K-12 teachers completed at least one hour of code tutorial from code.org. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to test our hypothesis model, as this approach has greater power for small sample sizes (Chin, 1998). SmartPLS 3.0 was adopted to present the PLS-SEM approach and to assess the measurements (reliability and validity) and structural model (all hypotheses in the research model) for this study.

5. RESULTS

5.1 Measurement Model

The measurement model was used for assessment in terms of factor loading, Cronbach's alpha (CA), composite reliability (CR), average extracted variance (AVE), and discriminant validity. As shown in Table 1, factor loadings for the corresponding constructs are greater than the threshold value of 0.70 (Chin and Newsted, 1999), while the AVE values ranged from 0.792 to 0.893—exceeding the standard minimum level of 0.5, and as a consequence demonstrating adequate convergent validity (Hair et al., 2006). The reliability of the measures was acceptable, due to the values of CR and Cronbach's alpha being higher than 0.7 and 0.6, respectively (Hair et al., 2006). The discriminant validity was assessed by the square root of AVE and latent variable correlations. Table 2 demonstrates that the results delivered by the measurement model were significant and acceptable, with all values meeting the required standards (Fornell and Larcker, 1981).

Table 1. The measurement model

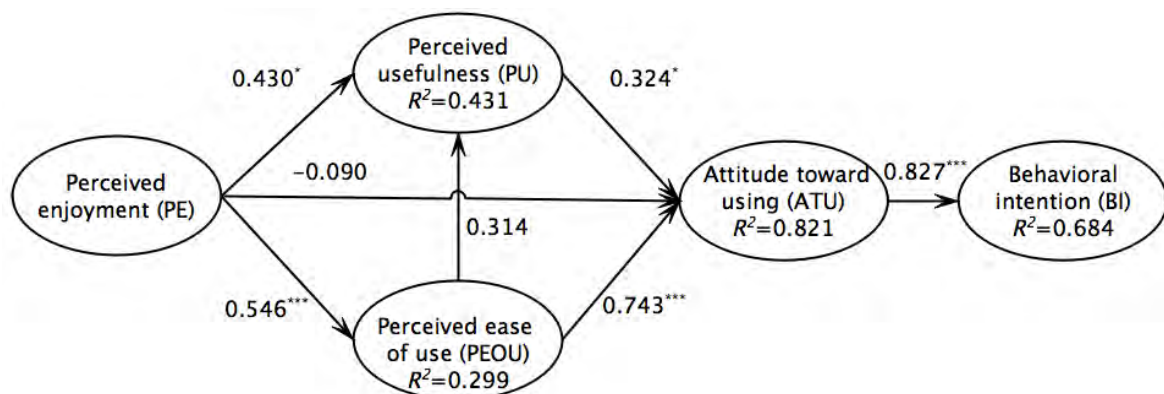
Construct	Item	Factor Loading	Cronbach's alpha	Composite reliability	Average extracted variance
Perceived usefulness	PU1	0.888	0.896	0.919	0.792
	PU2	0.871			
	PU3	0.911			
Perceived ease of use	PEOU1	0.938	0.940	0.961	0.893
	PEOU2	0.934			
	PEOU3	0.962			
Perceived enjoyment	PE1	0.886	0.915	0.947	0.855
	PE2	0.955			
	PE3	0.932			
Attitude toward using	ATU1	0.856	0.872	0.922	0.797
	ATU2	0.878			
	ATU3	0.943			
Behavioral intention	BI1	0.919	0.907	0.941	0.842
	BI2	0.935			
	BI3	0.899			

Table 2. Discriminant validity

Construct	1	2	3	4	5
1. Perceived usefulness	0.890				
2. Perceived ease of use	0.546	0.945			
3. Perceived enjoyment	0.600	0.546	0.925		
4. Attitude toward using	0.676	0.871	0.511	0.893	
5. Behavioral intention	0.665	0.736	0.400	0.827	0.918

