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**ABSTRACT**

Instructional technology can enhance the learning process for post secondary students. Colleges and universities have adopted computing initiatives that require every student to acquire their own portable computing device. Yet for such initiatives to improve students' learning and teaching effectiveness, such technology-based initiatives must be accepted by students and faculty alike.

This research evaluates students' acceptance of Tablet PC (TPC) as a mean to forecast, explain, and improve usage pattern of TPC in education. Using the Unified Theory of Acceptance and Use of Technology (UTAUT) model, a primary implication of this research is that while students may think favorably of TPC and thus intends to continue to use the technology, this does not necessarily explain actual use of TPC specific features. Universities wishing to ensure that students leverage the full feature set of TPC may have to further facilitate and support the use of TPC specific features.

**Keywords**

Education, Tablet PC, College students, Technology adoption, UTAUT

## INTRODUCTION

The application of information technology in collegiate classroom can improve teaching when used appropriately (Surry & Land, 2000). In the past few years many universities have introduced mobile computing to their campus but some faculty have raised concerns about the distractions caused by mobile computer hardware (Groves & Zemel, 2000). However, even with philosophical differences among faculty, many universities including Bentley College (Lowe, 2004), Notre Dame (Abbott, 2004), University of Texas (Mock, 2004), and the University of Washington (Willis & Miertschin, 2004) have implemented, or in the process of starting, mobile computing initiatives.

Colleges and universities have adopted computing initiatives that require every student to acquire their own portable computing device. In excess of fifty colleges and universities have, or are in the process of, implementing various mobile computing initiatives. Brown (2000) compiled a list of over seventy institutions who are involved in various levels of implementation.

Tablet Personal Computer (TPC) based mobile computing initiatives have been documented in the literature. For example, the University of Houston conducted a preliminary pilot study investigating TPCs in a mobile learning laboratory used by faculty (Willis & Miertschin, 2004). A university that integrates the TPC into student teacher interaction is the University of Washington where a Classroom Feedback System (CFS) is being used to give students the ability to provide feedback and ask real time questions during an instructor mediated lecture (Steel, 2003). Other universities with TPC programs include Purdue, MIT, Temple, Seton Hall, Chatham, and many others (Brown, 2000; Wachsmuth, 2003).

With the proliferation of mobile computing initiatives across campuses, evaluation of such initiatives becomes the logical next step. The evaluation ultimately centers on the students' learning and teaching effectiveness. Yet for such initiatives to improve students' learning and teaching effectiveness, such technology-based initiatives must be accepted by students and faculty alike.

The objective of this research is to evaluate the students' acceptance of TPC as a means to forecast, explain, and improve usage pattern. The research uses the Unified Theory of Acceptance and Use of Technology (UTAUT) model originally proposed by Venkatesh et al. (2003) to evaluate acceptance within the context of students' acceptance of TPC technology. From a practical perspective, this research contributes to a better understanding of the introduction and management of information technology (IT) based initiatives in education.

## LITERATURE REVIEW

Many information systems (IS) researchers have published on various theories that could be used to explain the adoption of information technology innovations. These theories include; the technology acceptance model (TAM) (Davis, 1989); the theory of reasoned action (TRA) (Fishbein & Ajzen, 1975); the theory of planned behavior (TPB) (Ajzen, 1991) among others which are modifications or developments of these models. Research in this area has generated adoption metrics that can be used to determine the probability of successful implementation of information system initiatives. The combination of these metrics into a single model entitled the "Unified Theory of Acceptance and Use of Technology (UTAUT)" has been proposed in a recent publication by several of the fields leading researchers (Venkatesh et al., 2003). The previous models were able to successfully predict the acceptance of an innovation in about 40 percent of the cases (Taylor & Todd, 1995; Venkatesh & Davis, 2000). The UTAUT model was shown to be 70 percent accurate at predicting user acceptance of information technology innovations (Venkatesh et al., 2003).

