AC 2011-107: MACROERGONOMIC ANALYSIS OF INSTRUCTIONAL TECHNOLOGY ADOPTION: A CASE STUDY ON TABLET PC ADOPTION

Leanna M. Horton, Virginia Tech

Leanna Horton is a Ph.D. Candidate in the Industrial and Systems Engineering Department at Virginia Tech and is a member of the Industrial Ergonomics and Biomechanics Laboratory. Her research is focused on the effects of job rotation on muscle fatigue and performance.

Kahyun Kim, Virginia Tech

Kahyun Kim is a graduate student currently pursuing Ph.D. in Industrial and Systems Engineering at Virginia Tech with a concentration on human factors and ergonomics. Her research interest is in the impact of various factors on team collaboration and effectiveness as well as team cognition.

Shreya Kothaneth, Virginia Tech

Shreya Kothaneth is a doctoral candidate in the Department of Industrial and Systems Engineering, Virginia Tech. She is also the lead of the College of Engineering's Instructional Technology Team. Her research interests include diffusion of technology, usability, and cultural ergonomics.

Catherine T. Amelink, Virginia Tech

Catherine T. Amelink, Virginia Tech Dr. Catherine Amelink is currently serving as the Research Coordinator for the Institute for Distance and Distributed Learning at Virginia Tech and Assessment Coordinator for the College of Engineering in the Office of the Associate Dean for International Programs and Information Technology. Previously she worked on assessment initiatives with the Division of Student Affairs and the Center for Excellence in Undergraduate Education at Virginia Tech and as the Assessment Coordinator for undergraduate education at University of Maryland University College. She is a graduate of the Ph.D. program in Educational Leadership and Policy Studies at Virginia Tech.

Macroergonomics Analysis of Instructional Technology Diffusion: A Case Study on Tablet PC Adoption

Abstract

Instructional technologies are widely used to improve classroom dynamics and foster learning. At Virginia Tech (VT), the College of Engineering (COE) has continually emphasized the use of instructional technologies as an important part of the educational experience. Tablet PCs have been implemented as an instructional tool at many universities, including VT, with varying degrees of success. These universities have identified many educational benefits associated with the use of Tablet PCs, including increased student engagement, more efficient lecture presentations, and overall improved learning experiences, yet difficulties have been reported regarding adoption of the technology. In order to fully assess the Tablet PC program at VT and determine its current level of success and future potential, a mixed-method investigation of the program was conducted. This analysis explored student and faculty usage of Tablet PCs, including benefits and barriers associated with Tablet PC use, through interviews with faculty members (n = 4), focus groups with undergraduate students (n = 21), an online survey to undergraduate students (n = 1090), and a sociotechnical systems analysis of the COE. Results indicated many improvements in student learning related to Tablet PC use as well as several barriers toward adoption affecting both faculty and students. Notable benefits associated with Tablet PC use included increased student engagement, improved visualization features, more streamlined classroom presentations/note taking, and better opportunities for collaboration. Reported barriers included a lack of incentives, traditional classroom infrastructure, perceived incompatibility with preferred learning/teaching methods, and challenges with hardware/software. Overall, Tablet PC adoption has been inconsistent among both faculty and students, with some enthusiastically utilizing Tablet PCs and others continuing to use older technologies; reasons for this are discussed as this finding is consistent with previous research. Suggestions for improving usage of Tablet PCs as well as other forms of instructional technology are discussed.

Background

Tablet PCs were first investigated for use at Virginia Tech in 2002, when faculty members began exploring ways in which they could be incorporated into classrooms [17]. From there, Tablet PCs were first implemented in the classroom in an *Introduction to Computer Engineering* class during the spring of 2004, in which 20 Tablet PCs were used in a class of 40 students [16]. More than 85% of the students expressed high satisfaction with using Tablet PCs and high levels of energy and participation were observed in students during active learning exercises [16]. In 2006, Virginia Tech became the first public university to require all incoming freshman in the College of Engineering to purchase a Tablet PC. In addition, this program has become the largest implementation of Tablet PC use across an engineering college [18].

Many universities have implemented Tablet PCs for teaching engineering and science courses [3, 8, 10, 12, 14, 15, 19]. These universities have identified many educational benefits associated with the use of Tablet PCs, including increased student engagement [4, 12, 13, 15, 20], more efficient lecture presentations [4, 10] and overall improved learning experiences [3, 8, 10]. In spite of these advantages, difficulties have been reported regarding adoption of the technology. Reported difficulties include problems with the hardware/software of Tablet PCs [4, 10, 19], the time required for faculty members to incorporate the new technology [15], and increased student distraction [4].

