Understanding Technology Acceptance in Pre-Service Teachers: A Structural-Equation Modeling Approach

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This study investigated a sample of pre-service teachers' (N=250) self-reported future intention to use technology. The Technology Acceptance Model (TAM) was used as a framework to determine intentions to use computers. This study contributes to the growing number of studies on TAM by demonstrating that perceived usefulness (PU), perceived ease of use (PEU), and attitude toward computer use (ATCU) are significant determinants of behavioral intention (BI). It also expanded TAM by including two variables: subjective norm (SN); and facilitating conditions (FC). Using structural equation modeling, there was a good model fit for both the measurement and structural models. Of the seven hypotheses, five were supported. No significant effects were found of SN on PU, and of ATCU on BI. Overall, the results of this study offer some evidence that TAM is effective in predicting pre-service teachers' technology acceptance.

Keywords: Technology acceptance Model (TAM), Pre-service teachers, Structural equation modeling, Subjective norm, Facilitating conditions

For some time, developers and procurers of technology could rely on organizational authority to ensure that technology was used, as is the case in many industrial or organizational contexts. However, the present working practices in many places as well as the large demand for leisure and educational applications of information technology have enabled greater discretion among users to decide on which technologies should be used and how they should be used. Consequently, technology adoption and use, often referred to as user acceptance, has become one of the most researched areas in the information science literature (Agarwal & Prasad, 1999; Smarkola, 2007).

User acceptance can be defined as the demonstrated behavior or willingness by a user to employ information technology for the tasks it is designed to support. Thus, researchers have shown greater interests in understanding the factors influencing the adoption of technologies as planned by users who have some degree of choice and are less concerned with unintended uses or nondiscretionary use of technologies. By developing and testing models of the forces shaping user acceptance, researchers on human interaction with technology seek to influence the process of design and implementation in a manner that will minimize the risk of resistance or rejection by users. Research on technology acceptance often includes: (1) determining the factors that cause individuals to completely accept or reject new information technology, or engage in sabotage or active resistance; (2) designing appropriate implementation tactics and interventions that mitigate problems associated with the rejection of information technologies; and, (3) identifying factors that ensure continual use of information technologies.

Research evidence has suggested that applying a range of technologies in teaching and learning has a direct impact on current educational practices and policies, and, subsequently, has the potential to alter traditional definitions of education. Bereiter and Scardamalia (2006) posited that it is important for teachers to understand the precise role of technology so that they can effectively cope with the pressure created by continual innovation in educational technology and tensions to prioritize the use of technology. However, there has been a history of teachers' use of computer technology being limited for mostly administrative support rather than instructive purposes. Becker (2001) surveyed more than 4,000 grade 4-12 teachers in over 1,100 schools across the United States of America. Among the major survey findings were teachers' infrequent use of computers in the classroom. For example, teachers use computers for drill and practice when they teach lower-ability students. These findings also reflected the use of computer technology as a support tool rather than its use as an instructional tool for teaching. Such instances of the less-than-optimal uses of technology are confirmed by Burns (2002) who found that teachers restricted the use of computers in the classroom due to their fears that students might break the computers. This could have resulted in the teachers resisting change and not using technology to its fullest potential. In recent years, research has revealed possible reasons for the low technology acceptance among educational practitioners. These are personal factors - such as computer self-efficacy (Gong, Xu, & Yu, 2004; Teo, 2008), technical factors - such as technological complexity (Thong, Hong, & Tam, 2002), and environmental factors - such as facilitating conditions (Ngai, Poon, & Chan, 2007). Therefore, the need to understand technology acceptance by teachers calls for an examination into the factors that influence teachers' acceptance of technology.

TECHNOLOGY ACCEPTANCE MODEL (TAM)

In the last three decades, researchers have developed and tested models with a view of predicting technology acceptance. Among the models, the Technology Acceptance Model (Davis, 1989) is arguably the most popular in technology acceptance studies (McCoy, Galletta & King, 2007). Overall, TAM has been empirically proven successful in predicting about 40% of a system use (Legris, Ingham, & Collerette, 2003) and found to be a parsimonious representation of how perceptions and attitudes affect technology use (Sivo & Pan, 2005; Teo, 2009). Many researchers have conducted empirical studies to examine the explanatory power of TAM and these yielded relatively consistent results.

Introduced and developed by Davis (1989), TAM is a model that addresses the issue of how users come to accept and use a technology. The origins of TAM are found in Ajzen and Fishbein's (1980) Theory of Reasoned Action (TRA). It posits that beliefs and attitudes are antecedents of individuals' intentions to perform a specific behavior. According to TRA, attitude towards a behavior is determined by behavioral beliefs about the consequences of the behavior (based on the information available or presented to the individual) and the affective evaluation of those consequences on the part of the individual. Beliefs are defined as the individual's estimated probability that performing a given behavior will result in a given consequence.

