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The influence of system characteristics on e-learning use [☆]

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Abstract

The benefits of an e-learning system will not be maximized unless learners use the system. This study proposed and tested alternative models that seek to explain student intention to use an e-learning system when the system is used as a supplementary learning tool within a traditional class or a stand-alone distance education method. The models integrated determinants from the well-established technology acceptance model as well as system and participant characteristics cited in the research literature. Following a demonstration and use phase of the e-learning system, data were collected from 259 college students. Structural equation modeling provided better support for a model that hypothesized stronger effects of system characteristics on e-learning system use. Implications for both researchers and practitioners are discussed.

Keywords: Adult learning; Computer-mediated communication; Distance education and telelearning; E-learning; Web-based learning

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1. Introduction

E-learning systems have become popular tools for teaching and learning. Advanced e-learning systems, such as WebCT (www.webct.com) and Cyber University of NSYSU (cu.nsysu.edu.tw)

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have been developed recently that integrate a variety of functions. For example, these systems can be used to integrate instructional material (via audio, video, and text), e-mail, live chat sessions, online discussions, forums, quizzes and assignments, and the World Wide Web. With this kind of system, instructional delivery and communication between instructors and students can be conducted at the same time (synchronously) or at different times (asynchronously). Such systems provide a variety of instructional aids and communication methods, and offer learners great flexibility as to the time and place of instruction. As a result, these e-learning systems may better accommodate the needs of learners who are geographically dispersed and have conflicting schedules.

Given these advantages, it is not surprising that business and educational institutions are making substantial investments in e-learning systems. For example, in 2000, investment in the e-learning market in the United States was $2.2 billion according to a report from the International Data Corporation, with one estimate indicating that this investment will exceed $23 billion in 2004 (Anderson, Dankens, & Julian, 2000). Postsecondary educational institutions have also experienced dramatic growth in the use of e-learning systems, with some institutions offering entire degree programs via distance education. As an example of this growth, in 1993, Peterson's College Guide indicated that 93 colleges offered on-line education, and by 1997, this number rose to nearly 800 (Gubernick & Ebeling, 1997). Further, in 2001, WebCT reported that over 2200 postsecondary institutions were using its products to offer on-line education.

Whereas business and educational institutions have invested substantial resources in e-learning systems, the benefits of such systems will not be realized if learners fail to use the system. For example, according to The survey of distance learning programs in higher education (1999), 16% of students enrolled in courses using distance learning in 1998 failed to complete the courses. Why some students use e-learning systems whereas others do not is the problem that motivated this study. Such information is of obvious benefit to those designing and purchasing web-based e-learning systems and may suggest actions that can be taken to promote greater use of the system.

In addition, although e-learning systems are increasingly being used, we found little theory-driven research examining the determinants associated with student use of an e-learning system when that system is used to provide a (a) supplementary learning tool for a traditional class or (b) stand-alone distance education course offering. Equally important, we found virtually no research on e-learning systems that examined the impact of specific system characteristics that are thought to be critical for such systems. As noted by Carswell and Venkatesh (2002), much of the research on e-learning 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 of teachers or learners. Further, studies examining the determinants associated with e-learning use have not examined specific system characteristics that are the focus of this study (Carswell & Venkatesh) or have not tested models which hypothesize that such characteristics are determinants of e-learning use (Selim, 2003). By examining the impact of specific system characteristics, we hope to expand the knowledge base on important determinants of e-learning use.

2. Theoretical model

As noted by Chen, Gillenson, and Sherrell (2002), research on technology adoption often produces conflicting findings. They noted that one potential reason for this inconsistency might be the focus on a single theory that excludes consideration of other possibly important determinants. To avoid that problem, we reviewed the technology adoption literature, identified the major theoretical perspectives and empirical research findings, and developed a model that integrates key constructs involved in e-learning use. The constructs of system and participant characteristics, perceived ease of use and usefulness of the system, and 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 e-learning and general information technology adoption.

2.1. TRA and TAM

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 Fig. 1, modified TRA to predict computer adoption by replacing the belief determinants of TRA with two key beliefs: perceived usefulness (the belief that use of a particular technology will improve one's performance) and perceived ease of use (the belief that using technology will be effortless). Further, in the model of Davis et al., perceived ease of use directly affects perceived usefulness, with both of the use beliefs affecting computer technology adoption. Davis et al. 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" (p. 173). 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.

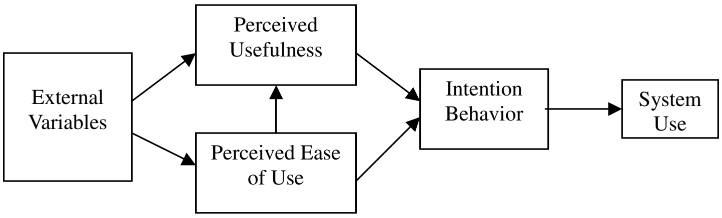

Fig. 1. The technology acceptance model.

