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THE EXPLORATION OF TEACHERS' INTENTION OF USING LEGO NXT IN PRIMARY SCHOOL

Bih-Yaw Shih,
Tsung-Hao Chen,
Yevvon Yi-Chi Chang,
Wen-Yaw Chung, Chen-Yuan Chen

Abstract. *More and more LEGO NXTs are applied to combine with different courses for designing multimedia instructional materials. Therefore, understanding the factors affecting the teachers' intention of using Lego NXT has been an eager research issue. The purpose of the current research is to explore the teachers' intention of using Lego NXT in primary school. A model combining the Technology Acceptance Model (TAM) as well as system and participant characteristics is proposed. Data were collected from forty seven primary school teachers in Kaohsiung and Pingtung county. Structural Equation Modelling (SEM) is used to test the hypothesis.*

Key words: *authentic, LEGO NXT, self-efficacy, teachers' intention, technology acceptance model.*

Bih-Yaw Shih
National Pingtung University of Education, Taiwan
Tsung-Hao Chen
Shu-Te University, Taiwan
Yevvon Yi-Chi Chang
Tunghai University, Taiwan
Wen-Yaw Chung, Chen-Yuan Chen
National Pingtung University of Education, Taiwan

Introduction

In last decades, information technologies and innovations have deeply affected our lives. Currently, robots are widely used for many applications including industry, entertainment and education.. The growth in the use of robotics in these areashas attracted increased attention from educators and prospective teachers in Taiwan. The well-known LEGO NXT is a low-cost robot which can be easily programmed via a graphical user interface and is an important educational tool, particularly its role in helping children develop self-confidence and conceptual understanding of mathematics, science and similar topics. Currently, the LEGO NXT is widely used for robotics education and has become a popular tool for teaching and learning in Taiwan. Eventually, more and more LEGO NXTs are applied to combine with different courses for designing multimedia instructional materials.

Although LEGO NXT are increasingly being used, there are rare theory-driven research discussing teachers' usage of applying LEGO NXT in teaching including (a) e-learning self efficacy tool for a traditional class or (b) stand-alone e-learning education course offering. Equally important, no research on LEGO NXT which explored the impact of specific system characteristics are thought to be critical for such systems. As noted by Carswell and Venkatesh (2002), much of the research on LEGO NXT has examined outcome differences between on-line and traditional classes (Alavi, 1994; Spooner, Jordan, Algozzine, & Spooner, 1999; Storck & Sproull, 1995; Webster & Hackley, 1997) or offered anecdotal experiences

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of teachers or learners. Further, studies examining the determinants associated with LEGO NXT usage have not examined specific system characteristics that are the focus of this study (Carswell & Venkatesh, 2002) or have not tested models which hypothesize that such characteristics are determinants of LEGO NXT use (Selim, 2003). By exploring the factors of teachers' intention, the knowledge about the important determinants of using LEGO NXT in school can be expanded. Therefore, understanding the factors affecting the teachers' intention of using LEGO NXT in school has been an eager research issue for the promotion of authentic robotic learning materials and environment. Moreover, in order to evaluate the effectiveness of the material, a formal study was implemented to assess whether users perceived the material as effective for learning with robotics. Their feedback was also expected to help us to improve the multimedia instructional material in the future.

Theoretical Model

Research on technology adoption often produces conflicting results where one hidden reason for this inconsistency might be the focus on a single theory that excludes consideration of other possibly important determinants (Chen, et al., 2002). Therefore, a hybrid model is developed including constructs of system and participant characteristics; perceived ease of use and usefulness of the systemand use of the technology, were taken from the (a) technology acceptance model (TAM) and the more general theory of reasoned action (TRA) and (b) research literature on LEGO NXT and general information technology adoption.

TRA and TAM

The TAM has been widely applied to studies of technology use. TAM was adapted from the well known TRA (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) which is a framework used extensively for predicting and explaining a variety of human behavior. TRA specifies that causal linkages flow in a sequence from beliefs, attitudes, intention, to behaviors. TAM, proposed by Davis, Bagozzi, and Warshaw (1989) and shown in Figure. 1, modified TRA to predict computer adoption by replacing the belief determinants of TRA with two key beliefs: perceived usefulness and perceived ease of use.

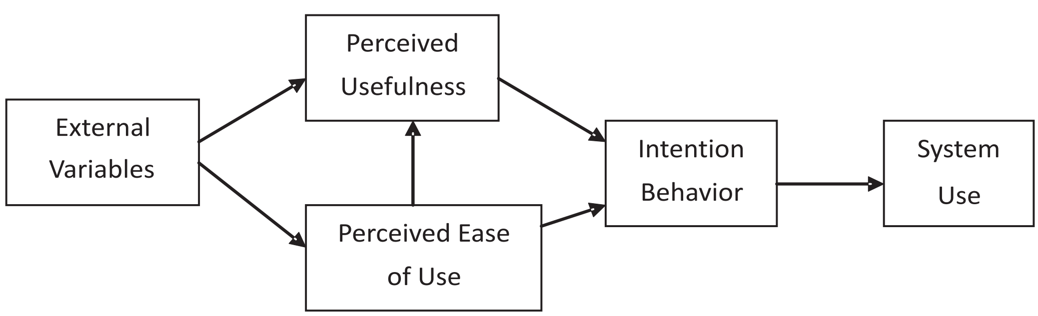

Figure 1: The technology acceptance model

Further, in the model of Davis et al.,(1989) perceived ease of use directly affects perceived usefulness, with both of the use beliefs affecting computer technology adoption. Davis et al., (1989) had also suggested that external factors may be important determinants of the usefulness constructs of TAM, but they did not empirically test such factors at that time. Researchers have extended TAM by proposing and testing specific antecedents to its two use belief constructs. As explained by Mathieson (1991), without external factors, TAM provides only very general information on users opinions about a system but does not yield "specific information that can better guide system development". For this research, we followed that line of reasoning and included not only the core determinants of TAM but also two sets of antecedents that have been found to directly affect the use belief constructs in other technology adoption studies. One set of such antecedents involves the characteristics of the system being studied, with the second set including individual attributes. We now describe the three general sets of study variables: external; use beliefs and outcomes.

External Variables

In issues of introductory programming, the use of robots is expected to have positive impact, since it can helptowards the understanding of an accurate and logical machine instructional language. LEGO NXTs are used as a tool for teaching problem solving methods, being a very pleasant and interesting past-time, offering at the same time a simple and educational interface. Students see them more as a game rather than educational tools since the majority of the kids have played with Lego bricks in the past. The game part is a very important factor promoting and motivating students to learn.

