## The Development, Validation, and Analysis of Measurement Invariance of the Technology Acceptance Measure for Preservice Teachers (TAMPST)

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# The Development, Validation, and Analysis of Measurement Invariance of the Technology Acceptance Measure for Preservice Teachers (TAMPST)

**Timothy Teo**[1]

**Abstract**

This article describes the development, validation, and measurement invariance of scores from a survey designed to measure preservice teachers' reported acceptance of technology. Drawing from conceptual models in the areas of information systems and technology acceptance, a five-factor Technology Acceptance Measure for Preservice Teachers (TAMPST) was developed and validated. The factors in the TAMPST are perceived usefulness, perceived ease of use, subjective norm, facilitating conditions, and attitudes toward computer use. Using three studies and a combined sample of 759 preservice teachers, data were obtained and analyzed to examine for factorial validity of the TAMPST scores. In addition, tests of measurement invariance were conducted to ensure that the scores obtained from the TAMPST were generalizable between graduate and nongraduate preservice teachers. This study resulted in a 16-item five-factor measure to assess the technology acceptance of preservice teachers.

**Keywords**

development, measure, technology acceptance, preservice teachers, structural equation modeling

For many years, the use and value of technology as an instructional tool has been debated by educators and policy makers. Despite evidence showing a direct impact of

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technology on current educational practices and policies and the potential to transform traditional conceptions of education, the use of technology in classrooms still remains minimal and peripheral in many instances and teachers do not appear to make effective use of technology for teaching (Lim & Khine, 2006; Zhao & Cziko, 2001). The teacher is the key to effective integration of technology in many educational systems and it is important to understand the factors that drive them to engage technology for teaching and learning (Zhao, Tan, & Mishra, 2000). In their workplaces, teachers face numerous pressures and high expectations from different agencies to employ technology for teaching and learning. However, we should be cognizant that the extent to which teachers accept technology for teaching and learning is affected by many variables that interact with each other that facilitate or act as barriers to their use of technology. From the literature, these variables include personal factors such as computer self-efficacy (Gong, Xu, & Yu, 2004), technical factors such as technological complexity (Teo, 2009), and environmental factors such as facilitating conditions (Ngai, Poon, & Chan, 2007). Fostering technology acceptance among teachers is a critical challenge for school administrators, technology advocates, and government agencies.

Technology acceptance refers to a user's willingness to adopt and use technology for the tasks it is designed to support. In the recent past, procurers of technology could rely on organizational authority to ensure that technology was used, as is the case in many industrial/organizational and profit-driven contexts. However, the working practices in nonprofit contexts such as schools and institutions of learning may have enabled greater discretion among technology users. Under these conditions, the success of any technological initiatives may be substantially influenced by the degree to which potential users are willing to use or adopt the acquired system/technology. Consequently, technology acceptance or user acceptance has become among the most researched areas in recent years (Smarkola, 2007).

Many of these studies drew on the factors that influence teachers' use of technology. As a group, teachers' engagement with technology differs from the users in the business settings. For example, the former are relatively independent and autonomous over their technology choices and uses. When using technology, teachers usually have less peer competition for resources compared to their counterparts in the business milieu. Research on teachers' technology acceptance has found the factors that acted as facilitators or barriers to teachers' use in teaching and learning are numerous and diverse, as exemplified by recent examples from different parts of the world (Baek, Jung, & Kim, 2008; Chanlin, Hong, Horng, Chang, & Chu, 2007; Monsakul, Espinoza, & Un, 2007; Robertson, 2007; Teo, Lee, & Chai, 2008; Teo, Wong, & Chai, 2008). Many of these studies drew on models and theories from psychology and information sciences as their framework to explore the determinants that affect teachers' use of technology. Using the cognitive/behavioral approach, these studies suggest that an individual is conscious about his or her decision to accept and use technology. To this goal, an individual's decision to use technology is affected by their attitudinal, cognitive, and normative assessments of factors relevant to the technology, the social system, the target task, and the implementation context (Hu, Clark, & Ma, 2003).

