International Journal of Education and Development using Information and Communication Technology (IJEDICT), 2010, Vol. 6, Issue 3, pp. 7-18

Assessing the dimensionality of computer self-efficacy among pre-service teachers in Singapore: a structural equation modeling approach

Timothy Teo and Joyce Hwee Ling Koh
Nanyang Technological University, Singapore

ABSTRACT

This study examines the computer self-efficacy among pre-service teachers (N=708) at a teacher training institute in Singapore. Data were collected through self-reported ratings on a 7-point Likert-type scale. Exploratory factor analysis (EFA) was performed on an initial sample (N=354) and the result revealed that pre-service teachers' computer self-efficacy was explained by three factors: Basic Computer Skills (BCS), Media-Related Skills (MRS), and Web-Based Skills (WBS). Using a separate sample (N=354), a confirmatory factor analysis was performed and this supported the three-factor structure from the initial EFA. A comparison of alternative models revealed that the correlated three-factor and second-order (three-factor) models had the best fits; and were adequate representations of pre-service teachers' computer self-efficacy.

Keywords: *computer self-efficacy; pre-service teachers; confirmatory factor analysis; structural equation modelling, model comparison*

INTRODUCTION

Teachers are expected to use ICT for teaching and administration in today's educational systems (Haydn & Barton 2008). They also act as change agents for technology integration in their schools (Zhao et al 2001). Teachers use technology in two ways (Tubin 2006); one of which is where technology is used to attain the same traditional goals under the same conditions, without significant changes to the classroom activities. The second way is to use technology to expand classroom boundaries, connect students to real-world events, and guide students to become independent learners. It is possible that teachers' use of technology is influenced by their beliefs about teaching and learning. For example, a teacher who believes that students who learn best through teacher-led instruction will tend not to encourage students to explore a technology tool for learning. A study on student teachers' beliefs about teaching and learning and technology use found a positive and strong correlation between teachers' beliefs in constructivist teaching and constructivist (or user-centered) use of technology (Teo et al 2008).

Teachers are generally open-minded about integrating technology into their teaching (Zhao & Frank 2003), but it has been observed that their technology adoption has been slow and below expectations (Selwyn 2003) Research studies have found that teachers' external work environments (Ertmer 2005) or teachers' attitude towards computer use (Teo 2010; Teo et al 2008) may influence how they use technology for teaching. However, Ertmer (2005) argued that although the environmental conditions affecting technology use (e.g. technology infrastructure) have improved, few studies have examined how personal factors such as teachers' beliefs affect technology use in teaching. From their study, Zhao and Cziko (2001) identified that teachers' perceived ability to use technology, i.e. computer self-efficacy affects their technology use. It is a significant predictor of the intention to use technology (Teo 2009a). In other words, teachers' beliefs about their ability to use technology play an important part in shaping their responses to instructional reforms, including technology integration for teaching and learning (Selwyn et al 2001). It is therefore worthwhile to examine the dimensions underlying their computer self-efficacy, so as to devise strategies to better scaffold their technology adoption process.

Computer Self-Efficacy

Self-efficacy refers to one's belief of their capability to perform a specific task (Bandura 1997). Bandura stated that the focus is not on the actual skills but the judgements one has of what one can do with whatever skills one possesses. Individuals who perceive themselves capable of performing certain tasks or activities are defined as being high in self-efficacy, and are more likely to attempt these tasks and activities; and vice versa. In the context of computer use, computer self-efficacy refers "*to a judgment of one's capability to use a computer*" (Compeau & Higgins 1995, p.192). For example, Compeau and Higgins found that an individual's use of technology was affected by their self-efficacy and that participants with higher self-efficacy beliefs used computers more often and experienced less computer-related anxiety. The authors also noted that individuals with higher computer self-efficacy beliefs tend to see themselves as able to use computer technology. Those with lower computer self-efficacy beliefs tend to become more frustrated and anxious when working with computers; and hesitate to use computers when they encounter obstacles.

