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Exploring preschool teachers' technological pedagogical content knowledge with educational games

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Abstract: Current technological pedagogical content knowledge (TPACK) studies are inclined to treat technology in a general manner, which may not be able to provide adequate guidelines to improve teacher preparation and professional development when teaching with games. This study developed two questionnaires, named technological pedagogical content knowledge –Game (TPACK-G) and acceptance of digital game-based learning (ADGBL), to investigate 352 preschool teachers' TPACK-G as well as to assess their attitudes toward game-based learning. The results show that both instruments were has satisfactory validity and reliability. Positive correlations were found between the factors between the TPACK-G and ADGBL. The framework of TPACK-G proposed by this study was supported, suggesting that an upper element is more general and fundamental and the more specific knowledge factors (GPK, GPCK) build on the GK.

Keywords: Games, TPACK, TPCK, preschool, digital game-based learning

1. Introduction

1.1 Games in Preschool Education

Kids love playing computer games (thereafter named games in this study). Numerous studies have pointed out that games, when designed properly, are able to foster students' engagement and motivation toward learning [1][2], and to maintain high levels of collaboration among children during game playing. Thus, there is a clear need for probing practitioners' knowledge about teaching with games. Current TPACK studies are inclined to treat technology in a general manner except for studies related to Interactive Whiteboard and science simulation [3]. The technology general approach may not be able to provide adequate guidelines to improve teacher preparation and professional development when teaching with games, which is a specific form of TPK.

1.2 Technological Pedagogical Content Knowledge-Game (TPACK-G)

The present study suggests that teachers may need the Technological Pedagogical Content Knowledge-Game (TPACK-G) while integrating games into their teaching. Developed from the ideas of TPACK [4], this study proposes an initial TPACK-G framework as consisting of game knowledge (GK), game pedagogical knowledge (GPK), and game pedagogical content knowledge (GPCK). The definition of GK refers to the knowledge about general usage of games (e.g., knowing how to play games, and having technical skills to play digital games effectively). GPK is knowledge about how to use games with

various pedagogical characteristics for teaching without specific reference to content knowledge. An example is utilizing a game with collaborative features to promote players' collaboration during the game playing. Last, GPCK is knowledge of using games to implement teaching methods for any targeted content. For instance, if one has sufficient GPCK, he/she is capable of choosing appropriate games to enhance what he/she teaches, how he/she teaches and what students learn in the classroom. The proposed framework does not include the CK, PK, PCK as these knowledge factors exclude the technology dimension. It also excludes the TCK knowledge factor. Games in the context of this study are designed for edutainment. It inevitably contains pedagogical elements and it is unlikely to be used for research. The exclusion of the four factors is also with consideration of designing a parsimonious questionnaire.

Figure 1 shows the framework of TPACK-G proposed by this study. As shown, the framework narrows down from GK to GPCK, suggesting that an upper element is more general and fundamental and the more specific knowledge factors (GPK, GPCK) build on the GK. That is, in order to develop specific GPCK, one should first possess adequate game knowledge and game pedagogical knowledge. Conversely, if one has no idea about games, he/ she may not have game pedagogical knowledge, not to mention having sufficient GPCK.

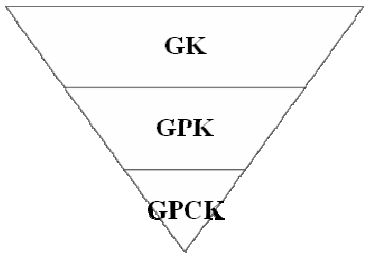

Figure 1 The framework of Technological Pedagogical Content Knowledge-Game

1.3 Teachers' Attitudes toward Game-Based Learning (ADGBL)

Playing games is generally considered as an unserious activity. This has resulted in underestimation of the educational potentials of games. However, researchers have found that both students' [5] and parents' perceived [6] that using games in the class can provide opportunities for learning had positively impact on their preference for games. Students' preference for games, according to [5], is also the important factor influencing the degree to which students believe the effectiveness of games on enhancing their learning. In addition, some studies have found that experience with games [7], and attitudes toward game-based learning are key features of directing his/ her acceptance of games. Studies [8] also show that if teachers do consider games as legitimate instructional tools, the chances of meeting the educational goals as well as facilitating students' acquisition of any academic skills or knowledge will increase. Based on the aforementioned, it is reasonable to hypothesize that teachers' perceived learning opportunities that games offer, preference for games, experience with games, and attitudes toward game-based learning are essential factors that guide their TPACK-G.