Conceptual Framework

Successfully implementing new instructional technologies is dependent on many factors. Rogers[11] described a process called 'diffusion of innovation', which describes the decision process for adopting a new technology and the many attributes that affect the adoption of technology as well as the speed of diffusion. According to this theory, the decision process for users to decide whether or not to adopt the new technology follows five steps: knowledge, persuasion, decision, implementation, and confirmation. During this process, users' decision to adopt as well as the speed of technology diffusion depend on the following attributes:

- relative advantage (is the new technology better?),
- compatibility (is the new technology consistent with past experiences?),
- complexity (is the new technology difficult to understand?),
- trialability (can users experiment with the new technology on a limited basis?), and
- observability (are the results visible to others?) [6, 11].

More specifically, Garland[5] summarized major barriers for diffusion and adoption of instructional technologies and found three primary types of barriers: personnel related, cost related, and infrastructure related issues. Personnel related issues include national or organizational cultures that are reluctant to adopt new technologies and risk aversion characteristics of potential users. Another major barrier is the cost of technology development and delivery. In addition, the availability of infrastructure, such as access to equipment and software, can affect the adoption of instructional technology [5]. Due to its extensive use in research, Rogers' theory was used as the conceptual framework for this analysis.

Additionally, a Macroergonomic framework was used for this analysis. This framework is based on sociotechnical system analysis, which defines a work system as two or more people interacting with a personnel subsystem, technological subsystem, an organizational design, and the environment [7]. The goal of this analysis was to analyze the subsystems of the work system, defined as the COE at Virginia Tech, and their interactions to highlight specific barriers towards Tablet PC use.

Methods

Using this framework, a mixed-method design was employed using interviews with faculty members considered lead adopters of Tablet PCs, focus groups with both freshman and senior students in the COE, an online survey administered to COE undergraduate students, and a sociotechical systems analysis (STS) to examine Tablet PC use and adoption in the College of Engineering (COE) at Virginia Tech.

Four COE faculty members representing several COE departments were identified by the research team as lead adopters of the Tablet PCs to be interviewed. These faculty members were chosen because of their consistent classroom use and long-term experience with Tablet PCs. The interview questions were designed to obtain the faculty members' experiences with Tablet PCs, including how and why they started using Tablet PCs, how the Tablet PC has changed their approach to instruction, how they currently use Tablet PCs in their classroom, and any possible barriers they see towards adoption by other faculty members and students. Recorded interviews took place in individual faculty members' offices and lasted approximately 30-minutes. Focus groups were conducted with freshman and seniors in the COE to obtain first-hand experiences from both new and experienced Tablet PC users. The questions were designed to obtain students' experiences with Tablet PCs, including their usage of and opinions about the Tablet PC and its features. One focus group was conducted with six freshman (all male) and two focus groups were conducted with seniors, one with twelve students (9 male, 3 female) and one with three students (all male). Two researchers facilitated the focus group interviews and they each lasted one hour and were audio- and video-recorded. An online survey was also given to students in the COE. The survey was designed to obtain students' experiences with Tablet PCs and general use of technology for learning. A total of 1090 students (829 male, 261 female) completed the online survey.

All interview audio recordings were transcribed verbatim and coded and analyzed based on grounded theory. The five attributes of Rogers'[11] innovation diffusion (relative advantage, complexity, compatibility, trialability, and observability) were used as *a priori* codes and additional codes were added as analyses progressed. Student survey questions were analyzed using descriptive statistics.

The sociotechnical systems (STS) approach was used to analyze the Tablet PC initiative using the results from the interviews, focus groups, and surveys. In addition, the Office of Information Technology was consulted regarding the organizational design of the COE as it relates to the Tablet PC initiative. The components of the four sociotechnical subsystems, namely the personnel subsystem, technological subsystem, organizational design, and environmental

subsystem[7], were identified and analyzed along with their interactions to determine how to address current barriers and increase usage of Tablet PCs.

Results

Many consistent benefits of Tablet PCs that served as motivations toward Tablet PC use, as well as several challenges towards full adoption affecting both students and faculty in the COE were found throughout the analyses. A brief summary of the reported benefits and barriers from faculty and students are shown Tables 1 and 2, respectively, and are then described in detail.