A second set of external variables is individual attributes. First, learners are assumed that they may form different perceptions of a LEGO NXT system due to individual attributes, and that such attributes may be related to technology usage. As such, Heinich, Molenda, Russell, and Smaldino (1996) asserted that learning characteristics must be considered in order for instructional technology to be used effectively. Therefore, in the current research, self-efficacy and intention to use are positioned as two factors that are expected to influence LEGO NXT use. Self-efficacy, the first user characteristic, reflects one's beliefs about the ability to perform certain tasks successfully (Bandura, 1977). Further, computer self-efficacy has been defined to reflect one's beliefs about the ability to use computers effectively (Compeau & Higgins,1995b). Similarly, in this study, self-efficacy is defined as the confidence in one's ability to perform certain learning tasks using an LEGO NXT system. Prior research has indicated that self-efficacy influences performance or behavior (Compeau & Higgins, 1995a; Compeau, Higgins & Huff, 1999; Taylor & Todd, 1995), including behavioral intention (Tan & Teo, 2000; Venkatesh, 1999)Other studies have found that computer self-efficacy and perceived ease of use are related (Davis, 1989; Venkatesh & Davis, 1996). Further, Lim (2000) found that computer self-efficacy influences participation of adult learners in e-learning education. The second individual attribute included in this study is computer experience. Based on related research, we believe that a learner's prior technical skills in using the computer may affect LEGO NXT use. For example, prior computer experience has been found to influence intent to use a variety of technology applications including microcomputers and Internet banking services (Igbaria et al.,1995; Tan & Teo, 2000), as well as e-learning education (Kerka, 1999).

Usefulness Constructs

As mentioned above, Davis et al., (1989) postulated that two belief dimensions perceived ease of use and perceived usefulness – impact intention to use a technology application. These belief constructs are central to TAM and routinely included in technology acceptance studies.

Outcomes

As noted by Carswell and Venkatesh (2002), empirical studies testing TAM-like models typically examine intention to use the technology application being studied and obtain user perceptions of the beneficial characteristics of the system. Further, given the resources invested in LEGO NXT systems by postsecondary institutions, it seems reasonable that those making the investment decision would want to know if teachers intend to use such systems both for supplementary learning and for e-learning education courses along with the factors that predict such intent.

As such, two behavioral intentions to use the LEGO NXT system are the primary outcomes of interest in this study. In nearly all TAM studies, a single behavioral intention construct is used. One reason for this may be that TAM features one behavioral intention construct. A second possible reason is that many studies examine technologies that have a general purpose and accordingly employ an outcome designed to reflect this general use. However, in a study of e-commerce adoption, behavioral intention was categorized into "intended inquiry" and "intended purchase" reflecting two distinct purposes of

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e-commerce (Gefen & Straub,2000). Similarly, in this study, to reflect two specific purposes of the LEGO NXT system under study, behavioral intention is categorized into two constructs: use for supplementary classroom learning and use for e-learning education.

Research Model

The key belief dimensions of TAM with antecedents found to be important predictors of the use beliefs in other technology adoption studies is combined in the research model as shown in Figure. 2. This model posits that three system characteristics (system functionality, interactivity, and response) and user attributes (self-efficacy) will directly affect both use belief constructs. Further, the impact of the antecedent variables on usage is hypothesized to be entirely through, or completely mediated by, perceived ease of use and perceived usefulness. Thus, we refer to this model as the fully mediated model. This specification is taken from TAM, and has been empirically supported by some studies (e.g., Agarwal & Prasad, 1999; Davis, 1993; Igbaria & Zinatelli, 1997).

Use of the system for e-learning self efficacy to be logically prerequisite for use of the system for e-learning education purposes is taken into account, such that teachers who find the system useful for e-learning self efficacy will tend to find it useful for e-learning education whereas those who do not believe the system is useful for e-learning self efficacy will not likely find it useful for e-learning education. Note that this expected positive relationship requires that the LEGO NXT system in question has features specifically designed to support both e-learning self efficacy and e-learning education purposes, which is the case in this study. The presence of such features also suggests that system characteristics may play a more important role in influencing the resultant use than this model implies. This leads us to consider a second research model for this study.

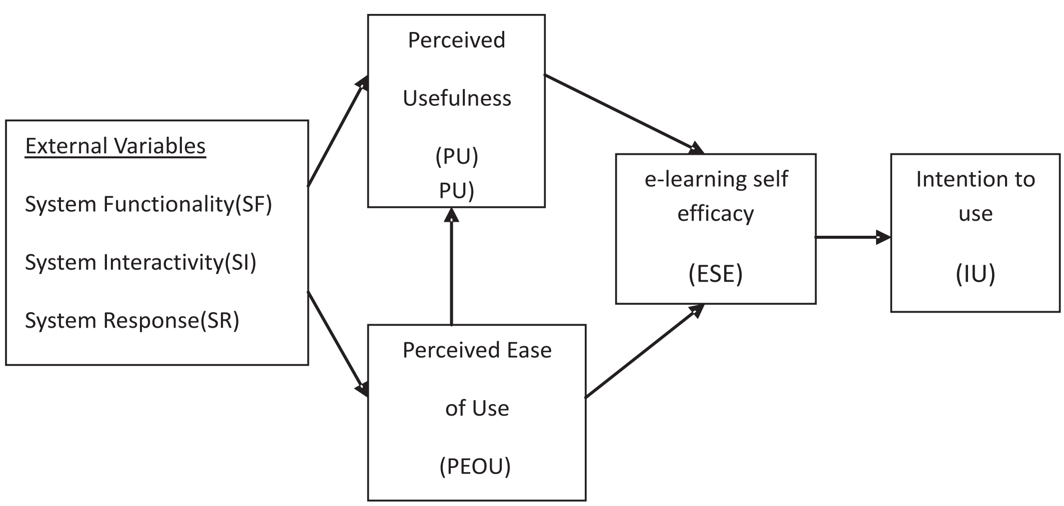

Figure 2: The Research Model

The research model of the current research is shown in Figure. 3 where the system functionality is hypothesized to have a direct effect on the use of the LEGO NXT system for e-learning self efficacy purposes. Specifically, learners who perceive that the LEGO NXT system effectively provides them with access to course content at a time and place of their choosing will be more likely to use the system for e-learning self-efficacy. Second, system functionality and system interactivity are hypothesized to have direct effects on the use of the LEGO NXT system for intention to use purposes. That is, when learners also believe that the system provides for effective student-student and student-instructor interactions, they will be more likely to use the LEGO NXT system.

