Assessing the Impact of Mobile Information Communications Technology on Student Attitudes and Perceptions in an Urban Higher Education Environment

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Abstract
Mobile platforms present an excellent opportunity to bridge the digital divide that has an impact on so many students. At Morgan State University, we proudly boast of our leadership as a "Gateway to Opportunity" for many underrepresented students. This paper will address our efforts to: correct and build positive attitudes toward mobile Information Communications Technology (ICT), understand computer usage habits, and experiment with what methods are most effective in using mobile ICT to improve academic performance. Our approach was to insert mobile platforms with differing form factors into a learning environment and investigate their impact on student perception and performance. Outcomes, strategies, and assessment instruments were developed within a generic modular framework to measure the effectiveness of our approach. The preliminary results presented in this paper will show how technology form factor, access, length of time of ownership, and student classification has a positive impact on our student's attitudes and perceptions as well as their academic performances.

Introduction
When students have limited access to computers outside of structured computer lab environments, there may exist a need to promote the usage of technology as an essential tool that is used as an integral part of the engineering curriculum. For some minority engineering students, studies show that access to computers and technology growing up may not be as vast as their majority counterparts[1]. Hence, there may be a fear factor when introducing students to technology[2]. Better understandings of what computers are how they work and how information is sent and received is an important consideration toward using technology effectively. Our effort addresses the need to correct and build positive attitudes toward mobile ICT and strongly promotes the need to understand computer usage habits of underrepresented groups and what methods are most effective in using mobile technologies.

Our approach is to first highlight the need to intensify the students' awareness of how computational tools (especially mobile tools) can impact their academic productivity and performance. Consequently, we have developed a short course module that can be used in nearly any discipline to assess and positively reinforce the productive aspects of mobile technology usage. Secondly, this effort dovetails ideally into a parallel effort within the Hewlett Packard Engineering Student Retention Initiative by providing supportive technology outside of the mobile classroom for an innovative Dimensions of Learning (DOL) based pre-calculus/calculus I course sequence. The idea is to provide the faculty and students with mobile technology in various form factors that they can take with them once the mobile class period has ended. Our passion drives us to exploit this opportunity to further study the impact of mobile computer ownership on user perception and performance within the pedagogical framework in that effort.

Freshman engineering student matriculation as a whole is relatively low and unstable where close to fifty percent of students leave the field of engineering before receiving a degree[3]. Students enter the University with little understanding as to: what tasks an engineer accomplishes, the courses involved, and the technical competencies required. The first semester is critical in determining if the student matriculates as well as the rate in which the student matriculates. However, it has been shown that the educational experience and structure has a larger effect on attrition than difficulty of the subject or aptitude[3]. The preceding factors make freshman minority engineering students interesting candidates for the mobility technology integration studies.

The Technology

The advent of local and personal area networks such as Wi-Fi (IEEE 802.11b) provide a low cost mobile solution to extend learning and collaborating capabilities beyond the classroom. Wi-Fi provides an infrastructure that furnishes the use of wireless capable laptops, personal digital assistants (PDAs), and tablet PCs by extending connectivity to the World Wide Web. It also enables students to setup peer networks where information is shared and analyzed in groups.

IPAQ POCKET PC HP/Compaq Model H5450	TABLET PC HP/Compq Model T1000	Notebook PC Gateway Model G-400
		

Figure 1. Illustration of the various Mobile devices used in this study.

Students participating in the mobile computing course modules had three mobile devices for which to choose from: COMPAQ/HP Tablet PC TC1000, HP IPAQ 5450 POCKET PC, and the Gateway notebook PC. The mobile devices ran a modified version of the Microsoft Windows Platform customized to processing power and memory allocations available.

- Gateway Notebook – Windows 2000 Professional
- IPAQ Pocket PC 5450 – Windows CE 3.0 (Pocket PC 2000)
- Tablet PC TC-1000 – Windows XP Table PC edition

Windows CE incorporates built-in support for the pocket pc touch screen, handwriting recognition, infrared file transfers, bluetooth connectivity, and biometric security. Likewise, Windows XP Tablet PC edition incorporates support for the pen stylus, handwriting recognition, and remote presentation displays.

