AC 2007-2548: FACTORS INFLUENCING ENGINEERING FACULTY'S USE OF TABLET PCS

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Factors Influencing Engineering Faculty's Use of Tablet PCs

Abstract

This paper reports on a study of Tablet PC (TPC) usage by twenty engineering faculty members at a large land-grant university in the mid-Atlantic region of the United States. The purpose of this study is to explore how engineering faculty choose to use TPCs, the faculty's perceptions of TPC use, and the factors related to the faculty's use of TPCs in engineering classrooms. The faculty are volunteers, representing eleven different engineering disciplines. The authors applied both qualitative and quantitative methods to identify the factors that influence TPC use. The research findings reveal that the percent of class time in which the TPC is used is significantly correlated with the faculty's perceived ease of use ($r=.429$, $p<.05$), perceived usefulness ($r=.454$, $p<.05$), and self-efficacy in TPC use ($r=.520$, $p<.05$). Individual interviews with the faculty support the relationships found in the correlational analysis. Possible explanations for these findings are presented and discussed.

Background

The Tablet PC (TPC) is the next step in the evolution of laptop computing [1]. TPCs are computers that allow faculty to use a stylus to input information just as they would with a pad and a pencil. This method of data entry translates a user's movements to "digital ink" to enter text, drawings, and equations. Different models are available, including slates (without a keyboard; stylus data entry only) and convertibles (notebook computers with displays that shift to allow stylus data entry in addition to the traditional keyboard/mouse). Given these characteristics, the TPC has the potential to alter the educational process and is making inroads in the engineering education arena [2].

A review of the current literature indicates that instructors are capitalizing on the TPC's potential for active and student centered learning in the classroom. TPCs provide unique characteristics that lend themselves to academic environments benefiting both instructors and students [3]. First, digital ink enables instructors to write 'on the fly' during class as one would write on a chalkboard or on a transparency [4]. This is especially meaningful for engineering courses where the material is often mathematically and graphically intensive [5]. Second, the freedom of marking-up significantly changes the way students and teachers interact [6, 7]. It facilitates bi-directional sharing of information, moving students beyond merely observing presentations to interacting with the material, the teacher, and each other. In addition, the use of TPCs supports more efficient management of information [4, 8]. Dynamic working notes can be saved in a searchable format, while lecture notes with vivid annotations become available for students' online viewing.

These characteristics are accelerating the adoption and use of TPCs in classrooms. This use has drawn the attention of researchers and practitioners in the field. However, most of the prior research reports survey results of student perceptions on the use of TPCs as exemplified by Mock [4], Anderson et al. [9], and Berque et al.[10]. The researchers believe that the diffusion

and implementation of this technology is in the hands of faculty, who demonstrate its use and act as role models. Therefore, it is critical to investigate TPC use from a faculty standpoint. While there is some literature dealing with faculty use of TPCs, the majority of this literature is focused on single case report studies of how individual faculty have used and implemented the TPC into their classrooms.

Given this background, the investigation centers on three questions. First, the researchers thought it important to investigate how faculty who are given free rein to implement the TPC in their classrooms would choose to do so. This is critical to understanding how and where the TPC could be best utilized in engineering education. Second, we were interested in exploring faculty perceptions related to TPC use. This facet was pursued in the hope that this might help the researchers better understand the faculty who are the actual users of TPCs. And third, we investigated the factors that might influence how engineering faculty implement the TPC into the classroom, which is related to the issue of diffusion of the innovation.

Specific variables for each research question emerged from two different sources. First, the researchers conducted a phenomenological study consisting of faculty interviews, classroom observations, and document analysis in the spring semester of 2006 [11]. Several factors, including faculty's self-efficacy on TPC use, appropriateness of classroom environment, and overall satisfaction on TPC use, were found to affect faculty TPC use.

Second, a literature review of technology acceptance models revealed that perceived ease of use, perceived usefulness, and the intention to use are the key factors influencing the adoption of new technology [12-14]. The Technology Acceptance Model (TAM) attempts to explain and predict why users sometimes accept and sometimes reject new technology [12, 13, 15]. TAM was considered an appropriate framework for this study, since the result of the first round of individual interviews revealed possible variations in faculty's Tablet PC use in relation to those factors. According to Davis [14], the model identifies a small number of fundamental variables suggested by previous research dealing with the cognitive and affective determinants of computer acceptance. It posits that two particular beliefs, perceived ease of use and perceived usefulness, are of primary relevance to computer acceptance behavior.

