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EURASIA Journal of Mathematics, Science and Technology Education, 2018, 14(10), em1594
ISSN:1305-8223 (online)
Research Paper https://doi.org/10.29333/ejmste/93379

Teachers' Beliefs About, Attitudes Toward, and Intention to Use Technology-Based Assessments: a Structural Equation Modeling Approach

Sung-Pei Chien[1], Hsin-Kai Wu [1,2*], Pai-Hsing Wu [1,3]

[1] Graduate Institute of Science Education, National Taiwan Normal University, Taipei, TAIWAN
[2] Faculty of Education, University of Johannesburg, Johannesburg, SOUTH AFRICA
[3] Department of Technology Application and Human Resource Development, National Taiwan Normal University, Taipei, TAIWAN

Received 18 May 2018 ▪ Revised 22 May 2018 ▪ Accepted 23 June 2018

ABSTRACT

This study aimed at determining the relationships among teachers' beliefs about, attitudes toward, and intention to use technology-based assessments (TBAs). These relationships were also compared among teachers with different degrees of usage. Based on the decomposed theory of planned behavior, this study collected questionnaire data from 494 high-school teachers who were classified into 3 groups: frequent users, occasional users, and nonusers. The results indicated that the models for the frequent and occasional users were similar, and confirmed the effects of attitude on the intention of teachers to use TBAs. However, perceived behavior control and subjective norms did not influence the intention of the included teachers.

Keywords: teacher beliefs, teacher education, technology-based assessments, decomposed theory of planned behavior model

INTRODUCTION

Many studies have indicated that teachers' beliefs impact on their acceptance and implementation of innovations in curricula (Gorozidis & Papaioannou, 2014; Pintó, 2005; Stylianidou, Boohan, & Ogborn, 2005), especially on their use of new technology tools (De Smet, Bourgonjon, De Wever, Schellens, & Valcke, 2012; Pynoo et al., 2011; Teo, 2011). Several theoretical models have been utilized to analyze and estimate the effects of beliefs on how teachers adopt technology for use in instruction. The technology acceptance model and theory of planned behavior are two powerful and validated models (Ajzen, 1991; Davis & Venkatesh, 1996; Taylor & Todd, 1995). However, the technology acceptance model is mainly based on beliefs about technology tools, and authors have argued more recently about the importance of factors associated with the context in which teachers work (Stylianidou et al., 2005; Wallace & Priestley, 2011; Wu, Hsu, & Hwang, 2008). For example, the influence of peers, supporting environments, and perceptions about students' learning have been suggested as influencing factors (Sassi, Monroy, & Testa, 2005; Stylianidou et al., 2005; Wallace & Priestley, 2011). Furthermore, new elements or constructs (e.g., perceived enjoyment and parents' expectations) have been added to the technology acceptance model and theory of planned behavior (Kriek & Stols, 2010; Teo & Noyes, 2011; Venkatesh, Morris, & Davis, 2003). This recent research has demonstrated a need for a more comprehensive model to explain how teachers' beliefs and contextual factors affect their use of technology. Additionally, while there has been a substantial amount of research on how teachers use technology in general, there has been relatively little research into how teachers use technology-based assessments (TBAs) in their teaching. This study addressed these gaps in the literature by including more factors found in previous qualitative research to examine the factors that affect the use of TBAs by teachers in their classrooms.

In addition to augmenting the relatively small amount of previous research, this study focused on teachers' beliefs about and use of TBAs due to the popularity and potential of these assessments. More TBAs have been adopted by large-scale and international evaluation programs in recent years (Quellmalz, Timms, Silberglitt, & Buckley, 2012), such as the Programme for International Student Assessment. Moreover, compared to paper-based

✉ cellist_2@hotmail.com ✉ hkwu@ntnu.edu.tw **(*Correspondence)** ✉ 695450153@ntnu.edu.tw

Contribution of this paper to the literature

- We have developed a specific and contextual questionnaire to elicit teachers' beliefs about technology-based assessments and conducted a confirmatory factor analysis to ensure unobserved beliefs could be identified by our questionnaire.
- Structural equation modeling was used to identify possible relationships among teachers' beliefs about, attitudes toward, and intention to use technology-based assessments.
- The results suggest that with the exception of teachers who had never used technology-based assessments previously, teachers' beliefs about usefulness, ease of use, and compatibility were significant predictors of their attitude, which could explain the intention of teachers to use technology-based assessments.

testing, TBAs have a greater potential to provide immediate feedback and automatic scoring, decrease the time required to collect and input test data, and allow the measurement of complex learning skills (Kuo & Wu, 2013). TBAs can help teachers diagnose students' learning problems by using data on students' performance (De Klerk, Veldkamp, & Eggen, 2015). Teachers could take advantage of specific characteristics of TBAs to achieve various teaching and assessment goals (Kuo & Wu, 2013; T. I. Wang, Su, & Hsieh, 2011).

However, not all TBAs take advantage of the potential described above (Kuo & Wu, 2013), while limitations in automated scoring (Kuo & Wu, 2013) and the required preparation time and lack of infrastructure (Lee, Feldman, & Beatty, 2012) have also prevented teachers from integrating TBAs into their assessment practices. It is therefore important for both researchers and teachers to know what factors may support teachers in implementing innovative TBAs in the way that aligns with the goal of educational reform (Lyon, 2011).

The present study investigated the beliefs of teachers and how they influence their intention to use TBAs by establishing and validating a novel model. The variables included in the proposed model were based on our previous qualitative study (Chien, Wu, & Hsu, 2014), and the model was developed to elicit teachers' thoughts about TBAs and the contextual factors of concern to them. Additionally, this study considered teachers' TBAs usage and compared differences between the models of teachers with different degrees of usage.

THEORETICAL BACKGROUND

According to Chen (2010), the definitions of teachers' beliefs and targeted behaviors need to be clarified when performing factor research about beliefs. In this section we therefore first define teachers' beliefs and articulate their beliefs about educational innovations and TBAs. We then introduce the models that have been developed in previous research to explain teachers' beliefs and technology use. Lastly, we propose the novel model that was developed and analyzed in this study.

Teachers' Beliefs

The definition. Teachers' beliefs can be viewed as the assumptions that they hold about teaching and learning (Pajares, 1992). Personal belief systems develop based on experience, and these systems generally contain multiple, nonindependent, and interrelated beliefs rather than having single and disconnected ones (Rokeach, 1968). Previous studies have shown that the different beliefs held by teachers interact with each other (De Smet et al., 2012; Teo, 2011) or combine with other beliefs (van Driel, Bulte, & Verloop, 2005). In addition, there is a complicated relationship between teachers' beliefs and practices and the mechanisms underlying the interactions between them (Graham, 2005). Some studies have asserted that teachers can interpret the events they encounter and make decisions about teaching based on their belief systems (Hart, 2002; Pajares, 1992; Quellmalz et al., 2012), resulting in their behaviors and practices being guided by their own specific beliefs about teaching (van der Schaaf, Stokking, & Verloop, 2008). However, other studies showed that positive beliefs or attitude do not guarantee that innovative practices will be implemented (Pintó, 2005; Viennot, Chauvet, Colin, & Rebmann, 2005). More research is therefore needed to reveal the complexity of teachers' beliefs and the interactions between beliefs and practices.