Table 1. Benefits and barriers reported by faculty.

Benefits	Barriers
Increased student interactions and engagement in class	Lack of tangible incentives
Helpful visualization features in DyKnow	Inconsistent performance of hardware/software
Better student understanding	Issues with classroom infrastructure
Active participation of shy students	Lack of compatibility with preferred pedagogy
Easier demonstrations	
Team collaboration out of class	
Easy digital annotations	
Intuitive interface	
Virtual office hours	
Access to lectures after classes	
Ability to import figures into DyKnow: increases quality of course notes and saves time	
Allowing faculty members to cover more material in less class time	
DyKnow offers a variety of tools: highlighters, pointers, drawing tools with templates, resizing, capture, screen sharing, in-class polling	
Accommodating visual learners	
Benefit for distance learning	
Interactive presentation for lectures	
Experience in electronic collaboration and pen-based technology may be a beneficial skill in job market	

Table 2. Benefits and barriers reported by students.

Benefits	Barriers
Note taking	Inconsistent performance of hardware/software
Backing up notes electronically	Issues with classroom infrastructure
Organizing notes	Lack of compatibility with preferred learning methods
Improved understanding	Lack of others to observe using the technology
Providing better visibility	
More functionality	
Collaboration with teammates	
Receiving feedback	
Drawing diagrams	
Shrinking the size of the classroom	

Benefits

Benefits of Tablet PCs included *relative advantages* compared to other instructional technologies, *compatibility* with current teaching/learning methods, and *observability* of the benefits of the technology. Faculty generally used the Tablet PC in ways that were compatible with the pedagogy they already employed in class, most often a lecture type format combined with small group activities. Overall, faculty reported increased engagement, better opportunities for team collaboration, and improved visualization features. Faculty also reported that Tablet PCs improved student learning and enabled them to cover more class material in less time. Students reported better interactions with faculty, improved collaboration with other students, better features for drawing diagrams/figures, improvements in note taking, and improved visibility during class.

Both faculty and students reported improved interactions with the use of Tablet PCs. For faculty, in-class interactions were improved through using in-class polling features of the Tablet PC. For example, “You get everyone engaged. All students get to contribute and write something. And it’s not as boring.” Faculty also noted that Tablet PCs allow for both outspoken and more reserved students to participate. For example:

> "I do feel like Dyknow or programs of that sort do encourage interaction a lot. I see people who I think otherwise be too shy to come up to the blackboard who are participating; they wouldn’t otherwise, because you can do things like what is the answer to this question? They submit their panel anonymously. They are actually participating as opposed to sitting in front of computer and being nervous."

Students also reported improved interactions during class. For example, one student highlighted the benefits of Tablet PCs used in conjunction in the presentation module, “when they write on the screen it comes straight to us or you can see it giant on the big screen.” For many students, the Tablet PC has helped make “big classes feel smaller” due to better visibility and increased interactions during class.

Tablet PCs have also improved out-of-class interactions for faculty and students. Faculty used Tablet PCs to increase the quality of interactions with students through virtual office hours. For example, one faculty mentioned the student reactions to the use of Tablet PCs for virtual office hours, stating, “My students have told me: it is just like I was sitting in your office and you were helping me.” Similarly, faculty members explained benefits of students using Tablet PCs for online collaboration. For example,

> "And the really nice thing is that we were able to form electronic collaborations between each team. Each team was able to set up an intranet using, sharing an IP address and they were able to work on assignments, you know, one person would be able to describe a part of the assignment, the next person could answer the next question in their own handwriting and then that saved a lot of time compared to paper."

Also reported by students were improvements in getting feedback from instructors. For example, “I like getting my homework back with handwritten notes on it. I can tell exactly what the grader wanted.”

Faculty also reported that incorporating features of the Tablet PC allowed more opportunities for visualization of course content to reach different types of learners. Specifically, Tablet PCs enabled improved demonstrations and importing figures into course lecture materials. Students also felt that the increased ability to visualize what the instructor was conveying improved their understanding. For example,

> "It’s just easier visually when they can write something and it can be translated to their projector and they can write stuff actually you know, type it or draw a picture. It usually helps me seeing it, understand it a little bit better."

Students also reported benefits of the Tablet PCs e-inking features for drawing diagrams and sharing them with other students. For example,

> “For civil engineering, if I am discussing how I am going to design a bridge for my design project, it’s really nice to be able to draw it out right there, and have it digital, so we can send it out to each other, and do it that way. Obviously, you can draw them on a paper, you know, it’s harder to make copies of that. Its very convenient for the diagramming purposes, I use that all the time.”