All three devices are capable of Wi-Fi connectivity. The type of device a particular student receives is based preference and availability. Student preference depended on five main categories: form factor or size, processing power, available memory, data entry, and network connectivity. We rated the mobile devices in Table 1 to quantify which device the student would choose if all devices were available.

	Tablet PC	IPAQ	Notebook
Form Factor	Intermediate	Best	Worst
Processing Power	Intermediate	Worst	Best
Available Memory	Intermediate	Worst	Best
Ease of Data Entry	Intermediate	Best	Worst
Network Connectivity	Intermediate	Best	Intermediate

Table 1. Feature comparison between various mobile platforms

The preceding table illustrates that the Table PC is the best tradeoff between size, data entry, processing power, memory, and connectivity. Hence, students were more likely to choose the tablet PC first. Our results will show that the students possessing tablet PC responded more positively to the mobile computing modules exercises. The wireless notebook can best be described as a desktop replacement class machine. The students received the devices at the beginning of the course or course module and were permitted to maintain ownership for the duration of the course (module). We felt ownership was an important characteristic to give students the freedom to explore the capabilities of the device and roam within the wireless infrastructure outside of the classroom. The usefulness of the device depends on the application and type of projects.

Mobile Technology Attitudes Assessment Module Design

Integrating mobile technology into the classroom needs a clearly defined educational goal for the student to gain anything valuable[4]. An overall goal of this course module is to curtail the anxiety associated with exposure to new technology. The expectation is to empower the students with the technology to increase investigative skills and collaborative skills. Students are initially advised to learn the material individually to gain core competency and comfort with the technology. Afterwards, students are placed in groups to collaborate on complex tasks using the mobile technology. When designing a course module, emphasis must be placed on all components of learning. A good model to follow is the dimensions of learning framework provided by Marzano and Pickering[5]. Their comprehensive model illustrates five dimensions of learning:

Dimension 1: Positive Attitudes and Perceptions about Learning
Dimension 2: Thinking Involved in Acquiring and Integrating Knowledge
Dimension 3: Thinking Involved in Extending and Refining Knowledge
Dimension 4: Thinking Involved in Using Knowledge Meaningfully
Dimension 5: Productive Habits of the Mind

Dimension one affects students' effort level in the course. The attitude and perception of course material upon entering the classroom may have a dramatic effect on the overall performance of the student. The second dimension involves the students' ability to integrate the knowledge into long-term memory. Hence, the student acquires the skills to apply what they have learned to future courses or employment assignments. Refinement of the integrated knowledge encompasses the third dimension. The student applies reasoning processes to help them extend and refine the material. Dimension four involves the application of the acquired knowledge for problem solving, decision-making, and analysis. The final dimension focuses on habit development for the student that allows think critically, creatively, and able to self-regulate themselves. After establishing the framework, strategies should be in place to fuse technology successfully into the course, record outcomes, and report results. The primary focus in the design of this course module will cover the first two dimensions. We want to curb the fear, and promote healthy attitudes, and perceptions that freshman engineering students have about technology and the engineering curriculum over the long term. As the students complete assignments, conduct research, and collaborate in teams, integrating and applying the acquired knowledge is desired.

There three objectives that were common to all activities that involved the use of mobile technology:

- Foster an environment that will allow the student to judge the strengths and weaknesses of computer ownership and how ownership may impact performance.
- The student will appraise advantages and disadvantages of various mobile platforms in a classroom environment.
- The student will learn about computer/network organization.

A detailed course strategies, outcomes, and assessment methods outline are shown in table 1.