In spite of the crucial role that technology acceptance plays in determining teachers' use of technology for teaching and learning, few instruments have been developed to explicitly measure technology acceptance. Among these are instruments that were developed to measure computer attitudes. For example, Loyd and Gressard's (1984) Computer Attitude Scale (CAS) examines three affective dimensions: computer anxiety, computer confidence, and computer liking. At a later stage, Loyd and Loyd (1985) added computer usefulness as the fourth dimension. Nickell and Pinto (1986) developed a 20-item Computer Attitude Scale (CAS) to measure positive (12 items) and negative (8 items) attitudes toward computers. The CAS was a generic scale, which has been found to yield reliable and valid scores by researchers (LaLomia & Sidowski, 1990; Rainer & Miller, 1996). Following on, Bear, Richards, and Lancaster (1987) developed the Bath County Computer Attitudes Survey to measure the attitudes of students from Grades 4 through 12 toward computers and used in conjunction with two other instruments to determine the factors in the students' background that affect their attitudes toward computers.

In the 1990s, Selwyn (1997) developed a computer attitude scale for 16- to 19-year-olds with subscales comprising affect attitudes toward computer, perceived usefulness of computers, perceived control of computers, and behavioral attitudes toward computers. At the same time, Levine and Donitsa-Schmidt (1998) designed the Computer Attitudes and Self-Confidence Questionnaire to measure the attitudes and self-confidence toward computer use among 7th through 12th graders. Levine and Donitsa-Schmidt hypothesized that positive computer attitudes and confidence would lead to a commitment to learning to use computers. Recently, Teo and Noyes (2008) developed the Computer Attitude Measure for Young Students (CAMYS). The CAMYS was designed for younger students ranging from 10 through 12 years. It is a 12-item scale comprising three factors: perceived ease of use, attitude toward use, and perceived usefulness. These factors are similar to the abovementioned scales in that they relate to the users' perceptions and beliefs about technology and its uses. However, the instruments discussed above were designed mostly for students.

Becker and Anderson (1998) developed an extensive instrument for research on teachers' use of technology. However, the focus of the instrument was directed toward teachers' histories with technology use rather than providing a measure of current implementation and integration. For example, teachers had to report the types of technology used, frequency of using certain technologies, and how various technologies were used. Furthermore, the Becker and Anderson instrument is long and complex hence limiting its utility. Flowers and Algozzine (2000) developed the Basic Technology Competencies for Educators Inventory to measure teachers; knowledge and skill on nine domains, including basic computer operations, word processing, networking, media communications, and social, legal, and ethical issues. A similar instrument was developed by Hogarty, Lang, and Kromrey (2003) to measure teachers' reported use of technology in their classrooms. This survey consists of four domains. The first measures the extent to which teachers were integrating computers and technology in the classroom. The second measures teachers' confidence and comfort using computers. The third measures the support given to teachers' computer use and the fourth was concerned with teachers' attitudes toward use of computers in the classrooms. However, Hogarty et al. were still mainly concerned with the state of technology use by teachers although the fourth domain, attitudes toward computer use, strikes a familiar note with the instruments mentioned earlier.

The literature suggests that technology use in classrooms is a complex phenomenon and that the multiple factors that influence technology use by teachers are interrelated. Although it is important to know the state of technology use by teachers in the classroom, it is necessary to obtain an understanding of the factor that motivate teachers to use or adopt technology for teaching and learning, in order to see a more complete picture of technology implementation in education.

## *Purpose of the Current Study*

The purpose of this study was to develop an instrument that would provide data to foster a better understanding of the factors that influence preservice teachers' acceptance of technology for teaching and learning. Preservice teachers are teachers in training and, given the high stakes that are involved in the use of technology in the schools, it makes sense to advance our understanding of the factors that influence preservice teachers' technology acceptance. In today's context, although it is reasonable to expect preservice teachers to be familiar with technology, the instrument developed from this study has the potential to provide useful information into the degree to which preservice teachers are willing to embrace technology as part of their professional activities while been trained to be a teachers thus allowing teacher educators to adjust and adapt their strategies with a view to influence preservice teachers' perception of technology in positive ways.

