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Surveying In-Service Teachers' Beliefs about Game-Based Learning and Perceptions of Technological Pedagogical and Content Knowledge of Games

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ABSTRACT

Using the Game-based-learning Teaching Belief Scale (GTBS) and the Technological Pedagogical Content Knowledge—Games questionnaire (TPACK-G), this study investigated 316 Taiwanese in-service teachers' teaching beliefs about game-based learning and their perceptions of game-based pedagogical content knowledge (GPCK). Both *t*-tests and ANOVA analyses were used to examine the differences due to their demographic backgrounds. Correlation and regression analyses were used to examine the predicting variables of the teachers' GPCK. The results showed that, among the factors of GTBS and TPACK-G, GPK plays the most critical role in predicting GPCK. In addition, the elementary school teachers had stronger Belief, Confidence and Motivation for using game-based teaching approaches, and had higher GPK and GPCK than middle school teachers. A gender difference only existed in GK. Younger teachers had better GK and GCK than older teachers. Compared with experienced teachers, novice teachers tended to believe that digital games can assist learning and instruction, and perceived higher self-efficacy in their TPACK-G.

Keywords

Game-based learning, TPACK, Games, Teacher, Teaching beliefs

Introduction

Digital games (hereafter named games) have been gaining tremendous interest as tools for teaching and learning in recent years. The merits of game-based learning (GBL) include supporting effective learning (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013), enhancing higher order thinking (Sánchez & Olivares, 2011; Yang, 2015), increasing problem-solving skills (Akcaoglu & Koehler, 2014; van de Sande, Segers, & Verhoeven, 2015), and promoting engagement (Annetta, Minogue, Holmes, & Cheng, 2009; Hsieh, Lin, & Hou, 2015). Despite the potential of games as tools for teaching and learning, teachers, as indicated by Klopfer, Osterweil, and Salen (2009), could possibly face barriers to adopting games in class. For instance, they might have little experience of integrating games into the classroom, and they might have problems engaging students due to insufficient understanding of the variety of games available. Most importantly, successful models of integrating pedagogy, content, and games into a range of curricular experiences are limited, which may reduce teachers' willingness to utilize games in class. While game-based learning is potentially useful for improving teaching and learning, finding a theoretical framework that helps to probe practitioners' knowledge of teaching with games has become crucial.

A potentially helpful framework for evaluating and guiding the integration of technology into classroom teaching and learning is technological pedagogical content knowledge (TPACK) (Chai, Koh, Tsai, & Tan, 2011). Due to the popularity of technology in education, Mishra and Koehler (2006) extended Shulman's (1986) pedagogical content knowledge (PCK) by adding technological knowledge (TK) as an integrated part of pedagogical knowledge (PK) and content knowledge (CK). Successful integration of technology into the classroom requires one to focus on the complex interplay of these three forms of knowledge (Mishra & Koehler, 2006). While the notion of TPACK has received attention and approval, many researchers (e.g., Hsu, Chai, Liang, & Tsai, 2013; Lee & Tsai, 2010) quickly found that the current TPACK studies tend to treat technology in a general manner. This may mean that the TPACK framework is unable to provide guidelines for teaching with a specific type of technology such as games. Thus, building on Mishra and Koehler's (2006) TPACK, Hsu et al. (2013) proposed a framework of Technological Pedagogical Content Knowledge-Games (TPACK-G). The TPACK-G includes game knowledge (GK), game pedagogical knowledge (GPK), game content knowledge (GCK), and game pedagogical content knowledge (GPCK). GK is knowledge about the general usage of games; GPK is knowledge about using games to implement different teaching methods; GCK is knowledge about subject matter

representation with games; and lastly, GPCK is knowledge about using games to implement pedagogical strategies for teaching any subject matter content.

Many researchers and educators have indicated that teachers play the dominant role in using games in the formal educational context (Blackwell, Lauricella, Wartella, Robb, & Schomburg, 2013; Celik & Yesilyurt, 2013; Ketelhut & Schifter, 2011). This is due to the fact that teachers' teaching behaviors are influenced by their beliefs, confidence and motivations for teaching. For instance, teachers who believed that technology works best for instruction were found to be able to integrate technology into their teaching practices (Blackwell et al., 2013; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Kordaki, 2013). Teachers with higher confidence in technology are likely to effectively and significantly succeed in technology-related tasks (Celik & Yesilyurt, 2013; Teo, 2009). Motivated teachers tend to integrate ICT into their classroom teaching as well as displaying continuous usage of technology in class (Sang, Valcke, van Braak, Tondeur, & Zhu, 2011). Thus, exploring the factors contributing to the individual differences in teachers' teaching beliefs about using games for teaching has become an essential issue in the game-based learning research.