2.2. External variables

2.2.1. System characteristics

Since TAM was proposed by Davis et al. (1989), system characteristics have been posited to directly affect user beliefs. Subsequent research has validated the role of system characteristics in predicting user beliefs and technology acceptance in other contexts (Davis, 1993; Igbaria, Guimaraes, & Davis, 1995; Lucas & Spitler, 1999; Ruth, 2000; Venkatesh & Davis, 1996). A variety of general information technology system characteristics have been proposed and examined. For this study, we selected three characteristics that are considered to be critical for the development of e-learning systems (Kerka, 1999; Palloff & Pratt, 1999; Seels & Glasgow, 1998; Selim, 2003).

The first of the system characteristics, functionality, refers to the perceived ability of an e-learning system to provide flexible access to instructional and assessment media. Such media, for example, allow students to access course content, turn in homework assignments, and complete tests and quizzes online. According to Seels and Glasgow (1998), e-learning systems perform these functions by integrating various types of media (audio, video, text) that are within the control of the system software, the learner, or both. Further, the e-learning system being studied was also designed to allow access to the system at remote locations, providing anytime anywhere access to course content, which is critical for promoting the use of e-learning systems (Selim, 2003).

In addition to providing access to instructional and assessment media, effective e-learning systems must provide for interactivity, which is the second system characteristic examined in this study. As stated by Palloff and Pratt (1999), for e-learning systems, the "key to the learning process are the interactions among students themselves, the interactions between faculty and students, and the collaboration in learning that results from these interactions" (p. 5). The e-learning system being studied allows for interactions among teachers and students, and students themselves. The system employs commonly used tools to provide for this interactivity, such as e-mail, bulletin board, and a chat room.

Finally, no matter how well the e-learning system integrates various media and allows for interactivity, the system will not be perceived as useful or easy to use if it has poor response time, which is the third system characteristic we examine. Kerka (1999) indicated that the potential disadvantages of an e-learning system are limited bandwidth (the capacity of the communication links) and slow modem, which can hamper the delivery of sound, video and graphics. Similar to the definition in Bailey and Pearson (1983), response time in this study is defined as the degree to which a learner perceives that the response from the e-learning system is fast, consistent, and reasonable.

2.2.2. User characteristics

A second set of external variables included in this study is individual attributes. We included individual characteristics in our study for two reasons. First, it seems reasonable to assume that learners may form different perceptions of an e-learning 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. Second, in empirical studies, user characteristics have been found to impact behavioral intention to use technology (Davis et al., 1989). In a distance learning application, learner success has been found to depend on (a) the ability to cope with technical difficulty and (b) technical skills in computer operation and Internet navigation (Kerka, 1999). Therefore, in this study, self-efficacy and Internet experience are posited as two factors that are expected to influence e-learning 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 e-learning 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), and 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 Web-based distance education.

The second individual attribute included in this study is Internet experience. Based on related research, we believe that a learner's prior technical skills in using the Internet may affect e-learning 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 distance education (Kerka, 1999).

2.3. Usefulness constructs

As mentioned above, Davis et al. (1989) posited 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.

2.4. 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 e-learning systems by postsecondary institutions, it seems reasonable that those making the investment decision would want to know if students intend to use such systems both for supplementary learning and for distance education courses along with the factors that predict such intent.

As such, two behavioral intentions to use the e-learning 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 (e.g., e-mail, word processing) 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 e-commerce (Gefen & Straub, 2000). Similarly, in this study, to reflect two specific purposes of the e-learning system under study, behavioral intention is categorized into two constructs: use for supplementary classroom learning and use for distance education.

3. Research models

We tested two research models in this study. Fig. 2 shows the first of these models, which integrates the key belief dimensions of TAM with antecedents found to be important predictors of the use beliefs in other technology adoption studies. This model posits that three system characteristics (system functionality, interactivity, and response) and two user attributes (self-efficacy and internet experience) 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). Also taken from TAM, perceived ease of use will directly affect perceived usefulness, and both of the use beliefs will impact the use outcomes. Finally, this model posits that use of the e-learning system for supplementary learning purposes will directly affect use of the system for distance education purposes. Because the functionalities needed in the e-learning system for supplementary learning are a subset of those needed for distance education, we consider use of the system for supplementary learning to be logically prerequisite for use of the system for distance education purposes, such that students who find the system useful for supplementary learning will tend to find it useful for distance education whereas those who do not believe the system is useful for supplementary learning will not likely find it useful for distance education. Note that this expected positive relationship requires that the e-learning system in question has features specifically designed to support both supplementary learning and distance 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 use outcomes than this model implies. This leads us to consider a second research model for this study.

Fig. 3 presents the second research model we tested in this study. This model differs from the previous model in two ways. First, system functionality is hypothesized to have a direct effect on use of the e-learning system for supplementary classroom learning purposes. Specifically, learners who perceive that the e-learning 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 supplementary learning. Second, system functionality and system interactivity are hypothesized to have direct effects on use of the

