Undergraduate Engineering and Psychology Students' Use of a Course Management System: A Factorial Invariance Study of User Characteristics and Attitudes

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Implementing information systems (IS) is expensive and sometimes unsuccessful due to low levels of system user acceptance (Legris, Ingham, & Collerette, 2003). For this reason, IS research has focused, in part, on variables contributing to system user acceptance of technology. As a part of this effort, Davis (1989) theorized and tested the technology acceptance model (TAM) to describe how system user characteristics influence patterns in technology use. Since then, the TAM has survived empirical scrutiny in varied contexts (e.g., Davis, 1993; Lee, 2002; Legris et al., 2003; Pan, 2003; Pan, Gunter, Sivo, & Cornell, in press; Pan, Sivo, & Brophy, 2003; Venkatech, 2000; Wiedenbeck & Davis, 1997). The viability of the TAM has encouraged a continued investigation of its applicability as well as revisions and extensions. Many modifications considered have in common a focus on client side variables exogenous to the original model (e.g., Anandarajan, Igbaria, & Anakwe, 2000; Legris et al., 2003; Venkatech, 2000; Wiedenbeck & Davis, 1997; Wolski & Jackson, 1999).

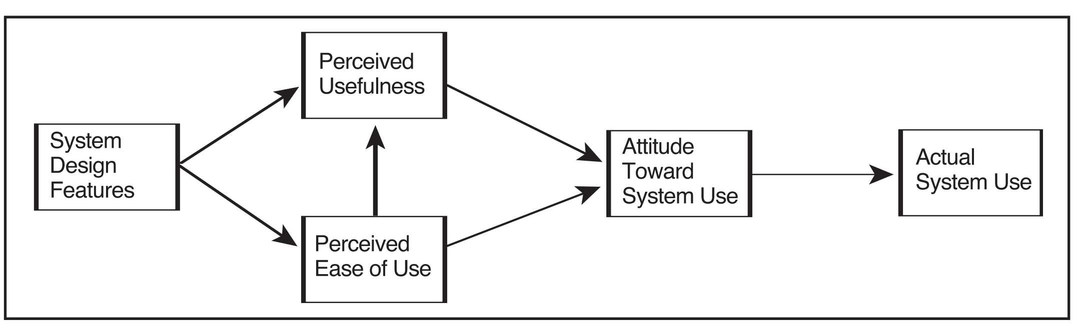
With respect to IS implementation in institutions of higher education, colleges and universities in the state of Florida and elsewhere are increasingly relying on the use of course management systems such as WebCT for the purpose of delivery of online courses. As a vendor's commercial product, WebCT is a Web-based course management system developed by the University of British Columbia (Goldberg, 1997). WebCT, a sophisticated learning management system, itself provides several features and functions that afford learning and teaching in a system-based environment by serving as a supplemental course tool/solution. In the present study, WebCT is conceptualized as an information system project and it is also considered a course management system.

Understanding student attitudes towards course management systems is important to study as student acceptance of this technology may conceivably have an impact on student use of the system in the completion of course requirements and therefore student grades. Indeed, research focused on how well psychology students respond to the use of WebCT in a Web-enhanced classroom has suggested that student grades are affected to some extent by student attitudes towards WebCT (Pan et al., 2003; Sivo, Pan, & Brophy, 2004). However, evidence of whether the relationships among factors involved in psychology student attitudes towards a course management system generalize to students of other majors has yet to be demonstrated. The assumption that student attitudes and related constructs are similar regardless of program major needs to be empirically evaluated because students in different majors arguably vary with respect to technological familiarity and expertise.

The Essential TAM

The TAM was designed to be a useful explanation of why people vary with respect to their success in using technology (Davis, 1989). According to Davis (1989), client side elements of this model include perceptions of a technology's usefulness, perceptions of a technology's ease of use, and attitudes toward the use of technology. The essential TAM proposes that these three variables work together to impact the actual use of technology in a given setting.