Teachers' beliefs about innovation. Teachers' beliefs about educational innovations can be viewed as their convictions about teaching and learning processes with implementations of educational innovations (Sassi et al., 2005; Stylianidou et al., 2005). There are also diverse opinions about the relationship between teachers' beliefs and practices regarding innovation, with the studies reviewed below indicating that teachers' beliefs can exert positive or negative effects on their practices, or be irrelevant to them.

Zacharia (2003) reported that teachers who hold positive attitudes toward computer simulations tend to incorporate technology in their teaching. Similarly, Styliandou et al. (2005) suggested that teachers' beliefs have a positive influence on their practices related to innovations. The teachers that they investigated had equal resources but different beliefs about learning and technology tools. Those authors found that the participating teachers demonstrated various ways to use these tools in their classrooms according to their different beliefs; in other words, teachers' beliefs about innovations can affect their decisions and transform their implementations of computer innovations in their schools. On the other hand, Kriek and Stols (2010) and some other authors have asserted that existing attitude or beliefs of teachers can also restrain them from using technology in the classroom, while other studies have indicated that even though most teachers show positive attitude toward or beliefs about educational innovations, a relatively small proportion of teachers actually implement innovations (Chien, Wu, & Hsu, 2014; Loogma, Kruusvall, & Umarik, 2012).

Furthermore, some studies have found external factors such as school resources and policy support to also exert important effects on innovation implementations (Loogma et al., 2012; Smarkola, 2008). As described in the introduction, hierarchical models were developed in the present study to portray the belief system and relevant factors, in order to reveal the variety of teachers' beliefs and explore the factors involved in their belief systems.

Teachers' beliefs about technology-based assessments. Most recent studies of teachers' beliefs have explored the general ideas that they have about teaching and learning (van Driel et al., 2005), but there has been little research into teachers' beliefs about TBAs in particular. Also, while research on TBAs and Web-based assessments has emphasized the design and scoring of Web-based assessments, only a few studies have investigated the assessment literacy of teachers (Fan, Wang, & Wang, 2011; T. H. Wang, Wang, & Huang, 2008). According to Wang et al. (2008), assessment literacy includes the knowledge and perspectives that teachers have about assessments. Ogan-Bekiroglu (2009) further identified difficulties in implementing alternative assessments and reported factors that affect teachers' attitudes toward assessment, such as time management and inadequate training. However, none of these studies systematically examined teachers' beliefs about TBAs or investigated the possible relationships between their beliefs about and use of TBAs.

This lack of research prompted Chien, Wu, and Hsu (2014) to conduct a qualitative analysis based on the decomposed theory of planned behavior, which was in accordance with the original assumptions about and definition of teachers' beliefs. The ten substantial beliefs that were identified could be categorized into behavioral, control, and normative beliefs. We found that although 34 of the 40 participating teachers perceived TBAs as useful instructional tools, only 19 of the teachers were accustomed to using, revising, or designing TBAs for their classroom activities, which classified them as frequent users. Regarding the relationship between teachers' beliefs about and use of TBAs, it was not surprising that the frequent users held more-positive beliefs about TBAs than did the nonusers and occasional users; however, the number of negative control and normative beliefs was the same for the frequent users and nonusers. These findings indicate the presence of a complicated relationship between beliefs and practices, and suggest that teachers with different degrees of TBA usage have different belief systems. However, the methodological limitations of our previous qualitative study meant that it could not provide further information about the connections between different types of teachers' beliefs, nor establish relationships between types of beliefs and degrees of usage. Therefore, the present study applied structural equation modeling (SEM) to explore teachers' belief systems, to validate possible relationships between types of beliefs and degrees of usage, and to compare models for teachers with different degrees of usage.

Models to Explain Teachers' Beliefs and Technology Use

The definition of teachers' beliefs and the interrelated nature of beliefs mean that any analysis of teachers' beliefs and technology use should be based on a systematic model. Below we review two powerful hierarchical models that have been validated and used to portray belief systems. We then present the novel model proposed and examined in this study.

Technology acceptance model. The technology acceptance model has been one of the most popular models used to explain how two beliefs of users—perceived usefulness and perceived ease of use—affect their behavioral intention, which in turn determines their actual use of technology (Davis & Venkatesh, 1996). Perceived usefulness is the belief that the use of new technology could improve the user's job performance (Davis, 1989), while perceived ease of use refers to the belief that the use of new technology will be free of effort (Davis, 1989). Research has shown that the perceived ease of use affects the perceived usefulness and has an indirect effect on attitude via the mediation of usefulness (Davis, 1993; Davis & Venkatesh, 1996). This means that the belief about ease of use could affect attitude both directly and indirectly.

While the technology acceptance model has been validated and adopted widely in the fields of psychology and education, limitations of this model have also been reported. Taylor and Todd (1995) argued that because the technology acceptance model contains only two personal beliefs about the technology itself, it excludes other important external factors such as the available resources and approval from colleagues. This might mean that the technology acceptance model is not sufficiently comprehensive to capture the effects of external variables or social factors on the actual use of technology (Smarkola, 2008; Taylor & Todd, 1995). Additionally, the perceived usefulness and ease of use may vary along with the context of the technology use (Cheon, Lee, Crooks, & Song,

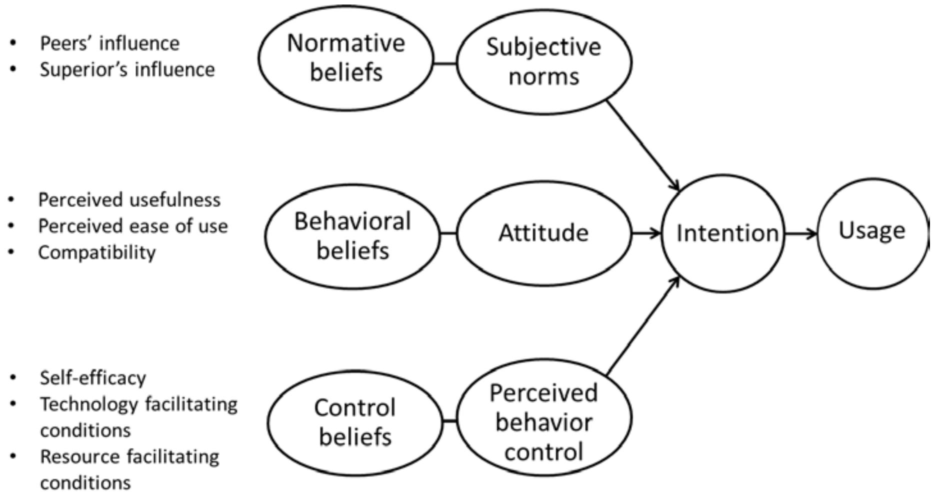

Figure 1. A model of the decomposed theory of planned behavior

2012), whereas the context (e.g., voluntary settings and mandatory settings) has usually been neglected in studies that have employed the technology acceptance model (Benbasat & Barki, 2007).