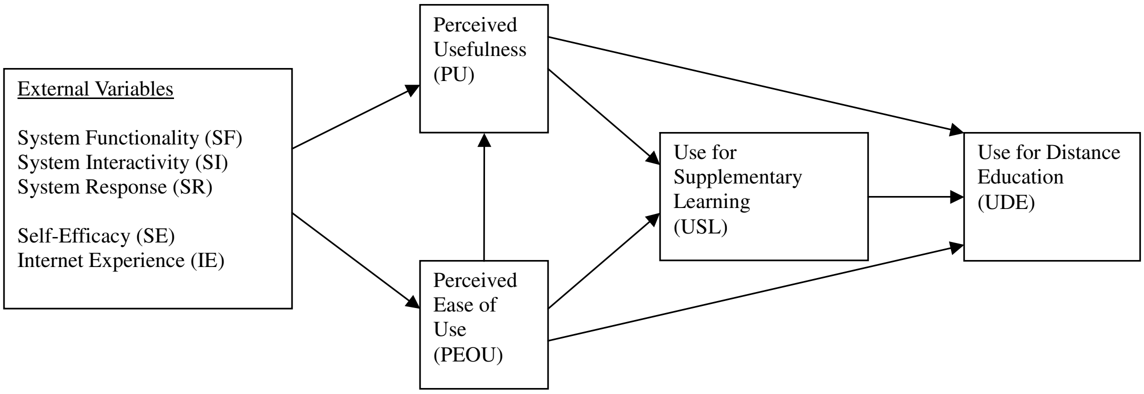

Fig. 2. The fully mediated model for e-learning use.

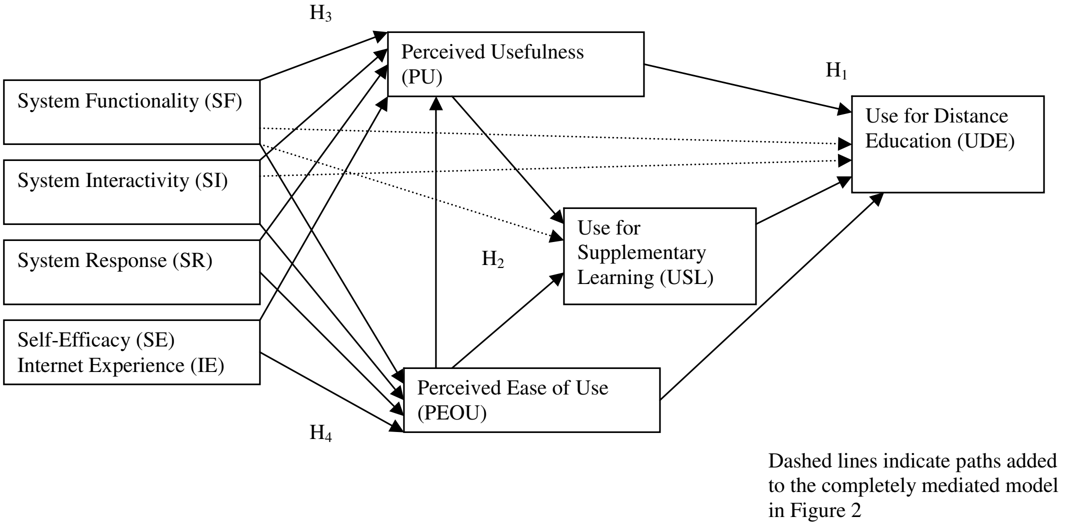

Fig. 3. The partially mediated model for e-learning use.

e-learning system for distance education 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 e-learning system for distance education. The primary reason, we believe, for these effects is that such a system will be perceived as being compatible with learner (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 an e-learning system for distance education purposes (Carswell & Venkatesh, 2002).

Further, we note that the second 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). Because the second research model posits that specific system characteristics will impact the use outcomes, even after taking into account their effects on the belief constructs, we refer to the second research model as the partially mediated model.

Accordingly, the research model in Fig. 3 involves testing four sets of hypotheses. The general and specific study hypotheses are as follows:

H_1. Use of the e-learning system for distance education purposes is positively influenced by each of the constructs in the model.

Specifically, use for distance education is positively affected by use for supplementary learning (H_{1a}), perceived usefulness (H_{1b}), perceived ease of use (H_{1c}), system functionality (H_{1d}), and system interactivity (H_{1e}). Further, system response (H_{1f}), self-efficacy (H_{1g}), and Internet experience (H_{1h}) will positively affect use for distance education indirectly, that is, through other determinants in the model.

H_2. Use of the e-learning system for supplementary classroom learning is positively affected by the use beliefs, system characteristics, and individual attributes.

Specifically, use for supplementary learning is positively influenced by perceived usefulness (H_{2a}), perceived ease of use (H_{2b}), and system functionality (H_{2c}). In addition, system interactivity (H_{2d}), system response (H_{2e}), self-efficacy (H_{2f}), and internet experience (H_{2g}) will positively and indirectly impact use for supplementary learning via other constructs in the model.

H_3. Perceived usefulness of the e-learning 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 (H_{3a}), the system factors of functionality (H_{3b}), interactivity (H_{3c}), and response (H_{3d}), and the user characteristics of self-efficacy (H_{3e}) and Internet experience (H_{3f}).

H_4. Perceived ease of use of the e-learning 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 (H_{4a}), interactivity (H_{4b}), and response (H_{4c}), and the user attributes of self-efficacy (H_{4d}) and Internet experience (H_{4e}).