Individual personal factors such as age, gender, teaching experience and teaching levels usually play important roles in teachers' teaching beliefs, confidence, commitments and motivations for teaching. Thus, the demographic factors such as gender, age, and teaching experience may also influence teachers' technology use in class. Researchers (Erdogan & Sahin, 2010; Jang & Tsai, 2013) have reported that male teachers were more competent in their technology-related knowledge (e.g., TK and TPCK) than female teachers. Others (Lin, Tsai, Chai, & Lee, 2013) also indicated that the older the in-service science teachers, the less their confidence in embedding technology into their teaching. Similarly, in Lee and Tsai's (2010) study on probing teachers' self-efficacy for teaching on the Web, teachers with more teaching experience tended to have lower self-efficacy for using the Web for instruction. Lastly, in Taiwan, middle school teachers are recruited to teach the subject based on their undergraduate major, whereas elementary school teachers are generalists. This may result in different GTBS and TPACK perceptions according to teaching level, which has rarely been examined. Moreover, one issue which needs to be noted in Taiwan is the difference in the ICT acceptance and implementations between elementary schools and secondary schools. For example, in a recent ICT project initiated by the Ministry of Education (2015) in Taiwan to enhance future citizen's literacy education, 80 percent of the projects were applied by elementary schools, whereas only 20 percent came from middle schools. These different participation rates may be related to the different motivations, willingness and attitudes toward using ICT of teachers at the different school levels. Therefore, it is important to explore if there are any differences in elementary and secondary school teachers' teaching beliefs and self-efficacy for using new technology such as games for teaching.

In sum, researchers have indicated the influences of teachers' demographic variables (e.g., age, gender, teaching experience) and affective variables (e.g., confidence, motivation) on their behaviors of integrating technology into education. However, little research has been specifically conducted to establish a similar link to teachers' classroom uses of games, especially in terms of the teaching beliefs regarding games-based learning. The present study aimed to fill this gap. The purposes of the study were to answer these two questions:

- What are Taiwanese in-service teachers' teaching beliefs about game-based learning (GTBS) and TPACK-G perceptions in terms of their demographics (teaching level, gender, age and teaching experience)?
- How do teacher demographics and GTBS (Beliefs, Confidence, and Motivation) and the TPACK-G constructs (GK, GPK, and GCK) predict in-service teachers' GPCK?

Methodology

Participants

The participants of this study included 316 in-service teachers teaching in the northern, middle and southern parts of Taiwan. Within this sample, 176 were elementary school teachers (45 males and 131 females) and 140 were middle school teachers (36 males and 104 females). The average age was 38.80 (SD = 7.78) and the average teaching experience was 14.29 years (SD = 8.51). Regarding the educational background, 50.9 % of the teachers had a bachelor's degree, and 49.1 % had a master's degree. The teachers reported that their average game playing experience was 3.15 years (SD = 4.92). After completing the surveys, some participants were randomly selected for interview to probe their beliefs about game-based learning.

Instruments

The questionnaires, Game-based-learning Teaching Belief Scale (GTBS) and Technological Pedagogical Content Knowledge—Games (TPACK-G), were employed in this study. The GTBS was revised from Chang and Tsai's (2014) previous work on assessing teachers' teaching beliefs about game-based learning. The original version (Chang & Tsai, 2014) included 13 items categorized into the three subscales of Belief, Attitude and Motivation, with an overall reliability of 0.87. Through a further validation using a confirmatory factor analysis, four items with a factor loading of less than 0.50 and with many cross loadings were deleted. The final GTBS scale used in this study consists of the following three factors: Belief, Confidence, and Motivation. Descriptions of the three subscales are presented below:

- *Belief*: assessing teachers' subjective and firm perspectives, values and trustworthiness of digital game-based learning, such as "I believe that digital games provide students opportunities to solve problems."
- *Confidence*: measuring teachers' experience and confidence in adopting digital games in teaching, such as "I have no idea how to integrate digital games into my curriculum" (scored in reverse).
- *Motivation*: assessing teachers' commitment and willingness to adopt digital game-based learning for teaching in the future, such as "When I prepare my teaching plans, I will link my curriculum with digital games."

The final GTBS scale consisted of 9 items which were categorized into 3 subscales. They were measured using a seven-point Likert scale, ranging from strongly disagree to strongly agree. In this study, the reliability coefficients were 0.83, 0.87, 0.86, respectively for the Belief, Confidence and Motivation subscales, and 0.87 for the overall scale. This suggests that this scale is highly reliable in terms of assessing teachers' teaching beliefs and commitments to using GBL in teaching.

The TPACK-G survey was developed by Hsu et al. (2013) to explore teachers' confidence in TPACK-G. Modified from Koh, Chai, and Tsai's (2013) and Lee and Tsai's (2010) survey items, this instrument includes the factors of game knowledge, game pedagogical knowledge, game content knowledge, and game pedagogical content knowledge. Descriptions of the factors are presented below.