Based on these sources, research questions were refined with detailed variables of interest. The goal of this study is to explore how engineering faculty are using TPCs in their classroom and identify the factors which are related to their use of TPCs in order to facilitate effective adoption of this technology. The following research questions were under investigation:

1. How do engineering faculty use Tablet PCs (in terms of the amount of usage time in/out of the classroom and the purposes of use)?
2. What are the faculty's perceptions related to TPC use (in terms of the levels of perceived ease of use, perceived usefulness, intention to use, satisfaction, availability of support, appropriateness of classroom environment, and self-efficacy related to TPCs)?
3. Among the variables mentioned in research question 2, which factors are related to the faculty's use of TPCs in engineering classrooms?

Methodology

Participants

In the Fall of 2005, the College of Engineering held two informational workshops on the Tablet PC. As a result of these sessions, approximately thirty faculty who were interested in teaching with a TPC were identified and supplied either with a new TPC or the support needed to use their own machine. The underlying goal of this "Tablet PC Initiative" was to place TPCs in the hands of engineering faculty and see what they could do with them.

Twenty participating faculty members, representing eleven different engineering disciplines, volunteered for this study. Of these, 19% are female. The years of teaching experience and TPC-related experience vary widely across the sample. At the beginning of the Fall semester in 2006, 85% of the participants already had at least 1 semester of teaching experience with the TPC (see Table 1).

Table 1. Prior experience of participants

(n=20)

Prior Experience	Categories		Descriptives
Prior College Teaching Experience	1-5 yrs	: 20%	Mean=10.95, SD= 7.74
	5-10 yrs	: 45%	Min=1, Max=26
	10-20 yrs	: 20%	
	More than 20 yrs	: 15%	
Prior Teaching Experience w/TPC	No experience	: 15%	Mean=1.45, SD= 1.24
	1 semester	: 55%	Min=0, Max=5
	2 semesters	: 10%	
	More then 2 semesters	: 20%	

Design of the study

Various methods and techniques, including both quantitative and qualitative data collection, were combined to achieve the goals of this study. To answer research questions 1 and 2, survey data collected from the participant was analyzed in a descriptive way. To answer research question 3, researchers conducted correlational analyses to examine the relationships among the variables of interest. Finally, existing qualitative data from a previous phenomenological study [see 11] was explored to further explain the correlational data. Content analysis of the transcription and the interviewer's reflective notes was conducted with an eye towards the variables investigated through the quantitative research. This application of mixed-methods was expected to provide a more complete understanding as well as improved perspectives on the research questions raised in this study.

Variables and measurement instruments

There are two categories of variables under investigation: the use of TPCs and the perception of TPC use. Table 2 presents the number of items, scales and sources of instruments for each

variable. Several instruments were newly developed for the purpose of the Tablet PC Initiative project, while others were adopted from existing instruments.

Table 2. Variables and measurement instruments

Categories	Variables	# of items	Scales	Sources
Use of TPC for Teaching	% of time in class	1	Open-ended	Newly developed for the purpose of the project
	Amount of time out of class	1	Open-ended	
	Purpose of TPC use	6	Likert (1-5)	
	Use of hand-writing functions	6	Likert (1-5)	
	Course preparation methods	1	Multiple choice	
Perception of TPC Use	Perceived ease of use	5	Likert (1-5)	Technology Acceptance Model [12]
	Perceived usefulness	6		
	Intention to use	3		
	Self-efficacy in TPC use	2	Likert (1-5)	Newly developed for the purpose of the project
	Satisfaction with TPC use in general	3		
	Appropriateness of classroom environment	2		
	Availability of support	3		

Use of TPC for Teaching is a self-report instrument consisting of five variables to explain faculty's general use of the TPC in their classrooms. A series of Likert-type items were included in which the faculty members rated the frequency with which they utilized the TPC for certain features, such as annotating, free-writing, etc. The items were generated from a previous phenomenological study of this group[11]. These Likert-type items constituted the variables of *Purpose of TPC Use* and the *Use of hand-writing functions.* Each Likert-type item utilized 5 anchors, which ranged from 1 ("not at all") to 5 ("very often"). Regarding *Course preparation methods*, faculty were asked to check all that apply to their way of preparing instructional material (e.g. refining digital materials). The instruments for the use of the TPC were administered at the end of Fall semester, 2006.

