Factors Influencing Preservice Teachers' Intention to Use Technology: TPACK, Teacher Self-efficacy, and Technology Acceptance Model

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ABSTRACT

This study aimed to investigate structural relationships between TPACK, teacher self-efficacy, perceived ease of use, and perceived usefulness for preservice teachers who intend to use technology, based on the Technology Acceptance Model (TAM). A total of 296 responses from the College of Education from three Korean universities were analyzed by employing the structural equation modeling methods. The results indicated that preservice teachers' TPACK significantly affected teacher self-efficacy and perceived ease of using technology. The teachers' TPACK also positively influenced their perceived ease of using technology and perceived usefulness of technology in the classroom. Finally, teacher self-efficacy, perceived ease of use, and perceived usefulness of using technology affected teachers' intention to use technology. However, TPACK did not directly affect their intention to use technology. Based on the findings, we discuss implications and suggest future research directions for preservice teachers' intention to use technology.

Keywords

Intention to use technology, Preservice teacher, TPACK, Teacher self-efficacy, Technology Acceptance Model (TAM)

Introduction

As information communication technology has developed, technology-integrated learning has also evolved, and the demand for technology in education has increased. In response to technical changes in educational settings, teachers, as experts, must both address the challenges of teaching with technology and maintain a good grasp of subject-matter content. In an era of highly valued technological knowledge, it is important that teachers develop an integrated knowledge of teaching, content, and technology, called Technology Pedagogy and Content Knowledge (TPACK), as suggested by Mishra and Koehler (2006). TPACK is becoming a required area of expertise for teachers in new learning environments in the 21st century.

In South Korea (hereafter Korea), technology-integrated learning and teaching has become increasingly prevalent, with high-tech learning environments, such as mobile technology, social media, smart classrooms, flipped learning, and live webcasts (Lee & Park, 2016). Flipped learning allows teachers to invert their classes. The benefit to students is that they have more time to digest material, rather than listen to lectures; teachers upload videos and lecture on a new platform which students can access both online and on mobile devices before class. Students can thus review the contents and materials in advance and actively participate in a discussion during class. In addition, the Korean government has encouraged schools and teachers to use and apply the flipped learning method (Korean Ministry of Education, 2016), based on scholarly evidence on the positive effect of the flipped learning approach on students' achievement (Chao, Chen, & Chuang, 2015; Zainuddin & Halili, 2016). To create such a technology-friendly learning environment, teachers' positive experiences with use of technology and their intention to use technology are critical (Baek, Jong, & Kim, 2008).

Scholars have discussed how to improve users' positive perception of technology and intention to use technology by adopting the Technology Acceptance Model (TAM) (Cheung & Vogel, 2013; Teo, Su Luan, & Sing, 2008). Davis (1989) first defined TAM as a theory that explains the factors influencing the intention to use information technology in order to improve performance in organizations. Perceived ease of use and perceived usefulness of technology are the most critical concepts that influence the intention to use technology; thus, external variables that affect these two concepts should be considered (Davis, 1989). More recent research emphasizes external variables that influence perceived ease of use and perceived usefulness in TAM (Venkatesh, Thong, & Xu, 2012). In addition to the intention to use technology, TAM further applies the intention to various learning technologies and diverse media-based learning environments, including online and mobile learning (Huang, Lin,

& Chuang, 2007). Therefore, we applied the concept of TAM to teaching contexts and educational settings from a teacher's perspective.

The affective aspect of teachers is important when they use new technology, because it can influence their decision-making and behavior (Kramarski & Michalsky, 2010). Various complicated tasks are needed to match appropriate technology to teaching methods (Kramarski & Michalsky, 2010; Shin, 2013). Therefore, when looking at the factors influencing technology adoption, not only the cognitive aspect but also the affective aspect should be considered.

Self-efficacy can be defined as an individual's belief in one's ability to organize and implement actions to carry out designated types of performance and tasks (Bandura, 1977). Teacher self-efficacy refers to "the teacher's personal belief in ability to plan instruction and accomplish instructional objectives" (Gavora, 2010, p. 18). Researchers have actively discussed teacher self-efficacy as they have paid more attention to the influence of self-efficacy on teacher behavior since the 1970s (Henson, 2001). In particular, self-efficacy is the most powerful factor affecting teacher behavior (Henson, 2001; Tschannen-Moran & Hoy, 2001). Those with higher teacher self-efficacy were more likely to use more advanced instructional methods closely related to their students' learning (Henson, 2001).