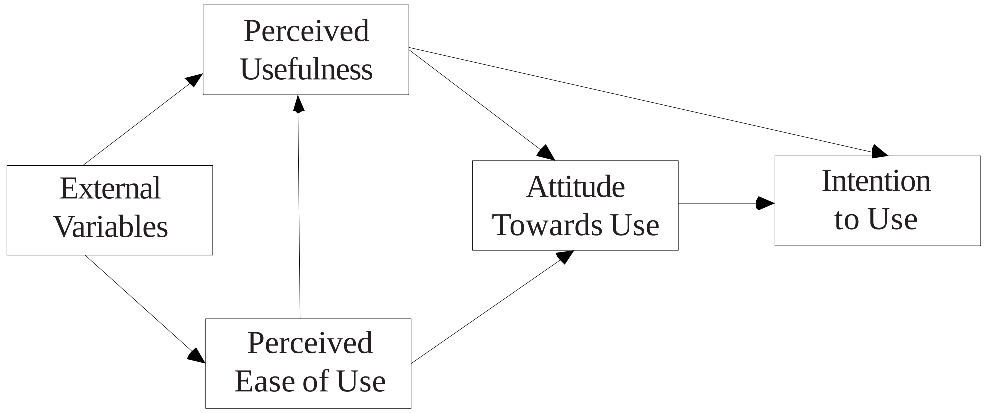

Figure 1. *Technology Acceptance Model (Davis et al., 1989)*

In TAM (see Figure 1), two specific variables, perceived usefulness and perceived ease of use, are hypothesized to be fundamental determinants of user acceptance. TAM posits that users' behavioral intentions determine actual technology use. Behavioral intentions are in turn influenced by the user's attitude towards technology. Davis (1989) stated that perceived usefulness and perceived ease of use are beliefs that lead to favorable attitudes and intentions to accept and use technology. Compared to the TRA, TAM is considerably less general, as the latter was specifically designed to apply only to computer usage behavior (Davis, Bagozzi, & Warshaw, 1989).

Despite its popularity, the use of TAM in education has been limited. One reason lies in the difference between the general technology users and teachers. Teachers tend to be relatively independent and have considerable autonomy over their teaching activities, including choice and use of technology. Hu, Clark, and Ma (2003) posited that because educational institutions (i.e., schools) have fundamentally different objectives from business organizations, teachers experience less peer competition in resources and promotions. Over the years, researchers have used TAM to examine users' acceptance toward various technology applications such as Graphic User Interfaces (GUI) (Agarwal & Prasad, 1999), mainframe applications (Dishaw & Strong, 1999), accounting applications (Jackson, Chow & Leitch, 1997), the World Wide Web (Riemenschneider, Harrison, & Mykytyn, 2003), and computer resource centers (Taylor & Todd, 1995). More recently, TAM has been used in education to investigate issues such as students' satisfaction with online learning (Drennan, Kennedy & Pisarksi, 2005), the acceptance of the online course companion site of a textbook (Gao, 2005), and the effect of technical support on students' acceptance towards WebCT (Ngai et al., 2007). Apart from that, a recent study by Teo, Lee, and Chai (2008) employed TAM as the basic model to examine the attitudes of pre-service teachers towards the use of technology in education and found that the model predicted 42% of the variance. This study extends the literature by applying TAM to study the factors affecting technology acceptance among Singaporean pre-service teachers. Previously, the validity of TAM was tested across different cultures such as Switzerland, US, UK, and Arab countries (Al-Gahtani, 2001; Straub, Keil, & Brenner, 1997; Srite & Karahanna, 2006).

AIMS OF THIS STUDY

The purpose of this study is to apply TAM to model the acceptance of technology among pre-service teachers. This study has the potential to contribute to technology acceptance research by empirically testing TAM within an educational context, through using participants drawn from an educational institution. Since 1990, many studies have extended TAM by adding external variables to the model. The choice of external variables varies, depending on the features of the technology, the research situation, and the research aim. This study extends TAM by including two additional user-related variables – subjective norm and facilitating conditions, proposed by Venkatesh, Morris, Davis, and Davis (2003) in their extension of TAM – the Unified Theory of Acceptance and Use of Technology (UTAUT). Hence, this paper seeks to answer the following questions:

1. To what extent do TAM and UTAUT predict technology acceptance among pre-service teachers?
2. What roles do subjective norm and facilitating conditions play in influencing technology acceptance and its antecedents within the framework of the TAM and UTAUT?

RESEARCH MODEL HYPOTHESES

To frame the study of user acceptance of technology among pre-service teachers, a model of technology acceptance is presented in Figure 2. This model employs the technology acceptance model and UTAUT, and includes facilitating conditions and subjective norm.

Perceived Usefulness (PU)

Perceived usefulness (PU) is defined as the degree to which a person believes that using a particular technology will enhance his or her job performance. People tend to use or not to use an application to the extent that they believe it will enhance their job performance (Davis et al., 1989). This includes decreasing the time required for doing the job, and achieving more efficiency and accuracy. In the view of Phillips, Calantone and Lee (1994), perceived usefulness reflects a prospective user's subjective probability that applying the new technology will be beneficial to his or her personal and/or the adopting organization's well-being. In addition, it has been reported in technology acceptance research that perceived ease of use is directly and indirectly related to behavior through its effect on perceived usefulness (e.g., Ngai, Poon, & Chan, 2007).

H_1. Pre-service teachers' perceived usefulness of computers is influenced by their perceived ease of use of computers.

Perceived Ease of Use

Perceived ease of use (PEU) refers to the degree to which a person believes that using a