Students also identified the swiveling monitor as a beneficial feature of Tablet PCs, specifically when working with other students. Students reported that “the swivel screen is nice for showing people stuff” and that Tablet PCs improve sharing things with other students, such as during a “group project or something and you have a picture on your screen to write on and show ideas.” Students also reported improvements in organizing class materials with Tablet PCs. Specific benefits included ease of taking notes during class, organizing class notes, and electronically backing up class notes.

Barriers

Despite many benefits that Tablet PCs can offer, there are still many challenges for full adoption of the technology. Barriers reported were related to the lack of *relative advantages* of the software, *incompatibility* with currently used technology and pedagogy, the *complexity* of the technology, and lack of *observability* of its use. Faculty members reported a lack of incentives, incompatibilities with teaching styles and course material, inconsistent performance, and unsupportive classroom infrastructure as primary barriers towards using Tablet PCs. Barriers consistently reported by students include problems with classroom infrastructure, incompatibility with preferred learning methods, and problems with the performance and durability of Tablet PCs.

The complexity related to learning a new form of instructional technology coupled with a lack of incentives for faculty was a major factor preventing usage. The emphasis of the current promotion and tenure system on research rather than teaching discourages faculty from investing the time to learn to use the technology in ways that would require changing how they taught currently. As stated by one interviewee:

> "You got to do a heck of lot of research to get tenured. You got to spend a lot time writing proposals and grants and things like that, and in that environment, why would I spend any time learning a new application, or changing what I am doing in the classroom?"

Faculty members were also deterred from incorporating Tablet PCs into their teaching due to the inconsistent performance of Tablet PCs and related software. They mentioned that they were reluctant to use Tablet PCs in class because they did not want the technology to fail in front of the students. For example, "I wasn't sure I knew how to push all the right buttons to make it do the things I wanted it to do and I was not willing to fumble around in front of the students." Another interviewee stated:

> "So, when you stand up in front of, as I do, close to three hundred students, and your computer fails because either the software is not as sophisticated as it will be in a couple of years or the wireless is down, which we are having trouble right now on campus, there are a lot of people that will not follow that, they will just drop that technology like a hot potato, the first time it fails."

Another interviewee stated issues with connecting the Tablet PC to the projector:

> “Cause for me, the rooms I taught in, it was a struggle. You had to find the cord. Sometimes you couldn’t even find a cord to connect to the box that connects to the monitor or projector, and then there were several sets of buttons in the room that you had to hit in a certain combination.”

Further, issues with the classroom infrastructure deterred faculty from requiring students to use their Tablet PCs during class. Specifically, issues were reported regarding power outlet availability in classrooms. One faculty member explained, “Students are saying that Tablet batteries aren’t lasting long enough to get them through the various classes. There are very few

classrooms that have outlets for students really to be able to plug in." This issue also deters students from using their Tablet PCs during class, explaining, "I would go to an engineering class and by the end the battery would die."

Another area of concern was compatibility of the technology course material and with preferred teaching/learning styles of faculty and students. Some faculty members were concerned that using Tablet PCs did not match their teaching styles and course material (e.g., theoretical classes). Students also reported that the use of Tablet PCs did not match their preferred learning methods, with some reporting a preference towards taking notes on paper. Further, students also did not think that Tablet PCs were useful for all departments. For example,

> "If you've ever taken a CS class… for the most part its programming and you get up to a lot of math based stuff in your senior level classes, but even doing programming… there is no point in having a Tablet PC… it's a complication you are never going to need while writing code."

Another barrier towards adoption of Tablet PCs by students is the lack of others to observe using the technology. Freshman reported not observing upper level students or faculty using Tablet PCs, leading students to think they will not need to use their Tablet PCs as they progressed through the degree program and discouraging them from using their Tablet PCs. For example, "I actually think you get to those upper level classes and they don't expect you to do that. That feature sort of becomes obsolete which kind of makes it a laptop." Another student stated that:

> "I've talked with other engineering students that were freshmen here and they said that after your freshmen year you almost never use the Tablet feature anymore. So I guess the upper level engineering people are not using it in the classes today."