Objective 1: Foster an environment that will allow the student to judge the strengths and weaknesses of computer ownership and how ownership may impact performance		
Strategies and Actions	Student Learning Outcomes	Assessment Methods/Metrics
Issue assignments that require extended hours to complete	Evaluate and assess the most effective mode of ownership that impacts the student's ability to complete an assignment.	Pre/Post Survey
Have the students try an interactive recreational activity during off hours.	Encourage students to explore other areas that will encourage them to consider private ownership	Monitor usage statistics Pre/Post Survey
Objective 2: The student will appraise advantages and disadvantages of various mobile platforms in a classroom environment		
Strategies and Actions	Student Learning Outcomes	Assessment Methods/Metrics
Divide the students into groups that have mobile computational platforms with varying form factor :	Recognize strengths and weaknesses of each platform in implementing a task.	Pre Post Test/Survey Embedded testing
Objective 3: The student will learn about computer/network organization and set-up a variety of simple wireless connections.		
Strategies and Actions	Student Learning Outcomes	Assessment Methods/Metrics
Have the students deploy simple fixed and wireless networks	Develop an introductory level understanding of network protocol stack and connectionless networks	Written Report
Have the students configure pda/laptops for peer-to-peer and infrastructure networking	Familiarize students with mobile computing techniques and information sharing.	Pre/Post Survey

Table 2. Program Strategies, outcomes, and assessment methods.

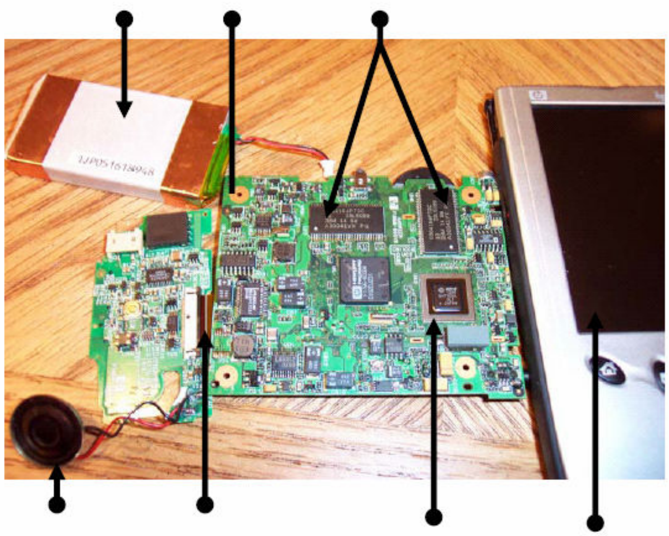
The objectives, outcomes and assessment methods shown in table 2 give a high-level view of material presented in the course module. The tasks were designed to be interactive where the student had the freedom to investigate capabilities of the technology further. In class activities were conducted in a co-operative learning type environment were the group size varied between two to four students. Outside of class the students were encouraged to collaborate but all written assignments were collected on an individual basis. The student was required to research and report on the technology, implement the technology, and show its usefulness. The student learned the intricacies of the device, wireless networks, computer networking, and computer/device architecture. Projects range from using the pocket pc and/or laptops to create peer-to-peer networks over 802.11b or Bluetooth. An example assignment is shown in figure 2.

In this exercise, the students are investigating a mobile architecture by examining the internals of a pocket PC class device. An in class hands-on demonstration was given where groups of students were allowed to explore the major components of a HP Jornada 520. Afterward they were required to complete this exercise as posted on Blackboard. In addition, they were required to research these components, using the internet, and write a short paper that had to be submitted electronically by the next class session. Students also utilized applications such as virtual network computing to control servers and desktops remotely[6]. Furthermore, applications such as Matlab contain servers that allow complex computation on the server to be reported on the device[7]. We divided the survey analysis into three categories: Student perception of mobile technology, mobile technology usage, and effect of mobile on retention.

Assignment 3

Pocket PC Architectures

1. Match the pocket PC components to the following in the figure below to the following computer components. The actual components will be available in class for inspection.
    a. Motherboard
    b. Microprocessor
    c. Power Supply
    d. Audio
    e. LCD
    f. Memory
    g. System bus



2. Write a short report summarizing the uses of the Strong ARM, ARM, MIPS, and SH3 processors as used in embedded mobile applications. Compare and contrast each processor as well as examples of devices where each processor is embedded.

Figure 2. Blackboard assignment illustrating the pocket PC architecture and major components.

