Exploring Pre-service Teachers' Use of Technology: The Technology Acceptance Model and Expectancy-Value Theory

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Abstract

Understanding how prepared teachers are to use technology to enhance their teaching can assist researchers to support them better, yet the theoretical basis for understanding teachers' self-beliefs is in need of stronger empirical support. The first objective of this study was to replicate and extend prior research that empirically tested portions of the technology acceptance model (TAM) among pre-service teachers. The second objective was to empirically test an alternative set of antecedents of behavioural intentions to use technology based on the expectancy-value theory (EVT). Four theoretical models were tested using structural equation modeling with a sample of pre-service teachers ($N = 249$). Results provide support for the TAM and the extended TAM models, however, no support was found for the combined EVT and TAM models. We discuss the implications to promote teacher integration of technology in the classroom by creating facilitating conditions.

Introduction

According to the *2017 National Education Technology Plan of the U.S. Department of Education*, a digital use divide continues to exist, where learners who use technology in active and creative ways to support their learning stand in contrast to those who use technology for passive content consumption (Office of Educational Technology, 2017). Digital literacy has become a central issue for parents, educators, and policymakers, as the last two decades have seen a shift from manufacturing towards an information economy (Porat, 1998; Warschauer & Matuchniak, 2010). Despite the stated importance of using digital technology and the importance of digital literacy, pre-service teacher educators often report that they are unprepared to implement technologies in the classroom to support teaching and learning practices (Barbour & Harrison, 2016). Furthermore, many teachers are not using these resources to their full potential in terms of enhancing how students learn with technology (Ertmer & Ottenbreit-Leftwich, 2010; Lim & Khine, 2006) or in ways that address inequalities with respect to learning with technology (Warschauer & Matuchniak, 2010). The question of how teachers use technology has been of interest to policymakers, administrators, and researchers since well before digital technologies became commonplace. A key aspect of teacher preparedness is teachers' beliefs about using technology, which is often overlooked in advancing technology in teacher preparation. Because teachers' attitudes towards computers develop during their training, it is important to investigate this issue among pre-service teachers (see Liu, Li, & Carlsson, 2010).

The primary objective of this study is to replicate and extend a prominent and highly-cited article¹ that investigated pre-service teachers' computer attitudes towards computer use in the classroom according to the technology acceptance model (TAM; Teo et al., 2008). Although Teo et al. (2008) provide empirical support for the TAM, an important part of the model was not included, namely, behavioural intentions to use technology. As such, in addition to replicating this study, we propose extending their results by including a measure of behavioural intentions. Furthermore, as a secondary objective, we build on these findings and examine an additional explanation for the underutilization of technology to support learning in the classroom by applying the expectancy value theory (EVT; Eccles et al., 1983; Wigfield & Eccles, 2000). This secondary objective of this study will test an alternative explanation for the underutilization of technology by preservice teachers. The EVT proposes an individual's expectancy for success, values, and costs predict achievement-related behaviours and choices. Therefore, this study attempts to further extend Teo et al.'s (2008) findings by examining pre-service teachers' intentions to use computers and technology in their classrooms within the EVT. The remaining part of the paper proceeds as follows, first a review of the technology acceptance model (Davis, 1989) and the expectancy-value theory (Eccles et al., 1983), followed by the rationale for the proposed study.

The technology acceptance model

There has been substantial research on teacher knowledge of teaching and learning with technology (i.e., Ertmer, 2005; Mishra & Koehler, 2006). One popular framework that was first used in communications and information science research is the technology acceptance model (TAM), which was advanced and refined by Davis (1986, 1989, 1993; Venkatesh & Davis 1996). TAM has been widely used in educational contexts (e.g., Teo et al., 2008). TAM builds

¹ Teo et al.'s (2008) article is the eighth-most cited article in the Journal of Computer Assisted Learning on the Web of Science (November 14, 2018)

on the theory of reasoned action (Fishbein & Ajzen, 1975), which broadly explains individuals' attitudes (such as attitudes toward using technology) in terms of expectations about the results of a particular behaviour and their affective evaluations of those expectations. TAM explains individuals' use of technology as a function of how easy it is to use the technology (perceived ease of use) and how useful it is to use a particular technology (perceived usefulness). These perceptions are affected by external factors (i.e., subjective norms and facilitating conditions). Individuals' perceptions lead to attitudes about technology, which in turn affect behavioural intentions to use and use of technologies (Davis, 1989; Venkatesh & Davis, 1996).

In an influential study, Teo et al. (2008) examined how perceived ease of use and perceived usefulness, as well as subjective norms and facilitating conditions, predicted pre-service teachers' computer attitude, as measured with self-report instruments. In contrast to prior work that has focused more on perceived ease of use and usefulness, Teo et al. (2008) considered the roles of the external factors of subjective norms and facilitating conditions. They used structural equation modelling to identify facilitating conditions and perceived ease of use as positive predictors of perceived usefulness (also predicted by subjective norms), and both perceptions and subjective norms as positive predictors of teachers' attitudes toward the use of technology, with perceived usefulness found to be the strongest predictor. This work provides empirical evidence that the TAM can be useful for understanding whether and how teachers use technology in their practice and therefore makes a strong theoretical and practical contribution to the field.