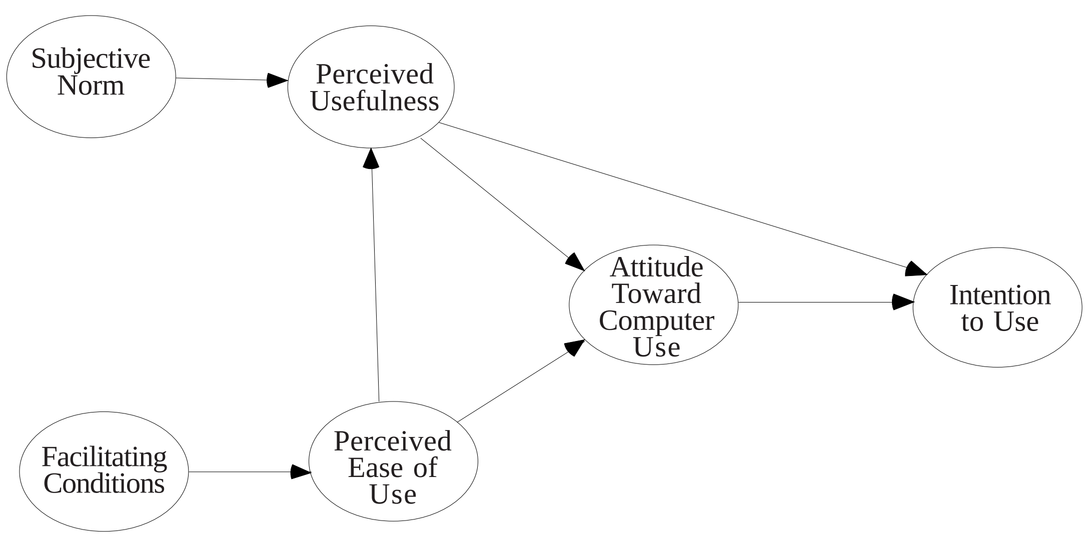

Figure 2. *Research model*

particular technology will be free of effort (Davis, Bagozzi, & Warshaw, 1989). It is possible that while users may believe that computers are useful, they perceive computers to be too difficult to use and that the benefits of usage are outweighed by the effort of using the application (Davis, 1989). Therefore, educational technology with a high level of PEU is more likely to induce positive attitudes. Furthermore, the relation between PU and PEU is that PU mediates the effect of PEU on attitude (Moon & Kim, 2001). In other words, while PU has direct impacts on attitude, PEU influences attitude indirectly through PU.

H_2. A pre-service teacher's attitude towards computer use is influenced by his or her perceived ease of use of computers.

Attitude Towards Computer Use (ATCU)

Attitudes guide behavior and are defined as the way individuals respond to and are disposed towards an object (Ajzen & Fishbein, 2005). This disposition may be negative or positive. The success of any initiatives to implement technology in an educational program depends strongly upon the support and attitudes of teachers involved. It has been suggested that if teachers believed or perceived computers not to be fulfilling their own or their students' needs, they are less likely to introduce technology into their teaching-learning process (Askar & Umay, 2001). In other words, attitudes toward computer use, whether positive or negative, are shaped by how teachers perceive the usefulness of technology in the instructional and learning environment. This in turn affects the way students view the importance of computers in schools (Teo, 2006) and affects the current and future use of computer by teachers and students. Further use of computers engenders positive attitudes in the user which reinforces the perceived usefulness of computers (Yildirim, 2000).

H_3: Pre-service teachers' computer attitude is influenced by their perceived usefulness of computers.

Subjective Norm

Subjective norm is a person's perception that most people who are important to him or her think he should or should not perform a particular behavior (Fishbein & Ajzen, 1975). In this study, subjective norm is the degree to which a person perceives the demands of the 'important' others on that individual to use the computer. This point was stressed by Venkatesh and Davis (2000), who argued that when a important co-worker thought that the system was useful, a person tended to have the same idea. A study that directly examined the influence of subjective norm on computer use was conducted by Marcinkiewicz and Regstad (1996), who reported that subjective norm is most predictive of computer use, alongside self-competence, perceived relevance and innovativeness. The 'significant others' were identified by Marcinkiewicz and Regstad to be the principal, colleagues, pupils, and a professional body.

H_4: A pre-service teacher's perceived usefulness of computers is influenced by his or her subjective norm.

Facilitating Conditions

Facilitating conditions are factors in the environment that exert an influence over a person's desire to perform a task. For example, Groves and Zemel (2000) found that supports (e.g., skills training, information or materials available and administrative support) were rated as very important factors which influenced the use of instructional technologies in teaching. Daugherty and Funke (1998) found that some of the barriers that confronted faculty members when adopting distance education include: (a) a lack of technical support; (b) a lack of adequate equipment or software; and, (c) a lack of faculty or administrative support. A recent study by Lim and Khine (2006) corroborated the importance of having necessary support for ICT integration in schools. The teachers in their study cited barriers to ICT integration to be a lack of access to computers, inadequate technical support, lack of support from peers, and inadequate numbers of computers. All these gave an impression that it took great effort to learn and use the computers.

H_5: A pre-service teacher's perceived ease of use will be significantly influenced by his or her perception of facilitating conditions.

Behavioral Intention to Use (BI)

A major difference between TAM and TRA is the presence of behavioral intention (BI) in TAM. TAM implies that two behavioral beliefs, PU and PEU, have an influence on an individual's intention to use technologies. In contrast to PU and PEU, which refer to process expectancy and outcome expectancy, respectively (Liaw, 2002), BI predicts the actual use of technologies. This claim has been demonstrated across a variety of contexts where technology was used (e.g., Chau, 2001; Fusilier & Durlabhji, 2005). Given sufficient support to conclude the existence of a strong link between intention and actual behavior (e.g. Mathieson, 1991; Hu, Clark, & Ma, 2003), BI is used as the dependent variable in this study. In addition, BI is also a practical approximate measure of actual use in this study. Although all pre-service teachers in this study have used technology for personal and academic reasons, most of them possess little or no experience in using technologies in the classroom. Therefore, it is deemed more accurate to measure respondents' intention rather than their actual use. The practice of measuring BI in pre-service teachers and undergraduates is widely reported in the literature (e.g., Hu et al., 2003; Liaw & Huang, 2003).

H_6: Pre-service teachers' behavioral intention is influenced by their perceived usefulness of computers.

H_7: Pre-service teachers' behavioral intention is influenced by their computer attitudes.

METHOD

Research Design

The purpose of the study is to build a model that predicts the technology acceptance among pre-service teachers in a teacher-training institute in Singapore. The structural-equation modeling (SEM) approach was used to develop a model of the relationships among a set of six latent variables: perceived usefulness, perceived ease of use, attitude toward computer use, subjective norm, facilitating conditions, and behavioral intention. A survey was employed to collect data, and correlations and covariances were analyzed to determine the extent to which the proposed model replicates the relationships of the observed variables.