Game-based learning, whether or not it is computer-based games, is a welcomed instructional strategy for young children. However, there is currently a clear dearth of studies with focus on investigating preschool teachers' self-efficacy in game-based learning, and in particular, in terms of their knowledge of game pedagogical content. Undoubtedly, researchers and practitioners need such information to improve teacher preparation and professional development while digital game-based learning has receiving growing attention. Thus, the purposes of this study were to:

1. Validate two instruments modified from the previous studies [5][9][10]. One was based on the TPACK-G framework to investigate the preschool teachers' self-efficacy regarding their TPACK-G. The other was to examine the preschool teachers' acceptance of digital game-based learning.
2. Explore the relationships between the preschool teachers' perceived self-efficacy regarding their TAPCK-G and their acceptance of digital game-based learning.

2. Methodology

2.1 Participants

The participants for this study were 352 in-service teachers selected from the preschools in Taiwan. They were predominantly female, with 342 responses (97.2 %) versus 10 (2.8 %) male, which is consistent with the percentage of preschool teachers in Taiwan. Their average age was around 39. Most participants reported having a Bachelor's degree (61.1%) and 4.3% had a Master's degree. Their teaching experiences were approximately 11 years on average (SD = 8.01). The participants, first of all, filled in questions about demographical information and then responded to the main part of the survey (describe below).

2.2 Evaluating teachers' perceived self-efficacy in TPACK-G

A new questionnaire, named Technological Pedagogical Content Knowledge-Game (TPACK-G) survey, was developed to explore the preschool teachers' self-efficacy regarding TPACK-G. This instrument was adapted from Chai et al.'s (in press) and Lee and Tsai's (2010) survey items, including game knowledge, game pedagogical knowledge, and game pedagogical content knowledge. The initial survey consists of 24 items. Description of the three scales is presented below:

1. *Game Knowledge (GK)*: assessing teachers' confidence in their knowledge of how to use digital games, such as "I can learn how to use digital games easily."
2. *Game-Pedagogical Knowledge (GPK)*: measuring teachers' confidence in their knowledge of how digital games can facilitate pedagogical approaches, such as "I know how to use characteristics of digital games to support teaching."
3. *Game-Pedagogical-Content Knowledge (GPCK)*: measuring teachers' confidence in their knowledge of facilitating students' learning of a specific content through appropriate pedagogy and digital games, such as "I can select games to use in my classroom that enhance what I teach, how I teach and what students learn."

2.3 Assessing teachers' acceptance of digital game-based learning (ADGBL)

This instrument contains factors of learning opportunity, preference for game, experience with games, and attitudes toward game-based learning. The first three were adapted from Bourgonjon et al.'s (2010) survey items, whereas the last factor was adapted from Lee and Tsai's (2010) questionnaire. The initial instrument consists of 21 items. Description of these factors with sample items was presented below:

1. *Learning opportunity (LO)*: measuring the degree to which teachers believe that the usage of games in the classroom can offer students' learning opportunities, such as "Games offer opportunities for students to experience things they learn about."
2. *Preference for games (PFG)*: measuring teachers' preference about using game in the classroom, such as "I am enthusiastic about using video games in the classroom."

3. *Experiences with game (EWG)*: assessing the amount of teachers' experience in games, such as "I play different types of digital games."
4. *Attitudes toward Game-based learning (A)*: surveying the extent of the teachers' agreement on using digital games in teaching, such as "Game-based learning can enhance students' learning motivation."

2.4 Data Analysis

The data analyses involve exploratory factor analysis (EFA) and path analysis. For the EFA, items that had initial loading below 0.50 and were cross loaded were removed. The validity and reliability of the survey were evaluated accordingly. In addition, multiple linear regression and path analysis were conducted to further examine the relations among the factors of TPACK-G and teachers' acceptance of digital game-based learning.