Although the TAM has been widely applied to educational contexts, it has recently been the subject of some noteworthy critique. For instance, the TAM has been critiqued by scholars for being too simplistic, not having very impressive predictive validity, and having limited practical value (e.g., Lim, 2018). These critiques have emphasized the importance of using TAM as a basic or foundational model, which can be extended, particularly by integrating motivational influences specific to a particular learning environment (Lim, 2018). In this study, we examine motivational influences (as described in the next section) in the specific, pre-service teacher context. As described in the next section, we do this using an important theoretical framework in motivational research, one that considers similar constructs to those that are the focus of TAM, namely, individuals' expectations for how good at a task individuals expect to be and how much they believe a task is important to them.

The expectancy-value theory

The expectancy-value theory is a comprehensive framework for understanding and predicting important outcomes such as achievement-related choices, persistence, and behaviours (EVT; Eccles et al., 1983; Wigfield & Eccles, 2000). In particular, this theory proposes that expectations of success and subjective task values are proximally predictors of these important outcomes. Although there is a complex sequence of antecedents of expectancy and values, to remain focused on relevant portions of the theory, we emphasize the latter portion of this framework. Expectancy for success refers to an individual's beliefs about how well they will do in an upcoming task. For instance, a teacher with a high expectancy for success related to using technology in their classroom may anticipate doing a good job of using audience response systems (i.e., clickers) in an upcoming course. Task value is broken down into four constituent parts, namely, attainment value, intrinsic value, utility value, and cost. Attainment value refers to how important an individual associates doing well on a task. Intrinsic value refers to how much one enjoys participating in a particular task or activity associated with the task. Utility value

refers to a perception of how useful a task is for future plans. Attainment value, intrinsic value, and utility value represent adaptive or desirable values that should predict greater engagement in the specific task. In contrast, cost value is conceptualized as what an individual has to give up or sacrifice, the amount of effort one must invest, or the emotional toll required to succeed at a task. Therefore, cost represents a negative appraisal associated with engaging in a task (see Flake, Barron, Hulleman, McCoach, & Welsh, 2015).

Cost is separated into four factors, namely, task effort cost, outside effort cost, loss of valued alternatives, and emotional cost (Flake et al., 2015). Task effort cost refers to the costs associated with the amount of time, effort, or work required for engagement in the task. Similarly, outside effort cost refers to the time, effort, or work; however, these investments are associated with other responsibilities rather than the task at hand. For instance, a teacher may report high task effort costs associated with using technology in their class because they think that it will take a long time to complete a technology-enriched lesson plan. Whereas a teacher may report high outside effort cost if they believe that they have too many other competing commitments, such as a heavy teaching load, a large amount of correcting, or too many meetings. Loss of valued alternatives refers to a desirable alternative that must be given up to engage in this activity. For instance, a teacher may feel as though to be able to effectively integrate technology into their classroom that they will not have time to continue making the learning content personally relevant. The final cost is emotional cost, which refers to the negative psychological impact of participating in the activity. For instance, a teacher may feel as though integrating technology into their classroom may be too stressful, anxiety-inducing, or less enjoyable than simply continuing to teach without making any changes.

Overall, expectancy of success and value tend to positively predict adaptive outcomes such as behavioural intentions, academic achievement, persistence, interest, and academic choices (e.g., Bong, 2001; Cole, Bergin, & Whittaker, 2008; Durik, Vida, & Eccles, 2006; Hulleman, Durik, Schweigert, & Harackiewicz, 2008; Plante, O'Keefe, & Théorêt, 2013). In contrast, cost tends to relate to more maladaptive outcomes, such as low levels of persistence, poor academic achievement, low levels of interest, and low overall motivation (Flake et al., 2015; Perez, Cromley, & Kaplan, 2014).

Comparing the technology acceptance model and the expectancy-value theory

Although the TAM developed out of a communications and information science approach whereas the EVT developed out of an achievement motivation approach, there is some overlap between these two perspectives. For instance, both theories focus on explaining human behaviours. Ultimately, the technology acceptance model proposes antecedents of behavioural intentions and actual behaviours associated with technology use. Similarly, the expectancy value theory proposes antecedents of achievement-related choices, which are often conceptualized and examined in terms of intentions towards a particular behaviour (e.g., career intentions) or actual behaviours (e.g., course enrolment; see Linnenbrink-Garcia et al., 2018). Therefore, both theories predict similar outcomes but approach these outcomes from distinct perspectives.

Another similarity between these perspectives is that both the TAM and the EVT highlight the importance of one's perceived practical benefit as an antecedent of behavioural intentions and actual behaviours. Notably, although these theories use different terminologies to refer to the “practical benefit” of engaging in the activity (i.e., perceived usefulness versus utility value), the conceptualizations and the approaches to measurement are quite similar. For instance, within the TAM, perceived usefulness is defined as “the degree to which a person believes that

using a particular system would enhance his or her job performance” (Davis, 1989, p. 320) with a sample item being “I would find [insert context] useful in my job” (Davis, 1989, p. 340). Similarly, within the EVT, utility value is defined as “how a task fits into an individual's future plans” (Wigfield & Eccles, 2000, p. 72) with a sample item being “in general, how useful is what you learn in [insert context]” (Wigfield & Eccles, 2000, p. 70). This may be an example of a jangle fallacy, which involves the use of different terminology to refer to similar constructs (Kelley, 1927; Marsh et al., 2018). Jangle fallacies are concerning because they create conceptual confusion, make it difficult to synthesize research findings, and reduce the efficient advancement of research.