In education the use of technology acceptance prediction models in educational technology acceptance situations would be a useful tool. Singletary, Akbulut, and Houston (2002) proposed the application of the TAM model to a Geometer's sketchpad. Yuan Gao (Gao, 2005) states that "technology acceptance models can serve the purpose of evaluating competing products such as text books and technology systems" and provide a valuable tool to educators. This study evaluates TPC adoption in an educational setting and examines the UTAUT model as a useful predictive tool in this context.

## CONCEPTUAL MODEL AND RESEARCH HYPOTHESES

Based on the UTAUT model, the research model postulates three constructs (performance expectancy, effect expectancy, and social influence) that determine the behavioral intent and two constructs influencing usage behavior (behavioral intent and facilitating conditions) (Figure 1). Performance expectancy is defined as the degree to which students believe that using the system will help them improve their performance. Effort expectancy is defined as the degree of ease associated with the use of the TPC. Social influence is defined as the degree to which a student perceives that important others believe he or she should use the TPC. Venkatesh et al. (2003) suggest that social influence is an important construct in mandatory use environments such as this study. This variable is important in the early stages of experience with technology, with the effect diminishing over time. Facilitating conditions are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the TPC. Venkatesh et al. (2003) found that this variable was not significant as a determinant of intention. However this variable was retained because of discussion pertaining to its importance in other publications (Taylor & Todd, 1995). Accordingly, in the context of this study, we tested the following hypotheses:

H1: The degree to which a student believes that TPC will help him or her to attain gains in school performance (performance expectancy) has a positive effect on his or her intention to use intention to use TPC.

H2: The degree of ease associated with the use of TPC as perceived by a student has a positive effect on his or her intention to use intention to use TPC.

H3: The degree to which a student perceives that important others believe he or she should use the system has a positive effect on his or her intention to use intention to use TPC.

H4: The degree to which a student believes that the university has the organizational and technical structure to support the use of TPC has a positive effect on his or her use of TPC.

H5: Behavioral intention will have a significant positive effect on usage.

## RESEARCH METHODOLOGY

### Setting and participants

The study is conducted at a Midwest public university. The institution started investigating pen-based mobile computing in 2002 when thirteen wireless access points were installed on campus. Approximately twenty students were given TPC devices and given the assignment to investigate the device as a learning instrument. The initial project was found to be beneficial resulting in an expansion of both the wireless network infrastructure and the number of students using Tablet PCs. In the fall of 2004, the institution evolved the initiative to include all 1st and 2nd year enrolled students. The initiative required each full time student to lease or buy a TPC. The program has been entitled the wireless mobile computing initiative (WMCI). By the spring of 2006 all students at this university would have their own TPC. As a relatively early adopter of the

TPC technology and with the pervasiveness of TPC on the campus, the institution provides a unique context for studying students' adoption of TPC.

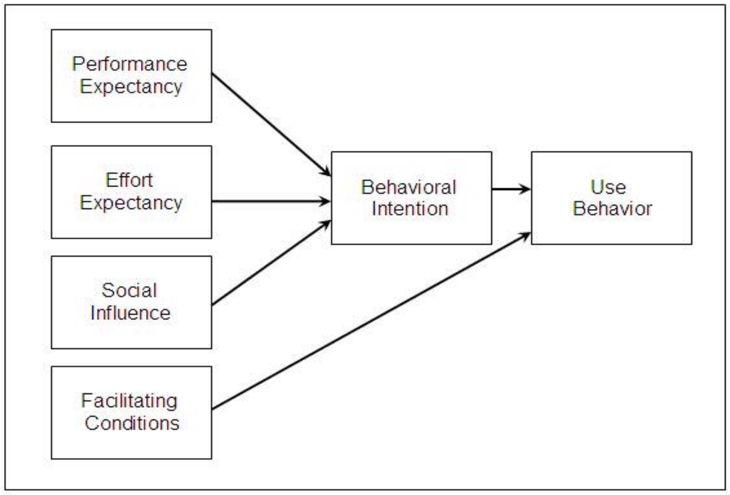


**Figure 1. The Research Model**

The participant pool is students enrolled in a number of computer-related courses within the College of Business and Information Systems (BIS). The courses included students who have been using the TPC since August 2005; it was postulated that most of these students were introduced to the device during the fall semester of 2005. The resulting set resulted in general education computer courses required by all majors as well as major specific courses