4. Methods

4.1. Participants and procedure

Participants in the study consisted of postsecondary students who had completed basic computer literacy classes at a college in Taiwan and were currently enrolled in another computer course. Participation in this study was voluntary, and 259 of the 321 students (81%) who were enrolled in these classes agreed to take part in the study. Table 1 provides the demographic profile of the sample. Although the students attended a single university, there was some considerable variation in the sample. For example, the ages of the participants ranged from 18 to 32, and somewhat more than half of the participants were females. In addition, participants had several majors, mostly in science fields. Finally, a little more than half of the students were traditional full-time students (i.e., higher education) and the remaining students were non-traditional part-time students (continuing education), who typically worked during the day and attended classes during the evening. Given the students' computer literacy and that the sample consisted of both traditional and "non-traditional" students, we believe these students, as a whole, represent those who would be interested in using e-learning systems for supplementary learning, distance education, or both.

Students were given a demonstration of the e-learning system of Cyber University at National Sun Yat-sen University in Taiwan. In a computer lab, a system trainer provided a 40-minute live demonstration of the system to students, following which they were given 30 minutes to practice individually with the system and ask questions. The time provided to students to become familiar with the e-learning system is consistent with studies that have tested TAM in a variety of technology applications (e.g., Davis, 1989; Szajna, 1996). The demonstration and

Table 1
Demographic attributes of the respondents

Variable	Number	%
Gender		
Male	108	41.7
Female	151	58.3
Educational division		
Higher education	143	55.2
Continuing education	116	44.8
Academic major		
MIS	76	29.3
Pharmacy	69	26.6
Healthcare administration	81	31.3
Others (industrial hygiene, nursing)	33	12.7
Degree program		
Associate	116	44.8
Post associate	102	39.4
Baccalaureate	41	15.8

practice phases were designed to provide students with an understanding of the capabilities of the e-learning system and show how the major functions could be accessed and used. The demonstration included reviewing the key features of the system, showing, for example, how students can access lecture materials in video, audio, and text format, take chapter and unit tests through the system, read and post articles in forums, participate in online chat or group discussions, and use email to turn in assignments. During the practice phase, each student had access to a computer and used a guest account that provided hands-on access to nearly all of the above-mentioned functionalities. Immediately after the practice phase, the survey instrument was administered to each student.

4.2. Instrument

We developed a survey instrument to measure constructs primarily by adapting previously validated instruments to fit the e-learning system context (Bailey & Pearson, 1983; Chau, 1996; Compeau & Higgins, 1995b; Davis, 1989; Gefen & Straub, 2000; Tan & Teo, 2000; Venkatesh & Davis, 1996). However, for the system characteristics, we were not able to locate previously validated items that matched our constructs of interest. Therefore, we developed items based on features considered to be important for e-learning systems as cited in the literature above. Appendix A shows the reference used for each scale and the 41 items that appeared on the instrument. The study instrument used a seven-point Likert scale to assess learners' agreement or disagreement for the items measuring perceived usefulness, ease of use, both use outcomes, and each system characteristic. A similar seven-point Likert scale was used to measure learners' confidence level in using the technology as well as the extent to which the learner had previously used the Internet.

Table 2
Descriptive statistics for study constructs

Construct	*M*	SD
System functionality	5.70	1.00
System interactivity	4.87	1.11
System response	4.80	1.00
Self-efficacy	4.71	1.15
Internet experience	5.11	1.28
Perceived ease of use	5.04	1.07
Perceived usefulness	4.93	0.98
Use for supplementary learning	5.11	1.13
Use for distance education	5.20	1.21

Because we developed some items and adapted other items to fit the e-learning context, we pretested the instrument on a small sample of college students. Pretest feedback led to minor wording changes in some of the items. In addition, we pilot tested the instrument on a sample of 77 students. As the scale reliabilities for this pilot sample, as measured by Cronbach α, ranged from .83 to .96, we made no further changes in these items. A more rigorous evaluation of this instrument for the entire sample is provided below. Table 2 shows descriptive statistics for each of the constructs in the research models. As shown in Table 2, while learner perceptions varied, students generally had favorable perceptions of the e-learning system characteristics (especially system functionality), had internet experience and were generally confident in using the system, expressed generally positive views of the ease of use and usefulness of the system, and intended to use the system for supplementary learning and distance education purposes.

4.3. Data analysis

We tested the measurement and research models by applying a structural equation modeling (SEM) approach, using the computer software program LISREL 8.30 (Joreskog & Sorbom, 1993). Various minimum sample sizes for the SEM approach have been recommended. For example, Bollen (1989) suggested a minimum sample size of 100, whereas Anderson and Gerbing (1988) recommended a minimum sample size of 200. Gefen, Straub, and Boudreau (2000) reported that the average sample size for MIS studies using LISREL was 249 (minimum 41, maximum 451). Therefore, the sample size of 259 in this study was considered adequate. This study used maximum likelihood estimation to obtain estimates of model parameters, and an alpha level of .05 was used for all statistical tests.