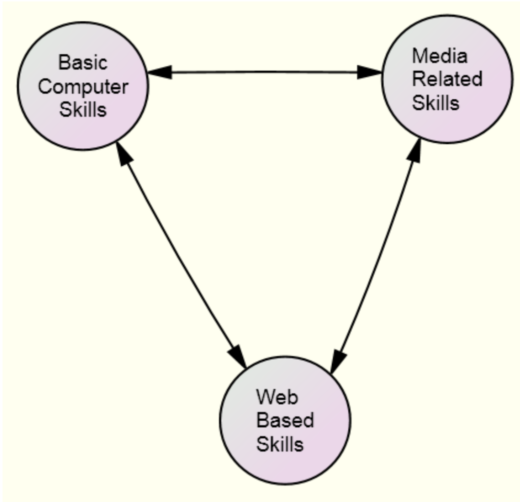
Computer self-efficacy has a major impact on an individual's expectations towards using computers (Compeau & Higgins 1995) and individuals who did not see themselves as competent computer users tend not to use computers (Oliver & Shapiro 1993). Studies conducted at the work force (Burkhardt & Brass 1990; Harrison & Rainer 1997) found that computer self-efficacy increases performance and reduces computer induced anxiety. Albion (2001) has noted that teachers' computer self-efficacy is a significant factor determining their patterns of computer use. For pre-service teachers, their computer self-efficacy significantly predicted their ability to integrate technology use in the classroom (Litterell et al 2005; Zhao et al 2002).

Computer self-efficacy can be viewed as application-specific and measured as one's perceived confidence for the different domain-specific skills with respect to computer use (Marakas et al 1998). A popular measure, the computer self-efficacy scale, was created by Murphy et al (1989) for measuring individuals' perceptions of particular computer-related knowledge and skills. The 32-item scale measures three levels of computing skills: beginner's level, advanced level, and a level associated with mainframe computers. Since then, many researchers have adapted the original Murphy's computer self-efficacy scale (Davis & Davis 1990; Harrison & Rainer 1997), while others have adapted a slightly modified version of the Murphy scale (Torkzadeh & Koufteros 1994; Zhang & Espinoza 1998). Computer self-efficacy scales have also been developed for teachers (e.g. Enochs et al 1993; Kinzie et al 1994; Ropp 1999; Wang et al 2004). However, a difficulty faced with using existing computer self-efficacy scales is the need to replace items associated with out-dated technology such as computer diskettes and CD-ROM databases (Abbitt & Klett 2007). The proliferation of Web 2.0 and media tools for educational has also made it important to consider these technologies as part of teachers' computer self-efficacy evaluation. Recent studies have started to explore more specific types of computer self-efficacy, e.g. internet self-efficacy (Lee & Tsai 2010). Less attention has been paid on developing a generic computer self-efficacy scale that incorporates basic computer skills, web-based skills, and skills with media tools.

Purpose of the Study

The purpose of this study is therefore to examine the dimensions of pre-service teachers' computer self-efficacy. Figure 1 shows the dimensions of computer self-efficacy in this study. In Figure 1, pre-service teachers' computer self-efficacy was hypothesised to comprise three dimensions: (1) Basic Computer Skills, (2) Media-Related Skills, and (3) Web-Based Skills. The research question examined was: Can the computer self-efficacy of pre-service teachers be adequately explained by three dimensions: Basic Computer Skills, Media-Related Skills, and Web-Based Skills?

***Figure 1**: Dimensions of Computer Self-Efficacy*



METHOD

Research Participants and Data Collection

Participation in this study was voluntary and 708 pre-service teachers were recruited from a cohort of 786 students enrolled in the one-year Postgraduate Diploma in Education programme at a teachers' institute in Singapore. They responded to an invitation issued by the author and those who agreed to take part in this study were given a URL to access an online survey questionnaire. The mean age of all participants was 26.39 (SD=4.68). All participants were briefed on the purpose of this study and told of their rights to withdraw during or after they had completed the questionnaire. No course credit or rewards were given to the participants who, on average, took less than 10 minutes to complete the questionnaire. In structural equation modeling, it is recommended that proposed initial model be validated with another sample that was not used in the initial model development (Schumacker & Lomax 2004). Therefore, the sample of this study (n=708) was randomly split into two (n=354).