- *Game knowledge (GK)*: measuring teachers' confidence in using digital games, such as "I can learn digital games easily."
- *Game pedagogical knowledge (GPK)*: exploring teachers' confidence in using digital games to enhance students' learning, such as "I know how to use characteristics of digital games to support teaching."
- *Game content knowledge (GCK)*: assessing teachers' confidence in using digital games to represent specific content, such as "I can identify whether the core concepts of the subject matter knowledge are displayed in the digital games."
- *Game pedagogical content knowledge (GPCK)*: measuring teachers' confidence in utilizing appropriate pedagogy and digital games to support students' learning of specific content, such as "I can teach lessons that appropriately combine my teaching subject, digital games and teaching approaches."

The TPACK-G survey includes 22 items presented with a seven-point Likert scale, ranging from strongly disagree to strongly agree. The Cronbach's alpha coefficients respectively for these scales were 0.94, 0.95, 0.97 and 0.96. The overall alpha was 0.96, suggesting that these scales had high reliability for assessing teachers' confidence in their TPACK-G.

Data analysis

A series of independent *t*-tests was conducted to examine any difference in the participants' GTBS and TPACK-G in terms of their teaching level and gender. The participants' ages and years of teaching experience were separately categorized into three levels. The former included the levels 21-30, 31-40, and over 40, while the latter included the levels 0-10, 11-20, and over 20. Analyses of variance (ANOVA) were conducted to investigate any differences among these groups. A stepwise regression model was conducted with GPCK as the dependent variable, and the GTBS constructs and the remaining TPACK-G constructs and demographic factors as independent variables.

Results

What are Taiwanese in-service teachers' GTBS and TPACK-G perceptions in relation to their teaching level?

A series of independent *t*-tests was conducted to compare different teachers' teaching beliefs about GTBS. As shown in Table 1, significant differences were identified in the dimensions of Belief (t = 4.06, p < .001), Confidence (t = 4.97, p < .001), and Motivation (t = 3.59, p < .001). The elementary school teachers outperformed the middle school teachers on Belief (Mean = 4.65; *SD* = 1.09), Confidence (Mean = 4.62; *SD* = 1.25), and Motivation (Mean =3.95; *SD* = 1.23). That is, in comparison with the middle school teachers, the elementary school teachers were more likely to utilize games in their teaching. They believed that games could offer more learning opportunities and increase the effectiveness of their teaching. Table 1 also shows the results of the independent t-test analysis of the teachers' TPACK-G. As shown, two statistical differences were found in GPK (t = 4.48, p < .001) and GPCK (t = 4.22, p < .001). The elementary school teachers outperformed the middle school teachers in terms of GPK (Mean = 4.63; *SD* = 1.32) and GPCK (Mean = 4.55; *SD* = 1.36). This suggests that the elementary school teachers were more inclined to enhance their students' learning by using digital games. In addition, they were more likely to combine teaching subject, digital games and teaching approaches appropriately. However, no statistically significant difference was found in GK and GCK.

Table 1. *t*-test analysis of teachers' GTBS and TPACK-G by teaching level

Scales	Teaching level	*N*	Mean	*SD*	*t*-value
Belief	Elementary school	174	4.65	1.09	4.06*
	Middle school	140	4.17	1.00	
Confidence	Elementary school	174	4.62	1.25	4.97*
	Middle school	140	3.93	1.19	
Motivation	Elementary school	174	3.95	1.23	3.59*
	Middle school	140	3.47	1.11	
GK	Elementary school	174	4.08	1.48	0.33
	Middle school	140	4.03	1.33	
GCK	Elementary school	174	4.68	1.28	1.14
	Middle school	140	4.51	1.32	
GPK	Elementary school	174	4.63	1.32	4.48*
	Middle school	140	3.95	1.39	
GPCK	Elementary school	174	4.55	1.36	4.22*
	Middle school	140	3.88	1.42	

Note. *p < .001.

What are Taiwanese in-service teachers' GTBS and TPACK-G perceptions in relation to their gender?

Teachers' GTBS and TPACK-G were further investigated by gender. No statistically significant difference was identified in the teachers' GTBS. The only statistically significant difference in TPACK-G was the GK factor (t = 4.15, p < .001). Male teachers' GK score (Mean = 4.60, *SD* = 1.41) was higher than that of female teachers (Mean = 3.87, *SD* = 1.37), which suggests that male teachers tend to learn digital games more easily and have the technical skills to play digital games more effectively. That is, no significant difference was found in male and female teachers' teaching beliefs about GBL teaching approaches, although they had significantly different self-efficacies regarding game playing knowledge.

What are Taiwanese in-service teachers' GTBS and TPACK-G perceptions in relation to their age?