As recommended for structural equation modeling applications (Kelloway, 1998; Kline, 1998), we used a variety of indices to evaluate model fit. The seven fit indices used and values indicating acceptable model fit include: (a) the ratio of the χ^2 statistic to its degrees of freedom, with values of less than 3 indicating acceptable fit; (b) root mean squared error of approximation (RMSEA), with values below .08 representing acceptable fit; (c) standardized root mean squared residual (SRMR), with values less than .05 indicating a good fit; (d) goodness of fit index (GFI), with values exceeding .9 indicating good fit; (e) adjusted GFI (AGFI), with values exceeding .8 indicating acceptable fit; (f) normed fit index (NFI), with values of .9 or larger representing acceptable fit; and (g) comparative fit index (CFI), with values exceeding .9 indicating acceptable fit (Chin & Todd, 1995; Kelloway, 1998; Kline, 1998; Segars & Grover, 1993; Tate, 1998). When these indicators suggest inadequate model fit, LISREL provides standardized residuals and modification indices to help identify specific areas in the model that may be responsible for the lack of fit.

In evaluating the adequacy of the measurement model, we also examined indicators of reliability and validity. In assessing scale reliability, we followed the suggestions of Fornell and Larcker (1981) and computed the composite reliability, with a value of .70 or higher considered evidence of adequate reliability (Nunnally & Bernstein, 1994). Convergent validity was assessed by examining the factor loadings and their statistical tests as well as computing the average variance extracted. A factor loading equal to or greater than .707 was used to identify if a given item was strongly related to its construct (Gefen et al., 2000). This value is used because it indicates that the construct accounts for at least 50% of the variation in the scores for a given item. For the average variance extracted, which reflects the overall proportion of indicator variance that is attributable to the underlying construct, we used a value of .50 or above to assess adequate convergent validity (Segars, 1997). Discriminant validity, referring to the distinctiveness of constructs, is present when the associations between indicators measuring different factors are not as strong as the associations among indicators that measure a given factor. The average variance extracted can be used to assess discriminant validity. If the square root of the average variance extracted, which reflects the associations among indicators measuring the same construct, exceeds the correlations between a given construct and others in the model, this suggests that a construct is more strongly correlated with its indicators than with other model constructs (Fornell & Larcker).

In evaluating the research models, we used a χ^2 test for the difference in fit to determine which of the two research models provided better fit to the data. This test is appropriate in this situation because the path model in Fig. 2 is nested within the model in Fig. 3 (Kelloway, 1998; Kline, 1998). That is, the completely mediated model (i.e., Fig. 2) can be obtained by simply constraining to a value of zero each of the three paths that were added to that model to obtain the partially mediated model shown in Fig. 3. If none of the additional paths are important, the two models will have similar fit, and, accordingly, the more parsimonious model (i.e., the completely mediated) is preferred. On the other hand, if one or more of the added paths are important, the partially mediated model will provide improved fit to the data and is therefore a better model. We also examined the fit indices for the two models as well as the path estimates and statistical tests of these additional effects. We note that the a priori specification and subsequent testing of plausible alternative models is considered good practice in structural equation modeling applications (Kelloway, 1998).

For the model better supported by the data, we also examined the standardized direct, indirect, and total effects associated with each determinant. A coefficient linking one construct to another in the path model represents the direct effect of a determinant on an endogenous variable. An indirect effect represents the impact a determinant has on an outcome through its effect on other constructs or intervening variables in the model. Indirect effects are computed as the product of direct effects linking the determinant to the outcome. When more than one indirect path was present, we computed the total indirect effect, which is the sum of a determinant's indirect effects on an outcome. Finally, the total effect a determinant has on a given outcome is the sum of the respective direct effect and indirect effects. We also examined *t* tests for each of these effects (Kline, 1998).

5. Results

5.1. Measurement model

Confirmatory factor analysis was used to evaluate the hypothesized measurement model. The results for the initial measurement model, as shown in Table 3, indicated poor model fit, as 5 of the 7 model fit indicators suggested inadequate fit. Examining LISREL output indicated that several items had large standardized residuals (greater than 3.0). In addition, inspection of the modification indices suggested that some of these items might load on multiple factors. Following established data analysis practices (Anderson & Gerbing, 1988; Byrne, 1998; MacCallum, 1986; Segars, 1997), we deleted problematic items one at a time, and reevaluated the measurement model. As a result, 17 of the 41 items were removed from the analysis.

To assess the influence of item deletion on content validity, we examined the items that remained for each construct. Content validity appeared to be adequate for the following reasons. First, no items were deleted for three of the nine constructs. Further, even after item deletions, each construct was measured by at least two items. Second, the items remaining for two of the constructs were the same or similar to the items used by other researchers to measure these constructs. Specifically, after item deletions, five items were used to measure perceived usefulness. Subramanian (1994) used only three items (i.e., PU3 to PU5) to measure the same construct. For perceived ease of use, after deleting items, we used the same three items (i.e., PEOU1, PEOU5, and PEOU6) as used by Segars and Grover (1993) to measure this construct. Finally, for the remaining four constructs, examining the items that remained after deletion suggested that key aspects of these constructs were still being measured.