### Survey instrument

The survey instrument is based on constructs validated in prior research (Davis, 1989; Venkatesh et al., 2003) and adapted to the context of this study. The constructs include; performance expectancy, effort expectancy, social influence, facilitating conditions, behavioral intent, and usage. The survey instrument collects additional information such as gender, age, and number of years at the institution. All questionnaire items were measured using a 7-point Likert scale ranging from "strongly agree" to "strongly disagree". A pilot study was conducted to test the survey instrument with a small group of upper class students enrolled in a one credit computer application class. Based on the students' feedback, several minor revisions in the wording and online format were made to improve the readability and completion rate of the survey. The modified survey tool was re-evaluated by the pilot group in a subsequent class session with discussion following the second trial run. The pilot group was pleased with the changes.

### Data collection

The survey instrument was made available to the participants via the World Wide Web. Survey participants were in a class setting and were guided to the instrument by one of the authors serving as a survey administrator. Participants were assured response anonymity by not being required to provide identifying information on the survey. Students who are enrolled in more than one of the classes surveyed were instructed to not complete the survey by the survey administrator. The survey was conducted during normal class sessions during the last ten minutes of class using each student's TPC. The time required to complete the survey was five to seven minutes.

### Data analysis

The statistical analysis method used for this study was partial least squares (PLS), a second generation statistical technique for conducting structural equation modeling (SEM) based analysis. In comparison to other SEM techniques, PLS has minimal demands on measurement scales, sample size, and residual distribution and avoids problems such as inadmissible solutions and factor indeterminacy (Chin, 1998). While the utility of PLS is detailed elsewhere (Falk & Miller, 1992), a number of recent technology acceptance studies utilized PLS including (but not limited to) (Al-Gahtani, 2001; Compeau & Higgins, 1995; Venkatesh et al., 2003).

PLS allows for evaluating the psychometric properties of the scales (indicators) used to measure a variable (construct) (the measurement model), and the estimation of the direction and strength of the relationships among the model variables (the structural model). In effect, PLS includes two sets of equation: the measurement model (also referred to as the outer model) comprised of equations representing the relationships between indicators and the variable they measure, and the structural model (also referred to as the inner model) comprised of equations representing the paths among variable (constructs). PLS calculates weights and loading factors for each item in relation to the construct it was intended to measure. The weights calculated by PLS are used to calculate latent variable scores for the constructs, which reflect the contribution of each variable to its construct.

Evaluating the measurement model includes estimating the internal consistency for each block of indicators and evaluating construct validity. With all variables having reflective indicators, internal consistency is evaluated using composite reliability (CR) developed by Werts (1974) and the average variance extracted (AVE) developed by Fornell (1981). Both CR and AVE are calculated using the loading factors for each item in relation to the construct it was intended to measure (Chin, 1998). Compared to Cronbach's alpha, CR does not assume that all indicators are equally weighted thereby providing a closer approximation when the parameters are accurate. Cronbach's alpha tends to be a lower bound estimate of reliability (Chin, 1998). Nunnally's (1978) guidelines were used to evaluate the composite reliability obtained for each variable. On the other hand, AVE tends to be a more conservative measure of reliability than CR (Chin, 1998). According to Fornell (1981) AVE should be greater than 0.5 indicating that 50% of the amount of variance in an item that its corresponding variable explains relative to the amount due to measurement error (Chin, 1998).