Research Participants

The participants for this study comprised 250 (175 females and 75 males) pre-service teachers enrolled at the National Institute of Education in Singapore. All owned a computer at home. The mean age of the participants was 24.0 years (SD= 4.4 years) and their daily computer use was 3.4 hours (SD=2.0 hours). Data was collected via an online survey questionnaire. Participants were asked to volunteer during the study term and those who consented to participate were given a URL to access the questionnaire. The sample in this study represented about 38% of the total student population in the study programme from which students were drawn.

Instrumentation

The instrument composed of 6 constructs and 18 statements on Perceived Usefulness (four items), Perceived Ease of Use (four items), Attitude Toward Computer Use (four items), Subjective Norm (two items), Facilitating Conditions (two items) and Behavioral Intention (two items). Participants gave their opinions to each statement on a 5-point Likert scale, ranging from 1 – strongly disagree – to 5 – strongly agree. These items were adapted from various published sources, as shown in the appendix. In many cases, the items remained unchanged, except for minor word changes to suit the context of this study. For example, 'system' was replaced with 'computer'. Additionally, besides their demographic details, participants also reported their daily use of the computer in terms of time spent.

Procedures and criteria of structural equation modeling analysis

The major feature of structural equations modeling (SEM) is its ability to analyze latent variables. In addition, SEM measures random errors in the observed variables, thus rendering a more realistic measurement. Other affordances of SEM include the introduction of coefficients for the loadings from latent variables to indicators. The error in measuring one variable can correlate with that of another and one latent variable can be measured by multiple indicators (Bollen, 1989). The current study follows the common steps for doing SEM statistical analysis. First, the data were screened in that issues such as the accuracy of data input, missing observations and outliers were dealt with. A correlation matrix was then created to examine concurrent, convergent, and discriminant validities of the data. To achieve reliable results, a researcher needs to consider the sample size in relation to model complexity, coefficient magnitudes, the number of observed variables, and the multivariate normality of distribution of variables (Klem, 2000).

RESULTS

The statistical analysis comprised two stages. The first stage examined the descriptive statistics of the measurement items and assessed the reliability and validity of the measures used in this study. The second stage tested the proposed research model and this involved assessing the contributions and statistical significance of the manifest variables' path coefficients. Using the procedures recommended by Anderson and Gerbing (1988), the measurement model was evaluated before the structural model.

Descriptive statistics, reliability, and validity

The descriptive statistics for each construct items are shown in Table 1. All means were greater than 3.0, ranging from 3.40 to 4.46. This indicates an overall positive response to the constructs that are measured in this study. The standard deviations for all variables were less than one and this indicates that the item scores were relatively close to the mean scores. The skewness ranged from -.28 to -1.29 and kurtosis ranged from -.17 to 4.07. Following Kline's (2005) suggestion that the skew and kurtosis indices should be below 3.0 and 8.0, respectively, there were no severe problems in the data and the data were considered fairly normal.

Table 1
Descriptive statistics of all constructs

Construct	Mean	Standard Deviation	Skewness	Kurtosis
PU	4.13	.55	-.45	1.57
PEU	3.69	.59	-.44	.36
ATCU	3.94	.57	-.42	1.82
SN	3.62	.70	-.28	.34
FC	3.40	.80	-.37	-.17
BI	4.46	.58	-1.29	4.03

PU= Perceived Usefulness; PEU= Perceived Ease of Use; ATCU= Attitude Toward Computer Use; SN= Subjective Norm; FC= Facilitating Conditions; BI=Behavioral Intention

Convergent validity

Fornell and Larcker (1981) proposed three procedures for assessing convergent validity of a set of measurement items in relation to their corresponding constructs. These are (1) item reliability of each measure, (2) composite reliability of each construct and (3) the average variance extracted.

Table 2 shows the principal component analysis of the six constructs. The total variance explained is 71.8% and factor extraction was based on the Kaiser-Guttman rule that retains principal components with an eigenvalue equal to or greater than 1. This was to ensure that each factor extracted accounts for as much variance as that of the individual variables (Nunnally & Bernstein, 1994).

The reliability of an item was assessed by its factor loading onto the underlying construct. Hair, Black, Babin, Anderson, & Tatham (2006) suggested that an item is high if its factor loading is greater than 0.60. Except for PEU3, all item loadings ranged from 0.69 to 0.92, exceeding the recommendation set by Hair et al. (2006), and demonstrated convergent validity at the item level. Item PEU3 (with a loading of 0.52) was eliminated from further analysis and the other items were retained.

The composite reliability of each construct was assessed using Cronbach's alpha. Robinson, Shaver and Wrightsman (1991) and DeVellis (2003) suggested that an alpha value of .70 should be considered acceptable. As shown in Table 3, the reliabilities of all the constructs are between .71 and .86, well within the range suggested by Robinson, Shaver, & Wrightsman (1991) and DeVellis (2003).

The final indicator of convergent validity, average variance extracted (AVE), is a more conservative test of convergent validity (Fornell & Larcker, 1981). It measures the amount of variance captured by the construct in relation to the amount of variance attributable to measurement error.

Table 2
Principal component analysis with varimax rotation

Item	PU	PEU	ATCU	SN	FC	BI
PU1	**0.71**	0.09	0.39	-0.01	0.12	0.13
PU2	**0.86**	0.15	0.24	0.01	-0.02	0.01
PU3	**0.84**	0.09	0.16	0.03	0.08	0.05
PU4	**0.69**	0.25	0.18	0.13	0.01	0.07
PEU1	0.19	**0.75**	0.22	-0.02	0.01	0.12
PEU2	0.22	**0.73**	0.09	0.08	0.24	-0.05
PEU3	0.04	**0.52**	0.05	0.08	0.38	0.09
PEU4	0.08	**0.82**	0.28	0.07	0.01	0.04
ATCU1	0.34	0.04	**0.73**	0.06	0.04	0.05
ATCU2	0.29	0.26	**0.71**	0.00	0.06	0.04
ATCU4	0.18	0.28	**0.74**	0.13	0.08	0.12
ATCU5	0.15	0.16	**0.76**	0.06	0.21	-0.12
SN1	0.02	0.06	0.07	**0.92**	0.04	-0.05
SN2	0.09	0.08	0.09	**0.91**	0.10	0.00
FC1	0.14	0.18	0.04	0.09	**0.86**	-0.01
FC2	-0.04	0.10	0.26	0.04	**0.84**	-0.13
BI1	0.14	0.07	0.01	-0.01	0.05	**0.88**
BI2	0.02	0.06	0.04	-0.03	-0.15	**0.86**
Eigenvalue	2.83	2.36	2.65	1.73	1.76	1.61
% Variance	15.74	13.09	14.70	9.61	9.78	8.92

