A Confirmatory Factor Analysis of the Technology Acceptance Model

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The study's intent was to confirm that the Technology Acceptance Model (TAM) would assist in explaining the three factors related to Cambodian secondary students' use of Modular Object-Oriented Dynamic Learning Environment (Moodle) to learn English. Employing a confirmatory factor analysis, findings from the study lend support for the corroboration of TAM as a three-factor model comprised of perceived usefulness, perceived ease of use, and attitudes.

Technology has been used widely in many social science fields to maximize learning opportunities. Before the existence of computer-based technology, face-to-face learning was the primary method adopted by instructors. Face-to-face learning allowed both instructors and students to interact in classrooms during study hours and sometimes through personal e-mails. Thus, limiting the communication time between instructors and students.

However, with the advancement of technology, devices such as computers have been included in teaching and learning environments (Mackay & Stockport, 2006). Moreover, modern information technology and telecommunications now enable the use of the Internet, voice records, and videos in teaching and learning environments to augment face-to-face instruction (Alshwiah, 2009). Some activities of face-to-face learning environments, such as lecture presentation; group discussion; feedback; assignment submission; and grading, can be implemented easily in a Virtual Learning Environment (VLE) via tools like Modular Object-Oriented Dynamic Learning Environment (Moodle), WebCT, or Blackboard (Ahmad, Edward, & Tomkinson, 2006).

This newer educational trend focuses on teaching and learning through online as it removes geographic, scheduling, and potential time barriers. According to Alshwiah (2009), online learning, or E-learning, refers to a form of learning that is realized through the use of the Internet. Online learning has become popular as it helps to conserve time and financial resources that students may spend on traveling to face-to-face learning environments. Solimeno, Mebane, Tomai, and Francescato (2008) compared the efficacy of face-to-face and online learning environments and found that online learning can be used to help students who may have issues with time management. Online learning is encouraged for students who cannot attend classes regularly since this design of learning provides very flexible time schedules. That is, online learners, via technology tools, are able to study whenever and wherever at their ease. Given the various VLE technology-based instructional tools available to learners, there have been numerous theories developed to explain factors related to attitudes toward using technology. One prevalent theory is the Technology Acceptance Model (TAM) (Davis, 1986). This study applied TAM to the context of the Moodle VLE tool.

Literature Review

Moodle

According to Šumak, Heričko, Pušnik, and Polančič (2009), more than 3,000,000 online courses have used Moodle and there are over 31,000,000 Moodle users. Often, Moodle is employed in the form of an asynchronous mode. An asynchronous mode refers to a delivery system of an online method that does not provide simultaneous transfer of learning materials and real time communication between instructors and students (Nong, 2012). In an asynchronous delivery mode, all materials are posted on websites for students and the communication among online participants happens via discussion forums or e-mail correspondence. According to Hrastinski (2008), the aforementioned asynchronous mode of delivery is more popular than a synchronous mode. The synchronous mode refers to a delivery mode of online learning via real time communication tools between instructors and students such as telephone and/or video-based interactive conferences (Nong).

In the current study, Moodle is used as a means of online communication between students and instructors and students and students within a blended learning environment. A blended learning environment refers to a course that combines techniques from face-to-face and online learning (Dos & Demir, 2013; Osguthrope & Graham, 2003).

TAM

TAM was developed by Davis (1986) to explain the "casual" link among the following constructs: 1) perceived usefulness; 2) perceived ease of use of a particular system; 3) users' attitudes toward using technology; 4) behavioral intention; and 5) the actual use of a system. TAM has become popular in the information and communication technology research field because of its simplicity (King & He, 2006). According to Davis (1986), technology use refers to "an individual's actual direct usage of the given system in the context of his or her job" (p. 25). Perceived usefulness is a cognitive construct and is defined as "the degree to which an individual believes that using a particular system would enhance his or her job performance" (p. 26). Perceived ease of use is a cognitive construct and is defined as "the degree to which an individual believes that using a particular system would be free of effort" (p. 26). Attitudes is an affective construct and refers to "a person's location on a bipolar evaluative or affective dimension with respect to some objects, actions, or events" (Fishbien & Ajzen, 1975, p. 216). Therefore, users' attitudes will be positive if they perceive that employing a particular system is beneficial and easy to use.