Figure 1. Original technology acceptance model



Specifically, a technology's perceived usefulness and ease of use jointly influence one's attitude towards the technology, which, in turn, affects a system's actual use (see Figure 1; Davis, 1993).

Previous structural equation modeling research has furnished evidence supporting the conclusion that the TAM is a parsimonious representation of how perceptions and attitudes affect actual system use (Bajaj & Nidumolu, 1998; Hu, Chau, Liu Sheng, & Yan Tam, 1999; Igbaria, Zinatelli, Cragg, & Cavaye, 1997; Mathieson, 1991; Subramanian, 1994). However, several researchers have increasingly entertained TAMs that exchange system design features with system user characteristics (Anandarajan et al., 2000; Legris et al., 2003; Pan et al., 2003; Venkatech, 2000; Wiedenbeck & Davis, 1997; Wolski & Jackson, 1999).

This transition in focus from system design variables to psychological variables is consistent with the nature of other variables in the model, which also focus on psychological aspects of the system user. For example, Wolski and Jackson (1999) found that within educational institutions, faculty and peer expectations are a prominent combined force in determining technology acceptance. It is not altogether surprising to find such normative influences (i.e., social pressure) at work particularly given the context in which technology acceptance is assessed.

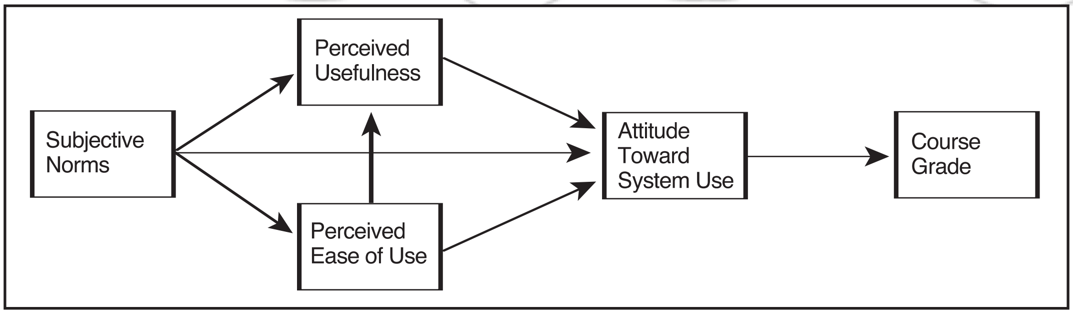
Developmentally, typical undergraduate students in the U.S. ages 18 to 22 are very susceptible to peer influence (Erikson, 1968) and, within the context of postsecondary education, students are, as well, shaped by their instructors. Indeed, the inclusion of perceived subjective norms as a psychological factor exogenous to the essential TAM continues to be a germane feature worthy of consideration (e.g., Anandarajan et al., 2000; Pan et al., 2003; Venkatech & Davis, 2000).

Pan et al. (2003) successfully replicated the TAM by identifying a causal relationship existing among students' perceived ease of use of WebCT, perceived usefulness of WebCT, their attitude toward WebCT, and their actual use of the course management system. They also succeeded in expanding the original TAM by adding subjective norms in addition to computer self-efficacy. These studies were conducted using students in a course on psychology. One of the two primary purposes of this study was to not only replicate this study with students in another psychology course, but to also contrast the TAM model results with results obtained from students in an engineering course. Factors affecting student use of a course management system (i.e., WebCT) in two large-sized, Web-enhanced, hybrid undergraduate courses was investigated. Other than the fundamental difference (i.e., course content), the two entry-level courses are compared and contrasted in Table 1.