Table 3

Parameter estimates, standard errors, critical ratios, and R^2 for the measurement model

Latent Variable	Item	Unstandardized factor loading	Standardized factor loading	Standard error[a]	Critical ratio[b]	R^2 (item reliability)
PU	PU1	1.22	0.77	0.12	10.42	0.59
	PU2	1.61	0.89	0.14	11.53	0.79
	PU3	1.36	0.79	0.13	10.62	0.62
	PU4	1.00	0.66	—[c]	—	0.44
PEU	PEU1	0.91	0.74	0.09	10.00	0.55
	PEU2	0.85	0.68	0.09	9.52	0.47
	PEU3	1.00	0.77	—	—	0.60
ATCU	CA1	0.84	0.73	0.09	9.27	0.54
	CA2	0.96	0.78	0.10	9.68	0.62
	CA3	0.85	0.70	0.08	10.63	0.49
	CA4	1.00	0.65	—	—	0.43
SN	SN1	0.67	0.71	0.17	3.91	0.51
	SN2	1.00	1.00	—	—	0.99
FC	FC1	0.87	0.72	0.15	5.90	0.52
	FC2	1.00	0.86	—	—	0.74
BI	BI1	0.73	0.69	0.22	3.31	0.48
	BI2	1.00	0.80	—	—	0.64

Fit indices: $\chi^2 = 131.176$ ($p = 0.14$), df = 98, χ^2/df = 1.339, GFI = 0.943, CFI = 0.980, SRMR = 0.045, RMSEA = 0.037, NFI = 0.929.

[a]SE is an estimate of the standard error of the covariance.

[b]CR is the critical ratio obtained by dividing the estimate of the covariance by its standard error. The value of exceeding 1.96 represents a level of significance of 0.05.

[c]Indicates a parameter fixed at 1.0 in the original solution.

Convergent validity is judged to be adequate when average variance extracted equals or exceeds 0.50 (i.e., when the variance captured by the construct exceeds the variance due to measurement error). As shown in Table 3, all AVEs are above .50 and this indicates that the convergent validity for the proposed constructs of the research model was adequate.

Discriminant Validity

Discriminant validity is assessed to measure the extent to which constructs are different. At the item level, Barclay, Higgins, and Thompson (1995) suggested that discriminant validity is present when the variance shared between a construct and any other construct in the model is less than the variance that construct shares with its measures (Fornell, Tellis, & Zinkham, 1982). The variance shared by any two constructs is obtained by squaring the correlation between the two constructs. The variance shared between a construct and its measures corresponds to the average variance extracted. Discriminant validity was assessed by comparing the square root of the average variance extracted for a given construct with the correlations between that construct and all other constructs. Table 4 shows the correlation matrix for the constructs. The diagonal elements have been replaced by the square roots of the average variance extracted. For discriminant validity to be judged adequate, these diagonal elements should be greater than the off-diagonal elements in the

Table 4
Measures of reliability and average variance extracted

Construct	alpha	AVE[a]	PU	PEU	ATCU	SN	FC	BI
PU	.86	.61	(.78)					
PEU	.78	.58	.39**	(.76)				
ATCU	.82	.54	.58**	.48**	(.73)			
SN	.83	.83	.14*	.18**	.19**	(.91)		
FC	.77	.73	.17**	.37**	.31**	.18*	(.85)	
BI	.71	.75	.17**	.12	.07	-.04	-.11	(.87)

Note. Diagonal in parentheses: square root of average variance extracted from observed variables (items); Off-diagonal: correlations between constructs. Off-diagonal: Pearson's correlation
[a]Average Variance Extracted. This is computed by adding the squared factor loadings and dividing by the number of variables of the underlying construct.
* $p < .05$; ** $p < .01$

corresponding rows and columns. From Table 4, all diagonal values are greater than their off-diagonal elements and this indicates that the each construct shared more variance with its items than it does with other constructs. Having achieved discriminant validity, the constructs in the proposed research model were deemed to be adequate.

Assessing model fit: Evaluation of the measurement model

The first step in testing was the evaluation of the goodness-of-fit of the measurement model. AMOS 7.0 (Arbuckle, 2006) generates a chi-square (χ^2) statistic, associated degrees of freedom (df) and a probability value whenever maximum-likelihood estimates are computed. In addition, AMOS uses Hoelter's formula for critical N (CN), the smallest sample size for a study which one would accept, at a particular significance level, a model with this χ^2 statistic and this degree of freedom. This analysis yielded CNs of 232 at a significance level of 0.05. The sample size for this SEM analysis is 250.

In AMOS, the t-value is the critical ratio (CR) which represents the parameter estimate divided by its standard error. A t-value greater than 1.96 or smaller than -1.96 implies statistical significance at the $p < 0.05$ level (Kline, 2005). The larger the factor loadings or coefficients as compared with their standard errors, the stronger is the evidence that there is a relationship between the observed indicators and their respective latent factors (Bollen, 1989; Koufteros, 1999). Table 3 shows that each item exceeds the critical ratio at the 0.05 level of significance. Thus, all indicators were significantly related to their specified constructs, confirming the posited relationships among the indicators and latent variables. Item reliability refers to the R^2 value in each observed variable accounted for by the latent variable influencing it. The R^2 can be used to estimate the reliability of a particular observed variable (item) (Koufteros, 1999); and R^2 values above 0.50 provide evidence of acceptable reliability (Bollen, 1989). An examination of the results reveals that five items (i.e., PU4, PEU2, CA3, CA4, BI1) did not meet the criterion. However, in view of the other properties demonstrated by these items (e.g., t-value, factor loadings), these items were retained. Table 3 shows that the critical ratios were all higher than 1.96, providing evidence of convergent validity.

