A Large-scale Tablet PC Deployment – 6 Years Later

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Abstract

Educational technology has been shown to be an effective mechanism to foster improvements in pedagogical practices in the learning environment. In the fall of 2006, the Virginia Tech College of Engineering became the first and largest public college of engineering to require all 1,400 incoming students to own a Tablet PC. The purpose of this requirement program is to better facilitate the *pedagogical practice* including but not limited to the following mechanisms known to improve learning: highly interactive classroom presentations, student-student and instructor-student collaboration, comprehensive note-taking and review, and a movement of the learning emphasis to more process-oriented lectures and away from simple information broadcasting.

A large deployment effort like the one described here is multi-faceted and requires the enthusiasm and support of a broad number of stakeholders. Decisions on hardware and software choices require input from across the university. Training of faculty and support personnel is central to the success of the initiative. Improvements to infrastructure including network connectivity, additional classroom projection systems and increased availability of power connections are some of the physical plant challenges that require attention. Sound and frequent assessment of the successes and failures of the program, and identification of potentially fruitful avenues to pursue in the future, has been part of the overriding deployment strategy from the beginning. In addition to these infrastructure challenges, the success of this type of program is also dependent on the willingness of the faculty to make changes in the way in which they teach. In this paper we describe our approach to identifying the needs and setting up the infrastructure, and provide information on successes and failures we have had during the first five years of the deployment process. We will also describe the challenges we anticipate as we look to the future of educational technology in engineering education.

Background

In 1984, the Virginia Tech College of Engineering was the first public institution to require all entering engineering freshmen to own a personal computer. In succeeding years the College continued to increase the level of technology in order to open new potential pedagogical practices. For example, the mid-90s move to multimedia computers allowed students to better visualize data so they could better understand multiple-representational modes. Faster computers allowed students to interact with formula parameters in order to perform self-monitoring of their understanding of cause and effect relationships. In 2002, the College moved to a laptop requirement and many of its academic buildings were outfitted with a wireless communication system that allows students to connect to the high-speed Internet from any location on campus. Laptop technology was selected so that students could perform computing and communication operations in a totally mobile environment. One of the improved pedagogical practices facilitated real-time collaboration in both the classroom with the teacher as well as with other students in and out of the classroom. Today's ubiquitous use of computers, slates and pocket-sized communication devices in the students' everyday learning practices and lifestyles is the anecdotal evidence that these technology requirement programs have been fruitful. In 2006 the College began to require that all students own a computationally powerful and well-connected Tablet PC. The goal in this change is to further extend the ability to compute and communicate in the mobile world, but more importantly to interact in a more meaningful and natural way using electronic ink (e-ink).

Targeted Pedagogical Improvements Facilitated by Tablet PCs

One of the most important practices known to improve learning is to actively engage the student in the learning process. Classroom activities in which students participate in an active discussion or problem solving session with the instructor and with their peers have been shown to improve learning. Felder and Prince state "The core elements of active learning are student activity and engagement in the learning process in [1, 2]. Active learning is often contrasted to the traditional lecture where students passively receive information from the instructor." The rich communications and multimodal input capabilities of the Tablet PC are believed to provide a facility for classroom interactions which when aptly used can increase the potential for an improved learning interaction.

Collaborative learning consists of one or more students working together to solve a problem or understand a concept as opposed to individual work on a topic [6]. Studies have shown that collaboration improved several desirable key learning outcomes including academic achievement, interpersonal interactivity, self-esteem and retention in academic programs [7-9]. Tablet PCs have the potential for facilitating intense collaborative activities using the built-in capabilities of some of the software either currently available or under development. The differentiating characteristic between notebook and tablet technology is the ability for the user to more naturally jot down ideas and sketch drawings that can be communicated with other collaborators on shared "electronic surfaces". Meaningful tablet-based collaborations have been demonstrated both locally as well as at Internet distances.

Comprehensive, organized, and easy to review note-taking is a skill typically described as an effective learning behavior. When students master effective learning behaviors such as effective note-taking, a demonstratively positive learning outcome is produced with a general increase in subject cognition [10,11]

Achieving the expected outcome of enhanced student learning is based on improving the three key pedagogical practices mentioned above: increased active learning, incorporation of collaborative exercises into the learning process, and improved notecollection and note searching/review. The Tablet PC requirement program is structured to support the improvement of these key practices. In order to do so, the hardware and software selected for student and faculty use must be sufficiently capable, faculty must be trained on the use of the technology as well as on appropriate pedagogical practices, students must be given a baseline understanding of the technology and its expected use, and sufficient infrastructure and support personnel must be in available. The overriding umbrella to all of this effort must be an assessment operation that formatively measures the success of the program and points out the most likely avenues for success as the initiative progresses.