It is thought that people will perceive usefulness of technology if they believe that their intention to use a particular system will help them accomplish tasks more quickly, enhance their productivity, and increase their capacity for obtaining knowledge. Furthermore, it is assumed that users will perceive ease of use if they recognize that their interaction with the system is clear and understandable. Also, they need to believe that it is easy for them to become skillful at using a system and that the system is easy to employ. Lastly, people will possess positive attitudes using technology if they think that a system is fun and interesting and they like working with it (i.e., an "authentic" interaction with a system). Finally, the current study will employ TAM's first three constructs (i.e., perceived usefulness, perceived ease of use, and users' attitudes) as a literature-accepted, modified, three-factor model. Thus, the latter two constructs are not part of the current study's TAM.

TAM and VLE Tools

There have been a small number of studies that have applied the aforementioned three-factor TAM with various VLE tools. The results have all confirmed a three-factor model fit. For instance, Šumak et al. (2009) conducted a study with undergraduate students (N = 235) at the University of Maribor in Slovenia that applied TAM within the context of the VLE, Moodle. Šumak et al. found that the study's modified, three-factor model was a good fit for the data. The model's factor loadings were all very high, fit indices were all beyond a specified threshold, and the items used to measure the model's constructs had high internal consistency and acceptable score validity. Lee, Cheung, and Chen (2005) conducted a study with undergraduate students (N = 544) who used TAM with a VLE, Internet-based learning, at the City University of Hong Kong. Lee et al. confirmed a modified three-factor TAM. Later, Saade, Nebebe and Tan (2007) directed a similar study using TAM with undergraduate students (N = 362) at Concordia University in Montréal, Canada and employed multimedia learning tools such as videos, graphics, and sounds. Saade et al. determined that the data fit the model well. Lastly, Park (2009) used TAM with undergraduate students (N = 650) with a VLE, e-learning courses, at Konkuk University in Seoul, South Korea. Park found that the modified, three-factor model was a good fit for the data.

Purpose of the Study

Based on TAM (Davis, 1986), this study posits that the constructs of perceived usefulness, perceived ease of use, and attitudes have a link with Cambodian secondary students' use of Moodle to learn English. Thus, it is anticipated that findings from the current study will confirm results from previous research in this area of the field to lend more support for the idea that a three-factor TAM is applicable in sundry, diverse VLEs as well as at the under-studied secondary education level within a Cambodian context.

Research Question and Hypothesis

asked the following research question: Can TAM be confirmed as a three-factor model comprised of perceived usefulness, perceived ease of use, and attitudes when employed using Moodle at the secondary education level in the context of Cambodia?

To answer the posed research question, a hypothesis will test and confirm the model's fit as a three-factor structure:

H_1: A confirmed three-factor TAM comprised of perceived usefulness, perceived ease of use, and attitudes will estimate a consistent fit between the reproduced covariance matrix and the observed covariance matrix.

Methods

Population

The accessible population (N = 697) was English language learners at the Australian Center for Education (ACE) in Cambodia enrolled in the English for Academic Purposes (EAP) program. Contextually, ACE provides English training programs to secondary-level students, depending on students' English proficiency abilities, to help them learn English as a foreign language. ACE students learn four macro skills: reading, writing, listening, and speaking. Relative to other programs, the EAP program is designed especially for students with advanced English proficiency. To enroll in the program, students must be at least 15 years of age.

Sample

The study recruited participants by using a non-random sampling method. The questionnaire was sent out to 300 students through their personal e-mail addresses. One hundred-fifty students completed the questionnaire. All of the sampled students were between the ages of 18 to 20 years and the majority were female (n = 81).

Instrumentation and Internal Consistency

The study collected data to measure the three constructs of interest, which were perceived usefulness, perceived ease of use, and attitudes that were measured by employing scales developed by Šumak et al. (2009). A nine-item survey (see Appendix) was used that incorporated the three aforementioned scales. The items on the scales were measured with seven ordinal response options ranging from 1 = Strongly Disagree to 7 = Strongly Agree.

An initial, internal consistency estimate check, via Cronbach's alpha (α), indicated that the 9 items had α = 0.91, where the recommended cut-off value for score reliability for survey research is α ≥ 0.80 (Nunnally, 1978). Thus, α = 0.91 signified that there was high internal consistency and the items on the survey were decidedly inter-correlated.