In using SEM, it is a common practice to employ a variety of indices to measure model fit (Kline, 2005). In addition to the ratio of the χ^2 statistic to its degree of freedom, with a value less than 3 indicating acceptable fit, researchers (e.g., Kline, 2005) recommended a handful of fit indices to assess model fit. These are the Goodness of Fit

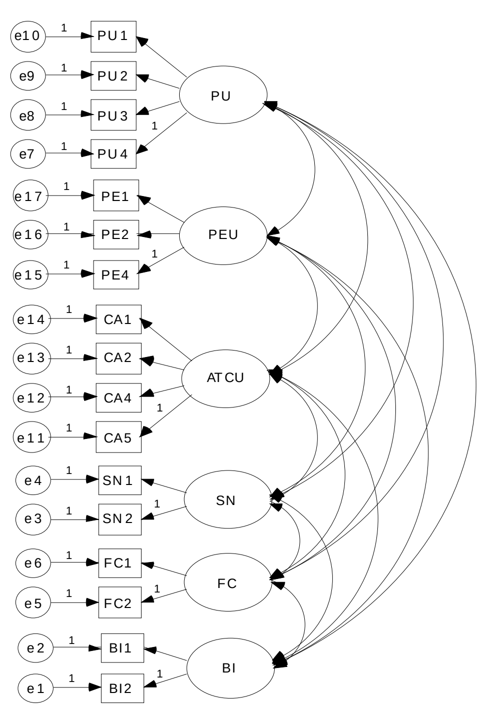

Figure 3. *Measurement model*

(GFI), Normed Fit Index (NFI), Standardized Root Mean Residual (SRMR), and the Comparative Fit Index (CFI). Table 5 shows the level of acceptable fit and the fit indices for the proposed research model in this study. Except for the χ^2 measure, all values satisfied the recommended level of acceptable fit. The χ^2 measure has been found to be too sensitive to sample size differences, especially for cases in which the sample size exceeds 200. Hair et al. (2006) noted that, as the sample size increases, there is a great tendency for the χ^2 to indicate significant differences. Therefore, this anomaly is assumed to be applicable in the present study with a sample of 250. However, the value of χ^2/ df in the present study is well within the recommended range (< 3). The results presented in Table 5 demonstrate a good model fit.

Table 5
Results of the Model fit of the Measurement Model

Model fit indices	Values	Recommended guidelines	References
χ^2	182.16, $p < .001$	Non-significant	Klem (2000); Kline (2005); McDonald and Ho (2002)
χ^2/df	1.67	< 3	Kline (2005)
GFI	.92	≥ .90	Klem (2000); Kline (2005); McDonald and Ho (2002)
NFI	.94	≥ .90	Klem (2000); McDonald and Ho (2002)
SRMR	.05	< .05	Klem (2000); McDonald and Ho (2002)
CFI	.96	≥ .90	Klem (2000); McDonald and Ho (2002)
RMSEA	.05 (.04, .07)	< .05	McDonald and Ho (2002)

Evaluation of the Structural Model: Hypothesis Testing

Figure 4 shows the resulting path coefficients of the proposed research model. Overall, five out of seven hypotheses were supported by the data. The results show that perceived ease of use significantly influenced perceived usefulness (β = 0.31, p < .001), supporting hypothesis H_1. Perceived ease of use was also found to be significant in influencing attitude toward computer use (β = 0.37, p < .001), thereby supporting H_2. Attitude toward computer use was also significantly influenced by perceived usefulness (β = 0.69, p < .001), thus supporting H_3. Facilitating conditions was significant in influencing perceived ease of use (β = 0.38, p < .001) and perceived usefulness was significant in influencing behavioral intention (β = 0.31, p < .001), supporting H_5 and H_6, respectively. Two hypotheses, H_4 (β = 0.04, p > .05.) and H_7 (β < 0.01, p > .05), were not supported.

Four endogenous variables were tested in the model. Perceived usefulness was found to be significantly determined by perceived ease of use, resulting in an R^2 of 0.22, explaining 22 percent of the variance in perceived usefulness. Perceived ease of use was significantly determined by facilitating conditions (R^2 = 0.18), accounting for 18 percent of the variance in perceived ease of use. Attitude toward computer use was significantly determined by perceived usefulness and perceived ease of use to a high degree of R^2 of 0.61, indicating that together, perceived usefulness and perceived ease of use explained 61 percent of the variance in attitude toward computer use. The dependent variable, behavioral intention was significantly determined by perceived usefulness, resulting in an R^2 = 0.04, explaining 4 percent of the variance of behavioral intention. A summary of the hypotheses testing results is shown in Table 6.