Some of the studies performed in the past decade have elaborated the technology acceptance model by adding new variables or new paths to it in accordance with the specific context of technology use. For example, Sanchez and Hueros (2010) integrated the variable of technical support into their technology acceptance model, because the Moodle course management system that they used may require supporting personnel to maintain a website or train the users. In addition to the perceived usefulness and ease of use, other studies also identified the facilitating conditions that would significantly influence teachers' usage of specific technology tools, such as the technical support (Pynoo et al., 2011; Sanchez & Hueros, 2010), environment settings (Chen, 2010), and expectations of superiors (Pynoo et al., 2011; Teo, 2011).

Decomposed theory of planned behavior. As an extension to the theory of planned behavior, the decomposed theory of planned behavior incorporates both personal and external factors (**Figure 1**). The attitude of users are decomposed into three behavioral beliefs in the decomposed theory of planned behavior: perceived usefulness, compatibility, and perceived ease of use (Kriek & Stols, 2010; Taylor & Todd, 1995). The self-efficacy, technology-facilitating conditions, and resource-facilitating conditions are control beliefs that affect perceived behavior control (PBC). The subjective norms (SN) are determined by normative beliefs, and include influences from peers and superiors (Taylor & Todd, 1995). The decomposed theory of planned behavior allows researchers to identify various external conditions and personal beliefs when teachers need to make decisions about technology use (Smarkola, 2008). Moreover, the theory suggests that the intention to use technology is not influenced by only a few disconnected beliefs, instead being affected by many antecedents and interactions between the beliefs (Benbasat & Barki, 2007; Cheon et al., 2012). Additionally, different beliefs could be found in the context of using TBAs in the classroom. While Chien, Wu, and Hsu (2014) found that the behavioral beliefs of teachers were similar to the original ones in the decomposed theory of planned behavior, it was also found that the facilitating conditions of technology and resources in the control beliefs could be classified into time, supporting personnel, infrastructure, and financial support. Also, in terms of normative beliefs, teachers were found to be more concerned about students' learning, parental support, and educational policies.

Based on the above-mentioned considerations, this study adopted both the technology acceptance model and the decomposed theory of planned behavior and modified them based on our previous qualitative study, which yielded a novel model (**Figure 2**). The proposed model has the structure of the decomposed theory of planned behavior, integrates internal and external factors, and includes the direct and indirect effects of the perceived ease of use on attitude as suggested by the technology acceptance model. It is worth noting that the definition of attitude in this study is teachers' feelings about using TBAs. Additionally, the definition of intention in this study is teachers' willingness to use TBAs. This comprehensive model facilitated our analysis of the relationships among teachers' beliefs about and intention to use TBAs. Below we explain why an SEM approach was utilized to examine the model.

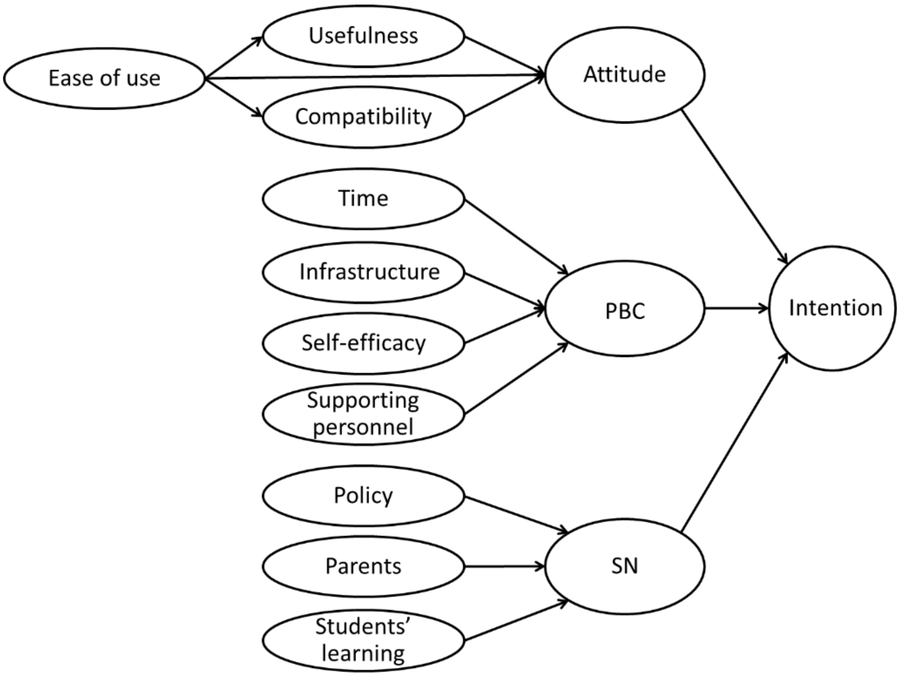

Figure 2. The model proposed in this study

Table 1. Latent Variables and Their Observed Items

Latent variable	Description of latent variable	Items
Intention (IN)	Teachers' willingness to use technology-based assessments (TBAs).	IN1, IN2, IN3
Attitude (ATT)	Teachers' positive feelings about using TBAs.	ATT2, ATT3
Usefulness (Au)	Degree to which teachers believe that using TBAs can improve their job performance.	Au1, Au2, Au3, Au4, Au5, Au6, Au9, Au10
Compatibility (Ac)	Degree to which teachers think that using TBAs can match their teaching goals and styles.	Ac1, Ac2, Ac3
Ease of use (Ae)	Degree to which teachers believe that using TBAs is free of effort.	Ae2, Ae5
Perceived behavior control (PBC)	Facilitating and constraining conditions related to using TBAs.	PBC1, PBC2
Time (Ct)	Degree to which teachers assert that using TBAs can save them time when assessing their students.	Ct1, Ct2
Infrastructure (Ci)	Degree to which teachers assert that they and their students have sufficient hardware and software resources.	Ci1, Ci2
Self-efficacy (Cse)	Teachers' confidence in using TBAs.	Cse1, Cse3
Supporting personnel (Csp)	Degree to which teachers assert that they receive sufficient support from the supporting personnel.	Csp1, Csp2, Csp3
Subjective norms (SN)	Expectations of important others about teachers' use of TBAs.	SN1
Policy support (Npo)	Degree to which teachers think that using TBAs might be supported by educational policies.	Npo1, Npo2, Npo3
Parental support (Npa)	Degree to which teachers think that using TBAs might be supported by parents.	Npa1
Student learning (Nsl)	Degree to which teachers think that using TBAs might be beneficial to their students' learning.	Nsl1, Nsl2

Using Structural Equation Modeling to Examine the Proposed Model

There were several reasons why an SEM approach was employed in this study. Firstly, because the beliefs are somewhat implicit (Pajares, 1992), we developed a questionnaire including both teachers' practical considerations and perceptions about TBAs to elicit teachers' beliefs about TBAs (see **Table 1**). To ensure that unobserved beliefs could be identified using items in the questionnaire, confirmatory factor analysis (CFA) was employed to examine the links between unobserved beliefs and observed items (Lay, Chi, Hsieh, & Chen, 2013; Teo, 2011). Additionally, the results of the CFA could also explain whether or not these items were reliable indicators of the unobserved beliefs (Teo, 2011).