Another similarity between the TAM and EVT is the relevance of attitude in these respective perspectives. Within the TAM, attitudes towards using technology are viewed as mediators of the relations between perceived usefulness and perceived ease of use and behavioural intentions to use technology. As such, attitudes are considered a proximal antecedent of behavioural intentions. Although attitudes are also found in the EVT, they are positioned as antecedents of expectancy, values, and costs (Wigfield & Eccles, 2000). Within the EVT, attitudes are therefore modelled as more distal antecedents of intentions, with expectancy, values, and costs considered as mediators of the relationship between attitudes and intentions.

Consequently, although the TAM and EVT have distinct origins and adopt unique terminologies, these perspectives may provide complementary explanations for behavioural intentions to use technology among pre-service teachers.

The present study

The present study has two main objectives. The first objective is to replicate and extend Teo et al.'s (2008) study. Reproducibility is a foundation of the scientific method and is incredibly important for the productive advancement of science. Replication efforts are especially important given poor reproducibility of psychological science studies recently reported by the Open Science Collaboration (2015). Because replication is desirable, but practically not possible for every study published, it is important to identify the replication value of various studies, which is a metric for establishing the benefits of replicating a particular study (see Nosek, Spies, & Motyl, 2012; Open Science Collaboration, 2012). This metric is based on how influential a study may be. As a proxy for a study's influence, we used a Web of Science citation search to identify a highly cited study published in the Journal of Computer Assisted Learning (JCAL). Teo et al. (2008) was selected for replication because it is a highly cited article (Times Cited: 169, eighth most cited article in JCAL) and consists of a research design that could feasibly be conducted within the timeframe of this special call for registered reports. Teo et al. (2008) consisted of an empirical test of portions of the technology acceptance model (Davis, 1989) among pre-service teachers. The present study will replicate the original study by using the same design, measures, and analyses with a new sample of pre-service teachers collected at three sites across the United States. Therefore, this study will test the same hypotheses proposed by Teo et al. (2008; Figure 1).

Figure 1. Hypotheses proposed by Teo et al. (2008).

Note. Solid lines indicate positive relations. Path from facilitating conditions to computer attitudes is hypothesized to be either positive or not statistically significant.

Furthermore, the present study extends Teo et al.'s (2008) results by including a measure of behavioural intentions to use technology in the classroom. According to the technology acceptance model, perceived usefulness of technology and attitude towards using technology should directly predict behavioural intentions to use technology (Davis, 1989; Figure 2). Figure 2. Extension of Teo et al.'s (2008) hypothesized model

Note. Solid lines indicate positive relations. Path from facilitating conditions to computer attitudes is hypothesized to be either positive or not statistically significant.

The second objective of the present study is to empirically test portions of the EVT in relation to pre-service teachers' attitudes towards using technology and behavioural intentions to use technology for teaching. Although the EVT has been used in various domains, limited research has investigated the predictive utility of this theory in relation to attitudes and

behavioural intentions associated with technology use. Consequently, two theoretical models with associated hypotheses are proposed. The first model investigates expectancy for success and task values (attainment, intrinsic, and utility) and costs (task effort cost, outside effort cost, loss of valued alternatives, and emotional cost) as mediators between attitudes towards using technology and behavioural intentions (Figure 3).

Figure 3. Hypotheses related to the EVT elaboration of the TAM model.

Note. Solid lines indicate positive relations, broken lines indicate negative relations.

A second model will be tested, which investigates expectancy for success and the task values and costs as antecedents of attitudes towards using technology and in turn attitudes as an antecedent of behavioural intentions (Figure 4). This model represents an integrative analysis of propositions within the TAM and the EVT.

Figure 4. Integration of the TAM model and EVT.

Note. Solid lines indicate positive relations, broken lines indicate negative relations.

Method

Participants

A sample of 249 pre-service teachers was recruited from three universities in the U.S. Pre-service teachers were asked to report their program of study, including undergraduate, graduate, and licensure programs. Mean age was 24.64 years ($SD = 7.13$). The sample consisted of 157 females, 26 males, and 65 did not report their gender. The majority of participants reported “white, Caucasian, European, not Hispanic” as their race/ethnicity ($n = 147$), followed by “Hispanic or Latino” ($n = 34$), “Asian or Asian American” ($n = 31$), “Black or African American” ($n = 22$), and “other” ($n = 10$).

Measures

TAM variables. TAM variables include subjective norms, facilitating conditions, perceived usefulness, perceived ease of use, and preservice teachers’ attitudes (Teo et al., 2008). Participants responded on a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree (See Table 1 for descriptive statistics for all variables).