Table 1: Comparison of Target Population by Characteristics

Characteristics	Psychology Class	Engineering Class
Textbook use	Yes	Yes
Office hours (primary)	Yes (TAs)	Yes (instructor)
Teaching assistants used	2	2
Extra credit offered	Yes	Yes
WebCT tool uses:		
Online grade	Yes	Yes
Online quizzes	Yes	Yes
WebCT mail	Yes	No
Online chatroom	Yes	Yes
Discussion forum	Yes (185 postings)	Yes (501 postings)
Content modules	Yes	Yes
WebCT calendar	Yes	No
Notes in WebCT	Yes (discussion)	Yes (PowerPoint files)
WebCT syllabus	No	Yes
Required WWW search	Yes	Yes
eCommunity use	Yes	Yes

Figure 2. The academic technology acceptance model



The outcome of interest in this case was attitudes towards system use and, secondarily, the impact of student attitudes on academic performance, operationally defined as a student's end of the course grade. This study was conducted with the permission of the psychology and engineering course instructors who supported the study by providing the grades they assigned to students at the end of the semester. The academic TAM fitted to the data is specified in Figure 2.

This model allows a direct path from the exogenous psychological variable, in this case subjective norms, to student attitude towards system use (i.e., the use of technology) because theoretically social pressure from peers and professors would have a direct effect on student attitude. In addition to subjective norms, perceptions of usefulness and ease of use are specified to jointly affect student attitudes, as these specifications are consistent with the original TAM defined by Davis (1985). For the same reason, user perception of how easy a technology is to use is specified to affect perceptions regarding the usefulness of the technology. In other words, the more strongly a student perceives a technology to be easy to use, the more strongly that student will regard the technology as useful.

The second purpose of this study was to determine whether this model is as applicable to psychology students as to engineering students. The assumption that the configuration of relationships among factors is the same for students in engineering and psychology needs to be evaluated. It is possible that the field of engineering, which has at its very heart the application of technology, draws students who, as a group, are more homogenous with respect to their comfort with technology. Though some students of psychology are likely to be comfortable with technology, it is not unreasonable to suppose that students in this major are more variable with respect to technological comfort levels relative to their peers in engineering. The academic TAM was fitted to engineering and psychology student data for the purpose of comparing the covariance structure across the two groups. The research question answered in this study was: Is the covariance structure of the academic TAM invariant (the same) across the psychology and engineering student data?

Method

Participants

This study included 460 students in both psychology (n = 230) and engineering[1] (n = 230) classes using WebCT for a Web-enhanced course. Each student completed an online questionnaire at two occasions in the spring semester of 2003. Permission to conduct this study at the University of Central Florida was provided by the engineering and psychology professors teaching the courses evaluated and the university's Institutional Review Board.

Measures

To measure subjective norms, a four-item scale that Wolski and Jackson (1999) developed was used. A sample question in the instrument included, "The instructor thinks that I should use WebCT for my course work." Furthermore, five items assessing system user attitudes toward technology were obtained from Davis (1989, 1993). A sample question in the instrument was, "All things considered, my using WebCT in my course work is: negative or positive?" Higher scores on the attitudinal scale suggested an overall more positive attitude. Results of reliability testing indicated that the alpha value for each factor was greater than .6, which suggested that adapted scales were deemed reliable (see Table 2).

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[1] Initially, 237 students of the engineering class fully participated in the study. In order to have an equal number of the participants in both classes, 230 were randomly selected.

Table 2: Reliability Testing of the Scales

Scale	# of items	α
Attitude toward WebCT	5	.93
Subjective norms	4	.60
Perceived usefulness	6	.91
Perceived ease of use	6	.94