The revised measurement model exhibited good fit and excellent psychometric properties. As shown in Table 3, all seven of the model fit indicators suggested good fit. As shown in Table 4, each item was strongly related to its respective factor, as the factor loadings ranged from .763 to .945, and each loading was statistically significant (except for the first item of each factor which was fixed to 1.0 and, therefore, was not tested). The values for the average variance extracted ranged from .613 to .885, suggesting that each construct was strongly related to the set of respective indicators. Further, the composite reliabilities ranged from .826 to .939, all of which suggested

Table 3
Measurement model fit statistics

Model	χ^2	df	χ^2/df $< 3.0^a$	RMSEA $< .08^a$	SRMR $< .05^a$	GFI $> .90^a$	AGFI $> .80^a$	NFI $> .90^a$	CFI $> .90^a$
Initial	1807.30^*	743	2.432	.080	.069	.730	.687	.804	.873
Revised	300.08^*	216	1.389	.036	.029	.915	.882	.940	.982

[a] Represents the range indicating acceptable fit.

[*] $p < .05$.

Table 4
Results for the revised measurement model

Factor	Item	Factor loading (>.707)[a]	Variance extracted (>.50)[a]	Composite reliability (>.70)[a]
SF	SF2	.912[b]	.712	.830
	SF3	.769*		
SI	SI1	.929[b]	.832	.908
	SI2	.895*		
SR	SR1	.825[b]	.812	.928
	SR2	.938*		
	SR3	.936*		
SE	SE1	.885[b]	.835	.910
	SE2	.942*		
IE	IE1	.763[b]	.613	.826
	IE2	.805*		
	IE3	.781*		
PEOU	PEOU1	.820[b]	.706	.878
	PEOU5	.850*		
	PEOU6	.851*		
PU	PU1	.788[b]	.659	.906
	PU2	.861*		
	PU3	.799*		
	PU4	.779*		
	PU5	.830*		
USL	USL1	.875[b]	.802	.890
	USL2	.916*		
UDE	UDE1	.936[b]	.885	.939
	UDE2	.945*		

Note. SF: system functionality; SI: system interactivity; SR: system response; SE: self-efficacy; IE: Internet experience; PEOU: perceived ease of use; PU: perceived usefulness; USL: use for supplementary learning, UDE: use for distance education.

[a] Represents the range indicating acceptable reliability or validity.

[b] Indicates a loading that was not tested, as its value was fixed.

* $p < .05$.

good score reliability. Finally, the measurement model exhibited adequate discriminant validity. As shown in Table 5, the correlations between factors, which ranged from .352 to .751, were smaller than the corresponding square root of the average variance extracted, which ranged from .783 to .941. Thus, the factors were more strongly related to their respective indicators than to other factors in the model. As all measures of model adequacy suggested a good fitting measurement model, we used this revised model to measure the constructs when evaluating the research models. [1]

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[1] We also administered this final set of items to another sample of 298 students enrolled at this school. These students received a demonstration of the e-learning system but did not have a hands-on practice session. For this second sample, all model fit indicators also exhibited good fit, providing further support for this final measurement model.

Table 5
Discriminant validity for the revised measurement model

Construct	1	2	3	4	5	6	7	8	9
1. System functionality	.844								
2. System interactivity	.485	.912							
3. System response	.516	.699	.901						
4. Self-efficacy	.535	.491	.490	.914					
5. Internet experience	.420	.352	.441	.605	.783				
6. Perceived ease of use	.579	.584	.640	.661	.525	.840			
7. Perceived usefulness	.470	.621	.584	.407	.380	.573	.812		
8. Use for supplementary learning	.639	.544	.556	.500	.418	.673	.680	.896	
9. Use for distance education	.656	.589	.556	.489	.396	.622	.624	.751	.941

Note. Diagonals represent the square root of the average variance extracted, and the other matrix entries are the factor correlations.

Table 6
Fit indices for the fully and partially mediated models

Model	χ^2	df	χ^2/df < 3.0[a]	RMSEA $< .08$[a]	SRMR $< .05$[a]	GFI $> .90$[a]	AGFI $> .80$[a]	NFI $> .90$[a]	CFI $> .90$[a]	χ^2_{diff}	df_{diff}
Fully mediated	348.13*	226	1.54	.044	.057	.901	.869	.931	.974		
Partially mediated	304.62*	223	1.37	.035	.030	.913	.883	.939	.983	43.51*	3

[a] Represents the range indicating acceptable fit.
* $p < .05$.

5.2. Research models

Structural equation modeling was used to evaluate the research models shown in Figs. 2 and 3. Table 6 shows the fit indices for each of the research models. For the first research model, where the two use beliefs were hypothesized to completely mediate the relationships between the external factors and the use outcomes (i.e., the fully mediated model), six of the seven fit indicators suggested good fit, with a slightly larger than desired value obtained for the SRMR. In contrast, for the research model in which some system characteristics were hypothesized to have direct effects on the use outcomes (i.e., the partially mediated model), all indicators exhibited good fit. In addition, Table 6 shows, with the χ^2 test of the difference in fit between the two models, that the partially mediated model had better fit than the fully mediated model. Further, inspecting Table 7 indicates, as hypothesized in the partially mediated model, that each of the three paths added to the fully mediated model (i.e., (a) system functionality and (b) system interactivity to use for distance education and (c) system functionality to use for supplementary learning) was positive and statistically significant. Therefore, the partially mediated model provided better fit to the data than did the fully mediated model.