Table 1. Descriptives

Variable	Mean	SD	Skew	Kurtosis
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Perceived usefulness	4.18	.58	-.91	3.08
Perceived ease of use	3.96	.69	-1.02	2.02
Computer attitudes	3.97	.75	-.75	.63
Behavioural intentions	4.62	.67	-.43	.64
Subjective norms	3.92	.71	-.41	.42
Facilitating conditions	3.81	.74	-.76	1.40
Attainment value	3.46	.87	-.27	-.32
Interest value	3.79	.83	-.52	-.20
Utility value	4.29	.60	-.71	.29
Expectancy for success	3.68	.67	-.39	.75
Task effort cost	3.06	1.56	.88	.60
Outside effort cost	3.15	1.51	.53	-.49
Loss of valued alternative	3.10	1.47	.68	.17
Emotional cost	3.03	1.57	.89	.53

Subjective norms were assessed with two items adapted from Taylor and Todd (1995). A sample item is “People whose opinions I value will encourage me to use technologies” ($\alpha = .77$). Facilitating conditions was assessed with two items adapted from Thompson, Higgins, and Horwell (1991). A sample item is “When I need help to use technology, guidance is available to me” ($\alpha = .75$). Perceived usefulness and perceived ease of use were measured with scales adapted from (Davis, 1989). Perceived usefulness consisted of four items, a sample item is “Using technology will enhance my effectiveness” ($\alpha = .80$). Perceived ease of use consisted of four items, a sample item is “I find it easy to get technology to do what I want it to do” ($\alpha = .80$). Computer attitudes were measured with a five-item adapted scale (Thompson et al., 1991; Compeau & Higgins, 1995). A sample item is “Technology makes work more interesting” ($\alpha = .88$).

EVT variables. EVT variables consisted of expectancy for success, attainment value, intrinsic value, utility value, task effort cost, outside effort cost, loss of valued alternative, and emotional cost. All items were drawn from validated scales and adapted for the context (Conley, 2012; Flake et al., 2015; Linnenbrink-Garcia et al., 2018; Marsh et al., 2018). Expectancy for success was measured with six items, a sample item is “When I sit down to thoroughly learn something with technology, I succeed in doing this” ($\alpha = .83$). Participants responded to this scale on a five-point Likert scale ranging from (1) not true to (5) absolutely true. Interest value was measured with five items, a sample item is “I enjoy the subject of educational technology” ($\alpha = .90$). Attainment value was assessed with five items, a sample item is “Being someone who is good with technology is important to me” ($\alpha = .87$). Utility value was assessed with five items, a sample item is “Technology is valuable because it will help me in the future” ($\alpha = .87$). A task value composite composed of utility, interest, and attainment value subscales also yielded satisfactory reliability ($\alpha = .93$). Participants responded to the interest, attainment, and utility value items on a five-point Likert scale ranging from (1) not at all true to (5) very true.

Task effort cost was measured with five items, a sample item is “Using technology while I teach demands too much of my time” ($\alpha = .95$). Outside effort cost was assessed with four items, a sample item is “I have so many other commitments that I can’t put forth the effort needed to use technology while I teach” ($\alpha = .92$). Loss of valued alternatives was measured with four items, a sample item is “I have to sacrifice too much to use technology while I teach” ($\alpha = .90$). Emotional cost was assessed with six items, a sample item is “I worry too much about using technology while I teach” ($\alpha = .94$). An overall composite composed of task effort, outside effort, loss of valued alternative, and emotional cost subscales reliability was also very high ($\alpha = .98$).

Behavioural intentions. Behavioural intentions were measured with two items (see Liu, Li, & Carlsson, 2010). Participants responded on a seven-point Likert scale ranging from (1) strongly disagree to (7) strongly agree. A sample item is “I intend to use technology when teaching in the future” ($\alpha = .73$).

Procedure

Pre-service teachers provided consent to participate in the study and completed the survey online. Participants completed the demographic questionnaire, the TAM items, and then the EVT items. Participants were compensated for their time with course credit. Data were collected from three different research sites in the Fall and Spring semesters.

Data Analysis

The statistical analyses in this study are separated into three stages. In the first stage, we examined the descriptive statistics of the variables as well as assessed the reliability and validity

of the measurement items. In the second stage, we tested the replicability of previous findings reported by Teo et al. (2008), and built on this model by incorporating behavioural intentions to use technology. In the third stage, we assessed the utility of the EVT factors for explaining computer attitudes and behavioural intentions. The fit of the four proposed models (see Figures 1-4) were compared using the Akaike information criterion (AIC), and the predictive power of the models were compared by examining r-square values for endogenous variables.

All analyses were conducted using R (R Core Team, 2018). We used the latent variable modeling R package lavaan (Rosseel, 2012). Missing data was imputed using full information maximum likelihood (FIML) with maximum likelihood estimation. Since data was collected from three different universities, prior to combining data from each site we first used a MANOVA to verify if there were any mean differences that should be controlled for in subsequent analyses. The overall MANOVA comparing means between sites on all relevant variables (i.e., perceived usefulness, perceived ease of use, computer attitudes, behavioural intentions, subjective norms, facilitating conditions, attainment value, interest value, utility value, expectancy, task effort cost, outside effort cost, loss of valued alternatives, and emotional cost) was non-significant, Pillai's Trace = 0.15, $F = 1.33$, $df = (246, 2)$, $p = .12$. This suggests that there are no differences between the three collection sites, and therefore the data was combined from each site and none of the subsequent analyses include covariates.