Computer Specification

In 2001 incoming Virginia Tech engineering students began to purchase their computers on the open market based on a set of specifications that the College issues in mid April. Prior to that the College of Engineering provided a mechanism for a bulk purchase through a single preferred vendor. Through a pseudo-bid process, a preferred vendor is still selected for the Tablet PCS, but students are free to purchase any brand that meets the minimum specifications. The advantages to the students in purchasing through the preferred vendor are several-fold including: negotiated very advantageous pricing, on-campus maintenance center, loaner program for students whose computers are in for repair, first access to new upgrades, and other benefits which vendors are willing to offer when roughly 1,300 students and faculty purchase their computers annually. Preferred vendor status is awarded on a three year basis. Vendors put together a proposal, as a response to an RFP issued by the College, in which certain benefits as described above are set up in a memorandum of understanding. While pricing depends on the list prices of new hardware for each year, the memorandum describes the estimated pricing as related to MSRP.

The minimum computer specification for students entering in the Fall of 2012, as shown in Table I, is a compromise between price, capability, longevity, and reliability. For example, choosing the minimum Core i5 processor and the associated 4 GB of RAM means that the computers will be capable of running all of the required software at reasonable speeds while at the same time is affordable by the majority of the entering class. Software that creates a fairly significant demand on the processing capability such as the AutoCAD suite is generally used as the benchmark for processor speed i.e., if the computer can comfortably run the benchmark software, it is appropriate as a a baseline computer for the engineering package. The minimum hardware configuration is chosen to ensure that the computer will be usable four years after entry when the senior student will likely be performing computational intense calculations and simulations. However, history has shown that about 40% of the entering students purchase the minimum hardware package while the remaining 60% add higher level capabilities to their systems such as an additional flat panel monitor, increased RAM, more disk drive space, or extra video RAM.

New slate technologies have allowed us to expand our requirements to give students more flexibility and choice in how they meet our computer requirement. Depending on what type of mobile device students already own, this option may be less expensive. For students with a recently purchased or pre-existing laptop, purchasing a Windows 7 slate with pen instead of a new convertible tablet may be a better option. Students may choose to bring a laptop if it has specifications that meet or exceed our convertible tablet requirements AND also bring a Windows 7 slate device with pen or older convertible tablet.

If a student chooses to deviate in any way from the computer requirement specified for his/her entering class, then there are consequences for such action:

1. Students who deviate from the computer requirement and therefore cannot participate in a specific course, complete a course assignment, or participate in the classroom where computer use is expected, without additional effort on the part of the faculty or the college, will be assessed any academic penalty deemed appropriate by the course instructor.
2. Students who deviate from the computer requirement and choose another hardware platform and/or operating system are still required to purchase the Engineering Software Bundle.
3. Students who deviate from the computer requirement and choose another hardware or operating system platform shall not receive technical support from any College of Engineering information technology personnel.
4. Students who deviate from the computer requirement and subsequently require repairs for their computer will not be eligible for College or departmental loaner hardware.

These stipulations are made not so much as to be punitive but rather as a practical inducement for students to work within the system in order for the system to be able to support all of the students properly.

Item	**Detail**
Platform	Tablet PC convertible
OS	Windows 7 Pro 64-bit Edition
Processor	Intel 2nd gen. Core i5 2.4 GHz or better
Memory (RAM)	4 GB min.
Hard Disk	320 GB hard drive; 7200 RPM
Video Card	128 MB
Optical drive	DVD/CD+-R writeable DVD dual layer
Input/Output	USB 3.0
Wireless	802.11 a/g/n
NIC/Ethernet	10/100/1000 Ethernet
Warranty	3 Years onsite with accidental damage
External backup	USB external backup drive 1TB

Table I Minimum hardware requirement.

Students are also required to purchase the Engineering Software Bundle which in the fall of 2012 cost $137. The software list shown in Table II is similar to what a practicing engineer in industry may have access to in their design environment.

Minimum Software Requirement
Matlab
Autodesk Inventor & Mechanical Desktop*
PDF Annotator
Labview
Microsoft Campus Agreement including:
Office Professional
OS upgrades
One Note
Microsoft Visio
Visual Project
Visual Studio
Client Access Licenses

* Not included in the price since it is available as a free download for students.

Table II Minimum engineering software requirement.

Deliberations on the choice of the hardware and software begin around the first of March and consider both the needs of the educational program as well as the expected offerings by hardware vendors. Discussions take place under the wraps of non-disclosure meetings and with careful consideration of whether or not hardware will truly be delivered in the July through August timeframe. An unfulfilled promise by a vendor can have disastrous results if a student is left without a computer to start the semester. To avoid these difficulties, the College has established working relationships with a set of reputable vendors and publishes pertinent information to support students and their families in making wise vendor-related decisions.

Deployment Challenges and Movement toward Solutions

Challenge

Wireless infrastructure, while greatly improved over the last four years, is unable to keep up with the increasing demand. Students often have two or three connected devices in class. Sourcing software continues to assume increased bandwidth and thus the bandwidth demanded by educational applications continues to grow.

Trial Solution

Load-balancing and effective coverage is constantly being addressed. Continually working with vendors to modify networking software ensures seamless wireless access for classes as large as 350 students.

Challenge

Ensuring that all 5,200 undergraduate students have access to a working computer is a difficult problem given the expected mean time-between-failure for standard portable computing systems.