However, little empirical research has focused on the relationships between TPACK, teacher self-efficacy, and TAM (Alsofyani, Aris, Eynon, & Majid, 2012; Hsu, 2016). Further, few scholars have paid much attention to the significant influence of TPACK on both preservice teachers' self-efficacy and their intention to use technology. More research on understanding preservice teachers and supporting them to apply TPACK in their future schools needs to be conducted. In this study, we regarded four factors (TPACK, teacher self-efficacy, perceived ease of use, and perceived usefulness) as the antecedents of the intention to use technology. Based on TAM, this study explores the predictors of preservice teachers' intentions to use technology by connecting preservice teachers' cognitive (TPACK) and affective (teacher self-efficacy) characteristics. That is, the purpose of this study is to investigate the structural relationships between the four factors and preservice teachers' intentions to use technology.

The significance of this study is that it identifies factors that affect intention to use technology, including TPACK and teacher self-efficacy, for preservice teachers who need to become able to integrate knowledge of teaching, content, and technology in new learning environments in the Korean context. Additionally, by examining the relationships between factors, this study emphasizes that teacher self-efficacy and TPACK are core formative factors for increasing intention to use technology. The current study implies that developing and improving TPACK plays a critical role in helping preservice teachers use and integrate technology into educational contexts appropriately.

Literature review

TPACK

TPACK is a theoretical framework for describing the interaction and integration of technology, pedagogy, and content knowledge needed to successfully integrate technology use into teaching (Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009). Shulman (1986) first claimed that teachers needed content knowledge (CK), pedagogy knowledge (PK), and pedagogical content knowledge (PCK). Mishra and Koehler (2006) extended Shulman's (1986) work by adding technological knowledge (TK) and used the term TPACK. The TPACK framework consists of seven domains: CK, PK, TK, PCK, technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPCK) (Mishra & Koehler, 2006).

Based on the three main knowledge categories for teachers (i.e., content, pedagogy, and technology), TPACK emphasizes the dynamic interaction and integration of knowledge with the use of technology (Schmidt et al., 2009; Thompson & Mishra, 2007). It describes the use of technology to support specific pedagogies within a particular content area. Additionally, TPACK describes the use of technology as an instructional technique. Finally, it describes the use of technology to help teachers improve student learning (Schmidt et al., 2009; Thompson & Mishra, 2007).

Scholars have found that TPACK is positively related to teacher self-efficacy, perceived ease of use, perceived usefulness of technology, and intention to use technology (Abbitt, 2011; Alsofyani et al., 2012;

Horzum&Gungoren, 2012; Liu, 2011; Sahin, Celik, Akturk, & Aydin, 2013; Semiz&Ince, 2012). Preservice teachers demonstrated a high level of teacher self-efficacy when using TPACK in different contexts, including math education, early childhood education, college education, and physical education (Abbitt, 2011; Semiz&Ince, 2012). In addition, TPACK significantly and positively influenced perceived ease of use and perceived usefulness (Alsofyani et al., 2012; Horzum&Gungoren, 2012). In technology-based learning environments, preservice teachers are more likely to perceive the easy use and usefulness of technology when they learn how to use and apply TPACK in the classroom (Horzum&Gungoren, 2012). Moreover, TPACK positively influenced teachers' and preservice teachers' intention to use technology in technology-integrated learning and teaching settings (Alsofyani et al., 2012; Liu, 2011). Teachers who developed TPACK were more likely to be confident and to intend to select and use a technology in an appropriate way in their instruction (Maeng, Mulvey, Smetana, & Bell, 2013).

Teacher self-efficacy

Teacher self-efficacy relates to teachers' personal beliefs about their abilities and skills as educators. It includes both their beliefs about their ability to plan instruction and to accomplish instructional objectives (Gavora, 2010) and their confidence in their ability to promote student learning (Hoy, 2000).

Many studies have also reported that teacher self-efficacy has a positive influence on student achievement (Denham & Michael, 1981; Moore & Esselman, 1992). According to these studies, teachers with high self-efficacy ask their students open-ended questions, use inquiry methods, and prefer small-group learning activities more than their counterparts with low self-efficacy do (Brouwers & Tomic, 2003; Henson, 2001). Teachers who have high self-efficacy are more likely to use innovative components in instructional activities and are more willing to try creative and untested teaching methods (Gavora, 2010). In addition, highly self-efficacious teachers are more open to new ideas, have a greater commitment to teaching, and are more willing to adopt better teaching methods (Tschannen-Moran & Hoy, 2001). As previous studies have discussed (Brouwers & Tomic, 2003; Henson, 2001), teacher self-efficacy can significantly motivate adoption of new technologies in the classroom.