## *Theoretical Background*

The theoretical framework for the construction of this scale was adapted from the theory of reasoned action (Fishbein & Ajzen, 1975), theory of planned behavior (Ajzen, 1991), technology acceptance model (Davis, 1989), and the unified theory of acceptance and use of technology (Venkatesh, Morris, Davis, & Davis, 2003). These models are widely reported in the literature to be effective in predicting user acceptance and intention to use technology.

From the theory of reasoned action, a behavior is determined by a person's intention to perform the behavior. Behavioral intentions are a function of that person's attitude toward the behavior and his or her subjective norm (Ajzen & Fishbein, 1980). The theory of reasoned action posits that attitudes are a function of the beliefs that a person accumulates over a lifetime. Another important element considered under the framework is subjective norm, defined as the product of what others think about the behavior and motivations to comply with those views. Subjective norms, together with attitudes, influence whether the behavior is carried out (or intentions to perform specific behaviors).

The theory of planned behavior (TPB) was proposed by Ajzen (1991) as an extension of the theory of reasoned action. According to Ajzen, a person's action is determined by behavioral intentions, which in turn are influenced by an attitude toward the behavior and subjective norms. In addition to attitude toward the behavior and the subjective norm, perceived behavioral control can influence intention as well. Perceived behavioral control influences the individual's decision through behavioral intention and defined as a person's perception of how easy or difficult it would be to carry out a behavior (Ajzen, 1991).

The technology acceptance model (TAM) assumes that behavioral intention to use a particular technology is a very important factor that determines whether users will actually use it (actual system use). Behavioral intention is affected by attitude toward usage, as well as the direct and indirect effects of perceived usefulness and perceived ease of use. Both perceived usefulness and perceived ease of use jointly affect attitude toward usage, whereas perceived ease of use has a direct impact on perceived usefulness (Davis, 1989).

The unified theory of acceptance and use of technology (UTAUT) aims to explain users' intentions to use technology and subsequent usage behavior. The theory holds that four key constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of usage intention and behavior (Venkatesh et al., 2003). The theory was developed through a review and consolidation of the constructs of eight models that earlier research had employed to explain information systems usage behavior (e.g., theory of reasoned action, technology acceptance model, theory of planned behavior). The contributions of each theoretical model to the TAMPST are shown in Table 1.

## Method

### *Item Generation*

From the above studies, five constructs were hypothesized to explain technology acceptance of preservice teachers. They are perceived usefulness, perceived ease of use, subjective norm, facilitating conditions, and attitude toward computer use. A search for appropriate items was made from empirical studies that (a) contained items to measure some or all of the above constructs and (b) included preservice teachers or teachers as participants. As a result of adapting and modifying items taken from various sources, a list of 35 items (between 2 and 8 items per construct) was shortlisted for consideration. An important consideration at the item generation stage was to ensure that the items could be understood by the potential respondents. For this reason, the 35 items were presented to two groups of 20 preservice teachers at two separate focus-group discussions. To ensure that their views would mirror those of the actual

**Table 1.** List of Constructs From TRA, TPB, TAM, and UTAUT

| Theory | Constructs | Contribution to TAMPST |
|---|---|---|
| TRA | Attitude | Yes |
| | Subjective norm | Yes |
| TPB | Attitude | Yes |
| | Subjective norm | Yes |
| | Perceived behavioral control | Yes |
| | (facilitating conditions) | No |
| | (self-efficacy) | |
| TAM | Perceived usefulness | Yes |
| | Perceived ease of use | Yes |
| | Attitude | Yes |
| UTAUT | Performance expectancy[a] | Yes |
| | Effort expectancy[b] | Yes |
| | Social influence | No |
| | Facilitating conditions | Yes |

TRA = theory of reasoned action; TPB = theory of planned behavior; TAM = technology acceptance model; UTAUT = unified theory of acceptance and use of technology; TAMPST = Technology Acceptance Measure for Preservice Teachers.
a. This is similar to perceived usefulness.
b. This is similar to perceived ease of use.

respondents, these preservice teachers were invited from the different teacher training programs. The 20 preservice teachers were asked to explain what they thought each item meant to allow for subsequent revisions with an aim to improve clarity and conciseness for each item. Based on the comments of the 20 preservice teachers, a list of 21 items was retained for the pilot study. At this stage, the items were distributed into five factors: Perceived Usefulness (PU; 4 items), Perceived Ease of Use (PEU; 4 items), Subjective Norm (SN; 2 items), Facilitating Conditions (FC; 3 items), and Attitude Toward Computer Use (ATCU; 8 items).