A series of ANOVA analyses were conducted to examine any statistically significant difference in GTBS and TPACK-G of the participants with different age groups. The results show that no statistically significant difference was found in the participants' GTBS. For TPACK-G (See Table 2), two statistically significant differences identified were GK (F = 11.97, p < .001) and GCK (F = 3.18, p < .05). For GK, the results of the post-hoc tests indicate that teachers in the age group of 21 to 30 (Mean = 4.83, *SD* = 1.11) outperformed the other two groups (Mean = 4.10, *SD* = 1.48, for group 31-40; Mean = 3.72, *SD* = 1.37 for group over 40). This implies that in comparison with older teachers, the younger teachers tended to have higher self-efficacy for using games to represent the teaching content and learning digital games. Regarding GCK, the results of the post-hoc tests show that those aged 21 to 30 (Mean = 4.98, *SD* = 1.03) outperformed those over 40 (Mean = 4.44, *SD* =

1.37). This finding suggests that when it comes to using games to represent subject knowledge, younger teachers were more confident than those who were over 40.

Table 2. ANOVA analysis of teachers' GTBS and TPACK-G by different age levels

TPACK-G	Age level (Mean, *SD*)			*F*	Post-hoc
	(1) 21-30 (*N* = 50)	(2) 31-40 (*N* = 119)	(3) over 40 (*N* = 139)		
Belief	4.40 (.97)	4.34 (.95)	4.54 (1.17)	1.16	
Confidence	4.48 (1.24)	4.22 (1.24)	4.31 (1.31)	.72	
Motivation	3.94 (1.17)	3.60 (1.14)	3.78 (1.24)	1.60	
GK	4.83 (1.11)	4.10 (1.48)	3.72 (1.37)	11.97***	(1)>(2)**, (1)>(3)***
GCK	4.98 (1.03)	4.64 (1.32)	4.44 (1.37)	3.18*	(1)>(3)*
GPK	4.47 (1.41)	4.28 (1.37)	4.31 (1.42)	.31	
GPCK	4.57 (1.22)	4.16 (1.44)	4.20 (1.48)	1.54	

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

What are Taiwanese in-service teachers' GTBS and TPACK-G perceptions in relation to their teaching experience?

This study divided the participants' teaching experience into three levels: 0-10 years (n = 124), 11-20 years (n = 105) and over 20 years (n = 84). A series of ANOVA analyses was conducted to examine teachers' teaching beliefs according to these three levels. As shown in Table 3, two statistically significant differences were found for Belief (F = 4.07, $p < .05$) and Motivation (F = 4.82, $p < .01$). For Belief, the results of the post hoc tests further showed that teachers with teaching experience of over 20 years (Mean = 4.62, *SD* = 1.10) significantly outperformed those with teaching experience ranging from 11 to 20 years (Mean = 4.21, *SD* = 1.12). In terms of Motivation, the results display that teachers whose teaching experience was less than 10 years (Mean = 3.92, *SD* = 1.13) scored higher than those whose teaching experience ranged from 11 to 20 years (Mean = 3.45, *SD* = 1.28).

As shown in Table 3, years of teaching experience played a role in GK (F = 19.16, $p < .001$), GCK (F = 6.51, $p < .01$), GPK (F = 3.18, $p < .05$) and GPCK (F = 4.41, $p < .05$). With a series of Scheffé tests, it was further indicated that teachers with teaching experience of less than 10 years tended to have higher self-efficacy in their GK, GCK, GPK and GPCK than those with teaching experience of more than 10 years. This implies that younger teachers tended to have higher confidence in appropriately integrating content, games and pedagogy for promoting students' learning.

Table 3. ANOVA analysis of teachers' GTBS and TPACK-G by years of teaching experience

GAS	Mean			*F*	Scheffe
	(1) 0-10 (*N* = 124)	(2) 11-20 (*N* = 105)	(3) over 20 (*N* = 84)		
Belief	4.54 (.98)	4.21 (1.12)	4.62 (1.10)	4.07*	(3)>(2)*
Confidence	4.33 (1.26)	4.32 (1.31)	4.29 (1.25)	0.03	
Motivation	3.92 (1.13)	3.45 (1.28)	3.84 (1.17)	4.82**	(1)>(2)*
GK	4.62 (1.21)	3.76 (1.45)	3.57 (1.38)	19.16***	(1)>(2)***; (1)>(3)***
GCK	4.92 (1.13)	4.37 (1.48)	4.40 (1.22)	6.51**	(1)>(2)**; (1)>(3)*
GPK	4.51 (1.31)	4.06 (1.49)	4.40 (1.35)	3.18*	(1)>(2)*
GPCK	4.52 (1.28)	3.97 (1.52)	4.21 (1.47)	4.41*	(1)>(2)*

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

How do demographic factors and GTBS (Belief, Confidence, Motivation) and TPACK-G constructs (GK, GPK, and GCK) predict in-service teachers' GPCK?