Several researchers have confirmed the relationships between teacher self-efficacy and intention to use technology (Anderson, Groulx, & Maninger, 2011; Jeung, 2014; Baker-Eveleth & Stone, 2008; Banas & York, 2014; Valtonen, Kukkonen, Kontkanen, Dillon, & Sointu, 2015). Preservice teachers' beliefs about the value of classroom technology integration were significant predictors of their intentions to use technology in classrooms (Anderson et al., 2011). Valtonen et al. (2015) also reported that preservice teachers' self-efficacy positively affected their intention to use information and communication technology.

Perceived ease of use and perceived usefulness

Perceived ease of use is the degree to which users believe they will use new technology without particular difficulty. Perceived usefulness means how much individual users recognize that new technology will help improve performance (Davis, 1989).

Based on TAM, researchers have explored the influence of perceived ease of use on perceived usefulness (Chow, Herold, Choo, & Chan, 2012; Joo, Lee, & Ham, 2014; Lee & Lehto, 2013). Data from 350 students who used mobile learning services at a leading online university in Korea confirmed that perceived ease of use significantly influenced perceived usefulness for integrating a user interface and personal innovativeness into TAM for mobile learning (Joo et al., 2014). In *Second Life*, a 3D virtual environment, 206 nursing students perceived the new system as being useful when they were able to use it easily (Chow et al., 2012).

Research has confirmed that perceived ease of use and perceived usefulness significantly affect teachers' intention to use technology (Jeung, 2014; Davis, Bagozzi &Warshaw, 1989; Suki & Suki, 2011; Teo, 2011; Wangpipatwong, Chutimaskul, & Papasratorn, 2008). For instance, Wangpipatwong et al. (2008) found that perceived ease of use and perceived usefulness were positive predictors of intention to use an e-government website.

Intention to use technology

Intention to use technology can be defined as the degree to which the user would like to use technology in the future. Scholars have proposed that intention to use technology is a form of technology acceptance behavior relevant to perceived ease of use and perceived usefulness (Chow et al., 2012; Lee & Lehto, 2013; Teo, 2011). Teachers are more likely to intend to use technology when they perceive the easy use and usefulness of technology in learning and teaching (Teo, 2011). In addition, teacher self-efficacy has been regarded as critical for explaining teachers' use of technology in the classroom (Albion, 2001). Furthermore, preservice teachers with developed TPACK tend to be confident and to intend to use technology in their instruction (Alsofyani et al., 2012; Liu, 2011; Maeng et al., 2013). In this study, we regarded intention to use technology as a final dependent variable to support previous studies on the relationships between the variables mentioned above.

Theoretical framework: Technology Acceptance Model (TAM)

The relationships between TPACK, perceived ease of use, perceived usefulness, and intention to use technology can be discussed in the context of the technology acceptance model (TAM). TAM, developed by Davis (1989), has been used to explain factors affecting individual acceptance of technology, based on Fishbein and Ajzen's (1975) theory of reasoned action. In TAM, perceived usefulness and perceived ease of use directly influence the intention to use technology; moreover, perceived usefulness is directly affected by perceived ease of use (Davis, 1989).

In the original version, TAM included only perceived usefulness, perceived ease of use, attitude toward using, and behavioral intention to use (Davis, 1989). To respond to criticism of the original TAM's parsimony, Venkatesh and Davis, (2000) extended TAM by including external variables that affect perceived usefulness, perceived ease to use, and, ultimately, intention to use technology. As Figure 1 shows, external variables influence perceived usefulness and perceived ease of use; perceived ease of use affects perceived usefulness; both perceived usefulness and perceived ease of use affect intention to use; and ultimately the intention to use influences actual usage. This study considers TPACK and teacher self-efficacy as cognitive and affective factors that influence preservice teachers' intention to use technology for their instruction.