Targeted Programs and Courses

Attitude and perception studies for four program/course areas are sought:

- Introduction to Electrical Engineering EEGR105
- Pre-Freshman Accelerated Curriculum in Engineering Summer Bridge Program

- Knowledge Management Center of Excellence Summer Institute
- Pre-Calculus/Calculus I course sequence MATH141/MATH241

The Freshman Introduction to Engineering course (EEGR105) has been designed to familiarize students with the engineering faculty, our facility and resources, and projects that require teamwork. Four three-week sections of the Introduction to Electrical Engineering course involved 118 freshmen students. In addition to using the course module to investigate curriculum courses, we attempted to infuse mobile technology into the various research organizations within the university. The Pre-Freshman Accelerated Curriculum in Engineering (PACE) Summer Bridge Program and the Knowledge Management Center of Excellence (KMCOE) Summer Institute are research driven student programs within the school of engineering. Thirty-six pre-freshmen students in the PACE summer program used notebook and tablet PCs for six weeks to compliment their research training itinerary. These pre-freshmen summer students studied varied topics such as basic engineering computation, networks, semiconductors, circuit analysis (figure 2.), and logic design. The constituents in the KMCOE program are primarily junior level

Figure 3. A photograph of PACE summer students working during a cooperative learning exercise involving circuit analysis.

engineering and computer science students. Twelve students, including two from Puerto Rico, in the Knowledge Management Center of excellence program used tablet PCs for eight weeks during the summer to explore knowledge fusion and acquisition techniques.

The applicability of the mobile technology to the students in the research groups varies depends on the nature of the research. For example, groups may deal more closely with mobile technology using remote procedure call technology or developing applications. Whereas, other groups may not utilize e-mobility technology for research purposes but may instead use them for information transmission and retrieval.

Mobile Technology Perception

Figure 3 illustrates the trends in the view that students have about mobile technology when they enter the classroom and their views after using the device. EEGER105 is the freshman engineering course module. The prominent trend in this analysis is that students felt that mobile technology had higher relevance to engineering after owning and using the device than before. Owning and using the device allowed the student to investigate capabilities and apply the device to his/her work environment. Another trend worthy of note is the relationship between time of ownership and the actual change in student's perception. The PACE and KMCOE students' ownership period was close to three times longer than that of the EEGR105 students. Therefore, looking back at figure 3, positive perceptions of students in EEGR105 changed approximately 12% on average. However the perceptions of students in KMCOE and PACE changed more dramatically. Positive perceptions for PACE increased close to 56% and students participating in KMCOE increased about 23% on average.

Mobile Technology Usage

While completing collaborative tasks with the mobile device and investigating its capabilities, most students gain a sense for the usefulness of the device and mobile networking. For example, while learning about the technology and completing a lab using Bluetooth technology, the student realized that his cell-phone was also capable of communicating via Bluetooth. The student was able to complete the lab by connecting his cell phone to network with other students using PDA's. The technology stirred the student's curiosity and he showed initiative to utilize the technology further. Based on a sense of ownership students' view may change from purchasing a device for entertainment and convenience to a purchase for information access and research. Figure 4 shows trends similar to those shown in Figure 1. Students with longer ownership found ways to use technology and thought more about using computational tools in their studies.