Many seniors reported that they had observed faculty members that either did not enjoy using their Tablet PCs or that they did not know how to use it. One student reported that "professors come up to me and ogle in awe of things that I can do in OneNote, and I am like, don't you have a Tablet provided by Virginia Tech that allows you to do this stuff?" Similarly, other seniors reported that "most faculty members… they'd use the pen as a mouse" and "I haven't seen it be used effectively since probably freshman year." Further, seniors reported that "most of the faculty don't even have a Tablet PC to use, or if they do, they don't bring them to class." An environment in which faculty did not make consistent use of the Tablet PC discouraged students from fully adopting the technology.

One student also emphasized the importance of all students having Tablet PCs when trying to collaborate. For example, if one student involved in a group did not have a Tablet PC then collaboration would be more difficult. "They wouldn't be involved in a diagramming process… They would have to sit by as we drew it, or we would have to take turns on somebody's Tablet."

Survey Results

These findings are further supported by the student survey data. In terms of Tablet PC function use, students indicated that they used Tablet PCs to take notes, create diagrams, and to organize and share course material (Table 3). Functions used most frequently included e-ink to mark

PowerPoint slides provided by the instructor, instructors presenting using e-ink, and e-ink to take notes using OneNote.

Table 3. Tablet PC Function Use: Frequency Scale: 1 (never) - 4 (frequently)

	Mean	SD
e-ink to mark slides provided by the instructor	2.39	1.17
Instructor presented using e-ink	2.30	1.08
e-ink to take notes using OneNote	2.30	1.25
e-ink to create diagrams	2.16	1.09
Imported web-based information into notes	2.00	1.1
Shared notes/slides with other students	1.94	0.98
e-ink to take notes with another program	1.93	1.06
e-ink was used to grade homework or projects	1.90	1.05
To respond to interactive class exercises using polling/voting	1.77	0.88
To respond to interactive in-class exercise using written responses	1.74	0.91
Special note take capabilities of OneNote	1.69	0.97
Shared electronic whitespace with other students	1.56	0.83
Audio recording of lectures/discussions using OneNote	1.23	0.59

Students also were asked about the general use of technology during class (Table 4). As shown, a disadvantage to using Tablet PCs over traditional learning tools is the distraction that is caused by the ability to use internet and email during class. However, many benefits were also reported, including improving organization of class materials, reviewing course material, illustrating concepts from class, and making class more interactive.

Table 4. Use of Technology During Class: Agreement Scale: 1 (strongly disagree) - 5 (strongly agree)

	Mean	SD
Caused me to be distracted by use of internet/email	3.61	1.07
Offered me the opportunity to locate class resources online	3.48	1.02
Helped me review materials	3.41	1.03
Was a distraction for me during class	3.34	1.07
Helped illustrate points made in class	3.31	0.95
Results in more rapid feedback from instructor	3.11	1.15
Helps me gather background information better	3.11	1.10
Made class more interactive	3.10	1.11
Helps me organizing my thinking about course materials	3.08	1.07
Distanced me from the instructor	3.06	0.99
Allows me to take greater control of my course activities	3.01	1.08
Improves how well I learn	2.94	1.08
Often did not work properly	2.94	1.13
Helps me better communicate and collaborate	2.9	1.08
Encouraged me to share notes or other materials with students	2.83	1.08
Helped me feel more alert and engaged during class	2.7	1.04
Was a distraction for the teacher	2.7	0.96
Encouraged me to do the readings ahead of time	2.21	0.97

Sociotechnical Systems Analysis

As described, STS includes analyzing the personnel subsystem, the technological work system, the organizational design, and the environment [7] of a work system and their interactions. This analysis is based on the COE as the work system with the goal of identifying barriers associated with Tablet PC use. In this work system, the personnel subsystem includes the undergraduate COE students and the COE faculty. The technological subsystem includes how the work is performed related to Tablet PCs, building infrastructure, courses. The Tablet PC related components include the hardware (hinges, screen, stylus, batteries, etc.) the software (DyKnow, PDF Annotator, OneNote, Classroom presenter, Windows Journal, etc.). Related to the building infrastructure, components include the wireless Internet, power outlet availability, power outlet location, classroom size, and layout of classrooms. Course-related components include the course material (presentation slides, computer simulations, and notes/annotation), course management system (Blackboard, Scholar), structure of courses (how content is delivered), and class size.