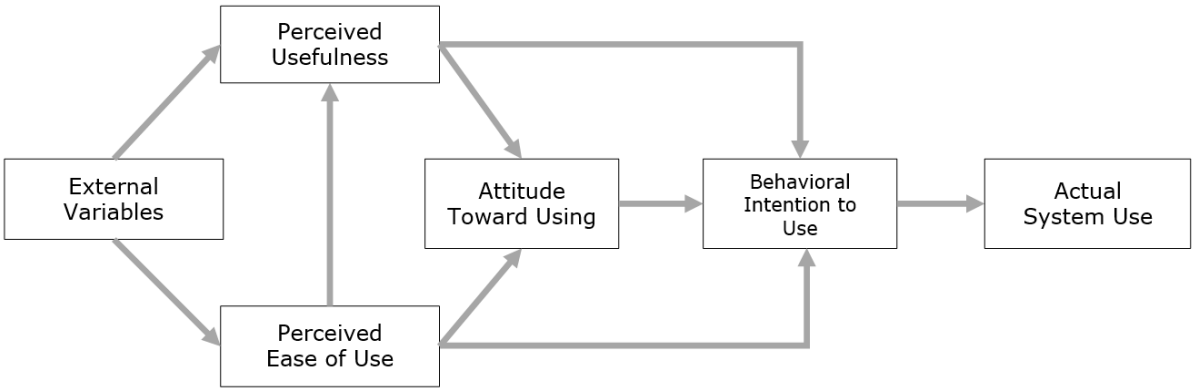

Figure 1. Technology acceptance model (TAM) (Davis, Bagozzi, &Warshaw, 1989, p. 985)

Based on the literature review and our theoretical framework, this study examined the structural relationships between factors influencing preservice teachers' self-efficacy, perceived usefulness, perceived ease of use, and their intention to use technology for teaching. TPACK was considered a critical factor that influences other variables in this study. Figure 2 displays the research hypotheses for this study.

Hypothesis 1: Preservice teacher's TPACK will positively affect teacher self-efficacy.
Hypothesis 2: Preservice teacher's TPACK will positively affect perceived ease of using technology.
Hypothesis 3: Preservice teacher's TPACK and perceived ease of use will positively affect perceived usefulness of technology.
Hypothesis 4: Preservice teacher's TPACK, teacher self-efficacy, perceived ease of use, and perceived usefulness of technology will affect intention to use technology.

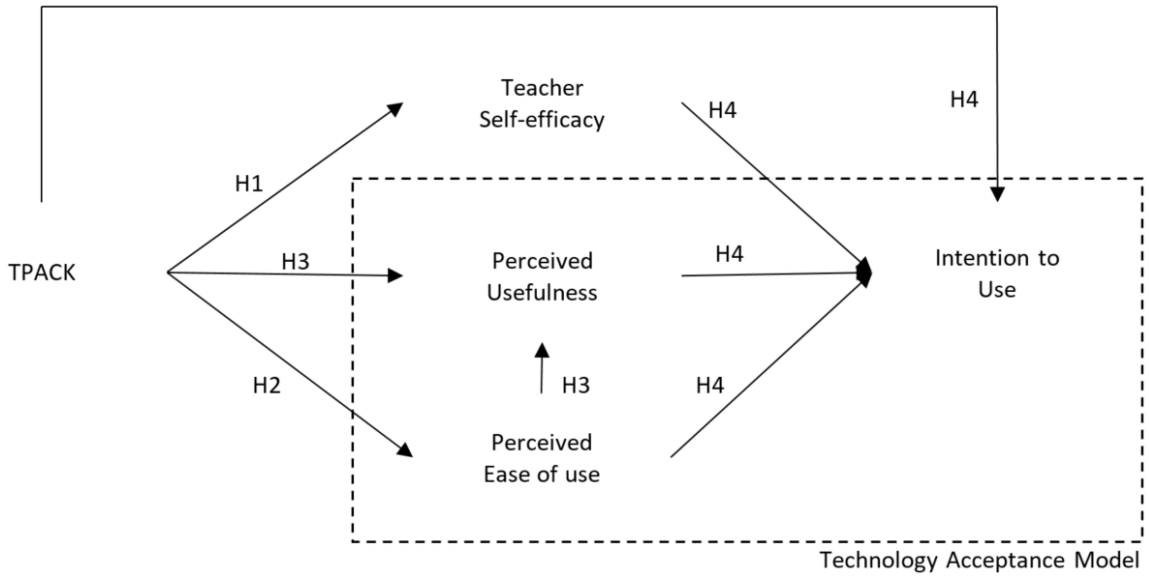

Figure 2. Hypothesized research model

Methods

Participants and procedures

The survey participants were undergraduate students enrolled in a required 2-credit teacher certification course in the College of Education at three Korean universities (Table 1). These preservice teachers intended to work in middle and high schools after graduation. The teacher certification course opened in Fall 2014 and ran for two hours a week for 16 weeks. Each week, students studied teaching and learning theories, instructional design concepts, and multimedia. Assessments included midterm exams, microteaching skill practice, group activities, and presentations. A paper-and-pencil survey was conducted during the last two weeks of the semester. To conduct the survey, instructors introduced this study, explained the purpose of the study, and distributed the questionnaire to students. Data were collected from 300 students; four incomplete responses were removed. Among the 296 (98.6%) respondents, 189 (63.9%) were female and 105 (35.5%) were male. Their average age was 22.3 years (*SD* = 1.71). Most were in their sophomore and junior year (78%).