Table 3: Instruments

Attitude Toward WebCT Instrument (on a 7-point bipolar semantics scale)
Question: All things considered, my using WebCT in my course work is: 1. Bad ↔ Good. 2. Foolish ↔ Wise. 3. Unfavorable ↔ Favorable. 4. Harmful ↔ Beneficial. 5. Negative ↔ Positive.
Subjective Norms Instrument (on a 7-point Likert scale)
1. The instructor thinks that I should use WebCT for my course work. 2. My peers think that I should use WebCT for my course work. 3. Generally speaking, I would do what my instructor thinks I should do. 4. Overall, I would do what my peers think I should.
Perceived Ease of Use Instrument (on a 7-point Likert scale)
1. Learning to use WebCT would be easy for me. 2. I would find it easy to get WebCT to do what I want it to do. 3. My interaction with WebCT would be clear. 4. I would find WebCT to be flexible to interact with. 5. It would be easy for me to become skillful at using WebCT. 6. I would find WebCT easy to use.
Perceived Ease of Use Instrument (on a 7-point Likert scale)
1. Using WebCT in my class would enable me to accomplish tasks more quickly. 2. Using WebCT would improve my job performance. 3. Using WebCT in my class would increase my productivity. 4. Using WebCT would enhance my effectiveness in my course work. 5. Using WebCT would make it easier to do my course work. 6. I would find WebCT useful in my course work.

These results, while favorable, must be treated with some degree of caution given that the errors associated with linked items may be correlated and thereby overestimate the reliability estimates (Gessaroli & Folske, 2002). For more details, see Table 3.

Data Collection and Analysis Procedures

Using Dreamweaver 4, Coldfusion, and MS Access, two online questionnaires were created and administered across two time occasions: at the beginning and end of the semester. Student informed consent was used. Two weeks before each administration, a friendly reminder (pre-notice) was sent via e-mail to make sure intended participants were informed of the incoming questionnaire. WebCT's Tip feature was also used for announcement making. Additionally, teaching assistants of the course made an announcement in front of the class every time the survey was being administrated. Student participants were given a week to finish each questionnaire on a voluntary basis. Data sets from both time occasions were housed in a password-protected server.

The overall response rates (across the two occasions) for both psychology and engineering classes were 51.7% and 30.4%, respectively. Responses of students who failed to complete the questionnaire at both occasions were not considered for further analysis. Overall, female students accounted for 55.44% of the study participants and 68.44% were freshman; 68.44% were novice WebCT users. More than 70% had used the computer for more than four years.

We downloaded the data sets from the high-secured server in MS Access. The engineering and psychology professors accordingly provided to us the final course grades assigned to the students under study. The data were imported to Notepad as a text file for filtering. Then, the final copy of data was imported to LISREL for further analysis. The results were evaluated in terms of their propriety, fit, and parsimony. With this in mind, three criteria were investigated: (a) the maximum likelihood estimator should converge for properly fitting models, (b) the estimated covariance matrix should be positive definite, with no negative eigenvalues and no collinearities, and (c) the standard errors should be within proper bounds.

Specifically, the following fit indices were examined: the goodness of fit index (GFI), comparative fit index (CFI), non-normed fit index (NNFI), and the standardized root mean square residual estimate (SRMR). These indices were chosen because of their relative merits. The GFI is a stand-alone index that has a long history in SEM research. The CFI and NNFI are both incremental fit indices that indicate how much the fit of a model improves upon the nested null model. These indices are more sensitive to misspecification between latent and manifest variables relationship misspecifications (Hu & Bentler, 1999). The SRMR is more sensitive to latent-latent variable relationship misspecifications (Hu & Bentler, 1999).

An assessment of adequate fit in structural equation modeling is not without standard cutoff criteria. In part, the cutoff criteria chosen were the result of Hu and Bentler's (1999) Monte Carlo simulation findings. The GFI, CFI, and NNFI were all expected to exceed .95 if the model was to be deemed as fitting well. The SRMR was expected to attain values no higher than .05.

Results and Discussion

Is the covariance structure of the academic TAM the same across the psychology and engineering student data? A multisample analysis was conducted using LISREL. The multisample analysis using LISREL constrains the parameters of both covariances to be equal and determines whether the fit assuming these constraints is very good.

The covariances and means analyzed in this study are presented in Tables 4 and 5. Upon gross inspection, the covariances and means appear to be somewhat dissimilar, but similarities are recognizable as well. The purpose of this analysis was to determine whether the differences were of a sufficiently large magnitude to preclude a comparable fit with respect to the model.