Stage 1 - Preliminary Analyses

A series of confirmatory factor analysis (CFA) were used to verify the theoretical factor structure of the measures, and to compare competing factor structures. The TAM factors were assessed with three CFAs. A two-factor CFA on the subjective norms and facilitating conditions scales suggested moderate fit, $\chi^2 (1) = 3.822$, $p = .051$, CFI = .990, RMSEA = .106. A separate two-factor CFA on perceived usefulness and perceived ease of use indicated moderate fit, $\chi^2 (19) = 83.583$, $p < .001$, CFI = .910, RMSEA = .117. One item was removed from the perceived ease of use scale due to low factor loadings ($< .50$), which led to a model with similar fit $\chi^2 (13) = 73.021$, $p < .001$, CFI = .912, RMSEA = .136. A one-factor CFA conducted on the computer attitude scale indicated adequate fit, $\chi^2 (5) = 11.602$, $p = .041$, CFI = .989, RMSEA = .073. One item was removed from the perceived ease of use scale due to low factor loadings ($< .50$), which slightly worsened the model fit, $\chi^2 (2) = 8.878$, $p = .012$, CFI = .988, RMSEA = .118.

The EVT factors were assessed with a series of four CFAs. First, a four-factor CFA was conducted on interest value, attainment value, utility value, and expectancy for success. This model yielded poor fit $\chi^2 (164) = 546.591$, $p < .001$, CFI = .876, RMSEA = .097. Due to low factor loadings ($< .50$) one expectancy for success item was removed from the model. This updated CFA produced similar fit $\chi^2 (146) = 524.812$, $p < .001$, CFI = .877, RMSEA = .102. Since interest value, attainment value, and utility value are often highly correlated (e.g., Linnenbrink-Garcia et al., 2018), a competing CFA was conducted with expectancy for success (with the low loading item removed) and task value (interest, attainment, and utility value). This model also yielded poor fit, $\chi^2 (151) = 842.374$, $p < .001$, CFI = .775, RMSEA = .136. Since fit statistics suggest that the data fits the four-factor CFA better than the two-factor model, the four-factor model (i.e., interest value, attainment value, utility value, and expectancy for success) was used in subsequent analyses.

A similar comparison between models was conducted for the cost measure. Specifically, a four-factor CFA was conducted on task effort cost, outside effort cost, loss of valued alternatives, and emotional cost, which indicated poor fit, $\chi^2 (146) = 911.894$, $p < .001$, CFI =

.879, RMSEA = .145. Next, since these four cost factors are often highly correlated (see Flake et al., 2015), a one-factor CFA was conducted for an overall cost factor, results suggest poor fit $\chi^2(152) = 1059.153, p < .001$, CFI = .856, RMSEA = .155. Since fit statistics suggest that the data fits the four-factor cost CFA better than the one-factor model, the four-factor model (i.e., task effort cost, outside effort cost, loss of valued alternatives, and emotional cost) was used in subsequent analyses.

A final CFA could not be conducted on the behavioural intentions items (Liu et al., 2010; Taylor & Todd, 1995; Venkatesh & Davis, 1996) because only two items were used to assess this construct, and therefore does not include sufficient degrees of freedom.

The correlation matrix of all variables largely fits the expected pattern of relations (see Table 2).

Table 2. Latent correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Perceived usefulness	-													
2. Perceived ease of use	.58**	-												
3. Computer attitudes	.62**	.67**	-											
4. Behavioural intentions	.20**	.20**	.21**	-										
5. Subjective norms	.56**	.29**	.39**	.12	-									
6. Facilitating conditions	.45**	.51**	.49**	.19**	.37**	-								
7. Attainment value	.42**	.44**	.62**	.12	.39**	.36**	-							
8. Intrinsic value	.46**	.53**	.76**	.19*	.40**	.45**	.76**	-						
9. Utility value	.48**	.37**	.46**	.22**	.41**	.33**	.64**	.67**	-					
10. Expectancy for success	.46**	.31**	.38**	.12	.41**	.35**	.49**	.47**	.51**	-				
11. Task effort cost	-	-	-	-.14*	-	-	-	-	-	-	-			
12. Outside effort cost	.28**	.42**	.41**		.18**	.29**	.30**	.36**	.34**	.30**				
13. Loss of valued alt.	-	-	-	-	-	-	-	-	-	-	.93**	-		
14. Emotional costs	.31**	.40**	.40**	.17**	.18**	.29**	.32**	.36**	.35**	.32**				
	-	-	-	-.15*	-	-	-	-	-	-	.88**	.90**	-	
	.34**	.42**	.47**		.18**	.31**	.35**	.41**	.35**	.35**				
	-	-	-	-.16*	-.15*	-	-	-	-	-	.90**	.88**	.88**	-
	.30**	.51**	.46**			.34**	.33**	.39**	.30**	.32**				

Note. Alt. = alternative. $*p < .05$, $*p < .01$

The correlations among perceived usefulness, perceived ease of use, computer attitudes, subjective norms, and facilitating conditions are all positive and therefore align with those reported by Teo et al. (2008). Notably, however, the magnitude of the correlations among these variables in the present study range from .29 to .67 and are therefore slightly larger than those reported by Teo et al. (2008), which range from .16 to .61. Similar to prior research (see Linnenbrink-Garcia et al., 2018) relations among values (i.e., attainment, intrinsic, and utility) are all strongly positively correlated (.64 to .76), and values all positively correlate with expectancy for success (.47 to .51). Similarly, the relations among costs (i.e., task effort cost, outside effort cost, loss of valued alternatives, and emotional costs) are all very strongly positively correlated (.88 to .93) and therefore align with results reported in the scale development study (Flake et al., 2015). Furthermore, in line with theoretical predictions, the relations among values and costs are all negative (-.30 to -.41).