Table 1. Participants' major programs

Major programs / Subjects	Frequency	Percentage (%)
Art, music, and physical education	68	23.0
Early childhood and elementary education	63	21.3
Foreign language (English, French, and German)	50	16.9
Social studies	42	14.2
Korean	30	10.1
Science (Physics and chemistry)	24	8.1
Mathematics	19	6.4
Total	296	100.0

Instruments

To examine the structural relationships between the variables, we used five measurement instruments that were based on existing instruments in English (see Table 2). The items were prepared for use in Korean by using appropriate translation-back-translation procedures. The questionnaire used a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) in order to have a consistent scale for the instruments. Cronbach's alpha was reviewed to consider internal consistency of the instruments. The questionnaire included 30 questions for participants, excluding demographics.

Table 2. Research instruments

Variables	Source	Sample	Items	Reliability	
				Original study	Current study
TPACK	Schmidt et al. (2009)	I can teach lessons that appropriately combine contents, technologies, and teaching approaches.	5	.92	.90
Teacher self-efficacy	Schwarzer et al. (1999)	If I try hard enough, I know that I can exert a positive influence on both the personal and academic development of my students.	10	.82	.86
Perceived ease of use	Davis (1989)	Teaching with technology is easy for me.	6	.94	.87
Perceived usefulness	Davis (1989)	Using technology enables me to teach more quickly.	6	.98	.90
Intention to use technology	Taylor & Todd (1995)	I intend to use technology in teaching when I become a teacher.	3	.91	.90

To measure TPACK, the scale developed by Schmidt et al. (2009) was adopted. Among the 47 TPACK instrument items, we selected eight items for TPCK, combined four repeated items (40-43) into one, and used the final five items. The original instrument was developed for preservice teachers in elementary and early childhood education, and included items to assess knowledge in all content areas. Since participants in this study were preservice teachers for middle and high schools, however, the subject matter for their courses had already been decided. Thus, we removed the expressions identifying specific subjects (such as mathematics, literacy, science, and social studies) in the four items and combined them into one item to assess content knowledge regardless of the subject. Experts in the field reviewed the modified and final instruments.

Teacher self-efficacy was also measured, using the instrument developed by Schwarzer and collegues (1999) because the original instrument was targeted at preservice teachers and focused on assessing their subjective beliefs about their own capability and personal competence.

To measure perceived ease of use and perceived usefulness, 12 items were employed from the instrument developed by Davis (1989). Finally, intention to use technology was measured by using three items developed by Taylor and Todd (1995).

Data analysis

The collected data were analyzed using the following procedures. First, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to confirm the validity and reliability of the measurement scale. After an exploratory factor analysis of each variable in this study, TPACK, teacher self-efficacy, perceived ease of use, perceived usefulness, and intention to use technology were found to be one-dimensional factors, requiring the use of item parcels in order to avoid placing too much weight on a particular variable in the hypothesized model (Kishton & Widamn, 1994). Item parceling was employed to reduce measurement error by combining individual items and using these combined items.

Second, descriptive statistics and correlation analysis were performed using SPSS. Multivariate normality was checked using AMOS by examining the skewness and kurtosis of each variable. The maximum likelihood estimation was selected as an appropriate statistical estimation method, because the variables fit the normal distribution. The goodness of fit indices used for this study were the minimum sample discrepancy (CMIN), Tucker-Lewis index (TLI), comparative fit index (CFI), standardized root mean square residual (SRMR), and root-mean-square error of approximation (RMSEA).

Structural equation modeling (SEM) was conducted to examine the structural relationships between the five variables in this study. SEM can analyze the integrated relationship among all variables in this study, and to estimate the relations among the variables that have been corrected for biases attributable to random error and construct-irrelevant variance (Bollen, 1989; Tomarken & Waller, 2005). By using multiple indicators to estimate the effects of latent variables, SEM corrects for unreliability within the construct and provides more accurate estimates of the relationship between the latent variable and the criterion (McCoach, Black, & O'Connell, 2007).

Results

The means, standard deviations, skewness, and kurtosis for all the variables were analyzed to confirm the multivariate normal distribution (Table 3). After item parceling, teacher self-efficacy was categorized into teacher self-efficacy in teaching (items 1-7) and administration (items 8-10). The mean scores ranged from 3.33 to 3.82; the standard deviations ranged from 0.57 to 0.71. Considering the skewness (ranging from |.09| to |.93|) and kurtosis values (ranging from |.46| to |1.69|), the collected data met the assumption of a multivariate normal distribution, in that the values of skewness were lower than 3 and the kurtosis values were lower than 10 (Kline, 2011). The VIF values were lower than 10, indicating that multicollinearity did not occur. The correlations among the variables were statistically significant ($p < .05$).