Measures

A 13-item survey questionnaire was developed to measure participants' computer self-efficacy in addition to demographic information. Each item was meant for participants to report their computer self-efficacy with respect to different types of basic, web-based, and media-based technologies. For example, "I am able to use the Internet to search for information and resources" and "I am able to use digital media collection tools (e.g. digital camera, digital video camera) for teaching or administration purposes". The actual technology tools (e.g. PowerPoint) were included in the questionnaire items to help participants relate to their personal experiences when responding to these items. In addition, as faculty members in the institution where the participants in this study were selected from, the authors had a good understanding of the technology tools that the pre-service teachers were exposed to. Each item was measured on a seven-point Likert scale with 1=strongly disagree to 7=strongly agree. Ten of these items were used in Teo (2009b) which loaded on three factors and were found to possess high composite reliabilities ranging from .88 to .89.

Statistical Analysis

Structural equation modeling (SEM) was used as the main technique for data analysis in the study. Data were screened for missing data and outliers. This was followed by exploring the factor structure implicit in the 13 items and establishing convergent and discriminant validities. Subsequently, the number of factors retained through exploratory factor analysis was confirmed using confirmatory factor analysis. Finally, the research model and various alternative models were compared against each to select the best fitting model that explained the dimensionality of computer self-efficacy of pre-service teachers in Singapore. To obtain reliable results in structural equation modelling, researchers recommend that a sample size of 100 to 150 cases (e.g. Kline 2005). In addition, Hoelter's (1983) conception of the critical N, which refers to the sample size for which one would accept the hypothesis that the proposed research model is correct at the .05 level of significance, was examined. The Hoelter critical N for the model in this study was 99. The sample size of this study was 354 for both the initial model and validation samples; and therefore the total sample for this study was considered adequate for the purpose of structural equation modelling.

RESULTS

Descriptive Statistics

All mean scores were above the mid-point of 4.0 except for three items. The standard deviations ranged from .74 to 1.84 and the skewness and kurtosis indices were within the recommended values of |3| and |10| respectively (Kline 2005). These values suggested that the data distribution was univariate and the sample size of 354 satisfied the minimum requirement for factor analysis as there were, over 20 cases per variable.

Exploratory Factor Analysis

Initially, the factorability of the 13-items scale was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all items correlated at least .3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was .87, above the recommended value of .6, and Bartlett's test of sphericity was significant (χ^2 (78) = 2338.91, p < .001). Finally, the communalities were all above .3, further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 13 items.

Principal components analysis was used because the primary purpose was to identify and compute composite scores for the factors underlying computer self-efficacy among the pre-service teachers. The initial eigenvalues showed that the first factor explained 38.78% of the variance, the second factor explained 19.97% of the variance, and a third factor explained 8.03% of the variance. Based on the rotated component matrix, one item was eliminated because it did not contribute to a simple factor structure and failed to meet a minimum criteria of having a primary factor loading of .60 or above (Hair et al 2006). The item was "I am able to use digital media collection tools (e.g. digital camera, digital video camera) for teaching or administration purposes." A principal components factor analysis of the remaining 12 items, using Varimax and Oblimin rotations was conducted, with the three factors explaining 68.5% of the variance. All items had primary loadings over .60. The factor loading matrix for this final solution is presented in Table 1.

From the items, the factors were labeled as *Basic Computer Skills* (BCS, Items 1, 2, 3, 4, & 10), *Media-Related Skills* (MRS, Items 5, 6, 7, & 8), and *Web-Based Skills* (WBS, Items 9, 11, & 12). The internal consistency for each of the factors was examined using Cronbach's alpha. The alphas were moderate -- .71 for *BCS* (5 items), .83 for *MRS* (4 items), and .68 for *WBS* (3 items). Overall, these analyses indicated that three distinct factors underlie pre-service teachers' computer self-efficacy and these factors had moderate internal consistency. Table 2 shows the descriptive statistics for the composite score data of the three factors retained from the principal components analysis. The results show an approximately normal distribution for in the current study. Thus, the data were well suited for further statistical analyses.