Secondly, the methodology or analytic process that is applied to establish the possible relationships among beliefs, attitude, and intention should be able to estimate the interactions and correlations between these variables (Chen, 2010; Pynoo et al., 2011). SEM allowed us to estimate the direct and indirect effects among variables through path analysis (Chen, 2010; Teo, 2011). In other words, we could specify the possible relationships among variables and estimate a series of relationships simultaneously by performing an SEM path analysis (Lay et al., 2013).

Finally, because the proposed model had a theoretical basis and the questionnaire was contextualized to the classroom setting, educational implications could be derived from the results of path analysis and estimations of direct and indirect effects. This meant that the implications could be both theoretically and practically supported.

PURPOSE AND RESEARCH QUESTIONS

The literature reviewed above indicates the importance of behavioral beliefs, control beliefs, and normative beliefs and their contributions to the intention of teachers to use technology. However, little research has been conducted on teachers' thoughts about TBAs, including what are the important beliefs that teachers have and how these beliefs may affect their intention. Therefore, the purposes of this study were to determine the relationships among teachers' beliefs about, attitudes toward, and intention to use TBAs, and to compare differences in these relationships among teachers with different degrees of TBA usage. The following research questions guided this study:

1. Are the measurements made using our instrument reliable and adequate for describing teachers' beliefs about TBAs?
2. How well does our proposed model fit the data?
3. What kinds of beliefs affect the intention of teachers to use TBAs?
4. What differences are there between three groups of teachers with different degrees of TBA usage?

The results of this study could provide insights into how teacher educators and researchers could effectively support teachers to fully exploit the potential of TBAs.

METHODS

Design of the Instrument

In order to explore teachers' beliefs comprehensively and contextually, we decomposed the beliefs identified by Chien, Wu, and Hsu (2014) into more-specific descriptions. As shown in **Figure 2**, our proposed model included 14 latent variables about beliefs and usage intention. The latent variables in our proposed model were measured by compiling a questionnaire with 36 items (i.e., 36 observed variables) based on previous studies (Chien, Wu, & Hsu, 2014; Taylor & Todd, 1995; Venkatesh et al., 2003). Each variable is described in **Table 1**. Examples of the included items are (1) "I would intend to use TBAs to assess my students' learning performance if I had access to TBAs" (IN1 in **Table 1**), (2) "I think that it is easy to use TBAs" (Ae2 in **Table 1**), and (3) "I think that the use of TBAs is consistent with my existing teaching styles" (Ac2 in **Table 1**). It is worth noting that the questionnaire utilized in this study was an elaborated version in which some items that did not show sufficiently high factor loadings or internal consistency with others had been removed.

Participants and Data Collection

This study used a convenience sampling technique to collect data, with a focus on junior- and senior-high-school science teachers who had sufficient experience in using educational technology. Teachers with more experience in using educational technology might be more likely to use or know about TBAs. Additionally, science teachers may need to use TBAs more frequently than other teachers because obtaining a deep understanding of science at the secondary-school level involves visualizing and interpreting complex systems and dynamic processes, and TBAs have the potential to provide accurate measures of such understanding (Kuo & Wu, 2013).

In total, 494 junior- and senior-high-school science teachers in Taiwan participated in our study. They had a mean of more than 6.8 years of experience in using technology in classrooms. The participating teachers were classified into three groups based on the frequency of and time spent using TBAs: (1) frequent users, who used TBAs every week for more than 5 hours per week (20%, n = 105), (2) occasional users, who used TBAs either less often than every week or for less than 5 hours per week (n = 211), and (3) nonusers, who had never used TBAs previously (n = 178). The teachers completed the questionnaire in pencil-and-paper form at their schools, indicating their level of agreement with the descriptions of each item on 7-point Likert scales.

Our previous study revealed some qualitative differences between the three groups (Chien, Wu, & Hsu, 2014). Teachers without any experience of TBAs could still recall that these assessments had some potential, but they were unable to indicate how they could potentially be integrated into their own teaching. On the other hand, teachers who belonged to the frequent or occasional user groups not only perceived the potential of different types of TBAs but also indicated various ways of using them. The main area of divergence between the frequent and occasional users was that the frequent users tended to actively look for more solutions to overcome the restrictions of practice or the lack of resources (Chien, Wu, & Hsu, 2014).

Data Analysis

SEM procedures were carried out to reveal the relationships among teachers' beliefs and intention. These procedures involved the construction of a measurement model and path analysis of the structural model The measurement model described how well the observed variables measured the latent variables, and the structural model specified the relationships among all of the latent variables (Teo, 2011). The statistics software LISREL (version 8.8) was used to estimate the measurement model and examine the goodness of fit of the model.

Path diagrams of the models for the three teacher groups were created, and their standardized path coefficients were estimated. To compare the three models, we also assessed direct and indirect effects to identify the extent to which the exogenous latent variables affected the endogenous latent variables (Teo & Noyes, 2011). According to Kline (2011), a direct effect is quantified by the standardized path coefficient from one exogenous latent variable to the endogenous latent variable. In contrast, an indirect effect is quantified as the product of the standardized path coefficient from one exogenous latent variable to an intervening variable and the standardized path coefficient from the intervening variable to the endogenous latent variable. Furthermore, the effect sizes were calculated based on the methodology suggested by Cohen (1988) and Liu (2012). Effect sizes of <0.5, 0.5–0.8, and >0.8 were considered small, moderate, and large, respectively.

RESULTS

Evaluation of the Measurement Model

We addressed Research Question 1 by testing the reliability and validity of our measurement model and conducting CFA using LISREL (version 8.8). Maximum likelihood estimation (MLE) was used. Since MLE can only be applied if the data conform to a normal distribution, we also calculated skewness and kurtosis indices of each item to check the normality of the observed variables. As indicated in **Appendix 1**, the absolute values of the skewness and kurtosis indices were smaller than the recommended values of 3 and 10, respectively, which confirmed the normality of the observed variables, and hence that the observed variables could be estimated using MLE.

We used the factor loadings of each item and Cronbach's alpha to evaluate the reliability and internal consistency. The factor loadings of all of the items used in this study exceeded the suggested threshold of 0.5 (see **Appendix 1**), which indicated that they were all reliable indicators of our latent variables. Moreover, all of the Cronbach's alpha values exceeded the suggested threshold of 0.7 except for the item of ease of use, for which it was 0.67 (Ae in **Table 2**). These results confirmed that the reliability of the latent variables was satisfactory.