Table 4: Covariances and Means of the Psychology Students

	PU	PEU	AT	Grades	SN
PU	53.11				
PEU	34.40	54.26			
AT	18.47	10.54	23.88		
Grades	0.11	-0.09	0.45	0.33	
SN	10.08	10.11	4.39	-0.03	13.64
Means	32.47	35.11	30.00	4.78	22.06

Note: PU = perceived usefulness; PEU = perceived ease of use; AT = attitude toward technology; SN = subjective norms.

Table 5: Covariances and Means of the Engineering Students

	PU	PEU	AT	Grades	SN
PU	57.93				
PEU	29.66	54.54			
AT	30.52	15.61	36.03		
Grades	0.67	0.67	0.74	0.44	
SN	18.60	14.88	11.96	0.14	16.32
Means	29.02	34.06	27.23	4.78	20.39

Note: PU = perceived usefulness; PEU = perceived ease of use; AT = attitude toward technology; SN = subjective norms.

Table 6: Results for the Goodness of Fit Indices

Fit Index	Value
Degrees of freedom (*df*)	6
Minimum fit function chi-square	4.75 (p = 0.58)
Goodness of fit index (GFI)	0.99
Comparative fit index (CFI)	1.00
Non-normed fit index (NNFI)	1.01
Standardized RMR (SRMR)	0.021

The maximum likelihood procedure converged to a proper solution in five iterations. The results suggest that the covariance in the responses of psychology students was very much like the covariance in the responses of the engineering students. All of the fit indices consulted suggested both models fit well and equivalently (see Table 6).

The GFI, CFI, and NNFI all exceeded .95, and the SRMR was less than .05. All fit criteria were exceeded, suggesting a magnificent fit. These results suggest that the same model is viable for both groups.

A review of the standardized path coefficients (regression weights) suggests many paths were indeed similar in value; however, notable differences could be observed as well (see Figures 3 and 4).

Both figures represent the configuration of relationships estimated for each group. A review of the parameters suggested that most of the paths specified were viable, though perceptions of how easy WebCT is to use had a negligible direct effect on attitudes toward WebCT for either groups (-.08 for psychology students; -.04, for engineering students). Furthermore, the effect of student attitudes towards WebCT on student course grades was statistically significant for either group, though small ($.02 \leq r^2 \leq .04\%$). This result suggests that regardless of whether students are in psychology or engineering, their attitudes towards WebCT plays only a minor role in their final grade. Although this result is not reassuring for this aspect of the model, it does imply that institutional concerns about how student attitudes may affect student grades may not be needed. With respect to utility of the academic TAM, perhaps outcome(s) variables other than course grades