Results

Using IBM-SPSS AMOS to conduct a confirmatory factor analysis (CFA), the study employed the maximum likelihood estimation method to minimize the discrepancy in the fit between the estimated population covariance matrix and the observed covariance matrix. There were three latent variables, perceived usefulness; perceived ease of use; and attitudes and nine manifest variables in the model: AT1 (AT = Attitude), AT2, AT3; PEU1 (PEU = Perceived Ease of Use), PEU2, PEU3; and PU1 (PU = Perceived Usefulness), PU2, PU3. Figure 1 shows the full model.

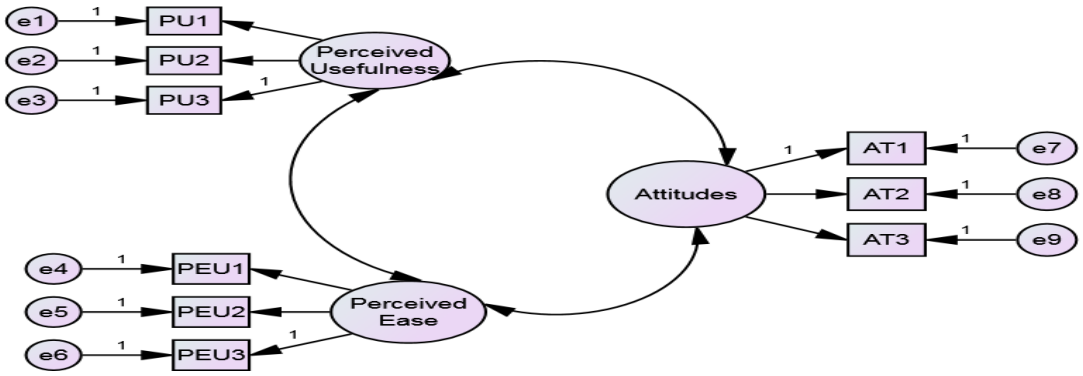

Figure 1. The Measurement Model for TAM.

Normality

A multivariate, normal distribution is a major assumption for running a CFA. However, these data did not show either a univariate or a multivariate normal distribution. The results indicated that the critical ratios pertaining to the univariate skewness values were all more extreme than ±1.96; the predetermined critical z-value. Also, the multivariate Mardia's statistic (86.15) and its affiliated critical ratio was 37.49, which for the latter was beyond ±1.96. Mardia's statistic values > 3.00 have been noted as indicative of

multivariate kurtosis (Bentler & Wu, 1993). Therefore, these data did not fulfill the assumption of univariate or multivariate normality.

Bollen-Stine Bootstrapping

Given the previously-noted issues with multivariate non-normality, it was not unexpected that the model's chi-square value was statistically significant (61.56; $p < 0.001$) indicating that there was a difference (i.e., discrepancy) in the two covariance matrices and the model was, potentially, not consistent with the data. In this initial, undesirable situation, AMOS offers Browne's (1984) Asymptotically Distribution Free (ADF) estimation and the Bollen-Stine (1992) bootstrap to address issues of non-normality. ADF estimation is employed with models where $N \geq 2{,}000$ (Kline, 2005), which was not the case with the current study's sample size. Consequently, a Bollen-Stine bootstrap procedure consisting of 5,000 iterations was conducted and yielded a p-value that was used to assess overall model fit (Nevitt & Hancock, 2001). The Bollen-Stine *p*-value = 0.144 was not statistically significant ($p > 0.05$), and, thus, the proposed model was retained as one that was consistent with the data. Note that via the Bollen-Stine bootstrapping procedure, the newly derived chi-square p-value (0.144) did not assist in obtaining a robust chi-square statistic itself for use with the computation of the model's subsequent fit indices. Therefore, it should be understood that any of the chi-square-based goodness- and badness-of-fit indices were not adjusted for non-normality under the Bollen-Stine bootstrapping procedure.

Coefficients: Factor Loadings

Further analysis of the model depicted in Table 1 indicated that the standardized factor loadings ranged from 0.483 to 0.891. All of the items, except for one, loaded highly on each factor per the a priori threshold of ≥ 0.50 for item salience (Kline, 1998). For example, the items used to measure perceived usefulness had very high factor loadings at 0.80 and above. Two items loaded very high on attitudes. For perceived ease of use, the loadings were also relatively large.