Perception of TPC Use consists of seven different variables examining faculty's attitude and feelings related to TPC use in general. The first three, *Perceived ease of use, Perceived usefulness,* and *Intention to use,* are adopted from the Technology Acceptance Model (TAM). *Perceived ease of use* refers to "the degree to which the user expects the target system to be free of effort"[12, p.985], while *perceived usefulness* is defined as the user's "subjective probability that using a specific application system will increase his or her job performance within an organizational context" [12, p.985]. Both of them influence the individual's behavioral *intention to use* the system, which predicts the actual use of the system. In this study, *perceived ease of use*, *perceived usefulness*, and *intention to use* are adopted to examine the degree of acceptance of the TPC by the engineering faculty. The remaining four variables were measured using instruments developed by the research team, based on the existing literatures on educational technology integration. Each variable was treated as a summated rating scale for descriptive reporting and correlational analysis.

In sum, the selected variables were chosen and refined based on the literature review as well as the first round of individual interviews. Survey items were further refined through the semesters leading up to this study, informed by interview results, observations, and informal interviews with faculty and technical support personal.

Results

Descriptive Data

Use of TPC. Table 3 presents the descriptive data on faculty's TPC use for teaching. On average, the TPC is used for 88% of in-class time, according to the faculty members. More specifically, 16 of 20 faculty report using the TPC for more than 80% of in-class time, including 11 faculty who reported using it for 100% of their class time. For each course taught with the TPC faculty spent 5.78 hours for teaching preparation and 1.48 hours for course management per week. That is, it took about 6 hours to create or refine the digital resources or lecture notes in addition to 1.5 hours to upload annotated files or communicate with students outside of the classroom. Related to this issue, 70% of participants reported that they usually refined or modified the digital resources they already had, while 50% of the participants reported that they created new lecture notes or slides from scratch.

Table 3. Descriptive data on faculty's TPC use

(n=20)

Variables		Descriptives		Range
Amount of Usage	% of class time using TPC per course	88%		15%-100%
	Hrs/week for preparation per course	5.78hrs		0.25hrs-19hrs
	Hrs/week for management per course	1.48hrs		0hrs-5hrs
Course Material Preparation Methods	Reuse digital material	30%		(N/A)
	Refine/modify digital materials	70%		
	Create from scratch	50%		
	No preparation(use blank slides)	10%		
		Mean	SD	Scales
Purpose of TPC Use	Annotating pre-developed materials	4.33	1.05	1: Not at all
	Free-writing on blank pages	2.87	1.36	5: Very often
	Providing feedback on students' assignments	1.93	1.39	
	Taking notes during meetings	1.87	1.41	
	Facilitating students' activities	1.67	.90	
	Integrate/switching between media	2.40	.91	
Use of Hand-writing Functions	Highlighting	1.93	1.16	1: Not at all
	Underlining	3.53	1.55	5: Very often
	Drawing graphs	3.80	1.15	
	Writing equations	4.20	1.15	
	Writing keywords	3.93	1.44	
	Color coding	3.07	1.33	

The TPC has been used most frequently for the purpose of "annotating pre-developed materials" (mean=4.33), while "facilitating students' activities" was endorsed the least frequently (mean =1.67). Reflecting the domain of engineering, "writing equations" is reported as the most frequently used function of handwriting (mean =4.20), followed by "writing keywords" (mean =3.93) and "drawing graphs" (mean =3.80).

Perception of TPC use. Survey results show that the faculty's cognitive and affective determinants of TPC use, according to the Technology acceptance model, were quite high at the beginning of the Fall semester in 2006. (This may be expected when working with "early adopter" volunteers, and should be considered when new technology is introduced into an educational environment.) They perceived the TPC as very easy to use (mean=4.40) and quite useful (mean=3.93). They also reported high levels of self-efficacy for TPC use (mean=4.55), which means they felt very confident and able to use the TPC. Table 4 presents these results, as well as presenting the results of faculty satisfaction with TPC use, the appropriateness of the classroom environment, and the availability of support.

Table 4. Descriptive data on faculty's perception on TPC use

(n=20)

Variables	Mean	SD	Scales
Perceived ease of use	4.40	.60	1: Not at all
Perceived usefulness	3.93	.56	5: A great deal
Intention to use	3.88	.61	
For teaching	4.60	.68	
For work	4.05	.94	
For personal use	3.00	1.08	
Self-efficacy on TPC use	4.55	.74	1: Not at all
Satisfaction on TPC use in general	4.32	.52	5: A great deal
Appropriateness of classroom environment	4.18	.82	
Availability of Support	3.88	.79	

Factors related to the use of TPCs. According to the correlational analysis results in Table 5, there are several variables related to the faculty's use of the TPC. The percent of class time taught with the TPC is significantly correlated with faculty's perceived ease of use ($r=.429$, $p<.05$), perceived usefulness ($r=.454$, $p<.05$), and self-efficacy related to TPC use ($r=.520$, $p<.05$). This could be interpreted to mean that they use the TPC more often when they perceive it to be easier and more useful, and when they feel more confident. It may just as easily mean that faculty who think the TPC is easy to use, more useful, and who have high self-efficacy use the TPCs more often. The design of this study does not allow us to attribute causality to this correlation.