The primary reason for these effects is that such a system will be perceived as being compatible with the learner. That is: (a) need for flexibility regarding the time and place of instruction and (b) value to receive a quality education. Compatibility is often thought to underlie technology acceptance (Davis et al., 1989; Moore & Benbasat,1991) and has been found to predict student intent to use a LEGO NXT system purposes (Carswell & Venkatesh, 2002). Further, the research model acknowledges that inconsistent findings have emerged about the role played by the two belief dimensions-perceived ease of use and perceived usefulness. As cited above, whereas some researchers have found that these beliefs fully mediate the relationships between external factors and technology use, other researchers have found direct effects between such external factors and technology use (Igbaria et al., 1995; Jackson, Chow, & Leitch, 1997).

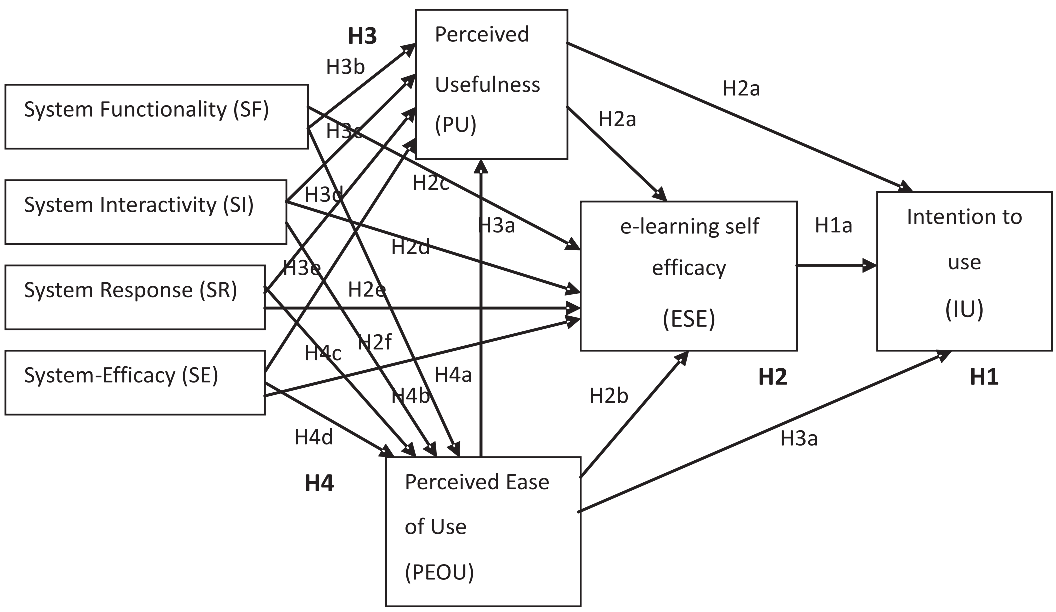

Figure 3: Hypothesized Model of the research.

The general and specific study hypotheses are as follows:

H1. Use of the LEGO NXT system for education purposes is positively influenced by each of the constructs in the model.

Specifically, the LEGO NXT system education is positively affected by use for e-learning self-efficacy (H1a), perceived usefulness (H1b), perceived ease of use (H1c), system functionality (H1d), and system interactivity (H1e). Further, system response (H1f) and self-efficacy (H1g), will positively affect use for intention to use indirectly, that is, through other determinants in the model.

H2. Use of the LEGO NXT system for e-learning self-efficacy is positively affected by the use beliefs, system characteristics, and individual attributes.

Specifically, use for e-learning self-efficacy is positively influenced by perceived usefulness (H2a), perceived ease of use (H2b), and system functionality (H2c). In addition, system interactivity (H2d), system response (H2e) andself-efficacy (H2f), will positively and indirectly impact use for e-learning self efficacy via other constructs in the model.

H3. Perceived usefulness of the LEGO NXT system is positively influenced by perceived ease of use, system characteristics, and user attributes.

Specifically, perceived usefulness is positively affected by perceived ease of use (H3a), the

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system factors of functionality (H3b), interactivity (H3c), response (H3d), and the user characteristics of self-efficacy (H3e).

H4. Perceived ease of use of the LEGO NXT system is positively influenced by system and individual characteristics.
Specifically, perceived ease of use is positively and directly affected by the system characteristics of functionality (H4a), interactivity (H4b),response (H4c), and the user attributes of self-efficacy (H4d).

Research Subject

The research subjects of the current research are teachers from southern Taiwan. These teachers participated in the county city study programs run by robots, after several days of study and practice, they began to like the course and were willing to try to use the equipment in courses, as teaching aids. After the teacher had been using the programs for a persiod of three months, they were asked to completed a questionanrie. All 47 valid questionanires were collected and the effctive return rate is 100%. Visual PLS 1.04 is used to analyse and predict data analysis. Measurements carried out using the PLS model validity and reliability, and then carried out using the PLS analysis, testing the concept proposed in this research of the structure, the dimensions of the relationships between the research hypothesis is established.

Partial least squares (PLS) statistical methods include reliability analysis with reliability of individual question items, internal consistencymeasurement and validity analysis by confirmatory factor analysis(CFA) to measure the dimensions convergent validity as well as discriminant validity. Primarily is to assess the convergent validity All measurement items asked the extent consistent with each other, and discriminant validity was measured between the different variables asked whether items identify with a certain degree. Meanwhile, the hypothesis test: the structure model and model the path coefficient estimates and explanatory power to conduct tests.

Partial Least Squares Method Overview

PLS is a structural equation modeling (SEM) analytical technique, it is a return to Based on the analysis derived from path analysis statistical methods, research and more recently it has become a causal model of surface reconstruction with power tools. By the PLS method one can test for the measurement instrument model And research organization composed of surface structure model. According to Barclay et al., (1995) proposal, as long as the sample size is greater than 80 or more independent variables in the research model is 10 times that number, that is suitable for PLS structural model of conduct. PLS has the two key advantages, first, for smaller study sample is still applicable. Second, the requirements for the error variables, representing such regression analysis, its limitations are more relaxed. It also analyzes the advantages of complex forecasting model ability (Chin and Newsted, 1999), it compared to the other SEM analysis method more suitable for this study.