The composite reliability (CR) and the average variance extracted (AVE) were used to assess the convergent validity (Cheon et al., 2012). As **Table 2** indicates, all of the CR values were higher than the suggested threshold of 0.7 except for the item of ease of use, and all of the values of AVE exceeded the suggested threshold of 0.5 except for the item of ease of use. These results indicate the presence of adequate convergent validity; in other words, our estimated value of each latent variable was both reasonable and acceptable.

To estimate the discriminant validity, the square root of AVE of a given latent variable was compared with the correlations between that latent variable and the other latent variables (Cheon et al., 2012; Teo & Noyes, 2011). Discriminant validity was present if the square root of AVE was greater than the coefficients for the correlation between the particular latent variable and the other latent variables. As indicated in **Table 3**, nearly all of the values of the square roots of AVE exceeded the values of the correlation coefficients. This suggests that most of the latent variables were more closely related to their own indicators than to the other latent variables, and hence that there was adequate discriminant validity.

Table 2. Reliability and Convergent Validity of the Measurement Model

Latent variable	CR	AVE	Cronbach's alpha	$\sqrt{\mathbf{AVE}}$
IN	0.89	0.74	0.86	0.86
ATT	0.85	0.74	0.86	0.86
Au	0.90	0.54	0.90	0.73
Ac	0.93	0.81	0.93	0.90
Ae	0.59	0.42	0.67	0.65
PBC	0.78	0.63	0.77	0.79
Ct	0.79	0.65	0.79	0.81
Ci	0.90	0.81	0.89	0.90
Cse	0.76	0.62	0.76	0.79
Csp	0.97	0.92	0.97	0.96
SN	-	-	-	-
Npo	0.85	0.66	0.85	0.81
Npa	-	-	-	-
Nsl	0.86	0.75	0.86	0.87

Note. Because SN and Npa were measured using a single item, the values of composite reliability (CR) and average variance extracted (AVE) were not calculated.

Table 3. Discriminant Validity of the Measurement Model

	IN	ATT	SN	PBC	Au	Ae	Ac	Ct	Ci	Cse	Csp	Npo	Npa	Nsl
IN	**0.86**													
ATT	0.83	**0.86**												
SN	0.23	0.30	**-**											
PBC	0.43	0.52	0.31	**0.79**										
Au	0.61	0.74	0.32	0.55	**0.73**									
Ae	0.62	0.75	0.40	0.70	0.79	**0.65**								
Ac	0.65	0.78	0.36	0.62	0.70	0.89	**0.90**							
Ct	0.51	0.62	0.34	0.54	0.66	0.83	0.74	**0.81**						
Ci	0.20	0.24	0.26	0.36	0.26	0.33	0.29	0.32	**0.90**					
Cse	0.47	0.56	0.33	0.81	0.59	0.76	0.67	0.51	0.33	**0.79**				
Csp	0.25	0.31	0.24	0.33	0.32	0.41	0.36	0.32	0.34	0.29	**0.96**			
Npo	0.36	0.44	0.43	0.52	0.52	0.59	0.52	0.49	0.57	0.39	0.55	**0.81**		
Npa	0.37	0.45	0.42	0.43	0.43	0.61	0.54	0.48	0.36	0.31	0.46	0.64	**-**	
Nsl	0.45	0.55	0.51	0.55	0.55	0.73	0.65	0.62	0.41	0.43	0.58	0.65	0.69	**0.87**

Note. Because SN and Npa were measured using a single item, the values for discriminant validity were not estimated. The values on the diagonal (in boldface) are the $\sqrt{\mathrm{AVE}}$ values for the latent variables, while the off-diagonal values are estimates of the correlation coefficients.

Goodness of Fit of the Proposed Model

We addressed Research Question 2 by estimating the goodness of fit of our model based on calculated absolute and incremental fit indices. Firstly, the root-mean-square error of approximation (RMSEA) and standardized root-mean residual (SRMR) were used as absolute fit indices. The RMSEA and SRMR values indicate the extent to which the absolute proportions of the observed covariance of the data were explained by our proposed model (Kline, 2011). Secondly, the comparative fit index (CFI) and the Tucker-Lewis index (TLI) were used as incremental fit indices. The CFI and TLI values indicate the relative improvement in the fit of our model (Kline, 2011). We also calculated the ratio of χ^2 to the degrees of freedom, with a value less than 3 considered to be acceptable (Wengrowicz, 2014). Finally, given that Cheon et al. (2012) suggested that using a combination of indices is better than evaluating these indices separately, we also required SRMR < 0.08 and CFI > 0.95 simultaneously.

According to the criteria for goodness-of-fit indices suggested by Cheon et al. (2012), Kline (2011), and Teo and Noyes (2011), the values of all of the indices for our proposed models were within the acceptable ranges (**Table 4**), thereby indicating that our proposed model provided a good fit to the collected data.

Table 4. Model Fit Indices for the Proposed Models

Model fit index	Suggested threshold	Full model (including all participants)	Model for frequent users	Model for occasional users	Model for nonusers
SRMR	<0.08	0.063	0.078	0.077	0.070
RMSEA	<0.08	0.058	0.078	0.065	0.061
CFI	>0.9	0.98	0.96	0.97	0.98
TLI	>0.9	0.98	0.95	0.97	0.97
χ^2/degrees of freedom	<3	2.67 ([a]1465.13/553)	1.63 (903.50/553)	1.87 (1038.08/553)	1.67 (921.71/553)

Note. SRMR = standardized root-mean residual; RMSEA = root-mean-square error of approximation; CFI = comparative fit index; TLI = Tucker-Lewis index; [a] the numerator and denominator are χ^2 and the degrees of freedom, respectively