Table 1*: Factor loadings and communalities based on a principle components analysis with Oblimin rotation for 12 items (N = 354)*

No	Item	1	2	3	h^2
BCS1	I am able to use the internet to search for information and resources	**.79**	-.05	.30	.71
BCS2	I am able to use word processor to create, edit and format documents for specific purposes. (e.g. Microsoft Word)	**.87**	.00	.28	.84
BCS3	I am able to use Presentation Software (e.g., Microsoft PowerPoint) for classroom delivery	**.81**	.11	.34	.79
BCS4	I am able to use spreadsheet to record data, compute simple calculations and represent data in the form of tables and graphs (e.g. Microsoft Excel)	**.74**	.33	-.24	.70
BCS5	I am able to use email (e.g., Hotmail, Outlook, Yahoo, Gmail, and MyEdumail) for communication	**.67**	-.16	.48	.70
MRS1	I am able to use website Editors (e.g. Microsoft FrontPage, and Macromedia Dreamweaver) to create and/or modify web pages	.03	**.85**	.05	.72
MRS2	I am able to use video editing software (e.g. Microsoft MovieMaker, Adobe Premier, and Ulead VideoStudio)	.01	**.77**	.30	.68
MRS3	I am able to use graphic Editors (e.g., Microsoft Paint, Adobe Photoshop) to create and/or modify resources for teaching	.14	**.64**	.37	.57
MRS4	I am able to use animation software (e.g., Macromedia Flash, Authorware, and Director) to create animations	-.02	**.88**	.02	.77
WBS1	I am able to use blogging for personal use	.13	.32	**.74**	.66
WBS2	I am able to use conferencing Software (e.g., Yahoo, IM, MSN Messenger, ICQ, and Skype) for collaboration purposes	.38	.05	**.69**	.62
WBS3	I am able to use a learning management system (e.g. Blackboard, IVLE, WebCT, and Moodle) to support teaching	.22	.27	**.59**	.46
	Eigenvalue	3.26	2.82	2.15	---
	Total Variance explained	27.15	23.46	17.93	---

Note: Factor 1= Basic Computer Skills; Factor 2=Media-Related Skills; 3=Web-Based Skills

Table 2*: Descriptive statistics for the composite scores of the three factors measuring pre-service self-efficacy (N = 354)*

	No. of items	M	SD	Skewness	Kurtosis	Alpha
Basic Computer Skills	5	6.26	.66	-2.09	10.52	.71
Media-Related Skills	4	3.56	1.45	.21	-.63	.83
Web-Based Skills	3	5.52	1.17	-1.12	1.57	.68

Confirmatory Factor Analysis

The research model in this study was tested with the structural equation model approach, using AMOS 7.0 (Arbuckle 2006). The parameters were estimated using the Maximum Likelihood (ML) estimator and data were tested for reliability and validity using confirmatory factor analysis (CFA) on a separate sample of participants (n=354). The model in this study included 12 items which loaded on three constructs. Prior to testing the model, convergent and discriminant validities of the constructs in this study were examined.

Convergent validity was established by examining the item reliability, composite reliability (internal consistency), and the average variance extracted for each construct (Fornell & Lacker 1981). Item reliability was measured by the critical ratio (CR) where the value of 1.96 or more indicated that an item was significantly different from zero at the $p < .05$ level. The R^2 measures the proportion of variance in the construct was explained by an item. At the construct level, the average variance extracted (AVE) was computed as a measure of the overall amount of variance that was attributed to the construct in relation to the amount of variance attributable to measurement error. Convergent validity was judged to be adequate when average variance extracted equalled or exceeded 0.50. Table 1 shows the analysis of the measurement model. All parameter estimates were significant at p < .001 and most of the R2 values were above .40. Composite reliability using Cronbach's alpha was moderate for all constructs, ranging from .68 to .83. All AVEs are above the recommended value of .50, indicating that convergent validity is achieved.