## Study 1: Pilot Study

The pilot study tested and refined the 21 items for the development stage. The 21 items were presented, using a 5-point Likert-type response scale (1 = *strongly disagree*, 5 = *strongly agree*) and a mixture of positively and negatively worded statements.

### *Participants and Procedures*

Participants were 171 teacher trainees (henceforth referred to as "preservice teachers") enrolled at the National Institute of Education (NIE) in Singapore. Being the only teacher education provider in Singapore, NIE offers undergraduate programs such as the 4-year bachelor of arts (with education; BA/BSc), and postgraduate program such as the 1-year postgraduate diploma in education (secondary) or PGDE(S) and the 1-year postgraduate diploma in education (primary) or PGDE(P). Participants were chosen from the PGDE(S) (68.4%), PGDE(P) (19.9%), and BA/BSc (11.7%) programs. The mean age of the participants was 24.5 years ($SD$ = 3.30) and there were 114 (66.7%) females in the sample. All participants were volunteers and they were briefed on the purpose of this study and informed of their rights not to participate and withdraw from the questionnaire completion at anytime during or after the data collection. On average, each participant took not more than 20 minutes to complete the questionnaire.

## Results

Apart from descriptive statistics, an exploratory factor analysis using principal components and varimax rotation was carried out on the 21 items. To test for internal consistency, the coefficient alpha for each construct was computed. The mean values of all items ranged from 2.37 (Item 16) to 4.25 (Item 4). The standard deviations ranged from 0.63 to 1.07 and the skew and kurtosis indices from −1.41 to 0.61 and from –0.81 to 5.31, respectively. Following Kline's (2005) recommendations, the data in this study were considered to be univariate normal.

A principal components analysis (PCA) with varimax rotation was conducted on the 21 items to explore the underlying structure of the TAMPST. Three criteria for determining the number of components were considered: Kaiser's (1960) criterion to retain eigenvalues greater than 1 (K1), Cattell's (1966) scree test, and Horn's (1965) parallel analysis. Although the K1 rule and the scree test are typically well known, parallel analysis is not as widely known but is considered a more accurate criterion to use in the assessment of the number of factors to retain (Hayton, Allen, & Scarpello, 2004; Henson & Roberts, 2006; O'Conner, 2000; Zwick & Velicer, 1986).

The initial solution yielded six components with eigenvalues exceeding 1, accounting for a total of 69% of the variance. Inspection of the scree plot supported the retention of six factors as well. However, using the SPSS macro developed by O'Conner (2000), the results of the parallel analysis supported the retention of only five factors for further investigation. Only the first five eigenvalues exceeded the criterion values for a randomly generated data matrix of the same size (171 respondents × 21 items). Details of the eigenvalues generated from the PCA and the criterion values obtained from the parallel analysis are shown in Table 2.

Following the recommendations by Hair, Black, Babin, Anderson, and Tatham (2006), all items with loadings of .50 and less were removed from further analysis. On this basis, all items, except for ATCU16, ATCU19, and ATCU 21, were retained for further analysis. These three items loaded on the sixth component, which, from the results from the parallel analysis, was removed. In addition, ATCU19 and ATCU 21 did not have factor loadings greater than .50. To provide further checks on the factor structure, orthogonal rotation (varimax) and oblique rotation (oblimin: $\delta = 0$) were conducted on the five-factor solution and these yielded consistent results.