Stage 2 - TAM Replication and Extension

Structural equation modeling (SEM) was used in Stage 2 and 3 to test the fit between the hypothesized models and the data. The first model (Figure 5) attempted to replicate the model established in Teo et al. (2008), and yielded moderate fit $\chi^2 (82) = 285.921$, $p < .001$, CFI = .899, RMSEA = .100, AIC = 7216.574. The model largely replicates the results found by Teo et al. (2008), only one of the paths tested (i.e., from subjective norms to computer attitude) was not replicated.

Figure 5. Replication of Teo et al. (2008).

Note. $*p < .05$, $*p < .01$

The second model (Figure 6) extended Teo et al.'s (2008) original model by including behavioural intentions as a final endogenous variable, predicted by computer attitude. Results indicate moderate fit, $\chi^2 (110) = 317.981$, $p < .001$, CFI = .902, RMSEA = .087, AIC = 8211.918. A comparison of the CFI, RMSEA, AIC, and R^2 between the first and second models suggests that the data fits the second model better, however, the path from computer attitude to behavioural intentions is small ($\beta = .25$, $p = .03$), and computer attitude accounts for a small amount of variance in behavioural intentions ($R^2 = .06$).

Figure 6. Extension of Teo et al.'s (2008).

Note. * $p < .05$, ** $p < .01$

Stage 3 - EVT Elaboration

The third model (Figure 7) is based on the EVT and examined expectancy, values, and costs as mediators of attitudes and behavioural intentions. Results indicate poor fit, $\chi^2(886) = 3353.701$, $p < .001$, CFI = .769, RMSEA = .106, AIC = 26326.263. Furthermore, the standardized beta coefficients between computer attitude and the four cost variables are all beyond -.96, which suggests multicollinearity.

Figure 7. EVT elaboration of the TAM model

Note. * $p < .05$, ** $p < .01$

The fourth model (Figure 8) was guided by both TAMs and EVT and tested expectancy, values, and costs as antecedents of both computer attitude and behavioural intentions.

Figure 8. Integration of the TAM model and EVT.

Note. $*p < .05$, $*p < .01$

Results from this model also indicated poor fit, $\chi^2(857) = 2323.911, p < .001$, CFI = .863, RMSEA = .083, AIC = 25354.474. The only statistically significant path is found between intrinsic value and computer attitude, and is greater than 1.00, suggesting multicollinearity. Although the fit statistics for the combined TAMs and EVT model improved from the EVT model, since both models yielded poor fit, and are likely biased by multicollinearity, we did not compare the models.

Discussion

Overall, the results largely support the replication and extension of the TAM reported by Teo et al.'s (2008), but fail to support the EVT elaboration of the TAM or the integration of the TAM and EVT. There are a few minor differences between the original model supported by Teo et al. (2008), and the replication of that model tested in the present study (see Figures 1 and 5). Specifically, the model fit was slightly different, the magnitude of four of the path coefficients differed, and one of the statistically significant paths was not supported in the replication. First, the fit statistics reported by Teo et al., (2008) were stronger than the fit found in the present study. For instance, Teo et al. (2008) reported a CFI of .97, whereas the CFI for the corresponding model reported in the present study was .899. Second, although six of the seven statistically significant paths identified by Teo et al. (2008) were replicated, the magnitude of four of the paths were slightly stronger in the present study. Specifically, the path from facilitating conditions to ease of use ($\beta = .39$, cf. $\beta = .24$), from ease of use to usefulness ($\beta = .65$, cf. $\beta = .44$), from subjective norms to usefulness ($\beta = .57$, cf. $\beta = .22$), and from ease of use to computer attitude ($\beta = .49$, cf. $\beta = .20$) were all slightly stronger in the present study. Furthermore, in contrast to prior results, the weak but statistically significant path from subjective norms to computer attitude ($\beta = .12, p < .05$) was not replicated (Teo et al., 2008). Nevertheless, the overall pattern of results and the large majority of the paths were replicated in the present study. This lends additional support to the TAM and to Teo et al.'s (2008) test of this model.

In addition to directly replicating prior results, this study also extended the initial model tested by Teo et al. (2008) by including behavioural intentions as an additional latent variable (see Figures 2 and 6). The fit statistics from this modified model were slightly better than the model without including behavioural intentions as a final endogenous latent variable. Although the hypothesized path from computer attitudes to behavioural intentions was statistically significant, the magnitude of the relation was weak ($\beta = .25, p < .05$), and the amount of variance in behavioural intentions accounted for was quite low ($R^2 = .06$). Therefore, the benefits of extending this model by including behavioural intentions are small, however, the addition of another latent variable only slightly increases the model complexity.

The EVT elaboration of the TAM (see Figures 3 and 7) and the integration of the TAM and EVT (see Figures 4 and 8) were not supported. Results from these two analyses indicate very poor fit. The first interpretation of the poor fit of preregistered and theoretically driven tests of these two models could be that EVT and TAM are not compatible, or that EVT does not generalize to preservice teachers' computer attitudes and behavioural intentions. However, prior to proposing this explanation we should take a deeper dive into the measurement portions of these models. Two primary concerns with the measures of values and costs must first be considered prior to generalizing back to the theoretical underpinnings of these models.