***Table 3**: Results for the measurement model*

Latent Variable	Item	UE	SE	CR	R^2	Alpha	AVE (= > .50)*
Basic Computer Skills						.72	.62
	BCS1	1.233	.799	15.726	.638		
	BCS2	1.523	.954	15.613	.910		
	BCS3	1.492	.901	15.189	.812		
	BCS4	1.285	.483	8.704	.233		
	BCS5	1.000	.672	***	.451		
Media-Related Skills						.83	.62
	MRS1	1.152	.829	12.539	.688		
	MRS2	.954	.659	11.225	.434		
	MRS3	.940	.696	9.972	.484		
	MRS4	1.000	.757	***	.573		
Web-Based Skills						.68	.51
	WBS1	1.104	.574	8.434	.330		
	WBS2	.974	.737	9.744	.543		
	WBS3	1.000	.652	***	.425		

Notes:
USE: Unstandardised Estimate
SE: Standardised Estimate
CR: Known as critical Ratio, this value tests whether a parameter is significantly different from zero.
R^2: This represents the proportion of variance in the latent variable that explained by this item.
AVE: Average Variance Extracted= $(\sum\lambda^2) / n$
*Indicates an acceptable level of reliability or validity (Hair et al., 2006)
*** This value was fixed at 1.00 in the model for estimation purposes.

To establish discriminant validity, the variance shared between a construct and any other construct in the model need to be assessed (Fornell et al 1982). This was done by comparing the square root of the average variance extracted for a given construct with the correlations between that construct and all other constructs. If the square roots of the AVEs were greater than the off-diagonal elements in the corresponding rows and columns, it suggested that the given construct was more strongly correlated with its indicators than with the other constructs in the model; and discriminant validity was achieved. In Table 4, the diagonal elements in the correlation matrix were replaced by the square roots of the average variance extracted. The values suggested that discriminant validity was present at the construct level or all the variables in the research model.

***Table 4**: Discriminant validity for the measurement model*

Construct	BCS	MRS	WBS
BCS	(.79)		
MRS	.27**	(.79)	
WBS	.46**	.41**	(.71)

**$p < .01$

Diagonal in parentheses: square root of average variance extracted from observed variables (items);
Off-diagonal: correlations between constructs

In testing for model fit, it is customary to use fit indices from various categories. Absolute fit indices measure how well the proposed model reproduces the observed data. Parsimonious fit indices are similar to the absolute fit indices but they take into account the model's complexity, and incremental fit indices assess how well a specified model fit relative to an alternative baseline (null) model. In this study, the Tucker-Lewis index (TLI), comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean residual (SRMR) were used. Researchers recommend a minimum value of .90 for TL and CFI, and .08 for RMSEA and SRMR to represent an acceptable model fit (e.g. Schumacker & Lomax 2004). Because the χ^2 has been found to be too sensitive to an increase in sample size and the number of observed variables (Hair et al 2006), the ratio of χ^2 to its degree of freedom (χ^2/df), was used, with a range of not more than 3.0 being indicative of an acceptable fit between the hypothetical model and the sample data (Carmines & McIver 1981). The results revealed an acceptable fit for the research model (figure 1) in this study (χ^2= 124.004; χ^2/df =2.952; TLI=.939; CFI=.961; RMSEA=.074 [.059, .090]; SRMR=.069).

As part of confirmatory factor analysis, several models were computed to compare different conceptualisations of the factor structure. The first was a one-factor model that tested whether all the items loaded on one overall factor. A one-factor model suggested that participants did not differentiate among the factors, and that all items were representative of a unidimensional construct. The second was an uncorrelated factor model that tested whether all the three factors in the model were independent. This model suggested that the three factors were not related to one another and were perceived as three different constructs. The third was a correlated factor model that tested whether the three factors were related to one another. Support for this model indicated that participants had discriminated between the three factors but they were inter-correlated with one another. The fourth was a hierarchical model that tested the notion that a second-order factor existed to account for the relationships among the three factors. Support for this model suggested that while all the three factors were related, they were also related to a higher order factor. A series of CFAs were conducted to test the four models described above. Table 5 shows the fit indices for each model. The results show that models three and four are better fitting models with no differences in their fit indices. In other words, the correlated and second-order models are adequate representations of the dimensions of computer self-efficacy of the pre-service teachers in this study. As such, models three and four would be retained as the models of best fit.