**Table 2.** Comparison of Results From Principal Components Analysis (PCA) and Parallel Analysis

| Component number | Eigenvalue generated from PCA | Criterion value from parallel analysis | Decision |
|---|---|---|---|
| 1 | 6.866 | 1.649 | Accept |
| 2 | 2.281 | 1.524 | Accept |
| 3 | 1.602 | 1.431 | Accept |
| 4 | 1.382 | 1.359 | Accept |
| 5 | 1.290 | 1.288 | Accept |
| 6 | 1.097 | 1.222 | Reject |

The intercorrelations between the components (following oblimin rotation) were relatively low with the strongest correlation ($r$ = .37) between PU and PEU. Given the consistent results for the different rotational techniques and the low component intercorrelations, only the varimax rotated solution is presented in Table 3, which shows the result of the PCA of the five-component, 18-item scale (the correlation matrix and results of the oblimin rotation are available from the author).

### *Discussion*

The pilot test resulted in five interpretable components that explained about 71% of the variance. There is a total of 18 items for the five factors: PU (4 items), PEU (4 items), SN (2 items), FC (3 items), and ATCU (5 items). The corrected item–total correlation coefficients ranged from .50 to .98 and the overall alpha coefficient is .88. The alphas for scores on the above constructs are .87, .77, .81, .79, and .82 respectively. Acceptable threshold for alpha coefficients are typically set at .70 (Nunnally, 1978) or .80 (Henson, 2001). This indicated sufficient evidence for score reliability.

## Study 2: Factorial Validity

The aim of this study was to assess the reliability and validity of scores on the 18-item scale. Participants in this study were 313 preservice teachers from the graduate (PGDE: 50.1%) and undergraduate (BA/BSc: 49.9%) programs. The sample consisted of 64.9% female ($n$ = 203) and the mean age of the participants was 24.76 years ($SD$ = 4.77). All participants were volunteers who were not rewarded by money or in kind. The participants in this study did not participate in Study 1 and data were collected 1 year after Study 1.

### *Confirmatory Factor Analysis*

In this study, confirmatory factor analysis (CFA) was used to examine the factorial structure of the 18-item scale using the maximum likelihood estimator (MLE) with

**Table 3.** Principal Component Analysis With Varimax Rotation

| Item | PU | PEU | SN | FC | ATCU | $h^2$ |
|---|---|---|---|---|---|---|
| PU1 | *.786* | .143 | .079 | .006 | .187 | .680 |
| PU2 | *.824* | .244 | .032 | –.079 | .185 | .780 |
| PU3 | *.831* | .090 | .065 | .062 | .164 | .733 |
| PU4 | *.768* | .266 | .190 | .114 | .111 | .721 |
| PEU5 | .374 | *.651* | –.126 | .129 | .160 | .622 |
| PEU6 | .175 | *.824* | .103 | .041 | .120 | .736 |
| PEU7 | .114 | *.632* | .152 | .219 | –.037 | .484 |
| PEU8 | .124 | *.802* | .130 | .066 | .232 | .733 |
| SN9 | .051 | .118 | *.876* | .122 | .131 | .816 |
| SN10 | .214 | .115 | *.854* | .095 | .166 | .825 |
| FC11 | .025 | .312 | .290 | *.695* | .063 | .669 |
| FC12 | –.005 | .214 | .062 | *.831* | .149 | .763 |
| FC13 | .048 | –.056 | –.011 | *.881* | .107 | .794 |
| ATCU14 | .483 | .014 | .145 | –.015 | *.652* | .681 |
| ATCU15 | .365 | .228 | .120 | .084 | *.721* | .726 |
| ATCU16 | .318 | .391 | .226 | .028 | *.571* | .633 |
| ATCU17 | .241 | .204 | .148 | .259 | *.667* | .633 |
| ATCU18 | –.042 | –.004 | .012 | .109 | *.810* | .670 |
| Eigenvalue before rotation | 6.388 | 2.222 | 1.594 | 1.317 | 1.179 | |
| Percentage variance before rotation | 35.486 | 12.343 | 8.856 | 7.317 | 6.549 | |
| Percentage variance after rotation | 18.637 | 15.128 | 14.773 | 11.976 | 10.038 | |

PU = perceived usefulness; PEU = perceived ease of use; SN = subjective norm; FC = facilitating conditions; ATCU = attitude toward computer use; $h^2$ = communality coefficient. All factor loadings greater than 0.5 are italicized.