The organizational design includes the Dean's office, specifically the Information Technology Branch, the COE Undergraduate Technology Committee (UTC), and the individual COE departments. The COE UTC is made up of the Associate Dean of Information Technology, the Director of Information Technology, representatives from COE departments, and student representatives. This committee makes decisions regarding instructional technology, including the Computer and Software Requirements Policy. In addition, the COE provides technology support available for Tablet PC users. Also included in this subsystem is the organizational culture of the COE, including the research oriented value system and low vertical differentiation.

The environment of the work system includes both internal and external components. For this analysis, the internal environment includes the stress and time pressure placed on COE faculty and students. The external environment includes the Tablet PC vendors (Fujitsu, Toshiba, HP, etc.), the State of Virginia, accreditation bodies such as ABET, and other departments, colleges, and administrative units within the university. The Tablet PC vendors affect the Tablet PC operability, reliability, and cost. ABET affects the Tablet PC requirement by encouraging the COE to implement things that will improve its ratings in the technology category. ABET requires that students demonstrate "an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice," an outcome of Tablet PC use. In addition, ABET requires that students have "an ability to function on multidisciplinary teams" and "an ability to communicate effectively,"[1], both of which can be improved through use of Tablet PC features. The State of Virginia influences the COE though availability of state funding. This funding can affect the infrastructure of buildings and classrooms and the availability of support staff and programs. Virginia Tech influences the COE through its own laptop requirement that the COE has to match or exceed. Another component of the external environment is the regulatory bodies, including the Occupational Safety and Health Administration, the National Electrical Code, National Electrical Safety Code, and Institute of Electrical and Electronics Engineers, that affect the power availability in classrooms, including the circuit structure and capacity of circuits[2]. Also in the external environment is the wireless network provided through the Data/Network Services in the office of Communications Network Services at Virginia Tech.