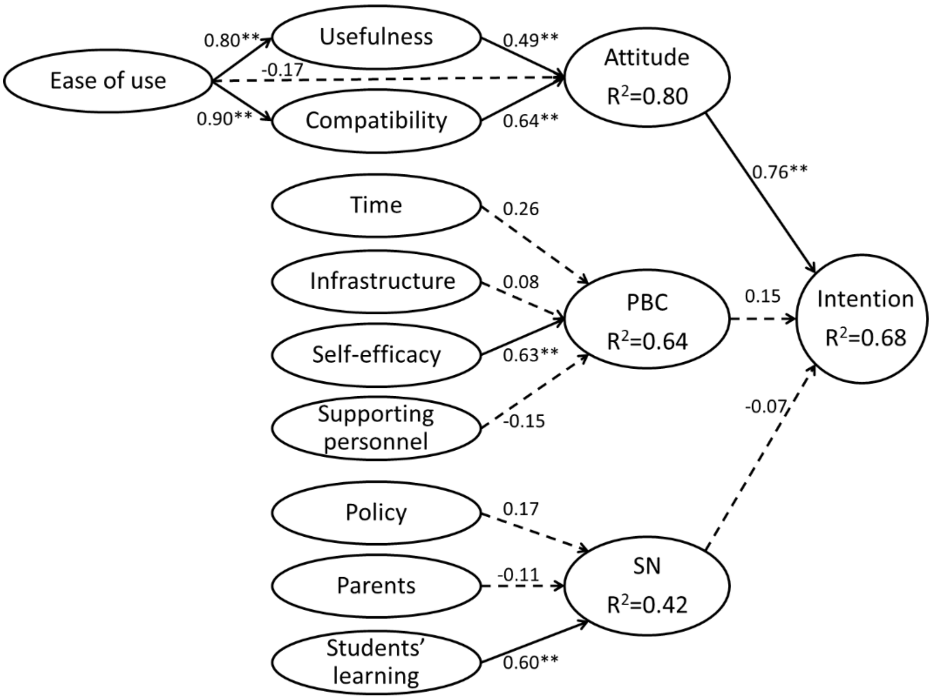

Figure 3. Structural equation model for frequent users

Path Analysis of the Models

We addressed Research Questions 3 and 4 by determining the path diagrams of the models and their standardized path coefficients. As evident from **Figure 3** and **Table 5**, the attitude of frequent users was determined directly by their beliefs about usefulness (β = 0.49, p < .01) and compatibility (β = 0.64, p < .01), while the ease of use affected usefulness (β = 0.80, p < .01) and compatibility (β = 0.90, p < .01) and had an indirect effect on attitude via mediation of usefulness and compatibility. Their PBC was determined by self-efficacy (β = 0.63, p < .01) but not by the beliefs about time, infrastructure, and supporting personnel. Additionally, their perceptions about students' learning had a significant effect on their SN (β = 0.60, p < .01). Finally, their attitudes (β = 0.76, p < .01) significantly influenced their intention. Furthermore, 68% of the variance of intention could be explained by attitude. The R^2 values for attitude, PBC, and SN also indicated that 80%, 64%, and 42% of the variances of these constructs, respectively, could be explained by these indicators. In other words, the four major latent variables were strongly supported by our model.

Table 5. Summary of Results from the Path Analysis for Frequent Users

Path	Path coefficient	*t*	Result
ATT → IN	0.76	7.09**	Supported
PBC → IN	0.15	1.69	Not supported
SN → IN	–0.07	–0.96	Not supported
Au → ATT	0.49	3.34**	Supported
Ae → ATT	–0.17	–0.60	Not supported
Ac → ATT	0.64	2.82**	Supported
Ct → PBC	0.26	1.87	Not supported
Ci → PBC	0.08	0.82	Not supported
Cse → PBC	0.63	4.48**	Supported
Csp → PBC	–0.15	–1.63	Not supported
Npo → SN	0.17	1.33	Not supported
Npa → SN	–0.11	–0.91	Not supported
Nsl → SN	0.60	3.87**	Supported
Ae → Au	0.80	5.13**	Supported
Ae → Ac	0.90	5.71**	Supported

Note. **$p < .01$

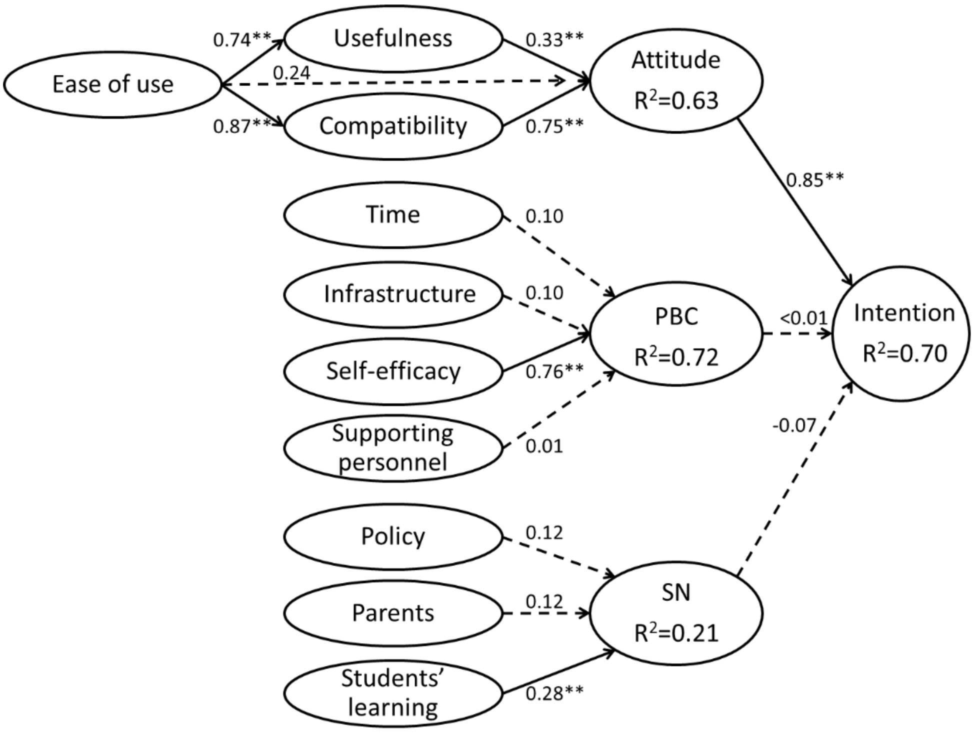

Figure 4. Structural equation model for occasional users

The findings for the occasional users' model were similar to those for the frequent users (**Figure 4** and **Table 6**). The beliefs about usefulness ($\beta = 0.33$, $p < .01$) and compatibility ($\beta = 0.75$, $p < .01$) directly affected the attitude of occasional users, whereas the ease of use had an indirect effect on attitude via mediation of usefulness and compatibility. Their self-efficacy determined the PBC ($\beta = 0.76$, $p < .01$), and their perceptions about students' learning had a significant effect on their SN ($\beta = 0.28$, $p < .01$). Furthermore, their attitudes ($\beta = 0.85$, $p < .01$) significantly influenced their intention. Finally, 70% of the variance of intention could be explained by their attitude. More than 63%, 72%, and 21% of the variances of attitude, PBC, and SN, respectively, could be explained by their indicators. These four major latent variables were strongly supported by our model for the occasional users.

Table 6. Summary of Results from the Path Analysis for Occasional Users

Path	Path coefficient	*t*	Result
ATT → IN	0.85	11.98**	Supported
PBC → IN	<0.01	0.022	Not supported
SN → IN	–0.07	–1.56	Not supported
Au → ATT	0.33	3.40**	Supported
Ae → ATT	0.24	–1.34	Not supported
Ac → ATT	0.75	5.05**	Supported
Ct → PBC	0.10	1.24	Not supported
Ci → PBC	0.10	1.32	Not supported
Cse → PBC	0.76	7.71**	Supported
Csp → PBC	0.01	0.15	Not supported
Npo → SN	0.12	1.25	Not supported
Npa → SN	0.12	1.23	Not supported
Nsl → SN	0.28	2.67**	Supported
Ae → Au	0.74	7.42**	Supported
Ae → Ac	0.87	9.74**	Supported