Table 4 shows that age and teaching experience were significantly highly related (r = .90, $p < .001$). Thus, both factors were also negatively related to the GK and GCK constructs (r = -0.14 ~ -0.32, $p < .05$). That is, the older

the teachers and the more teaching experience they had, the less their self-efficacy for GK and GCK. No significant relation was identified among age, teaching experience and the GTBS constructs. In addition, both GTBS and TPACK-G were significantly positively related. Among these, Confidence, Motivation, GK, GCK and GPK had stronger positive relations with GPCK, all above 0.60, suggesting large effect size coefficients (Cohen, 1988).

Table 4. Correlation among GTBS, TPACK-G, and demographics variables

	Age	Teaching experience	Belief	Confidence	Motivation	GK	GCK	GPK	GPCK
Age	1	.90***	.07	.00	-.03	-.31***	-.14*	-.03	-.09
Teaching experience		1	.05	-.03	-.06	-.32***	-.17**	-.05	-.10
Belief			1	.29***	.67***	.28***	.36***	.46***	.48***
Confidence				1	.47***	.44***	.46***	.61***	.65***
Motivation					1	.39***	.40***	.62***	.64***
GK						1	.65***	.58***	.60***
GCK							1	.66***	.63***
GPK								1	.86***
GPCK									1

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Stepwise regression analyses were conducted to identify the predictive effects of the GTBS, TPACK-G, and demographic factors (teaching level, gender, age and teaching experience) on GPCK. That is, GPCK served as the dependent variable and the remaining TPACK-G constructs, GTBS, and demographic factors were processed as the predictor variables. As shown in Table 5, stepwise regression of the models was statistically significant with an adjusted R^2 of 0.78. Among the predictors, GPK was the critical factor as it explained 73% of the total variance in Model 1. The addition of GK, GCK, Motivation, and Confidence merely increased 5% (see Model 4). According to the Beta values, all the variables had positive prediction of GPCK. The regression models also indicated that the demographic variables of teaching level, gender, age, and teaching experience were not significant predictors of GPCK.

Table 5. Stepwise regression models for GPCK

Model		B	Std. error	Beta	*t*	*F*	R^2
1	(Constant)	.46	.14		3.35**	826.95	.73
	GPK	.87	.03	.86	28.76***		
2	(Constant)	.02	.15		0.11	475.29	.76
	GPK	.74	.04	.73	20.36***		
	Confidence	.24	.04	.21	5.83***		
3	(Constant)	-.17	.16		-1.06	335.31	.77
	GPK	.67	.04	.66	16.52***		
	Confidence	.21	.04	.18	5.21***		
	Motivation	.16	.04	.14	3.76***		
4	(Constant)	-.31	.16		-1.94	265.10	.78
	GPK	.61	.04	.60	14.23***		
	Confidence	.19	.04	.17	4.76***		
	Motivation	.16	.04	.13	3.75***		
	GK	.12	.03	.12	3.65***		

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Discussion

Game-based learning, a specific pedagogical environment, has been receiving growing attention in the last decade. Many researchers (Eastwood & Sadler, 2013; Kenny & McDaniel, 2011) have indicated that teachers play a dominant role in game-based learning. Thus, probing practitioners' beliefs and perceptions of teaching with games has become essential. This study investigated Taiwanese in-service teachers' teaching beliefs about game-based learning (GTBS) and their TPACK-G perceptions. The results of the stepwise regression models suggest that the teachers' GPK plays an essential role in explaining their GPCK, accounting for 73% of the variance explained. This finding is resonant with prior research (Hsu et al., 2013) investigating 352 in-service preschool teachers' technological pedagogical content knowledge of games. Similarly, the results also identified

a positive relationship between GPK and GPCK. Prior research has highlighted the importance of embedding pedagogy into game-based learning. According to Kiili (2007), playing educational games is likely to support the practice of learning factual information since the players might merely exhibit trial-and-error behaviors. Thus, adding pedagogy into game-based learning may enhance players' engagement so as to achieve meaningful learning (Hsu, Tsai, & Wang, 2012), such as self-explanation (Adams, & Clark, 2014; Johnson & Mayer, 2010; Hsu et al., 2012), prediction-observation-explanation (POE) (Hsu, Tsai, & Liang, 2011), and problem-solving (Chang, Wu, Weng, & Sung, 2012; Kiili, 2007). Additionally, a recent study (Evans, Nino, Deater-Deckard, & Chang, 2015) used the TPACK framework to evaluate a learning game implementation. They found that while implementing games in class, teachers were able to have their students work in pairs and apply the concepts just learned in the gaming scenarios. Furthermore, traditional tests or quizzes were replaced with more innovative assessments, that is, playing games. Teachers could collect feedback or identify students with learning difficulties through the log files. As GPK is a fundamental element in developing GPCK, any strategies that enhance linkages between games and pedagogy, such as the aforementioned approaches, need to be pinpointed clearly for teachers.