Theanalysis of structural equation modeling is divided into measurement and structure.The PLS analysis and estimation procedure is divided into two phases. Thefirst stage model for the measurements carried out the letter level reliability and validity of the analysis,.The second stage, the model for the structure of the path coefficient and the model explains power estimation and testing conducted. Such estimates can be the first step is to confirm the order to measure the constructs whether the credibility and validity, the turn for the relationship between the constructs carrying out the examinations (Hulland 1999). PLS modeling for the test consists mainly of order of reliability and validity of measurement in the reliability aspect includes individual question, item reliability, internal consistencymeasurements, the validity, the aspect of convergent validityand discriminant validitymeasurement.

Individual question item reliability on the question item corresponding to the loadings the next test load, it presents a particular question item can measure this construct's level, while the load amount of the threshold of 0.5 or above 0.5 asked to indicate the reliability of individual items with (Fornell and

Larcker (1981)). The internal consistency of constructs to assess the composition of constructs composite reliability , by the scholars Fornell and Larcker (1981) of the definition. Chin (1999) proposed composite reliability of the threshold value should be above 0.7, if more than the threshold value, the representative of the constructs to achieve internal consistency. Gilford (1954) suggested,the cronbach'salpha greater than 0.7, the constructs with good reliability. In the validity, convergent validity of the multiple variables that are all the same constructs measured the degree of match.

Individual constructs are drawn to the average variance extracted(AVE) must be at least greater than 0.5, parties can be said that the constructs have adequate convergent validity (Fornell and Larcker 1981). When the variables for which the construct measured by the factor loading is greater than 0.5, also the requirements to achieve convergent validity (Nunnally 1978). Validity is to test different variables measuring different constructs for the identification between the degree. The PLS measurement model in different estimates of validity can be conducted from two aspects of testing. Thefirst one is to view cross-loading matrix, the various constructs in the individual asked whether the item loadings higher than in the other constructs in the loadings (Fornell and Larcker 1981).

The second part is to the individual constructs the average amount of AVEof the square root, placed on the constructs the correlation coefficient matrix, in order through the discriminant validity of the test, each variable and measuring the same one constructs the other variables related to the degree, should be greater than the constructs in the model of other constructs of the correlation coefficients (Chin 1998) Upon the completion of PLS modeling for CITIC and validity of the examination, to facilitate a PLS model for the ability to explain and predict the structural model estimation. Ability in the model to explain some of the main study is to test the relationship between constructs the path coefficient is significant, and PLS path coefficient for the estimation and testing methods are significant, the use of order "Bootstrap", "Blindfolding", and "Jackknifing" and other methods (Chin 1998). The predictive ability of the model on the R^2 index future is determined.

Results of Research

PLS Measurement Model Analysis

According to the Barclay et al. (1995) proposal, it is suitable for PLS structural model of conduct if the sample size is greater than 80 and has independent variables in the research model ~~is~~ 10 times that number. The 47 valid questionnaires from a number of variables 4, in line with the operation of PLS threshold for conducting PLS structural model analysis. Bootstrap methods in this study carried out model validation, Bootstrap is a non-parametric sampling method whoseadvantageis that is not required to do some advance on the mother of the assumptions that the way to use a computer automated execution of the whole process, save to order the tedious theoretical calculations. In normal circumstances, Bootstrap approximation provided by the limit than the commonly used approximation of the future be accurate. Therefore, this study used statistical software in the measurement mode for the Visual PLS analysis includes project load quantitative analysis, data reliability and validity analysis, and structural model analysis.

A) Reliability analysis

The experts cited the relevant scale, so order some already have content validity and empirical validity, in order to effective description of the items are sufficient to explain the dimensions of the relevant variables, so conducting confirmatory factor analysis (CFA), for the questionnaire for reliability and validity testing. Fornell and Larcker (1981) suggested good convergent validity of all items should be the factor loading should be obvious, that all options need to be asked more than 0.5, so the choice of this study asked their respective factor loading items must be greater than 0.5, or deleted (see Table 4). The study constructscomposites reliability (CR) values ranged from 0.80 to 0.89 (see Table 1) Theseare higher than the threshold 0.7 (Chin, 1999), items were sufficient to reflect the latent variables representing the constructs of this study with internal consistency. In the deleted items are not appropriate, the variables

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to conduct the reliability analysis, Nunnally (1978) also suggested the Cronbach's α values ranged from 0.51 to 0.82 between the values can be as high reliability, otherwise need to be rejected at the 0.35 convenience. In this study, the Cronbach's alpha of the constructs were greater than 0.51 (see Table 1), which is still an acceptable range, reliability analysis, this study has shown both reliability standards

B) Validity

The validity, convergent validity of the multiple variables that are all the same constructs measured the degree of match. Convergent validity table shows the measurement of multiple variables are all precisely the same constructs constructs the individual level the average AVE, and must be at least greater than 0.5, the party described as the constructs have adequate convergent validity (Fornell and Larcher 1981). This study constructs the average of the variance were between 0.54 ~ 0.67 (see Table 1), were higher than the recommended threshold of 0.5, the constructs that this study has convergent validity. Through CFA to measure the dimensions of the convergent validity and discriminant validity. To assess the convergent validity of all the major items measuring asked the extent consistent with each other, and discriminant validity is measured variables between the different items asked to identify whether a certain extent.

Fornell & Larcker (1981) suggested good convergent validity with three conditions: (1) Negative for all standard items: charge amount is greater than 0.5, and reached a significant level (see Table 4); (2) The value of composite reliability (composite reliability) is greater than 0.6 or greater than 0.7 (Nunnally 1978) (see Table 1); (3) The average variance extracted volume (average variance extracted, AVE) greater than 0.5, it calculates the measured variables on latent variables, the average power variance explained, if the AVE value is increased as the higher latent variables have convergent validity (see Table 1). The constructs of the study's composite reliability (CR) values ranged from 0.80 to 0.89 (see Table 2), were higher than the threshold value of 0.7 (Chin, 1999)All constructs, the average amount of variation are mediated extraction In between 0.54 to 0.67 (see Table II), indicating that the constructs have convergent validity.

Validity is to test different variables measuring different dimensions for the differential between the degree. Measurement of each variable with the same a dimension related to other variables level, should be higher than the measured variables of different dimensions of the correlation coefficient. In order to test discriminant validity through all the latent variables measuredAVE value of the square root of diagonal values, each latent variable must be greater than the correlation coefficient (non-diagonal values), That have discriminant validity (Chin 1998). Table 4 for each dimension of the correlation coefficient between the matrix, the diagonal dimension of the following that the average amount of AVEIt also shown that two dimensions of any correlation between the number of dimensions are smaller than the observed variables measured, the AVE. Measurement model shows the dimensions of the variables to each other is indeed abnormal, the designed questionnaire has adequate discriminant validity. The hypotheses were tested by the PLS structural model of the test in the assessment of the main path coefficient and R^2 values. Representatives of the path coefficient between variables related department of intensity and direction, and the observable variables and latent variables of the causal model to do hypothesis testing, the test should have a significant, to establish or verify the theoretical model.