First, preliminary analyses included a series of four confirmatory factor analyses focused on identifying the most suitable approach to measure expectancy, values, and costs. Results from

these analyses suggested that a four-factor model was most suitable for measuring expectancy, attainment value, utility value, and interest value, and another four-factor model was best for measuring task effort cost, outside effort cost, loss of valued alternatives, and emotional cost. However, although the fit for these two four-factor models was better than competing models, the fit for each of these models was quite poor. This suggests that despite using preregistered and validated scales to assess expectancy for success, values, and costs (i.e., Flake et al., 2015; Linnenbrink-Garcia et al., 2018; Marsh et al., 2018), and satisfactory internal consistency ($\alpha = .83$ to $.95$) for these scales, the factor structure of these measures was suboptimal and limits our ability to test the proposed structural models.

Second, the results from the EVT elaboration of the TAM and the integration of the TAM and EVT suggest that in addition to poor measurement models, the structural portions of these models are biased by multicollinearity. This is evident when we see that the path coefficients from computer attitude to the four cost factors range from $-.96$ to $-.99$ (Figure 7), whereas the corresponding correlations range from $-.40$ to $-.47$. Similarly, the only statistically significant path coefficient identified in the integration of the TAM and EVT model was greater than one (Figure 8), which also suggests a multicollinearity issue (see Kenny, 2015). Therefore, in addition to poor measurement models, the highly-correlated cost measures ($r = .88$ to $.93$) interfered with results of these two structural equation models.

Taken together, the results from this study provide support for the TAM (Teo et al., 2008) and the extension of the TAM by including behavioural intentions and results provide no support for the EVT elaboration or the integration of the TAM and EVT. However, due to poor measurement and multicollinearity issues, we recommend against interpreting these findings as indicating that EVT and TAM should not be integrated.

Limitations and Future Directions

The primary limitation that should be highlighted in the present study relates to the measurement of the EVT constructs, namely expectancy for success, values, and costs. Since the analyses were all preregistered, and the expectancy and combined task values confirmatory factor analysis and the single factor cost confirmatory factor analysis both had poorer fit statistics than the measurement models used, we did not include an additional analysis. However future researchers should test the proposed elaboration and integration models with a three-factor model of expectancy, task values as a single factor, and costs as a single factor (see Kosovich, Hulleman, Barron, & Getty, 2015). Although there is ample theoretical rationale to separate values into attainment, utility, and intrinsic, and to separate costs into task effort, outside effort, loss of valued alternatives, and emotional (see Flake et al., 2015; Wigfield and Eccles, 2000), the factor structure of these constructs can be difficult to support and high correlations among these variables can interfere with subsequent analyses. Consequently, future researchers should consider adopting a less fine-grained approach to investigating the relations between EVT and TAM by assessing expectancy, value, and cost as three factors with a measure such as the Expectancy-Value-Cost Scale (Kosovich et al., 2015).

Another possible explanation for the poor measurement of the values and costs may be because the scales used were adapted to the context of using technology while teaching (see Appendix A). Although all items were carefully adapted to the context of the present study and were approved in the preregistered submission, it is possible that the modification of the items interfered with scale psychometrics. As such, future researchers should consider a validation of an expectancy, value, and cost scale within the context of teachers' use of technology.

A final limitation of this study relates to measuring behavioural intentions rather than actual behaviours. This study extended Teo et al.'s (2008) evaluation of the TAM by including behavioural intentions in addition to computer attitudes (see Davis, 1989; Venkatesh & Davis, 1996). However, to more accurately assess the extent and how teachers are using technology in their classrooms it is necessary to measure actual behaviours rather than behavioural intentions. Consequently, in addition to investigating pre-service teachers' behavioral intentions to use technology in their classrooms, research needs to also investigate actual technology use in actual classrooms.

The present study contributes to the literature by providing a rigorous preregistered evaluation and extension of a highly cited article focused on pre-service teachers' computer attitudes within the TAM (Teo et al., 2008). Results offer additional support for the TAM and highlight the importance of carefully measuring values and costs within the EVT. Practically, these results suggest that pre-service teachers' attitudes and behavioral intentions to use technology are closely related to their perceptions of the usefulness and ease of use of technology. In turn, these attitudes and intentions are partially shaped by perceptions of facilitating conditions and subjective norms. Therefore, to foster future use of technology in the classroom we need to create facilitating conditions to support teachers, such as access to specialized guidance, and norms such as providing encouragement and support from respected peers. By investigating antecedents of behavioral intentions to use technology, and carefully testing potentially relevant models (i.e., TAM), theories (i.e., EVT), and possible integrations of these models and theories, we can support the implementation of technology in the classroom.

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APPENDIX A**Task value: Adapted from Conley (2012) and used in Linnenbrink-Garcia et al. (2018)**

Original Items	Updated Items
<i>Interest value</i>	
I enjoy the subject of science.	I enjoy the subject of educational technology.
I enjoy doing science.	I enjoy using technologies.
Science is exciting to me.	Using technologies is exciting to me.
I am fascinated by science.	I am fascinated by technology.
I like science.	I like technology.
<i>Attainment value</i>	
It is important for me to be a person who reasons scientifically.	It is important for me to be a person who reasons with technology.
Thinking scientifically is an important part of who I am.	Thinking with technology is an important part of who I am.
Being someone who is good at science is important to me.	Being someone who is good with technology is important to me.
It is important for me to be someone who is good at solving problems that involve science.	It is important for me to be someone who is good at solving problems that involve technology.
Being good in science is an important part of who I am.	Being good with technology is an important part of who I am.
<i>Utility value</i>	
Science concepts are valuable because they will help me in the future.	Technology is valuable because it will help me in the future.
Science will be useful for me later in life.	Technology will be useful for me later in life.
Science is practical for me to know.	Technology is practical for me to know how

Science helps me in my daily life outside of school.