<u>Trial Solution</u>
We have created a student-driven support system called SWAT or software assistance in triage. SWAT maintains a pool approximately 200 convertible tablets to loan to students who experience hardware failures. Hardware repairs are handled by our campus bookstore computer service center. Although most hardware repairs are complete in under a week our current loan period is for 3 weeks. The College no longer maintains centralized undergraduate computer labs and the savings have been invested in SWAT. Individual departments do maintain labs to provide students access to highly specialized expensive software that cannot be purchased by the individual.

<u>Challenge</u>
Faculty members don't have time to rework class processes, changing from traditional lecture style to more interactive work including using techniques such as: interactive lectures or exercises, flipping the classroom, in class group collaborative work, etc. How to fix this in higher education is both research-driven, and restricted by environments.

<u>Trial Solution</u>
The College has been working on a phased approach to change which can be very time-consuming:

Phase 1—Learn to use technology/tablet to do simple tasks—writing on slides (office, OneNote, PDF Annotator)
Phase 2—Low level interaction with student—simple polls—one way interaction currently dominates e.g., sending slides to students using tools like MS Interactive Classroom.
Phase 3—High Level interactions—polls, problem solving→sharing student work, (DyKnow Vision and Classroom Presenter)

<u>Challenge</u>
Teaching students how to effectively use technology when the lessons are not integrated into the curriculum is difficult. Low attendance at voluntary sessions, few student downloads of tutorial hand-outs, limited numbers watch tutorials or seek assistance unless the training impacts student ability to complete coursework.

<u>Trial Solution</u>

The program has found some success by fully integrating the tablet into the first year engineering program. All faculty teaching in the first year program use the Tablet PC to present their classes, to interact with students in the classroom, to collect and grade assignments, and perform other tasks that facilitated by the technology. Students in the first year program develop a set of skills for using the tablet and are relatively satisfied with the mechanisms they get used to for taking notes and turning in assignments.

Unfortunately, some of the upper level faculty are a bit more reluctant to take on the challenge of using the technology. In fact the first year students, armed with their knowledge and positive experience, end up performing the task of in-house technology evangelist and are able to convince some upper division faculty to try using the technology. Peer influence is also part of what positively influences faculty to work toward using the technology. Another favorable solution in bringing the faculty onboard the technology train is getting the newly hired faculty trained and equipped as soon as they report for the first day of work. Finally, the most effective mechanism to encourage faculty members to make an effort to try the technology is peer influence. Departmental champions have been identified, equipped, and empowered to help solicit and support faculty willing to make an attempt to start using the technology.

Challenge
Textbooks are extremely expensive and they don't take advantage of the newest technology in performing information transfer to students. Tablet PCs are a natural format on which e-textbooks can be used to allow students a more effective way to obtain source material.

While this list of challenges and solutions is not comprehensive, we feel that it characterizes many of the most important aspects of the primary and secondary difficulties that face those who look toward implementing similar educational technology deployments.

Trial Solution
The College is working with a vendor to run a pilot study of electronic textbook in order to judge the effectiveness of the medium. Currently the medium is webpage-based and incapable of taking full advantage of the capabilities of the Table PC. We are working with the vendor and others to integrate textbook content into a more user friendly form so that students can make use of e-ink, gestures, collaboration capabilities directly in the e-text, web exploration from within the e-text, integrated interactive simulation and visualization, and other capabilities provided by the Tablet PC platform. VText is an example of a platform that is designed to provide these types of facilities using content exported from more classic paper texts. [12].

Assessment – Plans and Progress

Assessing the effectiveness of the tablet requirement program is paramount in our efforts to ensure that the schema indeed produces the targeted pedagogical improvements. One of the assessment efforts is funded by the NSF and is examining whether an instructor's use of instructional technology, specifically slate enabled technology, has an impact on the engagement among engineering undergraduates enrolled in large lecture classes Further, if there is an impact, what type of use by the instructor might be more closely related to that skill development. Preliminary findings from weekly observations show what appears to be more engagement in classes where the instructor drives how and when the slate technology is being used rather than letting students choose how and when to use their slate devices. For instance, making consistent use of polling features and panel submissions that require inking from the students via the DyKnow Vision software promotes an observable uptake in student engagement throughout the lecture hall that seats approximately 300 students. Plans for sharing techniques to encourage student engagement are scheduled for the spring when the faculty member will share the pedagogical techniques and how those techniques are used in relation to different course content with other faculty members to promote further diffusion and adoption.

Summary

The Virginia Tech College of Engineering has explored the large-scale use of Tablet PCs in engineering and computer science education. Using a multi-faceted, collaborative approach we have developed an implementation process that includes computer acquisition, faculty training, infrastructure modifications, and multiple assessments for the purpose of continuous program evaluation. Initial results of this groundbreaking program were positive showing measurable improvements in pedagogical practices that we believe lead to learning improvements. Various aspects of the program's processes are scalable and extensible to other institutions and STEM disciplines. This paper provides some of the questions that others who are considering similar deployments should be asking along with some of the answers we have found for our environment.

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