PLS structural model through the analysis found that mutual relations between the constructs as: SF → PU (($\beta = 0.155$, $p < 0.05$), SI → PU ($\beta = 0.007$, $p < 0.05$), SR → PU ($\beta = 0.372$, $p < 0.05$), SE → PU ($\beta = 0.243$, $p < 0.05$) positive effect on job performance, SF → PEOU (($\beta = 0.109$, $p < 0.05$), SI → PEOU ($\beta = 0.336$, $p < 0.05$), SR → PEOU ($\beta = 0.429$, $p < 0.05$), SE → PEOU ($\beta = 0.032$, $p < 0.05$) positive effect on job performance, SF → ESE (($\beta = 0.265$, $p < 0.05$), SI → ESE ($\beta = 0.226$, $p < 0.05$), SR → ESE ($\beta = 0.271$, $p < 0.05$), SE → ESE ($\beta = 0.098$, $p < 0.05$) positive effect on job performance, PU → IU ($\beta = 0.343$, $p < 0.05$), PEOU → IU ($\beta = 0.322$, $p < 0.05$), PU → ESE ($\beta = 0.086$, $p < 0.05$), PEOU → ESE ($\beta = 0.046$, $p < 0.05$), ESE → IU ($\beta = 0.238$, $p < 0.05$) were significant positive influence on job performance. PLS structural model by the results of the analysis can see that that the proposed hypotheses were supported (Figure 4).

Table 1. Reliability, average variance extracted volume.

Construct	CompositeReliability	AVE	Cronbach's alpha
SF	0.804959	0.673601	0.515479
SI	0.853932	0.661083	0.740598
SR	0.891533	0.732762	0.815031
SE	0.807732	0.583425	0.630619
PU	0.863999	0.614147	0.786227
PEOU	0.852771	0.661079	0.740639
ESE	0.827341	0.545733	0.717189
IU	0.882829	0.653737	0.824913

Table 2. Factor loadings, residuals and the factor weights.

Construct	Indicator	Mean	SD	Loading	Residual	Weight
SF	B9	3.893617	0.698882	0.8281	0.3142	0.6205
SF	B13	3.723404	0.682136	0.8133	0.3386	0.5978
SI	B14	3.829787	0.789032	0.8473	0.2821	0.4303
SI	B20	3.638298	0.919015	0.8012	0.358	0.3558
SI	B22	3.446809	0.879934	0.7893	0.377	0.4438
SR	B8	4.106383	0.758547	0.8323	0.3073	0.3929
SR	B18	3.829787	0.731857	0.8889	0.2098	0.3884
SR	B24	3.893617	0.813849	0.8458	0.2846	0.3875
SE	B10	3.914894	0.58346	0.7722	0.4038	0.4141
SE	B15	3.723404	0.713294	0.7661	0.4131	0.4203
SE	B25	3.787234	0.778409	0.753	0.433	0.4758
PU	B2	3.893617	0.667052	0.7913	0.3738	0.3031
PU	B11	3.723404	0.682136	0.7181	0.4844	0.2685
PU	B17	3.87234	0.849988	0.8158	0.3345	0.3725
PU	B27	3.765957	0.86509	0.8046	0.3526	0.3274
PEOU	B1	3.744681	0.793125	0.7067	0.5006	0.3766
PEOU	B16	3.723404	0.799514	0.8518	0.2744	0.4685
PEOU	B26	3.723404	0.826257	0.8702	0.2428	0.3847
ESE	B4	3.638298	0.735011	0.7815	0.3892	0.405
ESE	B5	4.042553	0.588197	0.6748	0.5447	0.255
ESE	B19	4.042553	0.624063	0.7445	0.4457	0.3289
ESE	B21	3.553191	0.829052	0.7502	0.4372	0.3552
IU	B3	3.468085	0.952139	0.8197	0.328	0.259
IU	B6	3.617021	0.92203	0.8314	0.3088	0.3129
IU	B12	3.617021	0.848354	0.7348	0.4601	0.2904
IU	B23	3.808511	0.924034	0.8439	0.2878	0.3723

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Table 3. Correlation matrix of latent constructs.

-	SF	SI	SR	SE	PU	PEOU	ESE	IU
SF	0.820732							
SI	0.651	0.81307						
SR	0.564	0.658	0.856015					
SE	0.672	0.717	0.614	0.763823				
PU	0.656	0.676	0.766	0.708	0.783675			
PEOU	0.591	0.712	0.731	0.609	0.725	0.813068		
ESE	0.714	0.738	0.728	0.693	0.723	0.683	0.738737	
IU	0.726	0.621	0.662	0.569	0.749	0.734	0.706	0.80854

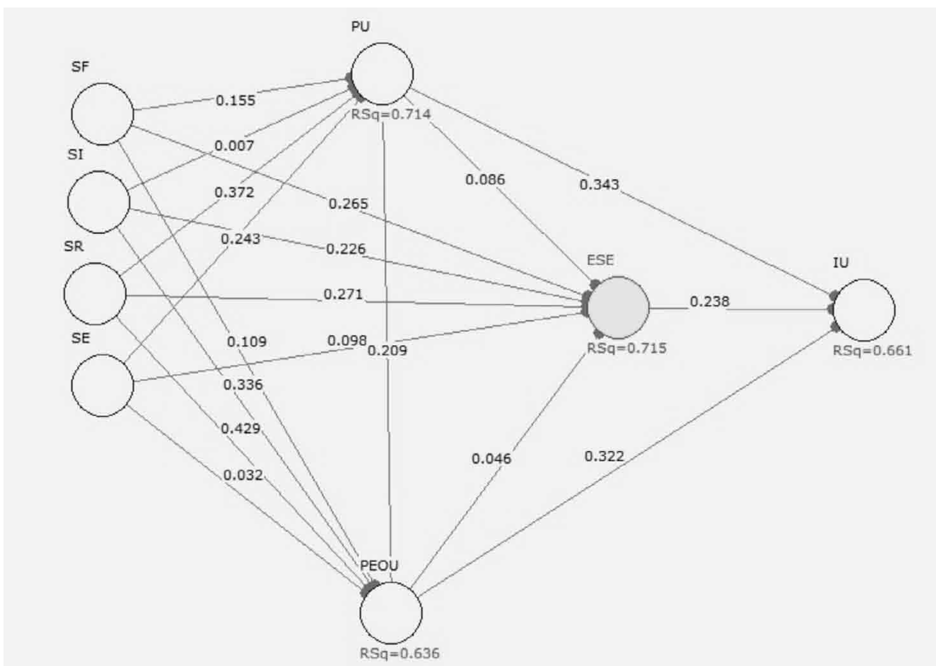

Figure 4: Results of calculation by PLS.