Figure 3. Psychology student data

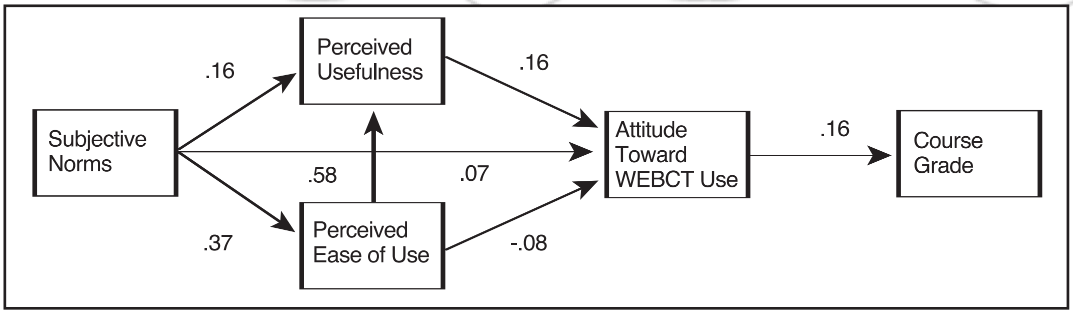
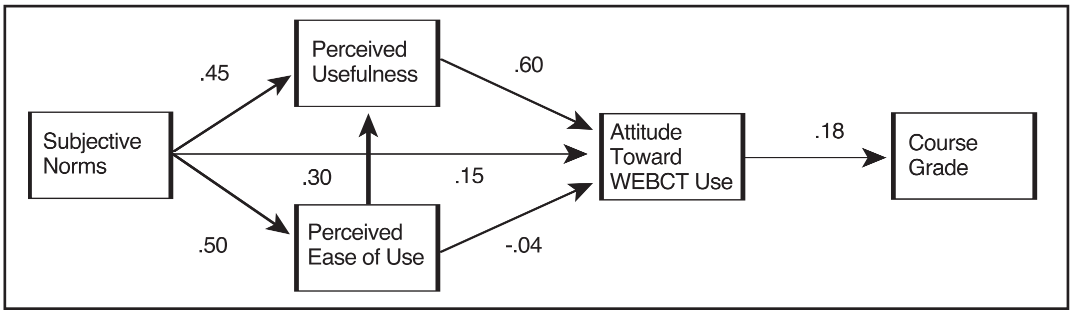


Figure 4. Engineering student data



should be considered such as frequency of technology use or the duration of technology use. Just how much do students' attitudes affect their exploitation of the technological resources made available to them and at what price?

To facilitate a further comparison of these paths, corresponding coefficients across the two path models are juxtaposed in Table 7.

A comparison of the differential effects of variables revealed that the influence of peer pressure and professorial expectations (subjective norms) were stronger for engineering students than for psychology students. For instance, the effect of subjective norms on student perceptions of how easy WebCT is to use was notably greater for engineering students (_ = .50) than psychology students (_ = .37). Subjective norms also had a stronger impact for engineering students on perceptions of how useful WebCT is as a course management system (_= .45) than for psychology students (_= .16). Similarly, subjective norms influenced engineering student attitudes towards WebCT (_= .15) more than psychology student attitudes (_= .07), although the coefficients were smaller. These results may be due to the engineering professor tending to hold his office hours primarily by himself and therefore having relatively more opportunities than the psychology professor to exert his influence in student perception of the WebCT use and student attitude toward the technology use. Conversely, psychology student perceptions of how easy WebCT is to use had a stronger effect on their perceptions of how useful WebCT is (_= .58) than engineering student perceptions (_= .30). These results may be due because of the limited social influence (or pressure) by the instructor, the psychology students behaved more like regular end users of a technology system, where they believed that WebCT had to be easy to use before they started to feel it is useful to their coursework (and then favored WebCT). Overall, these results suggest that although the same path model is viable for engineering and psychology students, differences in the two groups exist in the strength of certain effects.

The ultimate goal of this study was to assist the University of Central Florida in offering an alternative educational medium and a nontraditional paradigm to tailor customized instruction for the purpose of better suiting the wide variety of University of Central Florida students. Though the response rate of the engineering class was not noticeably high, the significance of this study may provide administrators from similar settings with insights into users' perception about the system employed from two different disciplines, which may mediate the acceptance of such technology.

Table 6: Academic TAM Path Values for Psychology and Engineering Students

	Standardized Paths (_s)	
	Psychology	Engineering
Subjective norms → Perceived usefulness	.16	.45
Subjective norms → Perceived ease of use	.37	.50
Subjective norms → Attitudes towards WebCT use	.07	.15
Perceived ease of use → Perceived usefulness	.58	.30
Perceived ease of use → Attitudes towards WebCT use	-.08	-.04
Perceived usefulness → Attitudes towards WebCT use	.55	.60
Attitudes towards WebCT use → Course grades	.16	.18