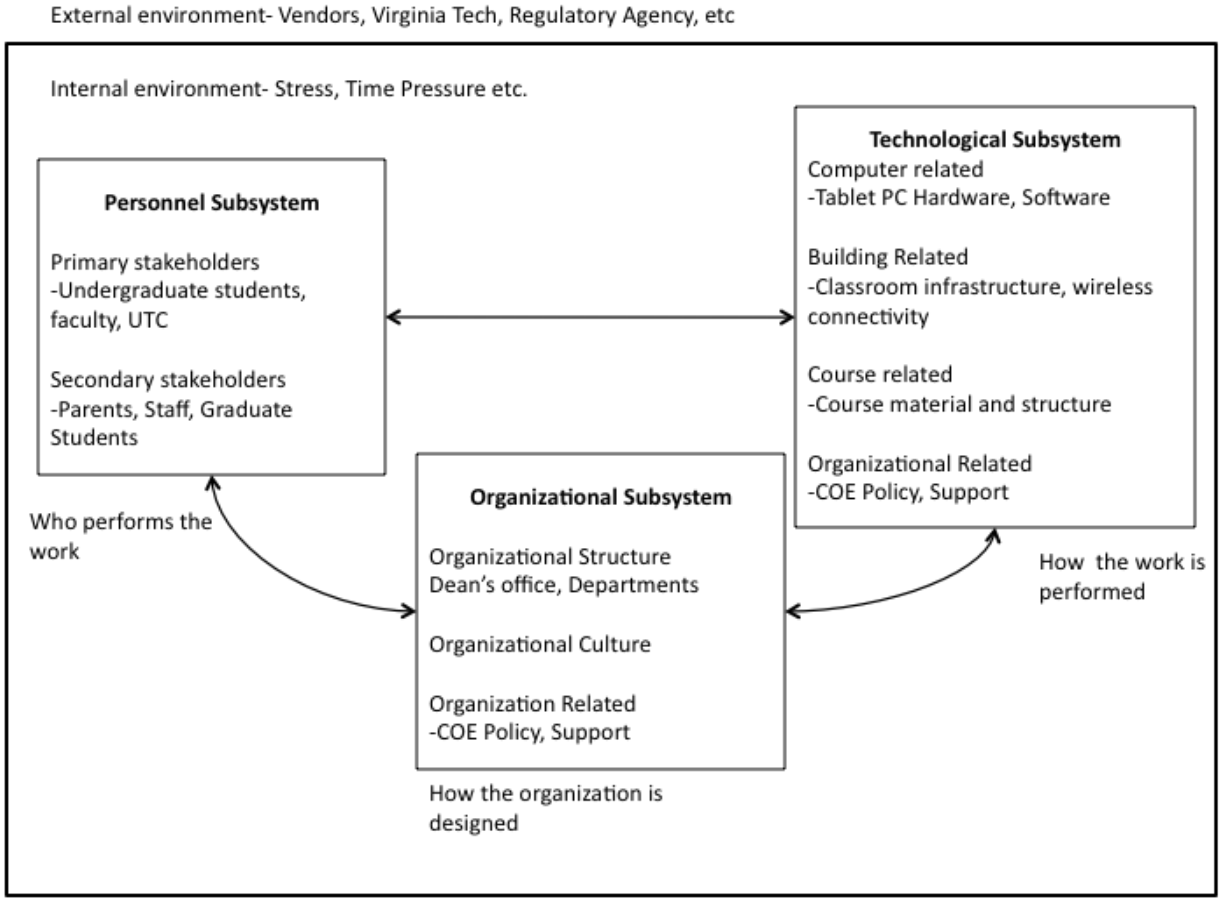

Figure 1. Sociotechnical Systems Analysis Framework

The most commonly reported problems with Tablet PCs, along with related subsystem interactions, are shown in Table 5.

Table 5. Sociotechnical System Component Interactions: Identified Issues with the Tablet PC

Problem	Subsystems Interacting
Inconsistent performance of Tablet PC hardware/software is frustrating to students and faculty members	Technological, Personnel
Research oriented tenure system discourages some faculty members from spending time to incorporate Tablet PCs into teaching	Organizational, Personnel, Technological
Some departments' curriculum does not match the features provided by the Tablet PC	Organizational, Technological
Some faculty members do not feel comfortable using Tablet PCs in classroom do to lack of knowledge about Tablet PCs and/or because of technical issues	Personnel, Technological
Lack of faculty use of Tablet PCs in class discourages use by students	Personnel, Technological
Lack of incentives for faculty to use Tablet PCs	Organizational, Personnel, Technological
Students are not taught how to use Tablet PC effectively	
Classroom infrastructure (e.g., outlets) not supportive of Tablet PC use	External Environment, Organizational, Personnel, Technological

Discussion

Increased student engagement during class and interactions out of class were a significant benefit of using Tablet PCs. This finding is consistent with findings from several other universities [4, 9, 12, 13, 15, 20]. Tablet PCs also assisted faculty members in using visuals during class that helped students to understand concepts more easily. Prior research has found similar results, with benefits of visualization features including figures imported from textbooks [12] and free-hand sketching [3]. Another benefit mentioned by both faculty and students was Tablet PCs' role in team collaborations. Students reported using Microsoft OneNote to share common files among team members, enabling them to work together electronically, a use also found by Willis & Miertschin[20] and Bilen[3]. Tablet PCs' e-inking features facilitated this, and faculty members reported that this contributed to overall student learning gains. Additionally, faculty members reported increased flexibility with the use of Tablet PCs, especially with electronic grading, which allows them to grade without carrying students' papers, a finding also found by Weitz[19].

It was also indicated that Tablet PCs increased the efficiency of lectures. Faculty members were able to cover more material in less time because Tablet PCs allowed them to prepare more

material in advance. Similarly, Chambers[4] reported that Tablet PCs allowed for quicker pace of lectures. Regarding the use of Tablet PCs for lectures, faculty members indicated that this technology is especially helpful for teaching large classes because of better visibility of lecture material. Students also felt that Tablet PCs aided in shrinking the size of classrooms by ensuring better visibility for everyone. In addition, students reported that Tablet PCs improve note taking during lectures by improving organization of notes and the ability to back up notes electronically.

A common barrier reported by faculty members is a lack of incentives, largely due to the research focus of the tenure system. With this system, faculty have little incentive to invest the time to learn to incorporate new instructional technologies into their teaching. The amount of time required of faculty members was also found as a barrier to Tablet PC adoption at Pennsylvania State University [15]. Another consistently reported barrier was technical difficulties associated with the Tablet PC use. For example, inconsistent performance of both hardware (e.g., stylus sensitivity, durability) and software (e.g., DyKnow crashing during class, incompatibility with MatLAB & LabVIEW) were reported. Sensitivity and calibration issues with the stylus pen were also reported, and have been found in previous research [4, 10, 19]. However, some compatibility issues may result from lack of knowledge of various applications of pen-based technology. For example, Stickel[14] found that faculty members have used inking with MatLAB. In addition, Mock[10] utilized M2Screen annotator software and was able to use Tablet PC functions with other applications, such as NetBeans.