***Table 5**: Confirmatory Factor Analysis of alternative models*

Model	χ^2	df	χ^2/df	TLI	CFI	RMSEA	SRMR
1. One-factor	603.045	45	13.401	.615	.737	.187	.160
2. Uncorrelated factor	282.270	45	6.273	.836	.888	.122	.194
3. Correlated factor	124.004	42	2.952	.939	.961	.074	.069
4. Second-order	124.004	42	2.952	.939	.961	.074	.069

*p <.001

DISCUSSION AND CONCLUSION

The aim of this study is to examine the dimensionality of pre-service teachers' computer self-efficacy. Using structural equation modelling, the results show that the pre-service teachers' computer self-efficacy is a multidimensional construct underlying three dimensions: BCS, MRS and WBS. These three dimensions significantly correlate with each other at a moderate level, suggesting that they are indeed perceived as separate skills although collectively, the results suggest that pre-service teachers perceived these dimensions as a unitary construct for self-efficacy.

This study provides additional insights to theory by statistically confirming the multidimensional nature of the computer self-efficacy, with special reference to users in an educational context such as pre-service teachers. In an age where the use of technology for teaching and learning is pervasive in many educational system, it is important to understand the drivers that predict and motivate technology usage. Research has shown that computer self-efficacy is a significant predictor of usage and intention to use technology. This study provides empirical evidence to support a position that suggests computer self-efficacy to be a multidimensional construct.

The findings of this study also contribute to the measurement of computer self-efficacy by using items which included the use of actual tools (I am able to use word processor to create, edit and format documents for specific purposes, e.g. Microsoft Word) and situations where technology are used (In my lesson, I use technology to teach my student to work collaboratively). Some instrument measuring computer self-efficacy had employed scale items that are worded in very general terms (e.g. I could complete a job or task using the computer if I could call someone for help if I got stuck). The statistical findings from this study suggest that the scores for the items for each dimension could be summed to obtain a composite score. These can then be summed or averaged to arrive that a single score to assess a user's computer self-efficacy. In this study, the item scores obtained from BCS, MRS and WBS could be averaged to obtain three mean scores. These can then be combined into one score to reflect a user's computer self-efficacy.

This study found that Singapore pre-service teachers had high computer self-efficacy with respect to BCS (M=6.26). They also had fairly high computer self-efficacy with respect to their WBS (M=5.52). The latter was similar to a survey of older, in-service Taiwanese teachers conducted by Lee and Tsai (2010). It can be interpreted that the proliferation of computer and web-based technologies has generally improved teachers' confidence with using these technologies. However, Singapore teachers were not confident with their MRS (M=3.56). This could be because media production software for graphics and animation are more specialised tools that were less familiar to the teachers (Koh & Frick 2009). There is a need to enhance Singapore's teachers' computer self-efficacy in these areas so that firstly, they have the confidence to produce media-rich learning objects to support teaching and learning. Secondly, enhancing their self-efficacy with media tools can help them become more confident of facilitating students' use of media production software for learning.

To conclude, this study has validated a three-factor scale for measuring the computer self-efficacy of teachers with respect to BCS, WBS and MRS. Further study of this construct can be carried out so that the relationships between computer self-efficacy and teachers' technology integration practice can be better understood.

Limitations of the Study

The use of self-reports in this study to collect data may lead to the common method variance, a situation that may inflate the true associations between variables. Next, using pre-service teachers may not accurately mirror the experiences of the practicing (in-service) teachers, hence limiting the ability to generalise the results of this study to all educational users. Finally, the total variance explained by each of the variables in this study: BCS, MRS and WBS were 69%, leaving 31% unexplained. There is a possibility that other dimensions may increase the explanatory ability of the research model in this study.

REFERENCES

Abbitt, J.T. & Klett, M.D. 2007, “Identifying influences on attitudes and self-efficacy beliefs towards technology integration among pre-service educators”, *Electronic Journal for the Integration of Technology in Education,* vol. 6, pp. 28-42.