Table 4. Factor structure matrix and cross-loading.

Factor Structure Matrix of Loadings and Cross-Loadings								
Scale Items	SF	SI	SR	SE	PU	PEOU	ESE	IU
B9	0.8465	0.5581	0.4729	0.5047	0.5593	0.4496	0.6576	0.6053
B13	0.8314	0.5345	0.4727	0.6251	0.5417	0.5442	0.5391	0.6106
B14	0.5453	0.8661	0.5987	0.616	0.5337	0.5936	0.7047	0.4712
B20	0.5446	0.819	0.407	0.4828	0.5463	0.4877	0.4894	0.542
B22	0.5348	0.8069	0.6091	0.6674	0.6066	0.6658	0.624	0.5362
B8	0.5405	0.5507	0.8507	0.5138	0.6719	0.5871	0.7113	0.604
B18	0.4542	0.6398	0.9087	0.6147	0.6971	0.6162	0.632	0.5163
B24	0.4833	0.5366	0.8646	0.4825	0.6533	0.7227	0.5668	0.6114

Factor Structure Matrix of Loadings and Cross-Loadings								
Scale Items	**SF**	**SI**	**SR**	**SE**	**PU**	**PEOU**	**ESE**	**IU**
B10	0.5196	0.4351	0.4136	0.7893	0.4999	0.4284	0.5473	0.4428
B15	0.605	0.7592	0.4919	0.7831	0.5543	0.439	0.5041	0.4215
B25	0.4569	0.4913	0.5246	0.7697	0.5909	0.5424	0.5678	0.462
B2	0.4732	0.3635	0.544	0.4673	0.8089	0.6475	0.5686	0.6148
B11	0.4892	0.4078	0.4971	0.6258	0.7341	0.3526	0.4743	0.5032
B17	0.5697	0.6841	0.8218	0.4978	0.8339	0.7063	0.6669	0.5834
B27	0.5615	0.6681	0.56	0.6902	0.8225	0.5823	0.5867	0.6809
B1	0.4053	0.3751	0.6081	0.3023	0.562	0.7222	0.5619	0.4456
B16	0.6135	0.7129	0.6583	0.6532	0.6754	0.8708	0.6404	0.7131
B26	0.4268	0.648	0.5527	0.5199	0.5632	0.8896	0.4927	0.6404
B4	0.5461	0.5634	0.6592	0.5447	0.6232	0.7146	0.7989	0.699
B5	0.5268	0.4173	0.4088	0.3154	0.4218	0.3823	0.6898	0.3596
B19	0.5269	0.5316	0.6237	0.5884	0.6184	0.506	0.7611	0.4516
B21	0.567	0.6892	0.4735	0.6027	0.4979	0.4159	0.7669	0.5623
B3	0.5026	0.4051	0.3844	0.411	0.5346	0.5591	0.4828	0.838
B6	0.5333	0.4318	0.3896	0.3925	0.5224	0.5675	0.5833	0.8498
B12	0.6968	0.5729	0.5681	0.4552	0.664	0.5218	0.5413	0.7511
B23	0.6478	0.6102	0.7744	0.5879	0.7171	0.7373	0.6939	0.8627

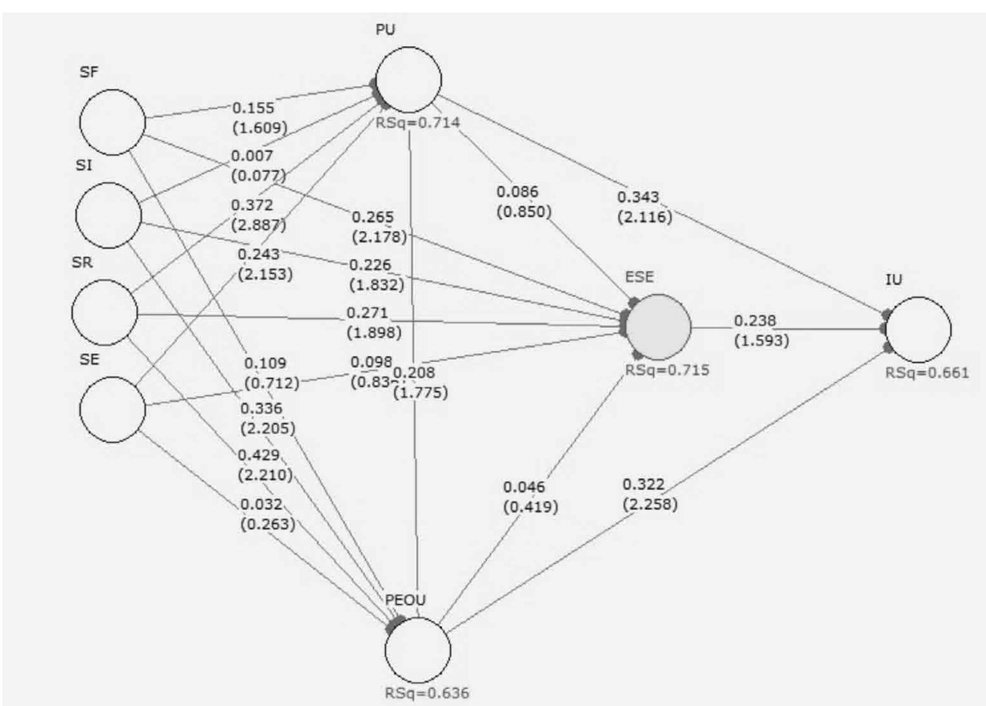

Figure 5: Calculation results of the implementation of BootStrap.

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Discussion

The main objective of this study was to test two alternative models of this study, trying to explain the use of teachers LEGO NXT system A system can be used for two different purposes: e-learning self-efficacy and intention to usethe LEGO NXT intends to use the system applicable to traditional teaching. The two alternative models differed in that one of the models reflected the TAM perspective, which posits that the effects of external variables (i.e., system and individual characteristics) on technology use are transmitted through perceived ease of use and perceived usefulness of the technology application. In contrast, the second research model posited that - for the type of e-learning system under study – system characteristics would not only influence the belief factors but would also directly impact teacher use. That is, the impact of specific system characteristics on use of the LEGO NXT system would be partially but not completely mediated by the TAM use-belief determinants.