Inconsistent performance and compatibility issues also caused faculty members to be uncomfortable using Tablet PCs during class. Faculty members reported that they were not comfortable showing performance deficiencies in front of students, discouraging them from using Tablet PCs in class. In addition, students reported frustrations with the durability and performance of Tablet PCs. Additional technical difficulties reported included issues with classroom infrastructure, including a lack of power outlets which, coupled with the low battery life, discouraged students from bringing their Tablet PCs to class. This finding has been similarly reported by Weitz[19] in which battery life was reported as an issue with Tablet PC adoption. Another infrastructure issue is regarding the bandwidth and reliability of the wireless network, which is required to use DyKnow during class. This problem is exacerbated in classes with large numbers of students, since DyKnow requires that everyone is connected to the Internet at the same time, an issue previously reported by Tront[17].

Another area of concern was compatibility of the technology with teaching and learning style of faculty and students. Some faculty members were concerned that the Tablet PCs do not match their teaching styles and course material (e.g., theoretical classes). Similarly, some students mentioned that the use of Tablet PCs did not match their preferred learning methods, such as for students that prefer note taking on paper during lectures. In addition, the lack of faculty usage contributed to lack of student usage of Tablet PCs; students indicated that they did not want to use Tablet PCs because they did not see faculty members using them.

Additional findings regarding barriers included staff turnover and lack of support and resources from the IT office. Also, some felt that Tablet PCs should be required for faculty, but not for students. This type of Tablet PC program, reported by Rogers and Cox[12] was used at Murray

State University, which followed a one-Tablet model in which only faculty members used Tablet PCs during class. Students gave positive feedback in terms of teaching effectiveness, classroom management, and overall learning experiences [12].

Application of Findings

Based on the findings the COE plans to undertake several initiatives to improve usage of Tablet PCs. While professional development sessions are already offered to faculty, the college plans to offer sessions that could be conducted within each academic department, such as software demonstrations or simple training sessions incorporated within regularly scheduled department faculty meetings. These training sessions could be framed around how various Tablet PC features can benefit them, such as how the Tablet PC can increase their flexibility through using virtual office hours. By doing so the college hopes that these workshops will decrease the complexity of the new technology and increase knowledge of the relative advantages of the new technology, which could improve usage. The college is also considering a faculty mentoring program that pairs lead adopters or those more comfortable with the technology to faculty members new to instructional technology may also be helpful. Graduate students and teaching assistants may also play a role in the mentoring program, being placed with faculty members who have a specific need that can be addressed if the other individual is more adept and has used the technology in the classroom before.

In order to increase student usage, the college plans on working to increase Tablet PC usage in upper level classes. Observing faculty using Tablet PCs in class may help encourage students to use their Tablet PCs as well. In addition, communicating to students how technical skills and using new technologies are important for jobs or how the Tablet PC is specifically being employed in careers they may want to pursue may motivate students to use new and different features associated with the Tablet PC. Finally, the college plans to increase the training and information sessions that are offered to students. Providing training and information sessions to incoming students and their parents might prove useful as students would enter prepared to use the Tablet PC and parents would also be informed as to the benefits of using such technology to enhance student learning. Improving the infrastructure of the environment to support Tablet PC adoption is also being investigated. The college plans to provide extra power strips for classrooms that lack adequate power outlets. Wireless issues are also being looked at to make sure faculty can deliver course content without interruption.

While this study provided useful information, a deeper analysis could explore secondary stakeholders among personnel systems more deeply including: the Undergraduate Technology Committee (UTC), and the Student Technology Council (STC). The UTC provides input related to which instructional technologies are used in the classroom and is the group that decided to implement the Tablet PC requirement. The STC tests new technologies and provides feedback to the COE. In addition, stakeholders in this subsystem include the parents of undergraduate COE students, graduate students (including graduate teaching assistants, graders, and instructors), and administrative staff. This study identified these groups as secondary stakeholders but did not examine their role in depth. Future studies could look into this in more detail.

Conclusion

Tablet PCs were found to have many beneficial features that can improve student learning. Though many students and faculty have enthusiastically adopted the new technology, there remain challenges towards full adoption in the COE. Suggestions for improvement include incorporating additional training for both faculty and students, creating an incentive plan for faculty members, improving the infrastructure of the classrooms to support Tablet PC use, and creating a mentoring program for faculty members as they are learning the new technology. Other institutions looking at implementing policies such as these can use the findings from this study to improve the diffusion process for Tablet PCs and other innovative technologies.

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