Note. ***p* < .01

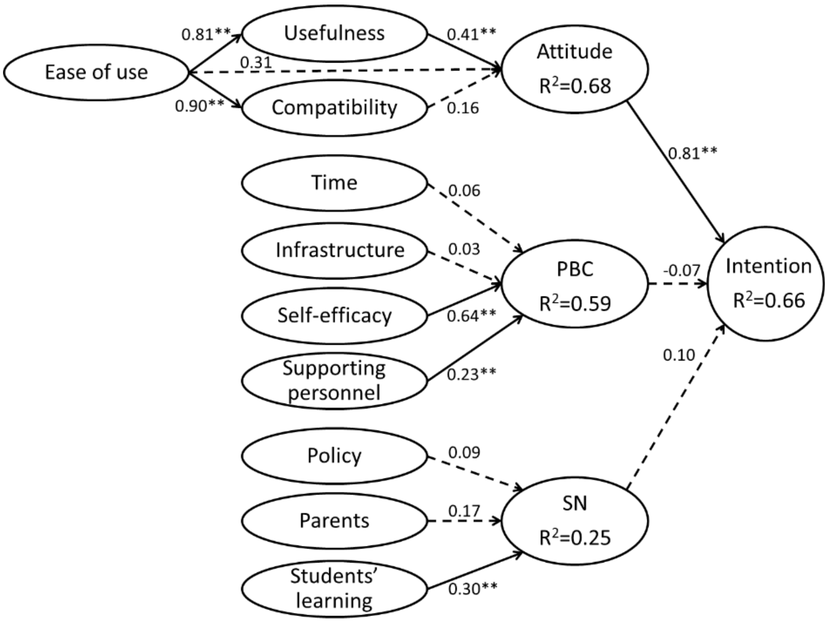

Figure 5. Structural equation model for nonusers

The relationships among variables for the nonusers model differed from those for the frequent and occasional users (**Figure 5** and **Table 7**). The attitude of nonusers was only determined directly by their belief about usefulness (β = 0.41, p < .01), while the ease of use still affected usefulness (β = 0.81, p < .01) and compatibility (β = 0.90, p < .01). Their PBC was determined by not only self-efficacy (β = 0.64, p < .01) but also the supporting personnel (β = 0.23, p < .01). Similar to the results found for the previous models, the nonusers' SN were only affected by their perceptions about students' learning (β = 0.30, p < .01), and not by the support from policies and parents. Their attitudes (β = 0.81, p < .01) significantly influenced their intention, with 66% of the variance of intention explained by their attitude. The R^2 values for attitude, PBC, and SN also showed that more than 68%, 59%, and 25% of the variances of these constructs, respectively, could be explained by these indicators.

Assessment of Direct and Indirect Effects

The results for the models of the three teacher groups showed that although the ease of use of TBAs did not affect their attitudes directly, this belief still had an indirect effect on attitude via mediation on the beliefs about usefulness and compatibility. The ease of use also had an indirect effect on intention via mediation on attitude, while the PBC and SN beliefs did not contribute to intention. Thus, based on the path diagrams for the three groups, we calculated the direct and indirect effects in order to determine the extent to which the exogenous latent variables could affect intention.

Table 7. Summary of Results from the Path Analysis for Nonusers

Path	Path coefficient	*t*	Result
ATT → IN	0.81	10.13**	Supported
PBC → IN	–0.07	–1.02	Not supported
SN → IN	0.10	1.86	Not supported
Au → ATT	0.41	3.30**	Supported
Ae → ATT	0.31	1.21	Not supported
Ac → ATT	0.16	0.84	Not supported
Ct → PBC	0.06	0.65	Not supported
Ci → PBC	0.03	0.35	Not supported
Cse → PBC	0.64	5.5**	Supported
Csp → PBC	0.23	2.89**	Supported
Npo → SN	0.09	0.82	Not supported
Npa → SN	0.17	1.68	Not supported
Nsl → SN	0.30	2.69**	Supported
Ae → Au	0.81	6.22**	Supported
Ae → Ac	0.90	6.97**	Supported

Note. ***p* < .01

Table 8. Direct and Indirect Effects of the Exogenous Latent Variables

	IN		ATT		PBC		SN	
	Direct	**Indirect**	**Direct**	**Indirect**	**Direct**	**Indirect**	**Direct**	**Indirect**
Frequent users								
ATT	0.76							
PBC								
SN								
Au		0.37	0.49					
Ac		0.49	0.64					
Ae		0.74		0.97				
Cse					0.63			
Nsl							0.60	
Occasional users								
ATT	0.85							
PBC								
SN								
Au		0.28	0.33					
Ac		0.64	0.75					
Ae		0.76		0.90				
Cse					0.76			
Nsl							0.28	
Nonusers								
ATT	0.81							
PBC								
SN								
Au		0.33	0.41					
Ac								
Ae		0.27		0.33				
Cse					0.64			
Csp					0.23			
Nsl							0.30	

Table 8 indicates that for the frequent users, only attitude had a significant direct effect with a moderate effect size (d = 0.76) on intention, and all of the beliefs related to attitude had significant indirect effects on intention, with small-to-moderate effect sizes (d = 0.37–0.74). Furthermore, the ease of use was the dominant belief related to intention, with a moderate effect size (d = 0.74). This effect was twofold times larger than the effect of usefulness on intention.

The model for the occasional users showed similar patterns. Their intention was mainly determined by their attitudes, with a large effect size (d = 0.85; see **Table 8**). The ease of use was the dominant belief related to intention, with a moderate effect size (d = 0.76). The effect sizes suggested that the main difference between the occasional and frequent users was in the former focusing more on compatibility and caring less about the usefulness of TBAs.

For the nonusers, attitude was still the only variable that directly affected intention with a large effect size (d = 0.81), but the belief that had the greatest effect on intention was that about usefulness (d = 0.33) rather than that about the ease of use. This may be explained by the lack of experience of nonusers in using TBAs, which meant that they might not know whether TBAs are easy to use, instead paying more attention to the degree to which TBAs will improve their job performance (i.e., the usefulness of TBAs).

CONCLUSIONS AND DISCUSSION

This study examined the relationships among teachers' beliefs about, attitudes toward, and intention to use TBAs, and compared differences in these relationships among teachers with different degrees of TBA usage. The findings of this study can contribute in various ways to future research on TBAs and the beliefs of teachers.

Firstly, all of the items developed in our study were validated as being adequate indicators for measuring teachers' beliefs about TBAs. Since no previous study has systematically measured and examined teachers' beliefs about TBAs, the reliable and validated questionnaire developed in this study represents an instrument that can make useful contributions to this area of research. Furthermore, adding to the factors found by Ogan-Bekiroglu (2009) that could affect teachers' attitudes, the present study has identified the dominant beliefs that might affect the PBC, SN, and the intention to use TBAs. Additionally, the comparisons between the three study groups indicated that with the exception of nonusers, beliefs about usefulness, ease of use, and compatibility were significant predictors of attitude, which could explain the intention of teachers to use TBAs.

Secondly, the path analysis showed that if all of the participating teachers held more-positive attitude and beliefs about the usefulness of and ease of using TBAs, this would significantly increase their intention to use TBAs. This finding represents evidence that teachers make their decisions about teaching based on their belief systems, as suggested by previous studies (Hart, 2002; Pajares, 1992; Quellmalz et al., 2012). This finding is also in accordance with Zacharia (2003) and Stylianidou et al. (2005) describing positive effects of teachers' beliefs on their intention to use technology.