AMOS 7.0 (Arbuckle, 2006). All analyses were conducted on variance–covariance matrices. All common factors were allowed to correlate freely and error terms were left uncorrelated. Model fit was assessed by a number of indices. First, model fit was determined using the minimum fit function $\chi^2$. As the $\chi^2$ has been found to be too sensitive to sample size (Hu & Bentler, 1995), the ratio of $\chi^2$ to its degree of freedom ($\chi^2/df$) 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). Because different indices reflect different aspects of model fit, researchers typically report the values of multiple indices. Two absolute fit indices are reported here: the standardized root mean square residual (SRMR) and the root mean square error of approximation (RMSEA) with values less than .08 and .06, respectively, as acceptable fit (Hu & Bentler, 1998). Finally, the comparative fit index (CFI), an incremental fit index, was also consulted, with a recommended value less than .95 (L. T. Hu & Bentler, 1998).

**Table 4.** Results of the Confirmatory Factor Analysis

| Item | Unstandardized estimate | Standardized estimate | *t*-value | $R^2$ |
|---|---|---|---|---|
| Perceived usefulness | | | | |
| PU1 | .94 | .82 | 19.86 | .68 |
| PU2 | 1.00 | .92 | — | .84 |
| PU3 | .94 | .84 | 20.57 | .70 |
| PU4 | .74 | .76 | 17.35 | .58 |
| Perceived ease of use | | | | |
| PEU5 | .83 | .80 | 15.39 | .63 |
| PEU6 | 1.00 | .82 | — | .67 |
| PEU7[a] | .97 | .62 | 11.20 | .38 |
| PEU8 | .98 | .85 | 16.71 | .73 |
| Subjective norm | | | | |
| SN9 | .89 | .86 | 16.51 | .75 |
| SN10 | 1.00 | 1.00 | — | .99 |
| Facilitating conditions | | | | |
| FC11 | .89 | .86 | 18.87 | .74 |
| FC12 | 1.00 | .91 | — | .82 |
| FC13 | .91 | .79 | 16.81 | .62 |
| Attitude toward computer use | | | | |
| ATCU14 | .93 | .80 | 16.85 | .64 |
| ATCU15 | 1.00 | .87 | — | .75 |
| ATCU16 | .88 | .81 | 17.03 | .65 |
| ATCU17 | .96 | .75 | 15.18 | .56 |
| ATCU18[a] | .60 | .39 | 6.79 | .15 |

a. Excluded from subsequent analyses.

## Results

Because MLE assumes multivariate normality of the observed variables, the data were examined with respect to multivariate normality. Multivariate normality was examined using Mardia's normalized multivariate kurtosis value. The Mardia's coefficient for the data in this study was 89.15, indicating multivariate normality of the data as the value was lower than the value of 360 computed based on the formula $p\ (p + 2)$ where $p$ equals the number of observed variables in the model (Raykov & Marcoulides, 2008).

From Table 4, all item parameters were statistically significant at the .001 level. It is important to examine the other aspects such as parameter estimates and $R^2$. Apart from items PEU7 and ATCU18, all standardized estimates and $R^2$ values fell within the recommended value of >.70 and >.50, respectively, calling the reliability of these two items into question. On this basis, PEU7 and ATCU18 were removed from further analyses, resulting in a total of 16 items.

**Table 5.** Matrix of Factor Intercorrelations

| Construct | PU | PEU | SN | FC | ATCU |
|---|---|---|---|---|---|
| PU | 1.00 | | | | |
| PEU | .65* | 1.00 | | | |
| SN | .45* | .40* | 1.00 | | |
| FC | .27* | .32* | .36* | 1.00 | |
| ATCU | .62* | .57* | .40* | .35* | 1.00 |

PU = perceived usefulness; PEU = perceived ease of use; SN = subjective norm; FC = facilitating conditions; ATCU = attitude toward computer use.
* $p < .01$.

On the relationship among the five factors, the matrix of factor intercorrelation in Table 5 shows that all coefficients were statistically significant at the .01 level. The magnitudes of these coefficients ranged from .27 (between PU and FC) to .65 (between PU and PEU). This suggests that the five factors in the TAMPST are distinct factors although they are significantly related.