Table 3. Descriptive statistics and correlations for the variables

Measurement variable	1	2	3	4	5	6	7	8	9	10
1 TPACK 1	-									
2 TPACK 2	.78*	-								
3 TSE (teaching)	.49*	.50*	-							
4TSE (administration)	.35*	.38*	.49*	-						
5 P-Ease of Use 1	.47*	.43*	.42*	.42*	-					
6 P-Ease of Use 2	.52*	.48*	.44*	.43*	.82*	-				
7 P-Usefulness 1	.47*	.46*	.48*	.35*	.53*	.55*	-			
8 P-Usefulness 2	.48*	.43*	.52*	.37*	.56*	.59*	.86*	-		
9 Intention to Use 1	.49*	.44*	.47*	.38*	.52*	.59*	.69*	.71*	-	
10 Intention to Use 2	.46*	.46*	.53*	.40*	.58*	.58*	.70*	.71*	.81*	-
Mean	3.43	3.47	3.72	3.33	3.45	3.43	3.82	3.78	3.77	3.80
Standard Deviations	.71	.66	.57	.62	.68	.65	.64	.63	.71	.69
Skewness	-.93	-.69	-.85	.22	-.09	-.12	-.53	-.37	-.70	-.63
Kurtosis	1.69	1.50	2.16	.46	.77	1.22	1.06	1.06	1.29	1.42

Note. *$p < .05$.

Additionally, analysis of variance (ANOVA) was performed to see if there are significant differences in teacher self-efficacy, perceived ease of use, perceived usefulness, and intention to use technology according to participants' seven major programs. The results showed that there were no significant differences (Table 4).

Table 4. ANOVA results

		Sum of squares	*df*	Mean squares	F-value	*p*
Teacher self-efficacy	Between groups	2.093	6	.349	1.324	.246
	Within groups	76.147	289	.263		
	Total	78.240	295			
Perceived ease of use	Between groups	3.585	6	.598	1.516	.173
	Within groups	113.891	289	.394		
	Total	117.477	295			
Perceived usefulness	Between groups	2.599	6	.433	1.173	.321
	Within groups	106.739	289	.369		
	Total	109.337	295			
Intention to use technology	Between groups	1.314	6	.219	.491	.815
	Within groups	129.033	289	.446		
	Total	130.347	295			

Note. *$p < .05$.

Construct validity

CFA provides evidence that the instruments have convergent and discriminant validity. Convergent validity can be confirmed when the correlations between observed variables and latent variables are more than .50; discriminant validity can be confirmed when the correlations between latent variables are less than .80 (Kline, 2011). In particular, average variance extracted (AVE) values should exceed .50 and be larger than the square of the correlations in order to have discriminant validity (Kline, 2011). In this study, all factor-loading values (the correlations between observed variables and latent variables) were between .61 and .94 ($p < .05$) and AVE values (.53-.86) were larger than the square of the correlations between latent variables (.45-.85). The results indicated a good level of convergent and discriminant validity.

Measurement model

Before examining the structural model, the fitness of the measurement model was evaluated by maximum likelihood. As seen in Table 5, all fitness indexes of the measurement model seemed desirable (χ^2 = 41.402; *df* = 25; χ^2 /*df* = 1.656; TLI = .986; SRMR = .021; CFI = .992; RMSEA = .047). All factor-loading values of the items of each latent variable, ranging from .61 to .94, were acceptable.

Table 5. Results of fitness examination of the measurement model

	χ2	*df*	TLI	SRMR	CFI	RMSEA (90% Confidence Interval)
Measurement model	41.402	25	.986	.021	.992	.047 (.019 ~ .072)
Fit criteria	-	-	> .90	< .08	> .90	< .08

Structural model and hypothesis testing

As the measurement model satisfied the fitness index criteria and structural model's estimate possibility was theoretically confirmed, the study employed maximum likelihood estimations to estimate the initial research model's fitness. As shown in Table 6, the initial structural model provided a good fit to the data (χ^2 = 76.556; *df* = 27; χ^2 /*df* = 2.835; TLI = .963; SRMR = .064; CFI = .977; RMSEA = .079).