A test of the in fit between the two models, as well as a comparison of model fit- indices and an inspection of path estimates, indicated that the partially mediated model was superior to the fully mediated model. The better performance of the partially mediated model attests to the strong impact of the system characteristics, which had some of the strongest effects in the model. For both use outcomes, system functionality had the strongest total effect, even stronger than those associated with the core determinants of TAM – perceived ease of use and perceived usefulness. In addition, system interactivity had the strongest total effect on perceived usefulness. Further, even after taking the effect of the use beliefs into account, system functionality and system interactivity directly influenced use of the e-learning The impact of the system characteristics is consistent with the influence of more general system characteristics reported in studies of other information technologies (Igbaria et al., 1995; Jackson et al., 1997) and is similar to those discussed in a study of course website acceptance (Selim, 2003). The importance of the system characteristics in influencing both the e-learning use outcomes and the use beliefs has several implications.

First, it validates the importance of attending to system characteristics when e-learning systems are developed. That is, learners who perceived that the system had more favorable characteristics not only indicated that the system was easier to use and more useful, but also reported greater intention to use the system for e-learning self efficacy and intention to use. Second, it suggests specific types of system characteristics that developers of LEGO NXT systems should target and educational institutions should ensure are present prior to implementation. For example, learners who perceived that the system had better response time and allowed for better remote access to important course content also indicated that the system was easier to use. Further, learners who indicated that the system allowed for more effective interactions between learners themselves and learner and teacher also perceived that the system would better help them learn. Thus, not only is the response time of the system important, but also the ability of the system to (a) enable effective interactions and (b) offer access to course content at the time and place of the teacher choosing play an important role in influencing teacher use.

In short, the findings about the system characteristics suggest that developers, designers, and institutional purchasers of LEGO NXT systems carefully consider the needs and values of system users and ensure that the system in question effectively meets these demands. Such compatibility between system features and user requirements has been found to enhance technology adoption in other contexts (Davis et al., 1989; Moore & Benbasat, 1991) and confirms recent findings for e-learning systems (Carswell & Venkatesh, 2002). In addition, the findings about other determinants in the model have several implications. First, this study corroborates the well-established importance of the belief constructs. That is, the perceived ease of use of the system influenced the perceived usefulness of the system, and both belief constructs were important determinants of LEGO NXT system use. As aLEGO NXT system should be perceived as both easy to use and useful to maximize use of the system, the faculty, when feasible, should demonstrate use of the technology and/or provide instructional materials that would ease teacher learning of the technology.

Second, learners who indicated that they intend to use the system for supplementary learning also indicated that they intented to use the system. This finding suggests that learner familiarity with an e-learning system may be an important determinant of user adoption of that system. In practice, this suggests that educators and corporate trainers who plan to use e-learning education consider implementing such technology in a traditional class first, if practical, as a supplementary course tool. This initial exposure to e-learning may lead to greater learner acceptance of the technology when it is used as a e-learning education method.

Despite the careful attention to study methodology, improvements can be made in future studies in the following areas. First, the study data were self-reported, which raises the possibility of common method variance, which may inflate the true associations between variables. Thus, whenever possible, researchers should employ more direct measurements. Second, better measures of system and user attributes should be developed. This is because we had to delete several items from these scales to attain good psychometric properties. Greater attention to measuring these constructs within the e-learning context will help ensure more reliable and valid scores and provide for more rigorous tests of the research models. Third, a logical follow-up to this study is to use direct use measurement instead of intent to use as employed in this study. While use intent is commonly measured in such studies and is highly predictive of actual use, system developers and institutional purchasers are undoubtedly also interested in actual use and its determinants.

Fourth, while our sample was representative of those who need or wish to use LEGO NXT systems and did vary in age, gender, and type of student (i.e., traditional and non-traditional), the sample characteristics observed here may not be of interest to some readers, who may wish to examine, for example, whether the findings obtained here hold for learners who have very little or much more computer experience. Finally, the scope of this study did not extend to examining the effectiveness of e-learning systems in promoting learning and whether such systems can provide as good as or better learning experience than provided by traditional classes. Well-designed experimental studies can shed light on this issue.

Conclusions

Based on established theory and empirical research, this study proposed and validated a research model that demonstrated the importance of specific LEGO NXT system characteristics. As such, this study represents an initial step in (a) highlighting specific system factors that appear to promote system use and (b) identifying how such system factors impact use of a LEGO NXT system for both e-learning self efficacy and intention to use purposes. Given the increasing use of LEGO NXT systems, a better understanding and implementation of effective system characteristics will enhance the use and educational value of such systems. LEGO NXT system, proved by this experiment have assisted in the teaching function. Ifthe teacher had used e-learning based on experience itwould be easier to promote suchteaching methods. It is suggested that appropriate scheduling of teacher training time and actual use of course material would be conducive for the promotion of the use of robots in education.

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References

Agarwal, R., & Prasad, J. (1999). Are individual differences germane to the acceptance of new information technologies? *Decision Sciences, 30*, 361–391.

Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall.

Alavi, M. (1994). Computer-mediated collaborative learning: an empirical evaluation. *MIS Quarterly, 18*, 159.