5.2 Structural Model

The structural model was examined through assessing the path coefficients and R2 values; the former was used as the indicator for the statistical significance of these hypotheses, and the latter was used to assess the model's ability in explaining the variance in the dependent variables (Chin and Newsted, 1999). Figure 2 shows the path coefficients, path significance and variance explained for each dependent variable. It implies that the hypothesis model explained 43.1% of the variance in perceived usefulness, 29.9% of the variance in perceived ease of use, 82.1% of the variance in teachers' attitude, and 68.4% of the variance in behavioral intention. Figure 2 also illustrates the seven path coefficients among the variables of the model. It was also found that the perceived enjoyment had a direct positive and significant impact on perceived usefulness ($\beta = 0.430, p < 0.05$) and perceived ease of use ($\beta = 0.546, p < 0.001$), supporting H1 and H3. For the attitude, perceived usefulness ($\beta = 0.286, p < 0.05$) and perceived ease of use ($\beta = 0.715, p < 0.001$) were direct positive and significant factors, supporting H4 and H6. Attitude ($\beta = 0.821, p < 0.001$) had a direct positive and significant effect on behavioral intention, supporting H7. However, perceived enjoyment had no significant effect on attitude, and perceived ease of use also had no significant effect on perceived usefulness. Thus, results showed that all hypotheses were supported with the exceptions of H2 and H5.



* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Figure 2. Path coefficients of the research model

6. DISCUSSION

This study attempted to investigate perceptions of in-service teachers with regard to using GBPTs in elementary and secondary schools by implementing an extended TAM integrated with perceived enjoyment as its theoretical base. All hypotheses, except two, were supported. The results demonstrated that the behavioral intention of teachers is determined by their attitudes toward using GBPTs in K-12 education, which in turn is determined by perceived usefulness and perceived ease of use. These findings are in line with the results of some previous studies (Chiu, 2017; Liu et al., 2017). However, this study found that perceived ease of use does not posit a significant impact on perceived usefulness, which is in agreement with the results by Su et al. (2018), but not in agreement with the findings by Chiu (2017) and Liu et al. (2017).

Moreover, this study showed that perceived enjoyment is positively associated with the core constructs of TAM—perceived usefulness ($\beta=0.430$) and perceived ease of use ($\beta=0.546$)—suggesting that an enjoyable learning experience is increasing the utility and ease of use of GBPTs. This study confirms that perceived enjoyment has a positive influence on perceived usefulness and perceived ease of use, which is consistent with previous studies (Park and Kwon, 2016; Elkaseh et al., 2015; Teo and Noyes, 2011). If in-service teachers feel the GBPTs to be enjoyable, they are more likely to perceive them as purposeful and easy to use. Surprisingly, perceived enjoyment is not found to posit a significant effect on teachers' attitudes toward using GBPTs. The results are not consistent with the findings by Cabada et al. (2018), which had previously found that perceived enjoyment does not influence students' attitudes toward using GBPTs. One possible explanation for this effect is that perceived enjoyment may affect attitude toward using only if the teachers themselves perceive GBPTs to be useful and easy to implement.

7. CONCLUSION

Our study provided several managerial implications of K-12 teachers' perceptions regarding the use of game-based programming tools in the classroom. These implications may serve to support academics, and assist academics, instructors and the general public in reaching a deeper understanding. Nevertheless, several limitations to this empirical study need to be acknowledged. First, this study did not perform a long-term investigation into teachers' use of GBPTs, nor did it consider individual differences such as gender (Venkatesh and Davis, 2000). Future research could examine other influencing factors/moderators on teachers' perceptions having previously used GBPTs in the classroom. Second, the study carried out a convenience sampling method in which just thirty Chinese K-12 teachers participated. The results may not be generalizable to the broader teacher population. Future studies could undertake multi-stage sampling to increase the sample size, or consider different user groups to examine and compare their perceptions regarding the use of game-based programming tools (GBPTs).

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