3. Results and discussion

3.1 Explanatory Factor Analysis of the TPACK-G and ADGBL

The results of the exploratory factor analysis for the TPACK-G survey are shown in Table 1. By using principal component analysis as the extraction method and the rotation method of varimax with Kasier normalization, the participants' responses were grouped into three orthogonal factors: GK, GPK, and GPCK. The items with factor loading less than 0.50 and with many cross loadings were deleted. The cumulative variances explained by the three factors were 78.9 %. A total of 14 items were kept in the final version of the TPACK-G survey. In addition, the respective reliability coefficients (Cronbach's alpha) were GK (0.90), GPK (0.92), and GPCK (0.94). The overall reliability coefficient was 0.95, suggesting that this instrument is highly reliable in assessing the sample of in-service preschool teachers' self-efficacy regarding the TPACK-G. As shown in Table 1, the participants scored relatively high on the GPK scale (an average of 4.80 per item) and relatively low on the GPCK (an average of 4.50 per item) scale. This reveals that the preschool teachers in Taiwan tended to have less confidence in their GPCK.

Table 2 shows the results of the explanatory analysis for the ADGBL. Similarly, the ADGBL used a factor loading greater than 0.50 for retaining the items. All the 21 items were kept in the final version of the ADGBL and four factors were extracted. The total variances explained are 81 %. The alpha coefficients of each factors were 0.95, 0.93, 0.91 and 0.95, respectively for LO, EWG, PVG and ATT. The overall reliability coefficient is 0.96, indicating a satisfactory level of internal consistency. As indicated in Table 2, the results show that the participants attained relatively high scores on the "Attitudes toward GBL" scale (an average of 5.23 per item) and low scores on the "experience with games" scale (an average of 3.75 per item). This result implied that the targeted participants were inclined to have favorable attitudes toward game-based learning but they might have insufficient experience with games.

Table 1 Rotated factor loadings, Cronbach's alpha values, factor means, and SDs for the three factors of the Technological Pedagogical Content-Game (TPACK-G) survey

	Factor 1	Factor 2	Factor 3
Factor 1: GK, alpha = 0.90, mean = 4.70, *SD* = 1.08			
GK1	0.88		
GK2	0.82		
GK3	0.80		
GK4	0.67		
Factor 2: GPK, alpha = 0.92, mean = 4.89, SD = 1.12			
GPK1		0.78	
GPK2		0.77	
GPK3		0.75	
GPK4		0.75	
GPK5		0.73	
Factor 3: GPCK, alpha =0.94, mean = 4.50, SD = 1.22			
GPCK1			0.85
GPCK2			0.85
GPCK3			0.78
GPCK4			0.72
GPCK5			0.71

Note. Overall alpha: 0.95; and the total variance explained: 78.9%.

Table 2 ***Rotated factor loadings, Cronbach's alpha values, factor means, and SDs for the three factors of the acceptance of digital game-based learning (ADGBL) survey***

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1: Learning opportunities, alpha = 0.95, mean = 5.01, SD = 1.10				
LO 1	0.85			
LO 2	0.82			
LO 3	0.82			
LO 4	0.81			
LO 5	0.76			
LO 6	0.75			
LO 7	0.74			
Factor 2: Experience with games, alpha = 0.93, mean = 3.75, SD = 1.41				
EWG 1		0.90		
EWG 2		0.89		
EWG 3		0.87		
EWG 4		0.82		
EWG 5		0.66		
Factor 3: Preference for games, alpha = 0.91, mean = 4.42, SD = 1.41				
PVG 1			0.71	
PVG 2			0.65	
PVG 3			0.64	
Factor 4: Attitudes toward DGBL, alpha = 0.95, mean = 5.23, SD = 1.10				
ATT 1				0.86
ATT 2				0.85
ATT 3				0.83
ATT 4				0.82
ATT 5				0.79
ATT 6				0.78

Note. Overall alpha: 0.96; and the total variance explained: 81%.

3.2 The correlation between TPACK-G and ADGBL

The Pearson correlation coefficients between the TPACK-G factors and the ADGBL factors were calculated to explore the relations between the teachers' TPACK-G and their ADGBL. As shown in Table 3, all the factors of TPACK-G were positively correlated to those of ADGBL with statistical significance. In comparison with other factors of

ADGBL, the TPACK-G factors were highly correlated with ATT (attitudes toward game-based learning). Especially, GPK was highly correlated with ATT (r = 0.57, p <0.01). This finding implies that the more positive attitudes the preschool teachers have toward digital game-based learning, the more confidence they may have in their game pedagogical knowledge.