Construct validity refers to the degree which a variable measures what it was intended to measure (Cronbach, 1951; Straub, Boudreau, & Gefen, 2004). Construct validity is comprised of convergent and discriminate validity. Convergent validity is degree which similar constructs are related; while discriminate validity is the degree that different constructs are different from each other. Following Gefen and Straub (2005) convergent validity of the variables is evaluated by examining the t-values of the outer model loadings. In effect, t-values of the loadings are equivalent to t-values in least squares regression. A t-value greater than 1.96 indicates that the particular indicator is explained by the linear regression of its variable and its measurement error (Gefen & Straub, 2005). Discriminate validity is the degree to which any single construct is different from the other constructs in the model. Discriminate validity is evaluated by examining item loadings to variable correlations and by examining the ratio of the square root of the AVE of each variable to the correlations of this construct to all other variables (Chin, 1998; Gefen & Straub, 2005).

For the structural model, path coefficients are interpreted as regression coefficients with the t-statistic calculated using bootstrapping (200 samples), a nonparametric technique for estimating the precision of the PLS estimates (Chin, 1998). To determine how well the model fits the hypothesized relationship PLS calculates an $R^2$ for each dependent construct in the model. Similar to regression analysis, $R^2$ represents the proportion of variance in the endogenous constructs which can be explained by the antecedents (Chin, 1998). The tool used for the analysis was PLS Graph (PLS Graph, Version 2.91.03.04).

### Sample size

Using the method and a table provided by Cohen (1988) it was determined that a sample of at least 175 participants would be needed to achieve 95% confidence. One of the benefits of using PLS-Graph is that it can resample the initial data set enlarging it thus reducing overall sample requirements. Guidelines provided with PLS-Graph recommend a sample size equal to the larger of two possibilities: (1) ten times the number of indicators on the most formative construct, in this study ten times the ten indicators of performance expectancy or one hundred participants, or (2) ten time the largest number of antecedent constructs used to determine a dependent variable, in this study ten times six, the number of constructs used to determine behavior intent. In all cases the 232 valid survey submissions is greater than the calculated sample size.

## RESULTS

### Sample characteristics

Data was collected from students in all the sections of courses thought to be most likely enrolled in by students in their first year of table PC use. The available participant pool was about 360 individuals enrolled in the selected courses. The database recorded responses from the participants resulting in a response rate of 74 percent. Several survey submissions were disqualified due to incomplete submissions, resulting in a total of 232 (n=232) usable responses were included in data analysis and model construction. The general demographics of the survey participants is illustrated in table 1.

Table 1: Survey Sample Characteristics

| Participant's demographics | Number | Percent |
|---|---|---|
| Number of participants | 232 | |
| Average age | 22 | |
| Gender | | |
| Male | 129 | 56 |
| Female | 98 | 42 |
| NA | 5 | 2 |
| Class placement | | |
| Freshman | 112 | 48 |
| Sophomore | 59 | 25 |
| Junior | 45 | 20 |
| Senior | 16 | 7 |
| College major | | |
| Arts & Sciences | 56 | 24 |
| Business and Information Systems | 103 | 44 |
| Education | 56 | 24 |
| Other | 17 | 8 |
| First use of computers | | |
| Elementary | 87 | 38 |
| Middle | 78 | 33 |
| High | 35 | 15 |
| College | 32 | 14 |
| Tablet PC period of use | | |
| Up to 3 Months | 36 | 16 |
| 3 to 6 Months | 84 | 36 |
| 6 to 9 Months | 40 | 17 |
| 12 Months | 8 | 3 |
| >12 Months | 64 | 28 |

Based on tests of univariate normality (Anderson-Darling test) none of the variables in this study were normally distributed. This phenomenon is similar to other studies of technology acceptance (Compeau, Higgins, & Huff, 1999). Nevertheless, the use of partial least squares (PLS) for data analysis is appropriate for this study because of its ability to model latent constructs under non-normal conditions (Cohen, 1988).