In addition to GPK, the findings of this study show that motivation, confidence and GK are the significant variables that predict GPCK. Although many researchers (Celik & Yesilyurt, 2013; Sang et al., 2011; Teo, 2009) have found that teachers' confidence and motivation would impact their ICT usage in class, rarely have the current TPACK studies investigated how teachers' confidence and motivation relate to their perceptions of TPACK, particularly games (e.g., GPCK). The findings of this study can bridge this gap. Moreover, direct influence of in-service teachers' TK on their TPACK has been identified in many TPACK studies (Graham et al., 2009; Koh et al., 2013; Koh, Chai, & Tsai, 2014). This study extends the findings of the aforementioned research by establishing a similar link to teachers' classroom use of games. The present study also found that teachers' perceptions of GPCK did not appear to be predicted by the demographic variables (e.g., teaching level, teaching experience, age and gender). This finding is resonant with the results of the prior research, suggesting that in-service teachers' age and gender (Koh et al., 2014) or age and teaching experience (Chai et al., 2011) have no significant influence on their TPACK. In contrast, some studies still indicated that gender differences exist in in-service teachers' TPACK (Lin et al., 2013). Teaching level and teaching experience play significant roles in predicting in-service teachers' TPACK (Koh et al., 2014). The older the in-service teachers are, the less confidence they have in their TPACK (Lee & Tsai, 2010). These contradictory findings warrant further investigation in future studies.

This study found that the elementary school teachers tended to have more favorable Belief, Confidence, Motivation, GPK and GPCK than the middle school teachers (see Table 1). A selective interview was conducted to probe teachers' beliefs about game-based learning. Most of the middle school teacher interviewees replied that due to the tight teaching schedule, they felt too rushed to find any spare time for integrating game-based learning into their classes. This, in comparison with elementary school teachers, might lead to their low confidence in GPK and GPCK together with their confidence and motivation for using game-based learning. Conversely, the elementary school teachers, even the more senior teachers, tended to show great interest in and willingness to utilize games to facilitate students' learning. This finding is in contrast with Koh et al.'s (2014) study which investigated in-service teachers' TPACK in Singapore. They found that due to the differences in college majors, secondary school teachers who were subject specialists and used ICT in a specific area tended to have higher confidence in their TPACK. However, the primary school teachers who were subject specialists and approached TPACK across various subjects were likely to have lower confidence in their TPACK. These inconsistent findings could be due to the cultural differences between the school teachers in Taiwan and Singapore. Another possible explanation could be that higher TPACK accompanies higher teaching loads, especially for teaching in a gaming context. Future studies can further explore the social, cultural and systematic issues in teachers' teaching beliefs, motivation and self-efficacy for using games for instruction.

Finally, the results showed that a gender difference only occurred in GK. That is, the male teachers tended to have more confidence in their GK than the females. This corresponds with previous studies (Jang & Tsai, 2013; Lin et al., 2013) which revealed that in-service male teachers perceived more confidence in their TK. Regarding teaching experience, previous studies have shown that more experienced teachers were inclined to demonstrate higher TPACK than novice teachers (Jang & Tsai, 2012). Conversely, this study found that teachers with teaching experience of less than 10 years tended to perceive higher self-efficacy in their GK, GCK, GPK and GPCK than those with teaching experience of 11 to 20 years (see Table 1). Indeed, prior research has indicated that preservice teachers' lack of teaching experience not only leads to their incapability of integrating technology into teaching (Ozgun-Koca, Meagher, & Edwards, 2010) but also the development of a new knowledge base (e.g., TPK) (Pamuk, 2012). Once they have accumulated some teaching experience, these younger teachers could be expected to confidently demonstrate a certain level of knowledge of game-based teaching.

In conclusion, this study found that the in-service teachers' GPK plays the most dominant role in predicting their GPCK. Other significant variables include motivation, confidence and GK, instead of teaching level, teaching experience, age and gender. In comparison with the middle school teachers, the elementary school teachers tended to have more favorable Belief, Confidence, Motivation, GPK and GPCK. Younger teachers whose teaching experience was less than 10 years tended to perceive higher self-efficacy in their GK, GCK, GPK and GPCK than those whose teaching experience ranged from 11 to 20 years.

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References

Adams, D. M., & Clark, D. B. (2014). Integrating self-explanation functionality into a complex game environment: Keeping gaming in motion. *Computers & Education, 73*, 149-159. doi:10.1016/j.compedu.2014.01.002

Akcaoglu, M., & Koehler, M. J. (2014). Cognitive outcomes from the game-design and learning (GDL) after-school program. *Computers & Education, 75*, 72-81. doi:10.1016/j.compedu.2014.02.003

Annetta, L. A., Minogue, J., Holmes, S. Y., & Cheng, M. T. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers & Education, 53*, 74-85. doi:10.1016/j.compedu.2008.12.020