### *Model Comparison*

Several models were computed as part of the CFA to allow comparisons of different conceptualization of the factor structure of the TAMPST to be made: First, a null model (Model 1) that assumes all the factors to be unrelated; second, a one-factor model (Model 2) that tests whether all the factors load on one overall factor; and third, a correlated factor model that tests whether the five factors are related to one another (Model 3). Support for this model indicates that participants had discriminated between the five factors but they are intercorrelated with one another. Finally, a hierarchical model (Model 4) was computed that represents a second-order factor structure to account for the relationships among the five factors. Support for this model suggests that although all five factors are related, they are also related to a higher order factor. A series of CFA were conducted to test the four models described above. Table 6 shows the results of the model comparisons, indicating that Model 3 has the best fit indices and within the recommended values for structural equation modeling. On this basis, Model 3 was retained as the model of best fit.

## Study 3: Validation and Measurement Invariance

The aim of this study was to confirm the validity of scores on the 16-item scale. In this study, a model with five correlated factors (Table 6, Model 3) will be tested for model fit. A test of factorial invariance was performed on the data across programs of study, to examine the generalizability of the TAMPST across graduates and nongraduates. Participants in this study were 275 preservice teachers from the graduate (PGDE: 51.6%) and undergraduate (BA/BSc: 48.4%) programs. The sample consisted of

**Table 6.** Confirmatory Factor Analysis of Alternative Models

| Model | $\chi^2$ | $\chi^2/df$ | TLI | CFI | RMSEA | SRMR | Model description |
|---|---|---|---|---|---|---|---|
| 1 | 3572.00 | 29.77 | — | — | .304 (.125, .144) | — | Null model |
| 2 | 1486.97 | 14.30 | .538 | .599 | .206 (.197, .216) | .126 | One-factor (16-item) |
| 3 | 244.24 | 2.60 | .944 | .956 | .072 (.061, .083) | .046 | Five-factor, correlated |
| 4 | 261.98 | 2.67 | .943 | .953 | .073 (.062, .083) | .056 | Hierarchical model |

*Note. df* = degrees of freedom; TLI = Tucker–Lewis index; CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

65.8% females ($n$ = 181) and the mean age was 24.85 years ($SD$ = 4.78). All participants were volunteers who were not rewarded by money or in kind. The participants in this study did not participate in Study 1 and/or Study 2.

## Results

Various multigroup invariance analyses were performed using AMOS 7.0 (Arbuckle, 2006). Estimation for each analysis was performed using maximum likelihood using variance–covariance matrices. Traditionally, the $\Delta\chi^2$ has been used as the index of difference in fit. Because the $\Delta\chi^2$ has been found to be overly sensitive to sample size, Cheung and Rensvold (2002) recommended using ΔCFI with values higher than .01 as indicative of a significant drop in fit. Table 7 shows the results of the model tests performed for graduates and nongraduates. The results indicated a good fit and support the performance of other invariance tests.

The configural test assesses whether the same structure in the model holds across groups (i.e., graduates and nongraduates). The results showed an acceptable fit, with a chi-square value of 374.33 ($\chi^2/df$ = 2.01), Tucker–Lewis index (TLI) of .928, CFI of .944, and an RMSEA value of .061.

To test for metric invariance, the factor loadings were constrained to be equal. Because the metric invariance model (Table 7, Model 2) is nested within the baseline model (Table 7, Model 1), a $\chi^2$ difference test was performed. Given that the $\chi^2$ difference of 5.07 with 11 degrees of freedom was not statistically significant at $\alpha = .05$, and CFI change was minimal, metric invariance was supported. Scalar invariance was tested by constraining the intercepts of the 16 indicators to be the same across the two samples. A $\chi^2$ difference test was performed comparing the scalar invariance model (Table 7, Model 3) and the metric invariance model (Model 2). The results revealed that the $\chi^2$ difference was statistically insignificant at $\alpha = .05$ ($\chi^2 = 15.0$, 16 degrees of freedom); scalar invariance was supported. This is also supported by examining the ΔCFI showing a value less than .01. It is generally accepted that having established invariance of equal form (configural), equal factor loadings (metric), and equal indicator intercepts (scalar), there is sufficient evidence to conclude that measurement invariance of a scale is achieved (Brown, 2006; Schmitt & Kuljanin, 2008).