Table 7 provides the direct, indirect, and total effects associated with each of the determinants in the partially mediated model. Overall, of the 26 hypothesized total effects, 18 were statistically significant. Of the eight insignificant effects, seven were obtained for the individual attribute variables,

Table 7
Direct, indirect, and total effects for the partially mediated model

Hypothesis	Determinant	Standardized estimate			Result
		Direct	Indirect	Total	
Use for distance education ($R^2 = .653$)					
H_{1a}	USL	$.396^*$		$.396^*$	Supported
H_{1b}	PU	.111	$.150^*$	$.261^*$	Supported
H_{1c}	PEOU	.066	$.174^*$	$.240^*$	Supported
H_{1d}	SF	$.240^*$	$.186^*$	$.426^*$	Supported
H_{1e}	SI	$.150^*$	$.121^*$	$.271^*$	Supported
H_{1f}	SR		$.101^*$	$.101^*$	Supported
H_{1g}	SE		.050	.050	Not supported
H_{1h}	IE		.046	.046	Not supported
Use for supplementary learning ($R^2 = .638$)					
H_{2a}	PU	$.378^*$		$.378^*$	Supported
H_{2b}	PEOU	$.285^*$	$.089^*$	$.374^*$	Supported
H_{2c}	SF	$.296^*$	$.104^*$	$.400^*$	Supported
H_{2d}	SI		$.179^*$	$.179^*$	Supported
H_{2e}	SR		$.154^*$	$.154^*$	Supported
H_{2f}	SE		.081	.081	Not supported
H_{2g}	IE		.070	.070	Not supported
Perceived usefulness ($R^2 = .479$)					
H_{3a}	PEOU	$.235^*$		$.235^*$	Supported
H_{3b}	SF	.108	.040	$.147^*$	Supported
H_{3c}	SI	$.349^*$	.029	$.379^*$	Supported
H_{3d}	SR	.146	$.062^*$	$.208^*$	Supported
H_{3e}	SE	−.100	$.075^*$	−.026	Not Supported
H_{3f}	IE	.086	.024	.109	Not supported
Perceived ease of use ($R^2 = .603$)					
H_{4a}	SF	$.170^*$		$.170^*$	Supported
H_{4b}	SI	.125		.125	Not supported
H_{4c}	SR	$.264^*$		$.264^*$	Supported
H_{4d}	SE	$.318^*$		$.318^*$	Supported
H_{4e}	IE	.101		.101	Not supported

Note. IE: Internet experience; PEOU: perceived ease of use; PU: perceived usefulness; SE: self-efficacy; SF: system functionality; SI: system interactivity; SR: system response; USL: use for supplementary learning.

* $p < .05$.

none of which had a significant effect on the use outcomes. In fact, for the individual attributes, only self-efficacy had a statistically significant effect with its impact being limited to perceived ease of use. However, nearly all of the remaining hypothesized total effects (17 of 18) were positive and statistically significant, indicating that the three system factors and two use beliefs were important determinants, more so than the individual attributes.

In assessing the effects of model determinants on the two use beliefs, Table 7 indicates that the majority of the predictors had statistically significant effects. Specifically, for perceived ease of use, the determinant with the strongest impact was self-efficacy, with system response and system functionality also having positive direct effects. For the perceived usefulness of the e-learning system, system interactivity had the strongest direct and total effect, with the other system factors also having significant and positive total effects. Consistent with TAM, perceived ease of use was also positively related to perceived usefulness. For perceived ease of use and perceived usefulness, model determinants accounted for 60% and 48% of the variation, respectively, in these use beliefs.

Turning our attention toward the two use outcomes, all determinants except the individual attributes had positive and statistically significant total effects. For use of the e-learning system for supplementary learning purposes, system functionality, perceived usefulness, and perceived ease of use had the strongest effects, with the remaining system variables having statistically significant but somewhat weaker effects. For use of the e-learning system for distance education purposes, system functionality and use for supplementary learning had the strongest effects. Interestingly, perceived ease of use and perceived usefulness had statistically significant total effects, but the impact of these variables was transmitted primarily through use for supplementary learning, as the direct effects of the use beliefs were not statistically significant. Compared to the impact of the use beliefs, system interactivity had a somewhat stronger total effect on use for distance education, whereas the impact of system response was weaker. Finally, for use for supplementary learning and use for distance education, model determinants accounted for 64% and 65% of the variation, respectively, in these outcomes.

6. Discussion

The primary objective of this study was to test two alternative models that seek to explain student use of an e-learning system, a system which could be used for two distinct purposes: as a learning tool that supplements a traditional face-to-face class or as method of providing a stand-alone distance education course offering. 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 student use. That is, the impact of specific system characteristics on use of the e-learning system would be partially but not completely mediated by the TAM use-belief determinants.

A test of the difference 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. Thus, for three of the endogenous variables in the model, the strongest single predictors were system characteristics. Further, even after taking the effect of the use beliefs into account, system functionality and system interactivity directly influenced use of the e-learning system for distance education purposes, and system functionality directly affected use of the system for supplementary learning purposes. 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 supplementary learning and distance education purposes. Second, it suggests specific types of system characteristics that developers of e-learning 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 the ability of the system to (a) enable effective interactions and (b) offer access to course content at the time and place of the student's choosing play an important role in influencing student use of the system for both supplementary learning and distance education purposes.