Table 1. Factor Loadings

Item		Factor	Estimate
PU3	<---	Perceived_Usefulness	0.818
PU2	<---	Perceived_Usefulness	0.843
PU1	<---	Perceived_Usefulness	0.873
PEU3	<---	Perceived_Ease	0.483
PEU2	<---	Perceived_Ease	0.685
PEU1	<---	Perceived_Ease	0.840
AT1	<---	Attitudes	0.862
AT2	<---	Attitudes	0.643
AT3	<---	Attitudes	0.891

Coefficients: Communalities

Further, the vast majority of communality (h^2) indices had very strong values that ranged from 0.233 to 0.794, with only three h^2 values in "violation" of the a priori threshold of ≥ 0.50 (Hair, Anderson, Tatham, & Black, 1995). The model's large h^2 values indicated that many of the items had a great deal in common with each other and could be considered as reliable measures of the existing model structure.

Model Fit: Standardized Residuals

Based on the standardized residuals in Table 2, all of the values, except for one, were within the range of ±1.96. These results indicated that, indeed, the reproduced covariance matrix was consistent with the observed covariance matrix, where standardized differences only ranged a small amount.

Model Fit: Indices

Given the strong results from Table 2, it was not unanticipated that the model indices showed good model fit to the data. Fit indices typically range in value from 0 to 1.0, with values close to 1.0 indicating a good fit. Indices used in this study were the comparative fit index (CFI; Bentler, 1990); the Tucker-Lewis index (TLI; Tucker & Lewis, 1973), and the incremental fit index (IFI; Bollen, 1989). The root mean square error of approximation (RMSEA; Steiger & Lind, 1980) was also employed to indicate the badness-of-fit of the model, where smaller values closer to 0 reflect good fit. Results indicated that the CFI = 0.955, the TLI = 0.933, and the IFI = 0.956 were all beyond the literature-supported threshold of ≥ 0.90 (Kline, 1998; Schumacker & Lomax, 1996). The observed value of RMSEA = .10 was reasonable, where lower values < .05 indicate close model fit and higher values between 0.05 and 0.10 indicate less than optimal fit, but still "realistic" error (Browne & Cudeck, 1993; Hu & Bentler, 1998).

Table 2. Standardized Residuals

	AT3	AT2	AT1	PEU1	PEU2	PEU3	PU1	PU2	PU3
AT3	.000								
AT2	.124	.000							
AT1	-.010	-.118	.000						
PEU1	-.158	.744	.313	.000					
PEU2	-.268	-1.336	-.226	-.250	.000				
PEU3	-.031	2.107	-.179	.234	.711	.000			
PU1	.373	-.640	.155	-.204	.881	-.932	.000		
PU2	-.515	-.394	-.133	.016	.586	-1.239	.092	.000	
PU3	.424	.181	-.179	-.065	.586	-.999	-.287	.223	.000

Validity: Convergent Validity

The following section describes validity and reliability evidence for the obtained scores based on the model. Convergent validity values of the constructs in the model were estimated by the Average Variance Extracted (AVE):

$$AVE = \frac{\Sigma\,(\mathrm{L})}{N} \tag{1}$$

where; Σ(L) = The sum of the standardized regression weights

As shown in Table 3, the majority of the constructs had AVE values that were > 0.50, which indicated good convergent validity. Therefore, the majority of indicators used to measure each construct had a high proportion of variance in common except for PEU, which was slightly lower in value (0.469) than the threshold of >0 .50.

Reliability: Construct Reliability

Construct reliability (CR) values of the constructs under study were estimated by using the following equation:

$$CR = \frac{\Sigma\,(L)^2}{\Sigma\,(L)^2 + \Sigma\,(\Delta)} \tag{2}$$

where; $\Sigma\,(\Delta) = 1 - h^2$.

Again, the results in Table 3 indicated high score reliability, with a desired threshold of > 0.70, where estimates ranged from 0.717 to 0.882. Thus, the items for each construct had high internal consistency.

Discussion and Conclusions

The model's factor loadings were all statistically significant ($p < .001$) and ≥ .50 (except for one at .48). All of the standardized residuals, except for one, were within the range of +/-1.96 and; thus, the model's goodness-of-fit indices were all > .90 and the RMSEA = .10. The constructs had very robust score reliability and validity. The hypothesis tested was answered in the affirmative that, indeed, a confirmed three-factor TAM estimated a consistent fit between the reproduced covariance matrix and the observed covariance matrix.