These results suggest that the academic TAM is as applicable to engineering students as it is to psychology students with respect to WebCT as a course management system, although perceptions of peer pressure and professor expectations play a more prominent role for engineering students and perceptions of WebCT ease of use has a greater impact on psychology students. If it is the goal of an institution to build student acceptance of a course management system, if for no other reason than to secure student satisfaction, then these results suggest that interventions should vary by the course sequence students are designated to take. Programmatically, this is useful because the relative strength of variable relationships at play in determining student attitudes towards technology is not the same. Specific recommendations of what programmatic strategies might be considered are not possible at this point, though this study does further develop our understanding of some of the dynamics. It is important to note that interventions designed to increase student attitudes towards technology should consider how a change in attitude would benefit students in academic ways beyond course grades. This research suggests that attitudes towards technology only play a minor role in affecting final grades.

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References

Anandarajan, M., Igbaria, M., & Anakwe, U. (2000). Technology acceptance in the banking industry: A perspective from a less developed country. *Information Technology and People, 13*(4), 298-312.

Bajaj, A., & Nidumolu, S. R. (1998). A feedback model to understand information system exchange. *Information and Management, 33*, 213-224.

Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results*. Unpublished doctoral dissertation, Massachusetts Institute of Technology, Cambridge.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13,* 319-340.

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.

Erikson, E. H. (1968). *Identity: Youth and crisis*. New York: Norton.

Gessaroli, M. E., & Folske, J. C. (2002). Generalizing the reliability of tests comprised of testlets. *International Journal of Testing, 2*, 277-296.

Goldberg, M. W. (1997). Using a Web-based course-authoring tool to develop sophisticated Web-based courses. In B. H. Khan (Ed.), *Web-based instruction* (pp. 307-312). Englewood Cliffs, NJ: Educational Technology Publications.

Hu, L., & Bentler, P. M. (1999). Cut criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1-55.

Hu, P. J., Chau, P. Y. K., Liu Sheng, O. R., & Yan Tam, K. (1999). Examining the technology acceptance model using physician acceptance of telemedicine technology. *Journal of Management Information Systems, 16*(2), 91-112.

Igbaria, M., Zinatelli, P., Cragg, P., & Cavaye, A. (1997). Personal computing acceptance factors in small firms: A structural equation model. *MIS Quarterly, 3*, 279-302.

Lee, C. (2002). *The impact of self-efficacy and task value on satisfaction and performance in a Web-based course*. Unpublished doctoral dissertation, University of Central Florida, Orlanda.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management, 40*, 191-204.

Mathieson, K. (1991). Predicting user intentions: Comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research, 2*(3), 173-191.

Pan, C. (2003). *System use of WebCT in the light of the technology acceptance model: A student perspective.* Unpublished doctoral dissertation, University of Central Florida, Orlando.

Pan, C., Gunter, G., Sivo, S., & Cornell, R. (in press). End-user acceptance of a learning management system in two hybrid large-sized introductory undergraduate courses. *Journal of Educational Technology Systems.*

Pan, C., Sivo, S. A., & Brophy, J. (2003). Students' attitude in a Web-enhanced hybrid course: A structural equation modeling inquiry. *Journal of Educational Media and Library Sciences, 41*(2), 181-194.

Sivo, S. A., Pan, C., & Brophy, J. (2004). Temporal cross-lagged effects between subjective norms and system user attitudes regarding the use of technology. *Journal of Educational Media and Library Sciences, 42*(1), 63-73.

Subramanian, G. H. (1994). A replication of perceived usefulness and perceived ease of use measurement. *Decision Sciences, 25*(5/6), 863-874.

Venkatech, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research, 11*(4), 342-365.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*(2), 186-204.

Wiedenbeck, S., & Davis, S. (1997). The influence of interaction style and experience on user perceptions of software packages. International *Journal of Human-Computer Studies, 46*, 563-588.

Wolski, S., & Jackson, S. (1999, February). *Technological diffusion within educational institutions: Applying the technology acceptance model*. Paper presented at the 10th conference of the Society for Information Technology & Teacher Education, San Antonio, Texas.