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Anderson, C., Dankens, A., & Julian, E. H. (2000). Worldwide and US corporate IT education and training services: forecast and analysis 1999-2004 (International Data Corporation Report No. W22154), 2000, Abstract retrieved October 30, 2001.
Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: a review and recommended two step approach. *Psychological Bulletin, 103*, 411–423.
Bailey, J. E., & Pearson, S. W. (1983). Development of a tool for measuring and analyzing computer user satisfaction. *Management Science, 29*, 530–545.
Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review, 84*, 191–215.
Bollen, B. M. (1989). Structural equations with latent variables. New York, NY: Wiley–Interscience.
Byrne, K. A. (1998). Structural equations modeling with LISREL, PRELIS, and SIMPLIS: Basic concepts, applications,and programming. Mahwah, NJ: Lawrence Erlbaum Associates.
Carswell, A. D., & Venkatesh, V. (2002). Learner outcomes in an asynchronous distance education environment. *International Journal of Human–Computer Studies, 56*, 475–494.
Chau, P. Y. K. (1996). An empirical assessment of a modified technology acceptance model. *Journal of Management Information Systems, 13*, 185–204.
Chen, L. D., Gillenson, M. L., & Sherrell, D. L. (2002). Enticing online consumers: an extended technology acceptance perspective. *Information and Management, 39*, 705–719.
Chin, W. W., & Todd, P. A. (1995). On the use, usefulness, and ease of use of structural equation modeling in MIS research. *MIS Quarterly, 19*, 237–246.
Compeau, D. R., & Higgins, C. A. (1995a). Application of social cognitive theory to training for computer skills. *Information Systems Research, 6*, 118–143.
Compeau, D. R., & Higgins, C. A. (1995b). Computer self-efficacy: development of a measure and initial test. *MIS Quarterly, 19*, 189–211.
Compeau, D. R., Higgins, C. A., & Huff, S. (1999). Social cognitive theory and individual reactions to computing technology: a longitudinal study. *MIS Quarterly, 23*, 145–158.
Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly, 13*, 319–339.
Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts. *International Journal of Man–Machine Studies, 38*, 475–487.
Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management Science, 35*, 982–1003.
Fishbein, M., & Ajzen, I. (1975). Belief, attitude, intention and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley.
Fornell, C. R., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*, 39–50.
Gefen, D., & Straub, D. W. (2000). The relative importance of perceived ease of use in IS adoption:a study of E-Commerce adoption. *Journal of the Association for Information System, 1* (8), 1–28.
Gefen, D., Straub, D. W., & Boudreau, M. (2000). Structural equation modeling and regression: Guidelines for research practice. *Communications of the Association for Information Systems, 4*, 1–79..
Gubernick, L., & Ebeling, A. (1997). I got my degree through e-mail. Forbes, June 16.
Heinich, R., Molenda, M., Russell, J. D., & Smaldino, S. E. (1996). Instructional media and technologies for learning (5th ed.). Englewood Cliffs, NJ: Prentice-Hall.
Igbaria, M., Guimaraes, T., & Davis, G. B. (1995). Testing the determinants of microcomputer usage via a structural equation model. *Journal of Management Information Systems, 11*(4), 87–114.
Igbaria, M., & Zinatelli, N. (1997). Personal computing acceptance factors in small firms: a structural equation model. *MIS Quarterly, 2*, 279–306.
Jackson, C. M., Chow, S., & Leitch, R. A. (1997). Toward an understanding of the behavioral intention to use an information system. *Decision Sciences, 2*, 357–389.
Joreskog, K. G., & Sorbom, D. (1993). LISREL8: Structural equation modeling with the SIMPLIS command language. Hillsdale, NJ: Erlbaum.
Kelloway, E. K. (1998). Using LISREL for structural equation modeling: A researcher's guide. Thousand Oaks, CA:Sage.
Kerka, S. (1999). Distance learning, the Internet, and the World Wide Web. ERIC Digest. (ERIC Document Reproduction Service No. ED 395214).
Kline, R. B. (1998). Principles and practice of structural equation modeling. New York, NY: The Guilford Press.
Lim, C. K. (2000). Computer self-efficacy, academic self-concept and other factors as predictors of satisfaction and future participation of adult learners in Web-based distance education. *Dissertation Abstracts International, 61*, 02A (UMI No. 9962612).
Lucas, H. C., & Spitler, V. K. (1999). Technology use and performance: a field study of broker workstations. *Decision Sciences, 30*, 291–311.

MacCallum, R. C. (1986). Specification searches in covariance structure modelling. *Psychological Bulletin, 101*,107–120.
Mathieson, K. (1991). Predicting user intentions: comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research, 2*, 173–191.
Moore, G. C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research, 2*, 192–222.
Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric theory (3rd ed.). New York, NY: McGraw-Hill.
Palloff, R. M., & Pratt, K. (1999). Building learning communities in cyberspace: Effective strategies for the online classroom. San Francisco, CA: Jossey-Bass Publishers.
Ruth, C. J. (2000). Applying a modified technology acceptance model to determine factors affecting behavioral Intentions to adopt electronic shopping on the World Wide Web: a structural equation modeling approach. *Dissertation Abstracts International, 61*, 03A. (UMI No. 9966196).
Seels, B., & Glasgow, Z. (1998). Making instructional design decisions. Englewood Cliffs, NJ: Educational Technology Publications.
Segars, A. H. (1997). Assessing the unidimensionality of measurement: a paradigm and illustration within the context of information systems research. *Omega, 25*, 107–121.
Segars, A. H., & Grover, V. (1993). Re-examining perceived ease of use and usefulness: a confirmatory factor analysis. *MIS Quarterly, 17*, 517–525.
Selim, H. M. (2003). An empirical investigation of student acceptance of course websites. *Computers and Education, 40,* 343–360.
Spooner, F., Jordan, L., Algozzine, B., & Spooner, M. (1999). Student ratings of instruction in distance learning and on-campus classes. *Journal of Educational Research, 92*, 132–140.
Storck, J., & Sproull, L. (1995). Through a glass darkly: what do people learn in videoconferences?. *Human Communication Research, 22*, 197–219.
Subramanian, G. H. (1994). A replication of perceived usefulness and perceived ease-of-use measurement. *Decision Sciences, 25*, 863–874.
Szajna, B. (1996). Empirical evaluation of the revised technology acceptance model. *Management Science, 42*, 85–92.
Tan, M., & Teo, T. S. H. (2000). Factors influencing the adoption of Internet banking. *Journal of the Association for Information System, 1*(1).
Tate, R. (1998). An introduction to modeling outcomes in the behavioral and social sciences (2nd ed.). Edina, MN: Burgess.
Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: a test of competing models. *Information Systems Research, 6*, 144–176. The survey of distance learning programs in higher education. (1999). New York: Primary Research Group, Inc.

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Bih-Yaw Shih	Ph.D., Director, Department and Graduate School of Computer Science, National Pingtung University of Education, No. 4-18, Ming Shen Rd., Pingtung 90003, Taiwan.
Tsung-Hao Chen	Ph.D., Director, Department of Business Administration, Shu-Te University, Yen Chau Dist., Kaohsiung City 82445, Taiwan.
Yevvon Yi-Chi Chang	Ph.D., Assistant Professor in the Department of Hospitality Management, Tunghai University, No. 1727, Taiwan Blvd. Sec. 4, Taichung City, Taiwan
Wen-Yaw Chung	Department and Graduate School of Computer Science, National Pingtung University of Education
Chen-Yuan Chen	Ph.D., Professor with Department of Computer Science, Professor with Graduate School of Computer Science, National Pingtung University of Education, No. 4-18, Ming Shen Rd. Pingtung 90003, Taiwan. E-mail: cyc@mail.npue.edu.tw