Interestingly, the hours for course preparation are negatively related to the intention to use ($r=-.397$, $p<.05$). It seems reasonable to say that the intention to use the TPC is lower if a faculty member reports that a lot of time is required to prepare a particular course.

Another interesting finding is the positive relationship between self-efficacy in TPC use and the perceived appropriateness of the classroom environment. The more confident they are, the easier they perceive it is to manage the classroom environment themselves (r=.550, p<.05). In terms of satisfaction with TPC use, availability of support was the only factor that correlated significantly (r=.509, p<.05).

Table 5. Correlational results

Variables	1	2	3	4	5	6	7	8	9	10
1. Perceived ease of use	1									
2. Perceive usefulness	.482*	1								
3. Intention to use	.369	.321	1							
4. Self-efficacy in TPC use	.835**	.632**	.302	1						
5. Satisfaction with TPC use in general	.355	.324	-.025	.296	1					
6. Appropriateness of classroom environment	.371	.280	.095	.550*	.192	1				
7. Availability of support	-.133	-.068	-.188	-.086	.509*	.144	1			
8. % of class time using TPC per course	.499*	.454*	.316	.520*	-.057	.398	-.234	1		
9. Hrs/week for preparation per course	.076	.262	-.397*	.316	.378	.526*	.256	.233	1	
10. Hrs/week for management per course	.151	.627**	.079	.153	-.165	.033	-.131	.261	.041	1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Qualitative Report

Given the limitations of the correlation findings, individual interviews with the faculty were used to support the relationships found in the correlational analysis. Regarding perceived ease of use, several faculty who had been using a TPC for 100% of their class time argued that it was not that difficult to lean how to use the TPC;

> *"It was so easy to learn. I mean, I didn't even try to learn how to use it. I just played with it."*

> *"I tried the Tutorial installed in the machine… for about 5 or 10 minutes. The only difference (from the laptops) is handwriting. What's [the] big deal?"*

In addition, they reported that the TPC makes teaching much easier compared to teaching with other media;

> *"I found [Microsoft] Journal faster because my handwriting is faster than using the Microsoft equation tool. Equations are much easier when you do it by hand. I use all different types of colors and arrows in this and that."*

> *"When I use overheads… after I create the material, I have to print it on paper, and go to [the] copy center to Xerox it to transparency. And when I get back from class I get things all covered with ink, which I should clean off so that I can reuse them again. It's much easier to work with [a] tablet electronically. Import a file with PowerPoint, work on it in class and just republish it later with or without annotation. It's much easier."*

Interview results also revealed that heavy users perceived the TPC as a useful tool for teaching. For example, they claimed that the TPC makes their presentations clearer, helps them to share course materials with students, and facilitates more interaction.

> *"…I write a lot bigger. When it's on the screen I'm sure that physical dimension of what I'm writing is a lot bigger and more crisp than what was on the overheads with markers…"*

> *"I've been posting my slides the day before onto the course management system, before they're marked-up, because some students want to print that out and then take notes as they go along, and I want to encourage that… I wish all the students [would] print out a copy and bring it in to class. Students who do bring the copy benefit a lot because they can write their own notes of what I say rather than writing down everything I say..."*

> *"I face my students. I don't have to turn my back to them to write on the board, which gives me more eye-contact. So I think I have more interaction with my students when facing them…"*

A high level of self-efficacy in the use of TPCs is another factor found among the faculty who have been using the TPC for most of their teaching time.

> *"Early on, I was very aware that I was using the Tablet PC…. But now it's very natural, and I don't give a second thought… I feel so comfortable writing on the tablet…Yes, definitely confident."*

One of the notable correlations, the negative relationship between the hours required for course preparation and intention to use, is clearly supported by the individual interviews. What follows is a comment from a faculty member who scored the lowest in intention to use as well as percent of time teaching with the TPC;

"I have a lot of stuff in overheads. I don't have electronic versions; I haven't done that yet. Like one of my colleagues, the material he is teaching is available electronically. So all the stuff he's using… he can just go and pull up electronic text. Some of the stuff I have are [sic] electronic, but not all of it. So if I had nothing else to do I could just focus on using the Tablet PC and get my stuff converted…but it takes some time that I haven't had yet."