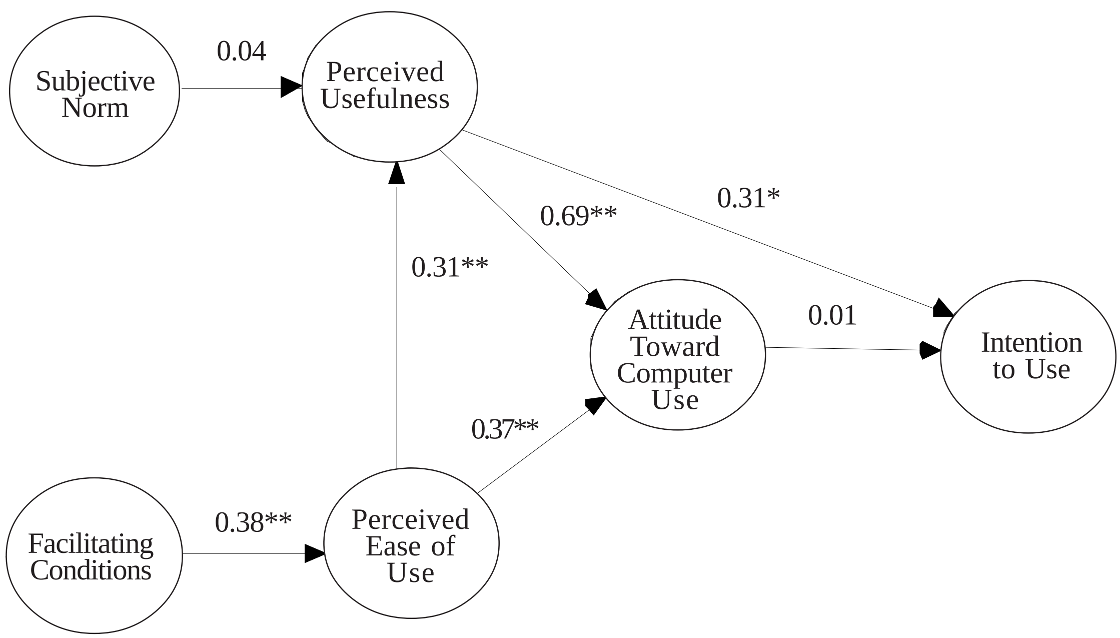

Figure 4. *Structural model*

Table 6
Results of the Structural Equation Modeling

Hypothesis	Causal path	Path coefficient	t-value	Supported?
H_1	PEU → PU	0.31**	5.54	Yes
H_2	PEU → ATCU	0.367**	4.86	Yes
H_3	PU → ATCU	0.69**	5.89	Yes
H_4	SN → PU	0.04	1.33	No
H_5	FC → PEU	0.38**	4.99	Yes
H_6	PU → BI	0.31*	1.93	Yes
H_7	ATCU → BI	0.001	0.34	No

Note. ** $p \leq .001$; * $p < .05$

DISCUSSION AND CONCLUSION

This study applied TAM to explore pre-service teachers' intention to use technology. It was found that perceived usefulness and perceived ease of use were direct and indirect determinants of behavioral intentions, respectively. In addition, two external factors were included in the research model, subjective norm and facilitating conditions. Subjective norm did not have an effect on perceived usefulness while facilitating conditions were influential on perceived ease of use.

Perceived usefulness is an important antecedent of intention to use and, by implication, of computer use. This study suggests that pre-service teachers are more likely to use computers in their work if during their training as a teacher they have seen examples of effective computer use, in particular for instruction, and have themselves used computers effectively. In addition, perceived usefulness was significantly influenced by perceived ease of use. From a practical perspective, pre-service teachers are likely to see technology as useful when they think that it does not require much effort to use (easy to use). The results of this study also revealed that facilitating conditions had a significant influence on perceived ease of use. This suggests that when pre-service teachers perceived an adequate level of support (e.g., technical support), they tend to see technology as easy to use. Finally, perceived usefulness and perceived ease of use significantly influenced attitude towards computer use although the latter did not influence intention to use significantly. These findings suggest that when pre-service teachers find technology useful and easy to use, they tend to develop positive feelings (liking) towards computer use.

From a theoretical point of view, this study validated TAM and extended it to include subjective norm and facilitating conditions, although the former was found to be non-influential in the model. While TAM has been validated in various contexts, its use has been limited in the educational contexts. The relationships in the proposed model supported recent studies which showed the significant links between perceived usefulness, perceived ease of use, and attitude toward computer use (Teo, Lee, & Chai, 2008). However, subjective norm was found to be non-significant in influencing perceived usefulness in the present study, contrary to recent research (e.g., Hu, Clark & Ma, 2003). A possible explanation is given by Venkatesh and Davis (2000) and Roberts and Henderson (2000) who suggested that subjective norm has a significant effect on one's attitudes towards computer use in a non-volitional setting, but it has no effect in a voluntary setting. The participants in this study were full-time students at the teacher training institute and it was possible that they had not begun to experience the 'mandatory' use of technology in the way they would if they had been in the schools. Furthermore, according to Roberts and Henderson (2000) subjective norm may not impact as much on users who have been using IT for some time. This fits the profile of the participants in this study who have an average of 8.12 years (SD=4.22) in using computers.

This study also found no significant relationship between attitude toward computer use and behavioral intention although the latter was significant as determined by perceived usefulness. This finding appeared contrary to other TAM studies which found behavioral intention to be significantly influenced by both perceived usefulness and attitude toward computer use (Gao, 2005; Gong, Xu, & Yu, 2004), but confirms UTAUT (Venkatesh et al., 2003) – in which attitude toward computer use is considered redundant. A plausible ground for such differences is the way pre-service teachers were trained in Singapore. All students undertake and are exposed to technology on various fronts. These include (1) attending compulsory modules in using ICT for instructional purposes, (2) using computers for assessment purposes, (3) relying on e-learning portals for information and course administration, (4) role modeling by lecturers, and (5) being exposed to national policies on the use of technology in the school curriculum. These factors may have resulted in students taking a practical approach toward technology acceptance, irrespective of their attitude. Therefore, and in anticipation of the widespread application of technology in the schools, it becomes plausible that perceived usefulness was more significant than attitude toward computer use in influencing participants' behavioral intentions to use technology. The results in this study also reflect the need to examine the influence of subjective norm in TAM and the relationship between attitude toward computer use and behavioral intention more closely in future studies.