Albion, P.R. 2001, “Some factors in the development of self-efficacy beliefs for computer use among teacher education students”, *Journal of Technology and Teacher Education,* vol. 9, no. 3, pp. 321-347.

Arbuckle, J.L. 2006, *AMOS* (version 7.0), [Computer software], SmallWaters, Chicago.

Bandura, A. 1997, *Self-efficacy: The Exercise of Control*, Freeman, New York.

Burkhardt, M.E. & Brass, D.J. 1990, “Changing patterns or patterns of change: The effects of a change in technology on social network structure and power”, *Administrative Science Quarterly,* vol. 35, no. 1. pp. 104-127.

Carmines, E.G. & McIver, J.P. 1981, *Analyzing Models with Unobserved Variables: Analysis of Covariance Structures*, Sage, Thousand Oaks, California.

Compeau, D.R. & Higgins, C.A. 1995, “Computer self-efficacy: Development of a measure and initial test”, *MIS Quarterly*, vol. 19, no. 2, pp. 189-211.

Davis, L.D. & Davis, D.F. 1990, “The effect of training techniques and personal characteristics on training end users of information systems”, *Journal of Management Information Systems,* vol. 7, no. 2, pp. 93-110.

Enochs, L.G., Riggs, I.M. & Ellis, J.D. 1993, “The development and partial validation of microcomputer utilization in teaching efficacy beliefs instrument in a Science setting”, *School Science and Mathematics,* vol. 93, no. 5, pp. 257-263.

Ertmer, P. 2005, “Teacher pedagogical beliefs: The final frontier in our quest for technology integration?”, Educational *Technology, Research & Development,* vol. 53, no. 4, pp. 25-39.

Fornell, C. & Larcker, D.F. 1981, “Evaluating structural equation models with unobservable variables and measurement error”, *Journal of Marketing Research*, vol. 18, no. 1. pp. 39-50.

Fornell, C., Tellis, G.J. & Zinkhan, G.M. 1982, *Validity Assessment: A Structural Equations Approach Using Partial Least Squares*, Proceedings, American Marketing Association Educators’ Conference.

Hair, J.F. Jr., Black, W.C., Babin, B.J., Anderson, R.E. & Tatham, R.L. 2006, *Multivariate Data Analysis,* 6th ed., Prentice-Hall International, New Jersey.

Harrison, A.W. & Rainer, R.R. 1997, “Testing the self-efficacy-performance linkage of social-cognitive theory”, *Journal of Social Psychology*, vol. 137, no. 1, pp. 79-87.

Haydn, T. & Barton, R. 2008, "First do no harm: Factors influencing teachers' ability and willingness to use ICT in their subject teaching”, *Computers & Education,* vol. 51, no. 1, pp. 439-447.

Hoelter, J.W. 1983, “The effects of role evaluation and commitment on identity salience”, *Social Psychology Quarterly*, vol. 46, pp. 140-147.

Kinzie, M.B., Delcourt, M.B. & Powers, S.M. 1994. “Computer technologies: Attitudes and self-efficacy across undergraduate disciplines”, *Research in Higher Education*, vol. 35, no. 6, pp. 745-768.

Kline, R.B. 2005, *Principles and Practice of Structural Equation Modeling*, 2nd ed., Guilford Press, New York.

Koh, J. & Frick, T.W. 2009, “Instructor and student classroom interactions during technology skills instruction for facilitating preservice teachers’ computer self-efficacy”, *Journal of Educational Computing Research,* vol. 40, no. 2, pp. 207-224.

Lee, M.H. & Tsai, C.C. 2010, “Exploring teachers’ perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web”, *Instructional Science,* vol. 38, pp. 1-21.

Litterell, A.B., Zagumny, M.J. & Zagumny, L.L. 2005, “Contextual and psychological predictors of instructional technology use in rural classrooms”, *Educational Research Quarterly*, vol. 29, no. 2, pp. 37-47.

Marakas, G.M., Yi, M.M. & Johnson, R.D. 1998, “The multilevel and multifaceted character of computer self-efficacy: Toward clarification of the construct and an integrative framework for research”, *Information Systems Research*, vol. 9, no. 2, pp. 126-162.