Table 6. Results of examination of fitness of the structural model

	χ2	*df*	TLI	SRMR	CFI	RMSEA (90% Confidence Interval)
Structural model	76.556	27	.961	.064	.977	.079 (.058 ~ 1.00)
Fit criteria	-	-	> .90	< .08	> .90	< .08

To test the hypotheses, the statistical significance of the path coefficient between the variables was examined. First, the direct effects of preservice teachers' TPACK (β = .73, t = 10.75, p < .05) on teacher self-efficacy was statistically significant. Second, the direct effects of preservice teachers' TPACK (β = .62, t = 10.59, p < .05) on perceived ease of use was statistically significant. Third, preservice teachers' TPACK (β = .29, t = 4.21, p < .05) and perceived ease of use (β = .49, t = 7.05, p < .05) had significant effects on perceived usefulness. Finally, teacher self-efficacy (β = .17, t = 2.07, p < .05), perceived ease of use (β = .19, t = 3.01, p < .05) and perceived usefulness (β = .64, t = 10.16, p < .05) also had significant effects on intention to use technology. However, the effect of preservice teachers' TPACK on intention to use technology was not significant (β = .00, t =.000, p > .05). In sum, hypotheses 1 through 3 were all supported, and hypothesis 4 was partially supported (Table 7).

Table 7. Hypothesis testing: Path coefficient estimates

	Paths			Path coefficient (*t*-value)
H1	TPACK	→	Teacher self-efficacy	.73* (10.75)
H2	TPACK	→	Perceived ease of use	.62* (10.59)
H3	TPACK	→	Perceived usefulness	.29* (4.21)
	Perceived ease of use	→	Perceived usefulness	.49* (7.05)
H4	TPACK	→	Intention to use technology	.00 (0.00)
	Teacher self-efficacy	→	Intention to use technology	.17* (2.07)
	Perceived ease of use	→	Intention to use technology	.19* (3.01)
	Perceived usefulness	→	Intention to use technology	.64* (10.16)

Note. $^*p$ < .05; *t*-value > |1.96|.

Based on the results from testing the hypotheses, a modified model (Figure 3) was created after removing one path (TPACK → Intention to use technology) because the effect of TPACK on intention to use technology was not significant in the hypothesized model. A chi-square statistic was generated to examine the statistical differences between the initial hypothesized model and the modified model. The results revealed no significant differences between the two models in goodness of fit ($\Delta\chi^2$= 0.00, p =.99), thus confirming the validity of the modified model as the final model used in this study. The modified model, as shown in Table 8, presented a good fit to the data (χ^2 =76.556; *df* = 28; χ^2 /*df* = 2.734; TLI = .963; SRMR= .064; CFI = .977; RMSEA = .077).

Table 8. Results of fitness examination of the hypothesized and modified models

	$\chi 2$	*df*	TLI	SRMR	CFI	RMSEA (90% Confidence Interval)
Hypothesized model	76.556	27	.961	.064	.977	.079(.058~.100)
Modified model	76.556	28	.963	.064	.977	.077(.056~.097)
Fit criteria	-	-	> .90	<.10	> .90	< .08

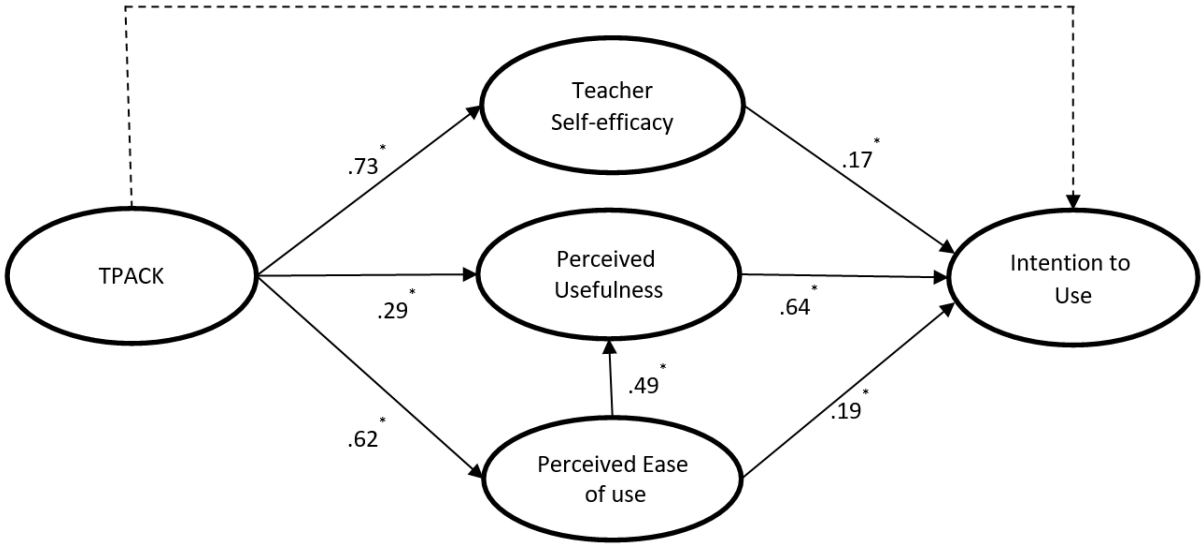

Figure 3. Modified model with standardized path coefficients ($^{*}p < .05$)