**Analysis of measurement validity**

While most questions items have been validated elsewhere in the literature (Venkatesh et al., 2003), we follow Straub (1989) recommendations and re-examine the survey instrument in terms of reliability and construct validity. The original thirty four variables initially included in the survey instrument were analyzed in PLS-Graph, resulting in ten items with loading less than .70, a level considered generally acceptable (Compeau & Higgins, 1995; Compeau et al., 1999; Fornell & Larcker, 1981). Following the recommendations by (Hair, Tatham, Anderson, & Black, 1998), items with low loading are considered as not contributing to the model and were deleted. The process is continued until no item loading is less than 0.7. Examination of the remaining items revealed that they adequately represent the underlying construct attesting to the content validity of the instrument.

Table 2 summarizes the results for the items comprising the model. The results show composite reliability (CR) exceeding 0.8 as recommended by Nunnally (1978). AVE which can also be considered as a measure of reliability exceeds 0.5 as recommended by (Fornell & Larcker, 1981). Together CR and AVE attest to the reliability of the survey instrument. The t-values of the outer model loadings exceed 1.96 verifying the convergent validity of the instrument (Gefen & Straub, 2005). Calculating the correlation between variables' component scores and individual items confirmed that intra-variable (construct) item correlations are very high compared to inter-variable (construct) item correlations attesting to the discriminate validity of the instrument. In addition, discriminate validity is confirmed if the diagonal elements (representing the square root of AVE) are significantly higher than the off-diagonal values (representing correlations between constructs) in the corresponding rows and columns (Chin, 1998). As shown in Table 3 the instrument demonstrates adequate discriminate validity as the diagonal, in bold, values are greater than the corresponding correlation values in the adjoining columns and rows. Overall, the instrument has achieved an acceptable level of reliability and construct validity.

Table 2. Individual Loadings, composite reliabilities (CR) and AVE.

| Construct | Items | Item Loading | Construct CR | Construct AVE |
|---|---|---|---|---|
| Performance Expectancy | PE1 | 0.7982 | 0.882 | 0.652 |
| | PE3 | 0.8072 | | |
| | PE5 | 0.7837 | | |
| | PE10 | 0.8387 | | |
| Effort Expectancy | EE1 | 0.8106 | 0.946 | 0.744 |
| | EE2 | 0.9005 | | |
| | EE3 | 0.9076 | | |
| | EE4 | 0.863 | | |
| | EE5 | 0.8435 | | |
| | EE6 | 0.8462 | | |
| Social Influence | SI1 | 0.7806 | 0.858 | 0.602 |
| | SI2 | 0.8253 | | |
| | SI3 | 0.7873 | | |
| | SI4 | 0.705 | | |
| Facilitating Conditions | FC1 | 0.8424 | 0.847 | 0.649 |
| | FC2 | 0.7503 | | |
| | FC5 | 0.8206 | | |
| Behavioral Intention | BI1 | 0.8576 | 0.922 | 0.747 |
| | BI3 | 0.7804 | | |
| | BI4 | 0.8983 | | |
| | BI5 | 0.9156 | | |
| Usage | USE1 | 0.8131 | 0.869 | 0.688 |
| | USE2 | 0.8273 | | |
| | USE4 | 0.8478 | | |

Table 3: AVE Scores and Correlation of Latent Variables.

| | PE | EE | SI | BI | USE | FC |
|---|---|---|---|---|---|---|
| PE | 0.807 | | | | | |
| EE | 0.343 | 0.863 | | | | |
| SI | 0.337 | 0.337 | 0.776 | | | |
| BI | 0.524 | 0.467 | 0.514 | 0.864 | | |
| USE | 0.264 | 0.205 | 0.304 | 0.275 | 0.829 | |
| FC | 0.476 | 0.665 | 0.564 | 0.67 | 0.344 | 0.806 |