Being good in science will be important for my future (like when I get a job or go to graduate school).

to use.

Technology helps me in my daily life outside of school.

Being good with technology will be important for my future (like when I get a job or go to graduate school).

Full cost scale: (Flake et al., 2015)

Original Items	Updated Items
<i>Task effort cost</i>	
This class demands too much of my time.	Using technology while I teach demands too much of my time.
I have to put too much energy into this class.	I have to put too much energy into using technology while I teach
This class takes up too much time.	Using technology while I teach takes up too much time.
This class is too much work.	Using technology while I teach is too much work.
This class requires too much effort	Using technology while I teach requires too much effort
<i>Outside effort cost</i>	
I have so many other commitments that I can't put forth the effort needed for this class.	I have so many other commitments that I can't put forth the effort needed to use technology while I teach.
Because of the all the other demands on my time, I don't have enough time for this class.	Because of the all the other demands on my time, I don't have enough time to use technology while I teach .
I have so many other responsibilities that I am unable to put in the effort that is necessary for this class.	I have so many other responsibilities that I am unable to put in the effort that is necessary to use technology while I teach.

Because of other things that I do, I don't have time to put into this class.

Because of other things that I do, I don't have time to use technology while I teach.

Loss of valued alternatives

I have to sacrifice too much to be in this class.

I have to sacrifice too much to use technology while I teach.

This class requires me to give up too many other activities I value.

Using technology while I teach requires me to give up too many other activities I value.

Taking this class causes me to miss out on too many other things I care about.

Using technology while I teach causes me to miss out on too many other things I care about.

I can't spend as much time doing the other things that I would like because I am taking this class.

I can't spend as much time doing the other things that I would like because I am trying to use technology while I teach.

Emotional cost

I worry too much about this class.

I worry too much about using technology while I teach.

This class is too exhausting.

Using technology while I teach is too exhausting.

This class is emotionally draining.

Using technology while I teach is emotionally draining.

This class is too frustrating.

Using technology while I teach is too frustrating.

This class is too stressful.

Using technology while I teach is too stressful.

This class makes me feel too anxious

Using technology while I teach makes me feel too anxious

Expectancy for success: Adapted from Marsh et al. (2018)

Original Items

Updated Items

When I sit down to thoroughly learn something in math, I succeed in doing this.	When I sit down to thoroughly learn something with technology, I succeed in doing this.
If I try hard not to get bad grades in math, I succeed in doing this.	If I try hard not to get bad grades while learning with technology, I succeed in doing this.
If I invest effort to avoid any errors when performing math tasks, I succeed in doing this	If I invest effort to avoid any errors when performing academic tasks using technology, I succeed in doing this
For me it does not make sense to work much for math as I won't get better grades anyways (reverse scored)	For me, it does not make sense to work much to learn with technology as I won't get better grades anyways (reverse scored)
I am usually sure to get good grades in math tests when I try hard.	I am usually sure to get good grades on tests when I try hard to learn using technology.
The more effort I invest in math, the better I perform.	The more effort I invest in learning with technology, the better I perform

Intentions to use technology: Adapted from Liu, Li and Carlsson (2010)

Original Items	Updated Items
I intend to use m-learning in the future	I intend to use technology when teaching in the future.
I believe I will use m-learning in the future	I believe I will use technology when teaching in the future.

Variables related to the TAM

Original Items	Updated Items
<i>Perceived usefulness (adapted from Davis, 1989)</i>	
Using computers will improve my work	Using technology will improve my work
Using computers will enhance my effectiveness	Using technology will enhance my effectiveness
Using computers will increase my productivity	Using technology will increase my productivity

I find computers a useful tool in my work

I find technology a useful tool in my work

Perceived ease of use (adapted from Davis, 1989)

My interaction with computers is clear and understandable

My interaction with technology is clear and understandable

I find it easy to get computers to do what I want it to do

I find it easy to get technology to do what I want it to do

Interacting with computers does not require a lot of mental effort

Interacting with technology does not require a lot of mental effort

I find computers easy to use

I find technology easy to use

Subjective norms (adapted from Taylor and Todd, 1995)

People whose opinions I value will encourage me to use computers

People whose opinions I value will encourage me to use technologies

People who are important to me will support me to use computers

People who are important to me will support me to use technology

Facilitating conditions (adapted from Thompson, Higgins, and Howell, 1991)

When I need help to use computers, guidance is available to me

When I need help to use technology, guidance is available to me

When I need help to use computers, specialized instruction is available to help me

When I need help to use technology, specialized instruction is available to help me

Computer attitudes (adapted from Thompson, Higgins, and Howell, 1991, and Compeau and Higgins, 1995)

Computers make work more interesting

Technology makes work more interesting

Working with computers is fun

Working with technology is fun

I like using computers

I like using technology

I look forward to those aspects of my job that
require me to use computers

Once I start using computers, I find it difficult
to stop

I look forward to those aspects of my job that
require to use technology

Once I start using technology, I find it
difficult to stop