Discussion

This study examined the structural relationships between TPACK, teacher self-efficacy, perceived ease of use, perceived usefulness, and intention to use technology for preservice teachers. The findings supported the following implications. First, preservice teachers' TPACK positively affected teacher self-efficacy. This finding is in accord with the findings of previous studies (Abbitt, 2011; Semiz & Ince, 2012). It implies that preservice teachers with high levels of TPACK are more likely to increase their self-efficacy in teaching. TPACK would significantly affect a teacher's self-efficacy in learning environments with new learning technologies and media. Teachers and preservice teachers would benefit from the implementation of workshops and training programs to improve the level of TPACK.

In addition, preservice teachers' TPACK positively influenced perceived ease of use and perceived usefulness of technology, which supports previous research (Alsofyani et al., 2012; Horzum & Gungoren, 2012). In other words, preservice teachers who have high levels of TPACK would probably find it easier to use technology and would perceive using technology as a helpful teaching tool. Broad technical training should be provided to teachers and preservice teachers to overcome reluctance to learn new digital media and enable them to perceive ease of use and usefulness of technology. By establishing TPACK competency criteria, a systematic TPACK training series can be offered. Then, teachers and preservice teachers can learn more (e.g., how to use diverse apps and new teaching techniques in technology-integrated classes) according to their individual abilities and levels.

The current study also confirmed that perceived ease of use significantly affected perceived usefulness in TAM, which is consistent with previous studies (Davis, 1989; Chow et al. 2012; Joo et al., 2014). When teachers and preservice teachers perceive ease of use of technology, they can also perceive usefulness of technology. Considering that teachers' perceptions of usability (3.31 out of 5) and satisfaction (3.30 out of 5) were lower overall than students' perceptions of usability (3.69) and satisfaction (3.61) (KERIS, 2011), it is important for teachers to have enough time and opportunities to practice new technologies until they feel comfortable enough to use the technology and perceive that technology is useful in teaching.

Finally, teacher self-efficacy, perceived ease of use, and perceived usefulness had a positive influence on their intention to use technology. That is, the level of intention to use technology was determined by levels of teacher self-efficacy, perceived ease of use, and perceived usefulness of technology. However, the findings of this study

indicated that TPACK did not directly affect intention to use technology, although it did so indirectly. Perhaps TPACK indirectly influenced teachers' intention to use technology because teachers with high levels of TPACK spent more time handling students' unexpected behaviors than playing an anticipated role in a technology-integrated class; this might have influenced their intention to use technology (Joo et al., 2014).

In other words, TPACK affected teachers' intention to use technology through teacher self-efficacy, perceived ease of use, and perceived usefulness of technology. Perceived usefulness of technology (β = .64) has a stronger influence on intention to use technology than does teacher self-efficacy (β = .17) and perceived ease of use (β = .19). Even though preservice teachers have high teacher self-efficacy and perceive the ease to use of technology in classrooms, they could not accept technology when they thought that the use of technology does not contribute to meaningful learning experiences. That is, preservice teachers do not blindly use new technology, and they critically accept the technology based on its benefits to teaching and learning. To encourage teachers to use new technology in practice, it is important to provide them a stable infrastructure/system, so they can easily use the technology without any problem, by offering technology that is based on subjects and learners' characteristics.

Limitations and recommendations for future research

There are several limitations in this study. Above all, it focused on preservice teachers for only middle and high schools. In addition, the findings cannot be generalized, because the questionnaire was given only to undergraduate students in three Colleges of Education in Korea based on convenience sampling. Another limitation is that this cross-sectional study collected self-reported data, which could lead to common method bias. The relevance of the study could be limited by its focus, which is based upon self-report and perceptions of the ease of use and usefulness of technology rather than on the actual use of technology in classroom practice.

In future studies, preservice teachers in elementary schools could be recruited in order to compare those results with our current findings on student middle- and high-schoolteachers. Subsequent research could also examine how teachers use technology in practice. Further studies should include a variety of data sources to capture broader phenomena on similar topics. By comparing other teacher groups in different cultural contexts, future studies could explore how cultural differences affect teachers' perceptions of the use of technology. Additionally, diverse factors influencing teachers' intention to use technology could be examined. Experience related to technology, school support for using technology in classrooms, or teachers' anxiety about technology use should be included to observe different dynamics in technology-oriented learning environments.

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