### Model testing results

Figure 2 depicts the structural model showing path coefficients and $R^2$ for dependent variables while Table 4 presents a summary of the results of the structural model. The $R^2$ values for each dependent variable indicate that the model explained variance for behavioral intention and use behavior were 45.3% and 12.2% respectively. Bootstrap method was used in PLS-Graph to assess the statistical significance of the path coefficients (which have similar interpretation to standardized Beta values in regression analysis). Consistent with hypothesis 1 (H1), the degree to which a student believes that TPC will help him or her to attain gains in school performance (performance expectancy) has a positive effect on his or her intention to use intention to use TPC ($\beta$=0.332, $p<0.001$). Similarly, the degree of ease associated with the use of TPC as perceived by a student has a positive effect on his or her intention to use intention to use TPC consistent with H2 with ($\beta$=0.245, $p<0.001$). Hypothesis 3 (H3) is also confirmed with the degree to which a student perceives that important others believe he or she should use the system has a positive effect on his or her intention to use intention to use TPC ($\beta$=0.319, $p<0.001$). Consistent with hypothesis 4 (H4), the degree to which a student believes that the university has the organizational and technical structure to support the use of TPC has a positive effect on his or her use of TPC ($\beta$=0.289, $p<0.001$). Inconsistent with hypothesis 5 (H5), behavioral intention does not seem to have a significant positive effect on usage. Overall, with the exception of the behavioral intention – use behavior path coefficient, all structural relationships are significant.