Discussion

This study aims to investigate engineering faculty's actual and perceived TPC use, and to examine the relationships between various factors that are expected to affect this use. The design of the study limits our ability to assign causality to significant correlations, and the participants were all volunteers. Given these limitations, there are some interesting findings to discuss.

The first is that the faculty in the study tended to use the TPC a great deal in their courses, for an average of 88% of their class time. Considering that most of them had only one or two semesters of experience teaching with the TPC, the possibility for rapid adoption of the TPC appears likely. Faculty reporting high degrees of self-efficacy in TPC use were even able to overcome difficulties in classroom environment (technology limitations, etc.) and continue to teach effectively. The relationship between self-efficacy in TPC use and the amount of use indicates that practitioners and others interested in successfully adopting TPCs for instruction should consider developing the faculty's confidence and comfort level as a means of support. Providing successful experiences that range from easy to more difficult can encourage the development of self-efficacy. Explicit training such as this will likely be required as we move forward from our small group of volunteers to involve the larger faculty.

The statistically significant relationship between the percent of class time taught with the TPC and faculty's perceived ease of use, perceived usefulness, and self-efficacy related to TPC use can mean either that more use leads to higher favorable views of the TPC or that higher favorable views lead to greater use. The qualitative data adds some strength to the relationship, but the question of which comes first remains unanswered. Fortunately, this is not a critical question. It is sufficient to note that frequent use and high positive perceptions of the TPC are significantly related and important factors to consider when adopting TPCs.

Conclusion

The Technology Acceptance Model was appropriate for this project. Faculty who perceived the use of TPC as easy and useful reported that they used the TPC more often. Since it is clear that perceived ease of use is highly correlated with self-efficacy in TPC

use, these two factors should be considered together at the beginning stage of adoption and diffusion. Programs considering the adoption of TPCs for faculty use should develop support structures that encourage understanding about the technology's ease of use and its usefulness as a tool of instruction. Faculty should also receive enough training to feel competent while using a TPC in a classroom environment.

Bibliography

1. Toto, R., et al. *One Step Beyond: Lecturing With a Tablet PC*. in *ASEE*. 2006.
2. Wise, J.C., R. Toto, and K.Y. Lim. *Teaching with Tablet PCs*. in *ASEE/IEEE Frontiers in Education Conference*. 2006. San Diego, CA.
3. Willis, C.L. and S.L. Miertschin. *Tablet PC's as Instructional Tools or the Pen is Mightier than the 'Board*. in *SIGITE*. 2004. Salt Lake City, Utah.
4. Mock, K. *TEACHING WITH TABLET PC'S*. in *Consortium for Computing Sciences in Colleges*. 2004. Northwestern Conference.
5. Frolik, J. and J.B. Zurn. *Evaluation of Tablet PCs for engineering content development and instruction*. in *ASEE Conference*. 2004.
6. Alvarado, C., et al., *Microsoft Research University Relations Program: Tablet PC and Computing Curriculum*, in *Tablet PC and Computing Curriculum Workshop*. 2004: A White Paper.
7. Wilkerson, M., W.G. Griswold, and B. Simon. *Ubiquitous Presenter: Increasing Student Access and Control in a Digital Lecturing Environment*. in *SIGCSE*. 2005. St. Louis, Missouri.
8. Willis, C. and S. Miertschin. *Tablet PC's as Instructional Tools or the Pen is Mightier than the Board*. in *SIGITE*. 2004. Salt Lake City, Utah.
9. Anderson, R., et al. *Experiences with a Tablet PC Based Lecture Presentation System in Computer Science Courses*. in *SIGCSE*. 2004. Norfolk, Virginia.
10. Berque, D., D. Johnson, and L. Jovanovic. *Teaching Theory of Computation Using Pen-based Computers and an Electronic Whiteboard*. in *ITICSE*. 2001. Canterbury, UK.
11. Lim, K.Y., J.C. Wise, and R. Toto. *Tablet PC as a Teaching Tool: A Phenomenological Study*. in *Proceeding for AERA Annual Conference*. 2007, accepted.
12. Davis, F.D., R.P. Bagozzi, and P.R. Warshaw, *User Acceptance Of Computer Technology: A Comparison Of Two.* Management Science, 1989. 35(8): p. 982-1003.
13. Igbaria, M., T. Guimaraes, and G.B. Davis, *Testing the determinants of microcomputer usage via a structural equation model.* Journal of Management Information Systems, 1995. 11: p. 87-114.
14. Davis, F.D., *Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology.* MIS Quarterly, 1989. 13: p. 319-340.
15. Szajna, B., *Empirical evaluation of the revised technology acceptance model.* Management Science, 1996. 42(1): p. 85-92.