Blackwell, C. K., Lauricella, A. R., Wartella, E., Robb, M., & Schomburg, R. (2013). Adoption and use of technology in early education: The Interplay of extrinsic barriers and teacher attitudes. *Computers & Education, 69*, 310-319. doi:10.1016/j.compedu.2013.07.024

Celik, V., & Yesilyurt, E. (2013). Attitudes to technology, perceived computer self-efficacy and computer anxiety as predictors of computer supported education. *Computers & Education, 60*, 148-158. doi:10.1016/j.compedu.2012.06.008

Chai, C. S., Koh, J. H. L., Tsai, C.-C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education, 57*, 1184-1193. doi:10.1016/j.compedu.2011.01.007

Chang, K.-E., Wu, L.-J., Weng, S.-E., & Sung, Y.-T. (2012). Embedding game-based problem-solving phase into problem-posing system for mathematics learning. *Computers & Education, 58*, 775-786. doi:10.1016/j.compedu.2011.10.002

Chang, Y.-H., & Tsai, M.-J. (2014, December). *Developing an instrument to assess teachers' belief, confidence and motivation about digital game-based learning.* Paper presented at the Proceedings of the 22nd International Conference on Computers in Education, Japan.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A Systematic literature review of empirical evidence on computer games and serious games. *Computers & Education, 59*, 661-686. doi:10.1016/j.compedu.2012.03.004

Eastwood, J. L., & Sadler, T. D. (2013). Teachers' implementation of a game-based biotechnology curriculum. *Computers & Education, 66*, 11-24. doi:10.1016/j.compedu.2013.02.003

Erdogan, A., & Sahin, I. (2010). Relationship between math teacher candidates' technological pedagogical and content knowledge (TPACK) and achievement levels. *Procedia - Social and Behavioral Sciences, 2*, 2707-2711. doi:10.1016/j.sbspro.2010.03.400

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A Critical relationship. *Computers & Education, 59*, 423-435. doi:10.1016/j.compedu.2012.02.001

Evans, M., Nino, M., Deater-Deckard, K., & Chang, M. (2015). School-wide adoption of a mathematics learning game in a middle school setting: Using the TPACK framework to analyze effects on practice. *The Asia-Pacific Education Researcher, 24*, 495-504. doi:10.1007/s40299-014-0225-y

Graham, R., Burgoyne, N., Cantrell, P., Smith, L., St Clair, L., & Harris, R. (2009). TPACK development in science teaching: Measuring the TPACK confidence of inservice science teachers. *TechTrends, 53*(5), 70-79. doi:10.1007/s11528-009-0328-0

Hsieh, Y. H., Lin, Y. C., & Hou, H. T. (2015). Exploring elementary-school students' engagement patterns in a game-based learning environment. *Educational Technology & Society, 18*, 336-348.

Hsu, C.-Y., Liang, J.-C., Chai, C.-S., & Tsai, C.-C. (2013). Exploring preschool teachers' technological pedagogical content knowledge of educational games. *Journal of Educational Computing Research, 49*, 461-479. doi:10.2190/EC.49.4.c

Hsu, C.-Y., Tsai, C.-C., & Liang, J.-C. (2011). Facilitating preschoolers' scientific knowledge construction via computer games regarding light and shadow: The effect of the prediction-observation-explanation (POE) strategy. *Journal of Science Education and Technology, 20*, 482-493. doi:10.1007/s10956-011-9298-z

Hsu, C.-Y., Tsai, C.-C., & Wang, H.-Y. (2012). Facilitating third graders' acquisition of scientific concepts through digital game-based learning: The effects of self-explanation principles. *The Asia-Pacific Education Researcher, 21*(1), 71-82.

Jang, S.-J., & Tsai, M.-F. (2012). Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards. *Computers & Education, 59*, 327-338. doi:10.1016/j.compedu.2012.02.003

Jang, S.-J., & Tsai, M.-F. (2013). Exploring the TPACK of Taiwanese secondary school science teachers using a new contextualized TPACK model. *Australasian Journal of Educational Technology, 29*, 566-580.

Johnson, C. I., & Mayer, R. E. (2010). Applying the self-explanation principle to multimedia learning in a computer-based game-like environment. *Computers in Human Behavior, 26*, 1246-1252. doi:10.1016/j.chb.2010.03.025

Kenny, R. F., & McDaniel, R. (2011). The Role teachers' expectations and value assessments of video games play in their adopting and integrating them into their classrooms. *British Journal of Educational Technology, 42*, 197-213. doi:10.1111/j.1467-8535.2009.01007.x

Ketelhut, D. J., & Schifter, C. C. (2011). Teachers and game-based learning: Improving understanding of how to increase efficacy of adoption. *Computers & Education, 56*, 539-546. doi:10.1016/j.compedu.2010.10.002

Kiili, K. (2007). Foundation for problem-based gaming. *British Journal of Educational Technology, 38*, 394-404. doi:10.1111/j.1467-8535.2007.00704.x

Klopfer, E., Osterweil, S., & Salen, K. (2009). *Moving learning games forward*. Cambridge, MA: The Education Arcade.