Table 3 The correlations among the factors between the TPACK-G and ADGBL

	Learning opportunities	Experience with game	Preference for games	Attitudes toward DGBL
GK	0.40**	0.48**	0.43**	0.50**
GPK	0.49**	0.48**	0.50**	0.57**
GPCK	0.43**	0.52**	0.50**	0.51**

**p < 0.01.

3.3 Path analysis

To explore the roles that teachers' ADGBL in their TPACK-G, this study utilized the multiple linear regression and path analysis technique to examine the relationships between these variables. The ADGBL factors were considered as predictors, while the TPACK-G factors were viewed as outcome variables that were respectively entered to predict GPCK. A collinearity analysis was performed to examine whether there was any multicollinearity problem among the predictors in the regression model. The results showed that all the VIF (Variance Inflation Factor) values were around 2, suggesting no multicollinearity issue in the models [11]. The model indicates several significant associations between the factors in the TPACK-G and those in the ADGBL (See Figure 2). First of all, "Experience with games" and "Attitude toward DGBL" could significantly explain the outcome of GK (β = 0.38, p < 0.001, and β = 0.41, p < 0.001). The preschool teachers who had more experience with games and more positive attitudes toward digital game-based learning would have more confidence in their game knowledge. Second, "Learning opportunity", "Attitude toward DGBL" and GK had significantly positive influence on GPK (β = 0.11, p < 0.05; β = 0.19, p < 0.001; β = 0.53, p < 0.001). This finding reveals that the teachers who had more game knowledge, more positive attitudes toward digital game-based learning, and stronger belief that games can provide opportunities for learning appeared to have more GPK. Third, both "Experience with games" and GPK exert a significantly positive impact on GPCK (β = 0.17, p < 0.01; β = 0.59, p < 0.001), indicating that the teachers' GPK and their experience with games contribute to their GPCK.

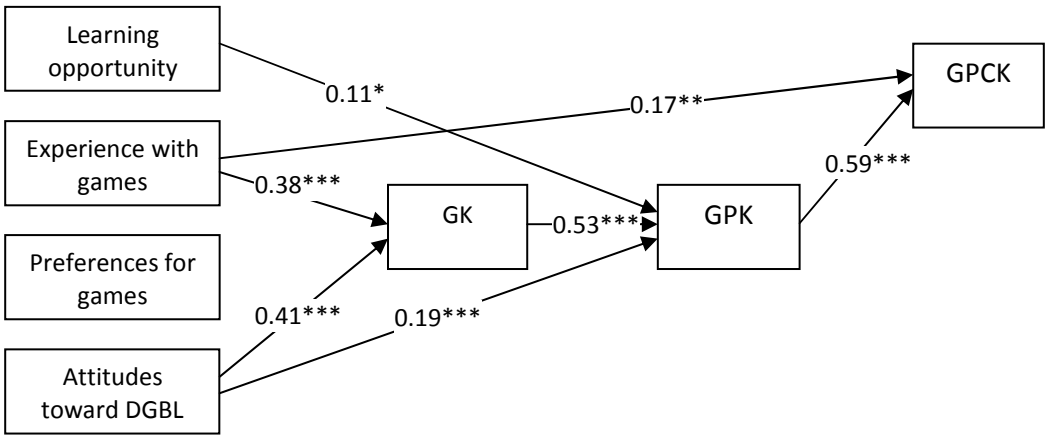

Figure 2. The structural model between TPACK-G and ADGBL.
*p < 0.05; **p < 0.01; ***p < 0.001.

5. Implications

The framework of TPACK-G proposed by this study was examined and supported, which suggests that GK is more general and fundamental and the more specific knowledge factors (GPK, GPCK) build on the GK. This sequence implies that, instead of diving in ways of promoting preschool teachers' GPCK during professional development, an instructor should first help to acquire adequate amount of game knowledge and game pedagogical knowledge in order to develop specific GPCK. In addition, while facilitating development of GK, critical factors also include one's attitudes toward digital game-based learning as well as experience with games. People's preferences for games may not necessary contribute to their game knowledge. Further, while developing GPK, in addition to GK, how one believes that the usage of games in the classroom can offer students' learning opportunities may guide their GPK. Thus, it is essential to offer cases, for instance, to convince practitioners that games can become legitimate instructional tools.

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