Thirdly, this study modified the decomposed theory of planned behavior and confirmed the effects of attitude on teachers' intention, and revealed that the PBC and SN have much weaker influences that those asserted in this model (Kriek & Stols, 2010; Taylor & Todd, 1995) for experienced teachers. This suggests that the teachers who participated in the present study tended to make their decisions by considering the functions of TBAs, the convenience and interfaces of TBAs, and their past teaching styles, rather than based on the resources available to them or the expectations and suggestions of important others. This finding is also in line with those of other studies that focused on experienced teachers (Teo, 2011), because experienced teachers will have developed their own teaching styles via accommodation and assimilation, and so they may have a more-fixed perspective about teaching and tend to rely less on outside resources or the suggestions of others. It may be useful for future research to investigate whether the considerations about TBAs are similar in preservice teachers and experienced teachers. More studies of the beliefs of preservice teachers should be undertaken to further explore the relationships among their attitudes, beliefs, and intention.

Fourthly, this study considered how compatibility is predictive of attitude, and found that in the models for frequent and occasional users, the effect sizes of compatibility were even larger than the effect sizes of usefulness. This result implies that teachers valued their existing teaching goals and styles more than the potential of TBAs that they perceive, and may be explained by the notion of a belief system as described by Rokeach (1968). The belief about teaching goals and styles could be more closely related to how teachers identify themselves as a teacher, whereas the belief about usefulness of TBAs is probably more closely related to the perceived utility of TBAs. Thus, the compatibility belief may occupy a more-central place in the belief system and may influence the decision-making by teachers more than does the perceived usefulness.

Furthermore, the models for the three groups of teachers in this study all showed that the ease of use did not have a direct effect on attitude. These results are inconsistent with Davis (1989) and Davis and Venkatesh (1996) asserting that the ease of use had both direct and indirect effects on attitude. This discrepancy between studies may be due to the inclusion of different populations: while Davis (1989) and Davis and Venkatesh (1996) addressed the ideas that general users have about technology, the present study focused on teachers' beliefs about a specific type of educational technology. Individual teachers usually have their own preferred teaching styles and certain instructional goals when using TBAs, so even though the ease of use is of concern to them, teachers tend to consider this variable alongside the usefulness and compatibility of the technology. This may explain why the belief about the ease of use did not affect attitude directly, because whether the use of TBAs in a school setting and teaching context can improve students' learning achievements and align with their teaching goals may be even more closely related to their attitudes.

Finally, although the models for the three teacher groups shared some similarities, the nonusers' model was notably different from the other two in showing a stronger need for supporting personnel. A finding from our previous study (Chien, Wu, & Hsu, 2014) may explain this difference: some of the frequent users also encountered constraints including insufficient infrastructure and technician support, but they developed various strategies to overcome the difficulties, such as forming a teacher team, collaborating with teachers who had expertise in technology use, and looking for resources from nearby universities. These strategies may ease the dependence on the supporting personnel in schools.

IMPLICATIONS FOR TEACHER EDUCATION

To provide insights into how teacher educators and researchers could support teachers to exploit the potential of TBAs, in this section we discuss some ideas based on the present findings for involving more teachers in the use of TBAs.

Our models suggest that enhancing the attitude toward TBAs could directly increase the intention of teachers to use TBAs. Furthermore, the results from the path analysis and the effect sizes reveal that the development of positive attitudes could be achieved in the following three ways. Firstly, TBAs need to be designed so that they are easy to use, which would benefit all teachers regardless of their degree of TBA usage. For example, the design of TBAs should take teachers' opinions into consideration, use simple and friendly interfaces, and make them more accessible to teachers who have very little experience of using TBAs. As we indicated in the Results section, our participating teachers' beliefs about ease of use could affect the perceived usefulness and compatibility of TBAs, which in turn could affect their attitudes toward them. Consequently, the positive attitude could increase teachers' intention to use TBAs, even if the effect of ease of use is indirect.

Secondly, it is important to promote the beliefs of frequent and occasional users about compatibility between TBAs and teaching practices. Long-term workshops and other professional-development interventions that help teachers to see how the use of TBAs can match their teaching goals and styles could be useful. These interventions could emphasize the connections between curricula and TBAs and the alignment between different teaching styles and TBAs. Positive beliefs about compatibility may lead to positive effects on attitude and intention.

Finally, the lack of experience of nonusers means that they have not had opportunities to perceive the actual potential and limitations of TBAs. Thus, professional-development programs in universities and schools may help teachers to explore the potential of TBAs and enhance their beliefs about the usefulness. As suggested by the nonusers' model, supporting this belief could lead to a positive attitude, which in turn could increase their intention to use TBAs.

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APPENDIX 1

Standardized Factor Loadings and the Normality of Observed Items

Latent variable	Item	Skewness	Kurtosis	Standardized loading
Intention	IN1	–0.47	–0.16	0.95
	IN2	–0.52	–0.19	0.96
	IN3	0.55	–0.79	0.63
Attitude	ATT2	–0.11	–0.23	0.85
	ATT3	–0.17	–0.19	0.87
Perceived behavior control	PBC1	0.04	–0.56	0.84
	PBC2	0.06	–0.87	0.75
Subjective norms	SN1	0.00	–0.32	1.00
Usefulness	Au1	–0.81	0.51	0.73
	Au2	–0.72	0.41	0.80
	Au3	–0.88	0.72	0.73
	Au4	–0.35	–0.03	0.75
	Au5	–0.80	0.47	0.76
	Au6	–0.81	0.21	0.64
	Au9	–0.32	–0.39	0.69
	Au10	–0.54	0.37	0.76
Ease of use	Ae2	–0.09	–0.57	0.60
	Ae5	–0.03	–0.01	0.69
Compatibility	Ac1	–0.02	–0.42	0.87
	Ac2	–0.16	–0.36	0.93
	Ac3	–0.09	–0.53	0.90
Time	Ct1	–0.19	–0.85	0.80
	Ct2	–0.09	–0.75	0.81
Infrastructure	Ci2	0.11	–0.73	0.92
	Ci2	0.23	–0.72	0.88
Self-efficacy	Cse1	–0.33	–0.42	0.80
	Cse3	0.00	–0.86	0.77
Supporting personnel	Csp1	0.1	–0.97	0.93
	Csp2	0.21	–0.83	0.98
	Csp3	0.21	–0.83	0.97
Policy support	Npo1	–0.2	–0.05	0.74
	Npo2	–0.05	–0.17	0.83
	Npo3	–0.07	–0.24	0.86
Parental support	Npa1	–0.09	0.20	1.00
Students' learning	Nsl1	–0.15	–0.38	0.85
	Nsl2	–0.07	–0.03	0.88

Note. Because both subjective norms and parental support were measured using a single item, their values for factor loadings were fixed to 1.00.