Murphy, C.A., Coover, D. & Owen, S.V. 1989, “Development and validation of the computer self-efficacy scale”, *Educational and Psychological Measurement,* vol. 49, pp. 893-899.

Oliver, T.A. & Shapiro, F. 1993, “Self-efficacy and computers”, *Journal of Computer Based Instruction, v*ol. 20, no. 3, pp. 81-85.

Ropp, M.M. 1999, “Exploring individual characteristics associated with learning to use computers in preservice teacher preparation”, *Journal of Research on Computing in Education,* vol. 31, no. 4, pp. 402-424.

Schumacker, R.E., & Lomax, R.G. 2004, “*A Beginner’s Guide to Structural Equation Modeling*”, Lawrence Erlbaum, Mahwah, NJ.

Selwyn, N. 2003, “Exploring patterns of computer use in schools”, *Welsh Journal of Education*, vol. 12, no. 1, pp. 75-97.

Selwyn, N., Dawes, L. & Mercer, N. 2001, “Promoting Mr. ‘Chips: The construction of the teacher/computer relationship in educational advertising”, *Teaching and Teacher Education*, vol. 17, no. 1. pp. 3-14.

Teo, T., Lee, C.B. & Chai, C.S. 2008a, “Understanding pre-service teachers’ computer attitudes: Applying and extending the Technology Acceptance Model (TAM)”, *Journal of Computer Assisted Learning*, vol. 24, no. 2, pp. 128-143.

Teo, T., Chai, C.S., Hung, D. & Lee, C.B. 2008b, “Beliefs about teaching and uses of technology among pre-service teachers”, *Asia Pacific Journal of Teacher Education*, vol. 36, no. 2, pp. 165-176.

Teo, T. 2009a, “Modelling technology acceptance in education: A study of pre-service teachers”, *Computers & Education*, vol. 52, no. 1, pp. 302-312.

Teo, T. 2009b, "Examining the relationship between student teachers' self-efficacy beliefs and their intended uses of technology for teaching: A structural equation modelling approach", *The Turkish Online Journal of Educational Technology*, vol. 8, no. 4, pp. 7-16.

Teo, T. 2010, "A path analysis of pre-service teachers' attitudes to computer use: Applying and extending the Technology Acceptance Model in an educational context", *Interactive Learning Environments,* vol. 18, no. 1, pp. 65-79.

Torkzadeh, G. & Koufteros, X. 1994, "Factorial validity of a computer self-efficacy scale and the impact of computer training", *Educational and Psychological Measurement*, vol. 54, no. 3, pp. 813-821.

Tubin, D. 2006, "Typology of ICT implementation and technology application", *Computers in the Schools*, vol. 23, no. 1, pp. 85-98.

Wang, L., Ertmer, P.A. & Newby, T.J. 2004, "Increasing preservice teachers' self-efficacy beliefs for technology integration", *Journal of Research on Technology in Education,* vol. 36, no. 3, pp. 231-250.

Zhang, Y. & Espinoza, S. 1998, "Relationships among computer self-efficacy, attitudes toward computers, and desirability of learning computing skills", *Journal of Research on Computing in Education*, vol. 30, no. 4, pp. 420-438.

Zhao, Y. & Cziko, G.A. 2001, "Teacher adoption of technology: A perceptual control theory perspective", *Journal of Technology and Teacher Education*, vol. 9, no. 1, pp. 5-30.

Zhao, Y. & Frank, K. 2003, "Factors affecting technology use in schools: An ecological perspective", *American Educational Research Journal*, vol. 40, no. 1, pp. 807-840.

Zhao, Y., Pugh, K., Sheldon, S. & Byers, J.L. 2002, "Conditions for classroom technology innovations", *Teachers College Record*, vol. 104, no. 3, pp. 482-515.

Zhao, Y., Tan, H. & Mishra, P. 2001, "Teaching and learning: Whose computer is it?", *Journal of Adolescent & Adult Literacy*, vol. 44, no. 4, pp. 348-355.