In short, the findings about the system characteristics suggest that developers, designers, and institutional purchasers of e-learning 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 e-learning system use. As an e-learning system should be perceived as both easy to use and useful to maximize use of the system, faculty, when feasible, should demonstrate use of the technology and/or provide instructional materials that would ease student learning of the technology. In addition, the findings suggest that faculty should describe how the technology will benefit students and help them learn course content or achieve other learning goals, as students who perceived that the system would help them learn expressed a greater intent to use the system.

Second, after taking into account the system characteristics and the use beliefs, individual attributes were not important determinants of the use outcomes. From a developer's perspective, this is a desirable result, as it suggests that the use of a well-designed e-learning system does not depend on previous Internet experience or self-efficacy. As few studies have addressed the impact of e-learning system characteristics, further research involving the system characteristics examined here will need to confirm these findings.

Finally, learners who indicated that they intend to use the system for supplementary learning also indicated that they intend to use the system for distance education. 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 for distance 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 distance education method. In addition, faculty members who teach distance education classes may wish to prearrange some face-to-face class meetings prior to use of the technology as a distance education method. During these initial meetings, they should train learners to use the e-learning system so that students may be more receptive to the distance 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 measures. Second, better measures of system and user attributes should be developed, as 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 measures 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 e-learning 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. In fact, the typical student in this study reported having used the Internet for two years and used this medium a few times a week. 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.

7. Conclusion

Based on established theory and empirical research, this study proposed and validated a research model that demonstrated the importance of specific e-learning 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 an e-learning system for both supplementary learning and distance education purposes. Given the increasing use of e-learning systems, a better understanding and implementation of effective system characteristics will enhance the use and educational value of such systems.

Appendix A. List of items by construct

Item	Statement	Reference
System functionality (SF)		
SF1	The Web-based learning system allows learner control over his or her learning activity	Self-developed
SF2	The Web-based learning system offers flexibility in learning as to time and place	
SF3	The Web-based learning system offers multimedia (audio, video, and text) types of course content	
SF4	The Web-based learning system provides a means for taking tests and turning in assignments	
SF5	The Web-based learning system can present course material in a well-organized and readable format	
SF6	The Web-based learning system can clearly present course content	
System interactivity (SI)		
SI1	The Web-based learning system enables interactive communication between instructor and students	Self-developed
SI2	The Web-based learning system enables interactive communication among students	
SI3	The communicational tools in the Web-based learning system are effective (email, Bulletin Board, chat room, etc)	
System response (SR)		
SR1	When you are using the Web-based learning system, system response is fast	Bailey and Pearson (1983)
SR2	In general, the response time of the Web-based learning system is consistent	
SR3	In general, the response time of the Web-based learning system is reasonable	
Self-efficacy (SE)		
	I am confident of using the Web-based learning system:	Compeau and Higgins (1995b); Tan and Teo (2000)
SE1	Even if there is no one around to show me how to do it	
SE2	Even if I have only the online instructions for reference	
SE3	Even if I have never used such a system before	
SE4	As long as I have just seen someone using it before trying it myself	

Appendix A (*continued*)

Item	Statement	Reference
SE5	As long as I have a lot of time to complete the job for which the software is provided	
SE6	As long as someone shows me how to do it	
Internet experience (IE)		
	Please indicate the extent to which you use the Internet to perform the following tasks:	Tan and Teo (2000)
IE1	Gather information	
IE2	Communicate (e.g., email, chat)	
IE3	Download free software	
IE4	Watch video	
IE5	Listen to audio	
IE6	Span of Internet usage	
IE7	Frequency of Internet usage	
Perceived ease of use		
PEOU1	Learning to operate the Web-based learning system is easy for me	Davis (1989); Gefen and Straub (2000)
PEOU2	I find it easy to get the Web-based learning system to do what I want it to do	
PEOU3	My interaction with Web-based learning system is clear and understandable	
PEOU4	I find the Web-based learning system to be flexible to interact with	
PEOU5	It is easy for me to become skillful at using the Web-based learning system	
PEOU6	I find the Web-based learning system easy to use	
Perceived usefulness (PU)		
PU1	Using the Web-based learning system will allow me to accomplish learning tasks more quickly	Davis (1989); Gefen and Straub (2000)
PU2	Using the Web-based learning system will improve my learning performance	
PU3	Using the Web-based learning system will make it easier to learn course content	
PU4	Using the Web-based learning system will increase my learning productivity	
PU5	Using the Web-based learning system will enhance my effectiveness in learning	
PU6	I find the Web-based learning system useful in my learning	

(*continued on next page*)

Appendix A (*continued*)

Item	Statement	Reference
Use for supplementary learning (USL)		
	The Web-based learning system as a supplementary course tool:	Chau (1996); Venkatesh and Davis (1996)
USL1	I will always try to use the Web-based learning system to do a learning task whenever it has a feature to help me perform it	
USL2	I will always try to use the Web-based learning system in as many cases/occasions as possible	
Use for distance education (UDE)		
	The Web-based learning system as an entire distance education method:	Chau (1996); Venkatesh and Davis (1996)
UDE1	I intend to take this course and always try to use the Web-based learning system to do a learning task whenever it has a feature to help me perform it.	
UDE2	I plan to take this course and always try to use the Web-based learning system in as many cases/occasions as possible	

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