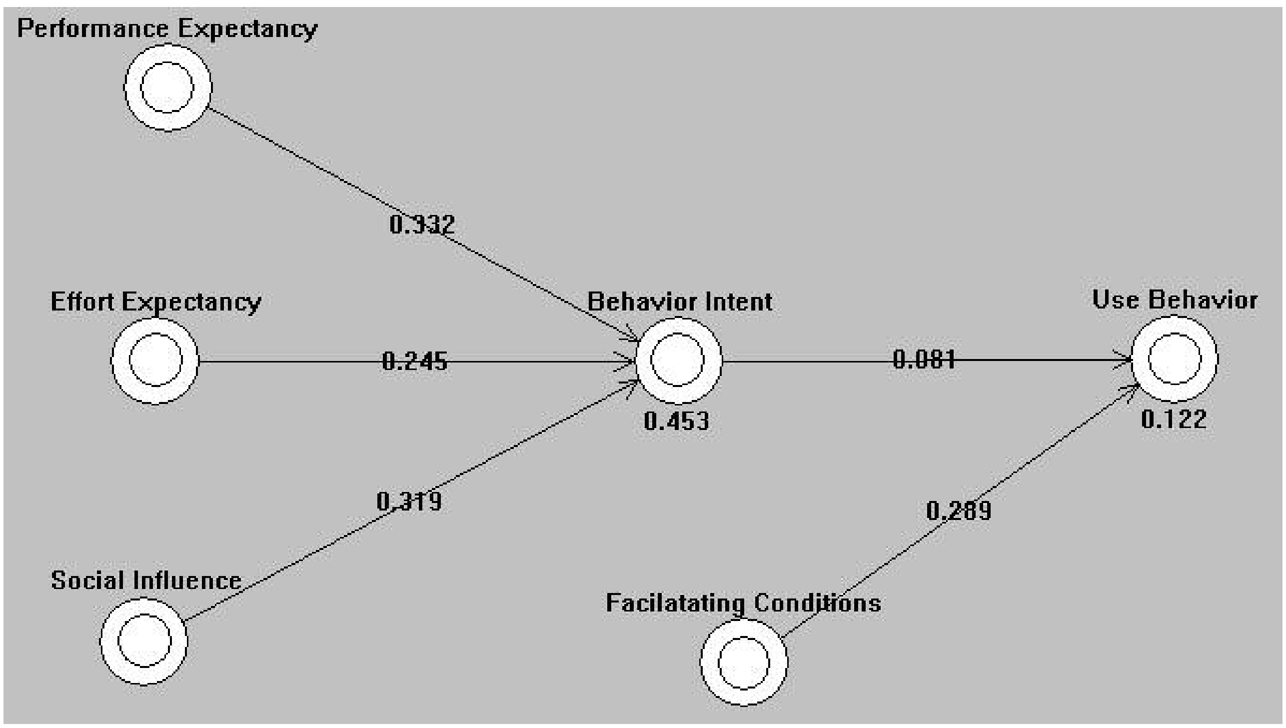


**Figure 2. Model testing results**

### DISCUSSION

This study examined students' acceptance of Tablet PCs (TPC) using a simplified version of the Unified Theory of Acceptance and Use of Technology (UTAUT) model. Overall, the model is consistent with the UTAUT model with respect to the determinants of students' intention to continue to use TPC. In effect, performance expectancy, effort expectancy, and social influence are significant determinants of students' intention to continue to use TPC.

While PE appears to have a slightly higher effect on BI than the other factors, it does not play a prominent role as in other studies with other use groups such as law enforcement officers where efficiency gains and perceived usefulness where the single most important acceptance drivers (Hu, 2005). Interestingly, SI's impact on intention appears almost as strong as PE suggesting that students intention to continue to use TPC is affected by people they interact with (peers, professors and advisors) as much as their belief that using TPC will help them attain gains in their performance at school.

SI appears to be a significant determinant of BI. This is consistent with other research findings (Venkatesh & Davis, 2000; Venkatesh et al., 2003) for mandatory adoption. However, our results differ when time is taken into consideration. While earlier results support declining effort of SI with experience, the results of this study indicate that even with experienced users (more than 80% of respondents have been using TPC for more than 6 months), SI continue to influence behavior. The results suggest that students as a user group are more susceptible to social influence over time.

Consistent with prior research (Davis, 1989; Venkatesh et al., 2003) EE is also a significant determinant of BI. However, the results suggest that the degree of ease associated with using TPC as perceived by students continue to play a major role in influencing student intention to continue to use the technology even after 80% have been using TPC for more than 6 months. The primary implication of this result is the need to continue to ensure that students continue to perceive TPC as easy to use. One approach, is for the continuous support/training beyond the initial adoption period (which is normally up to 6 months).

While facilitating condition is a significant determinant of students' use of TPC specific features (consistent with UTAUT), students' intention to continue to use TPC is not a significant determinant of students' actual use TPC specific features. One plausible interpretation is that 'other' TPC features may come into play to promote the intention to continue to use TPC, most notably mobility and wireless connectivity across campus. Accordingly, a primary implication of such research is that while students may think favorably of TPC and thus intend to continue to use the technology, this does not necessarily explain actual use of TPC specific features. Universities wishing to ensure that students leverage the full feature set of TPC may have to further facilitate and support the use of TPC specific features. This is further supported by the results of this research where facilitating conditions is a significant determinant of actual use.

## CONCLUSION

With the proliferation of technology-based initiatives in education, studies analyzing the adoption of such initiatives complement existing attempts to evaluate students' learning and teaching effectiveness. Specifically, evaluating the adoption of such IT-based initiatives in education provide insight regarding the factors behind the success or failure (measured in students' learning and teaching effectiveness) of such initiatives. These results can be used for diagnostic purposes and for the planning and management for technology-based initiatives in education. From a theoretical perspective, the research will add to the literature dealing with mandatory adoption of technical innovations. The research also contributes to the general adoption literature by studying the theoretical validity and empirical applicability of the relatively recently proposed UTAUT model.

### Recommendations for future work

From practical perspective, it is interesting to evaluate students' acceptance over time as well as by individual groups (e.g., freshman versus seniors, or information systems majors versus arts and sciences majors). A case study will complement and provide insight into the findings of the study. Moreover, a study comparing TPC to other mobile devices such as notebooks and handheld PC can shed light into the effect of mobility versus TPC specific features. On the other hand, from a theoretical perspective, and extending the work by Venkatesh et al. (2003), it would be interesting evaluate the superiority of the UTAUT model over other technology acceptance models.

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