**Table 7.** Results of the Measurement Invariance Tests

| Model | $\chi^2$ | *df* | $\chi^2/df$ | TLI | CFI | $\Delta\chi^2$ | $\Delta df$ | *p* | $\Delta$CFI |
|---|---|---|---|---|---|---|---|---|---|
| 1. Configural invariance (equal form) | 374.33 | 186 | 2.01 | .928 | .944 | — | — | — | — |
| 2. Metric invariance (equal factor loadings) | 379.40 | 197 | 1.93 | .934 | .946 | 5.07 | 11 | .93 | .002 |
| 3. Scalar invariance (equal indicator intercepts) | 394.44 | 213 | 1.85 | .939 | .946 | 15.0 | 16 | .52 | .000 |

*Note. df* = degrees of freedom; TLI = Tucker–Lewis index; CFI = comparative fit index.

## General Discussion

The goals of this research were to develop an instrument that would yield data to facilitate a better understanding of how preservice teachers or teacher education students respond to technology and to conduct initial examinations to establish the validity of scores obtained from the instrument. The Technology Acceptance Measure for Preservice Teachers (TAMPST) was developed and its scores validated through three studies using separate samples.

The results provide evidence for the factorial structure of the TAMPST and it may be useful for educational researchers. Gaining a better understanding of preservice teachers' technology acceptance will increase our understanding their computer-related behaviors. Several researchers have demonstrated the positive relationship between users' acceptance and their overall satisfaction with computers (e.g., Burkhardt, 1994; Venkatesh & Davis, 2000). As information technology becomes an integral part of teacher training, the TAMPST allows researchers to measure and understand the extent to which preservice teachers would embrace technology. For example, researchers investigating the implementation of new technology-driven pedagogy could use the TAMPST to collect data on various constructs that influence technology acceptance. Because behavior has been shown to be driven by attitude under many circumstances (Ajzen & Fishbein, 2005), the TAMPST may be used to identify students who may be adopters as well those who will choose to be nonadopters.

Teacher educators may find the TAMPST a useful tool to collect information on their preservice teachers' level of technology acceptance at the beginning of the teacher education courses. Such information would assist educators in introducing new teaching strategies that involve the use of computer for subject teaching, assessment and curriculum planning purposes. For example, if students in a class were found to have low levels of technology acceptance; educators could highlight the usefulness and ease of use of technology during formal lessons and out-of-class interactions, activities that might make the difference between a successful and an unsuccessful educational initiative. It is anticipated that TAMPST would be further developed by conducting cross-cultural validation studies and factorial invariance studies for preservice teachers and practicing teachers. These developments may provide useful tools for researchers to work with a wider range of participants in the area of technology acceptance.

The appendix lists the items in the TAMPST. Items in the TAMPST are measured using a 5-point scale, ranging from 5 for *strongly agree* to 1 for *strongly disagree*. The scores of the 16 items can be collectively summed to represent an individual's overall acceptance of technology ranging from 16 to 80, with higher scores indicating greater levels of technology acceptance.

# Appendix

### Items in the Technology Acceptance Measure for Preservice Teachers (TAMPST)

Using computers will improve my work (PU)
Computers make work more interesting (ATCU)
My interaction with computers is clear and understandable (PEU)
When I need help to use computers, specialized instruction is available to help me (FC)
Working with computers is fun (ATCU)
I find it easy to get computers to do what I want it to do (PEU)
Using computers will increase my productivity (PU)
I find computers easy to use (PEU)
When I need help to use computers, a specific person is available to provide assistance (FC)
People whose opinions I value will encourage me to use computers (SN)
I like using computers (ATCU)
People who are important to me will support me to use computers (SN)
Using computers will enhance my effectiveness (PU)
When I need help to use computers, guidance is available to me (FC)
I find computers a useful tool in my work (PU)
I look forward to those aspects of my job that require me to use computers (ATCU)

*Note*. PU = perceived usefulness; PEU = perceived ease of use; SN = subjective norm; FC = facilitating conditions; ATCU = attitude toward computer use.

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