The model, though, did have some potential limitations. In terms of a threat to external validity, the use of a non-random sampling method (i.e., convenience) could have compromised the level of generalizability. In the area of a threat to internal validity, there was sample truncation because program students who were 15-17 years of age (i.e., considered minors) were not included in the sample due to a Cambodian institutional review board decision. Lastly, a threat to statistical validity could be considered where the study's results may have

Table 3. Validity and Reliability Evidence for Model Constructs

Constructs	Items	Convergent Validity	Convergent Reliability
Perceived Usefulness	PU1 PU2 PU3	0.714	0.882
Perceived Ease of Use	PEU1 PEU2 PEU3	0.469	0.717
Attitudes	AT1 AT2 AT3	0.650	0.845

lacked some stability because of the violation of normality assumption (i.e., particularly multivariate kurtosis). That is, there was an absence of multivariate normality and the chi-square value was statistically significant ($p < 0.001$). The latter, preliminary result suggested that there was a potential discrepancy in the two covariance matrices; however, findings affiliated with the standardized residuals, the goodness-of-fit indices, and the badness-of-fit indicator all suggested a defined, confirming model. As noted previously, this evidence assisted in answering the study's hypothesis and also the posed research question that TAM was confirmed to be a three-factor model employed with Moodle at the secondary education level in Cambodia. Thus, given the results associated with factor structure and the Moodle VLE, the current study's findings are consistent with results derived from earlier research involving TAM by Lee et al. (2005), Park (2009), Saade et al. (2007), Šumak et al. (2009), Wong, Osman, Goh, and Rahmat (2013), and Yang (2007).

Further, Lee et al. (2005), Park (2009), Robles-Gómez et al. (2015), Saade et al. (2007), Šumak et al. (2009), Wong et al. (2013), and Yang (2007) all conducted research using TAM with post-secondary level students in various countries. Venkatesh and Davis (2000) and Venkatesh, Speier, and Morris (2002) studied participants with TAM in private business sectors. Huntington (2011) examined high schools teachers' use of TAM. However, an important aspect from the current study is that findings suggested TAM appears to be applicable with a sample of students at the under-studied secondary education level within the context of Cambodia. That is, TAM has been infrequently applied to research at the secondary level (cf, Horzum, Ozturk, Bektas, Gungoren, & Cakir, 2014; Rajagopal, Ismail, Ali, & Sulaiman, 2015) and never employed in the locale of Cambodia with this type of sample. Tangentially, it is worth noting that Sang, Lee, and Lee (2009) studied TAM in Cambodia with public ministry officials, and Elwood and MacLean (2009) used a second, modified version of TAM, different from the current study's TAM, with post-secondary students in Cambodia.

Future Research

This study used a smaller sample size ($N = 150$) then is typically employed with CFA. Though larger samples have been conducted within post-secondary learning environments, future research might conduct a similar study in a secondary learning environment with a larger sample, between 300 to 600 participants, to compare findings. Additionally, based on factor(s) prevalent in the literature and/or the field of practice, a model should be conducted using TAM and possibly Moodle, or another VLE tool (Park, 2009), to determine if the structure indicated by the literature, and supported by the current study, is invariant, for example, by gender or age grouping.

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APPENDIX

Questionnaire

Perceived usefulness, perceived ease of use, and attitudes toward the use of Moodle in learning English: Below, please indicate in the column the response that best applies to you per question:

Constructs	**Items**	**Strongly Agree**	**Agree**	**Somewhat Agree**	**Can't Decide**	**Somewhat Disagree**	**Disagree**	**Strongly Disagree**
Perceived Usefulness (PU1)	5. Using Moodle for learning English enables me to accomplish tasks more quickly							
Perceived Usefulness (PU2)	6. Using Moodle for learning English increases my productivity							
Perceived Usefulness (PU3)	7. If I use Moodle for learning English, I will increase my chances of getting knowledge							
Perceived Ease of Use (PEU1)	8. My interaction with Moodle would be clear and understandable							
Perceived Ease of Use (PEU2)	9. It would be easy for me to become skillful at using the Moodle for learning English							
Perceived Ease of Use (PEU3)	10. I would find Moodle easy to use							
Attitudes Toward Using Moodle (AT1)	11. Moodle makes learning more interesting							
Attitudes Toward Using Moodle (AT2)	12. Working with Moodle is fun							
Attitudes Toward Using Moodle (AT3)	13. I like working with Moodle							