This study examined the various beliefs held by pre-eservice teachers and their influences on the intention to use technology. While beliefs can act as facilitators to teachers' use of technology, sometimes they present themselves as barriers. In their professional practice, teachers are faced with external and internal barriers that hamper successful technology implementation. For example, external barriers include limited equipment, training, and time. Internal barriers confront beliefs about current practice and lead to new goals, structure, and roles. These barriers are intrinsic to teachers and include beliefs about teaching, beliefs about computers, established classroom practices, and unwillingness to change (Ertmer, Addison, Lane, Ross & Woods, 1999).

From an Asian context, Lim and Khine (2006) found a lack of access to ICT, insufficient time for planning, and inadequate technical support as barriers to technology integration. A study in Malaysia by Wong, Ng, Nawawi, and Tang (2005) of 310 pre-service teachers found that the use of Internet technology was influenced by support from friends, confidence level, attitude towards the Internet, and perceived usefulness. In Hong Kong, Leung, Watters, and Ginns (2005) found that teachers were negatively affected by poor infrastructure, lack of resources, and lack of equipment for ICT, and the low perception of one's knowledge of ICT. Using a Taiwanese sample, Liao (2003) studied how teachers' personal attitudes had an impact on their use of ICT for teaching. Findings revealed that previous computer experience, comfort level in using the computer, perceived usefulness, and computer ownership were significant determinants of teachers' intention to use technology. These studies reflected the need for a further examination of the factors that facilitate or act as barriers that explain teachers' acceptance and resistance to technology.

From a practitioner's perspective, the results of this study have direct implications for school administrators and teacher educators. Perceived usefulness and perceived ease of use do not remain static, and neither does the influence of their antecedents (Venkatesh, 2000). Users who perceive computers to be useful and easy to use may soon experience limitations if they do not participate in continuing professional development to keep abreast with more advanced skills and knowledge on the use of computers. This is true especially among students in today's classroom who are generally competent in using technology-rich media. In the classrooms, expectations of these students on how technology should be used may cause insecurity and stress to teachers (Sugar, Crawley & Fine, 2004). Therefore, school administrations should devise implementation strategies and place effective support structures to create successful experiences for teachers in the use of technology in order to cultivate positive perceptions of usefulness and ease of use as well as attitudes toward computer use that, in turn, reinforces the behavioral intention to use technology over time.

On the part of teacher educators, it is important to ensure that pre-service teachers have access to technology – not just for administration, but also for instruction – in the teacher training curriculum. In the course of their training, pre-service teachers could be provided with the skills and experiences that will be relevant in their future jobs as teachers because the effective use of technology would enable these future teachers to facilitate and adjust their instructional strategies to optimize students' learning (Yuen, Law, & Chan, 1999).

LIMITATIONS AND FUTURE RESEARCH

This study is subject to several limitations. Firstly, it is possible that there may be additional variables that need to be included in the study. Although TAM has been extensively validated, the use of technology in most environments has become increasingly complicated and it is reasonable to expect other variables not included in TAM to exert their influence on users' acceptance of technology in significant ways. The above discussion of studies in Asia supports the need to include other variables such as self-efficacy, computer experience, computer knowledge, and computer ownership.

Secondly, pre-service teachers were used as participants and their views may differ from the practicing teachers. In addition, practicing teachers are more likely than pre-service teachers to be exposed to actual demands related to the use of technology from within and outside their professional environments. In this way, pre-service teachers may not fully appreciate the demands and stress involved when technology is used in a real-life school setting. Future research could be conducted to collect data from practicing teachers to compare the results with those from pre-service teachers. It might also be worthwhile to compare the way antecedents affect teachers' and students' technology acceptance outcomes. Longitudinal studies may be designed to trace the stages of attitudinal changes experienced by pre-service teachers when they become practicing teachers. Finally, it is useful to examine whether there are discrepancies between self-reports and actual practice and, if these exist, to identify the factors that explain the gap.

Thirdly, the use of self-reports in this study raises the possibility of common method variance, a situation in which variations among the scores are due to the method of data collection instead of the intended constructs. This may give an inflated association between constructs (Kline, Sulksy & Rever-Moriyama, 2000). The issue of generalizability is also a concern when self-reports are used. Future work should examine the extent to which the results of this study could be applied to other populations, context and times. Furthermore, the lack of significance for the two hypotheses (H_4 and H_7) may be the result of a measurement artifact due common method variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Future research could employ a multi-trait multi-method matrix (MTMM), an approach that has been suggested to minimize common method variance that is associated with a single method of data collection. Furthermore, research should extend TAM to include other variables of interest to the wider education community and to show how additional variables may vary in their importance at various levels of technology acceptance.

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Appendix

Constructs and Corresponding Items

Construct	Item	
Perceived Usefulness (adapted from Davis, 1989)	PU1	Using computers will improve my work.
	PU2	Using computers will enhance my effectiveness.
	PU3	Using computers will increase my productivity.
	PU4	I find computers a useful tool in my work.
Perceived Ease of Use (adapted from Davis, 1989)	PE1	My interaction with computers is clear and understandable.
	PE2	I find it easy to get computers to do what I want it to do.
	PE3	Interacting with computers does not require a lot of mental effort.
	PE4	I find computers easy to use.
Computer Attitudes (adapted from Thompson et al. 1991; Compeau and Higgins, 1995)	CA1	Computers make work more interesting.
	CA2	Working with computers is fun.
	CA3	I like using computers.
	CA4	I look forward to those aspects of my job that require me to use computers.
Subjective Norm (adapted from Taylor and Todd, 1995)	SN1	People whose opinions I value will encourage me to use computers.
	SN2	People who are important to me will support me to use computers.
Facilitating Conditions (adapted from Thompson, et al., 1991)	FC1	When I need help to use computers, guidance is available to me.
	FC2	When I need help to use computers, specialized instruction is available to help me.
Behavioral Intention (adapted from Davis, 1989)	BI1	I will use computers in future.
	BI2	I plan to use computers often.