Koh, J. H. L., Chai, C. S., & Tsai, C.-C. (2014). Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK. *Journal of Educational Technology & Society, 17*(1), 185-196.

Koh, J. H. L., Chai, C. S., & Tsai, C.-C. (2013). Examining practicing teachers' perceptions of technological pedagogical content knowledge (TPACK) pathways: A Structural equation modeling approach. *Instructional Science, 41*, 793-809. doi:10.1007/s11251-012-9249-y

Kordaki, M. (2013). High school computing teachers' beliefs and practices: A Case study. *Computers & Education, 68*, 141-152. doi:10.1016/j.compedu.2013.04.020

Lee, M.-H., & Tsai, C.-C. (2010). Exploring teachers' perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web. *Instructional Science, 38*, 1-21. doi:10.1007/s11251-008-9075-4

Lin, T.-C., Tsai, C.-C., Chai, C. S., & Lee, M.-H. (2013). Identifying science teachers' perceptions of technological pedagogical and content knowledge (TPACK). *Journal of Science Education and Technology, 22*, 325-336. doi:10.1007/s10956-012-9396-6

Ministry of Education (2015). *The Digital reading in primary and secondary schools* [中小學數位輔助學科閱讀計畫]. Retrieved from http://elfess.ee.ncku.edu.tw/planCase/

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A Framework for teacher knowledge. *Teachers College Record, 108*, 1017-1054.

Ozgun-Koca, S. A., Meagher, M., & Edwards, M. T. (2010). Preservice teachers' emerging TPACK in a technology-rich methods class. *Mathematics Educator, 19*(2), 10-20.

Pamuk, S. (2012). Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning, 28*, 425-439. doi:10.1111/j.1365-2729.2011.00447.x

Sánchez, J., & Olivares, R. (2011). Problem solving and collaboration using mobile serious games. *Computers & Education, 57*, 1943-1952. doi:10.1016/j.compedu.2011.04.012

Sang, G., Valcke, M., van Braak, J., Tondeur, J., & Zhu, C. (2011). Predicting ICT integration into classroom teaching in Chinese primary schools: Exploring the complex interplay of teacher-related variables. *Journal of Computer Assisted Learning, 27*, 160-172. doi:10.1111/j.1365-2729.2010.00383.x

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Teo, T. (2009). Examining the relationship between student teachers' self-efficacy beliefs and their intended uses of technology for teaching: A Structural equation modelling approach. *Turkish Online Journal of Educational Technology-TOJET, 8*(4), 7-15.

van de Sande, E., Segers, E., & Verhoeven, L. (2015). The Role of executive control in young children's serious gaming behavior. *Computers & Education, 82*, 432-441. doi:10.1016/j.compedu.2014.12.004

Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A Meta-analysis of the cognitive and motivational effects of serious games. *Journal of educational psychology, 105*, 249-265. doi:10.1037/a0031311

Yang, Y.-T. C. (2015). Virtual CEOs: A Blended approach to digital gaming for enhancing higher order thinking and academic achievement among vocational high school students. *Computers & Education, 81*, 281-295. doi:10.1016/j.compedu.2014.10.004

Appendix 1

Belief 1: Digital games can improve teaching effectiveness.
Belief 2: Using digital games makes teaching easy.
Belief 3: Digital games can provide students with problem solving opportunities.

Confidence 1: It is difficult for me to integrate digital games into my instruction.
Confidence 2: I have no idea how to integrate digital games into my curriculum.
Confidence 3: I always feel frustrated when I use digital games in my classroom.

Motivation 1: I will not consider using digital games in my courses.
Motivation 2: I plan to use digital games in my classroom.
Motivation 3: When I prepare my teaching plans, I will link my curriculum with digital games.

Note. Confidence 1~3 and Motivation 1 were scored in reverse.

Appendix 2

GK1: I can learn digital games easily.
GK2: I can familiarize myself with the game interface.
GK3: I have the technical skills to play digital games effectively.
GK4: I know how to search for and download digital games.

GCK1: I can identify the knowledge related to the subject matter in the digital games.
GCK2: I can tell whether the digital games represent the targeted subject matter knowledge.
GCK3: I can identify whether the core concepts of the subject matter knowledge are displayed in the digital games.
GCK4: I can identify whether the subject matter knowledge is applied in digital games.

GPK1: I know how to use the characteristics of digital games to support teaching.
GPK2: I know the relevant instructional strategies of digital games.
GPK3: I know how to integrate digital games into teaching.

GPCK1: I can teach lessons that appropriately combine my teaching subject, digital games and teaching approaches.
GPCK2: I can craft real world problems about the content knowledge and represent them through digital games to engage my students.
GPCK3: I can select digital games to use in my classroom that enhance what I teach, how I teach and what students learn.