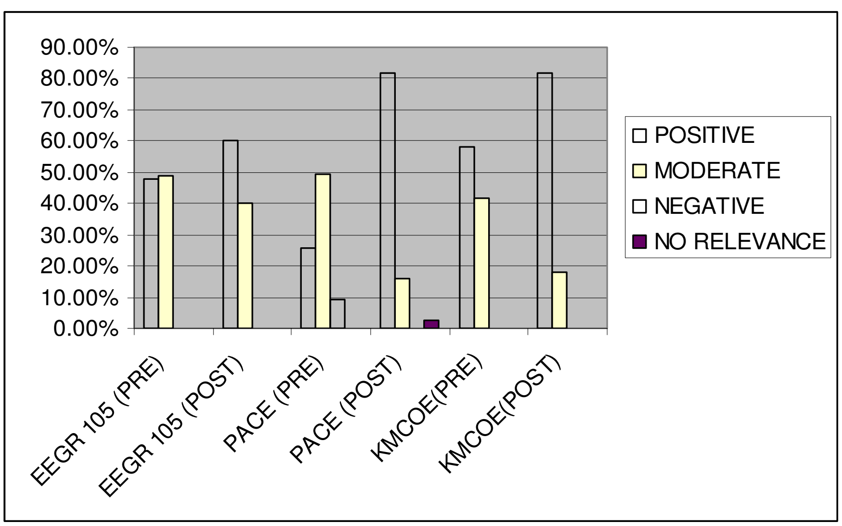


Figure 4. Graph illustrating student perception of the relevance between mobile computing and engineering.

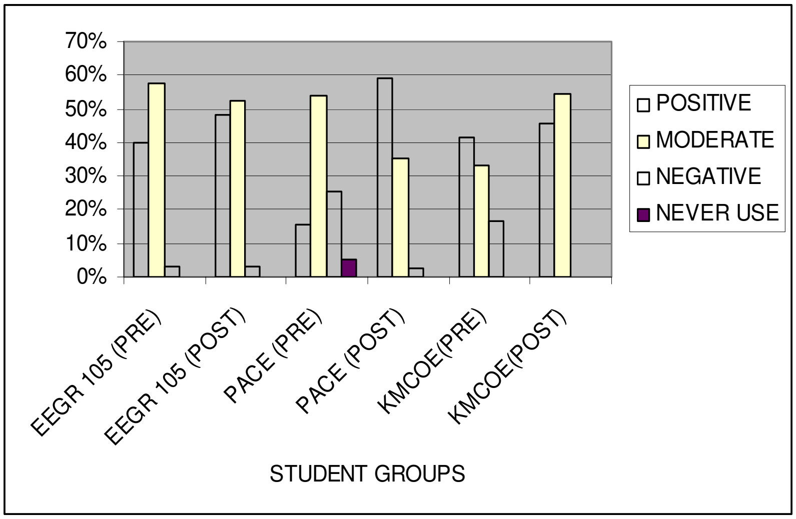


Figure 5. Graph reflecting student viewpoints on the need for using Mobile Technology in Courses and Research.

Student Retention

Attrition in engineering programs was discussed earlier in this paper. Theories within engineering education research indicate that exposure to technology make the curriculum more interesting[9]. The expectation is to stimulate the students, increasing probability of matriculation through the engineering program. Figure 5 shows that even limited exposure to Mobile Technology increased the students' interest in the electrical engineering field.

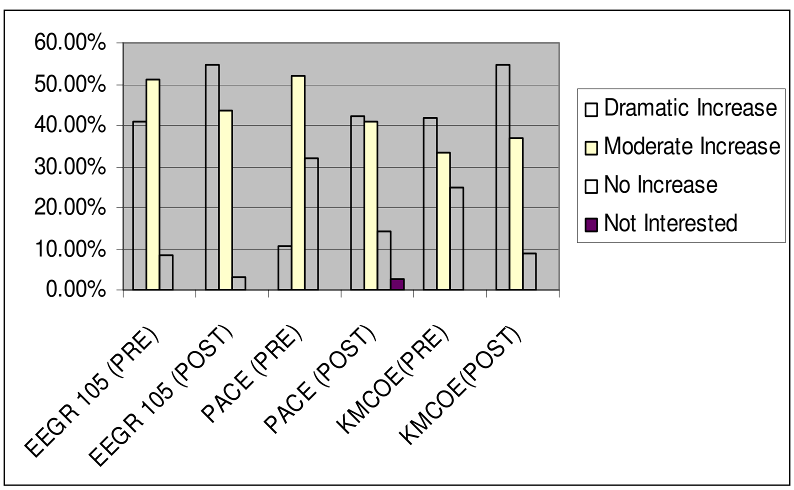


Figure 6. Graph illustrating whether there was increased interest in the engineering field as a result of technology exposure.

Pre-Calculus Course Technology Assessment

A modified Computer Attitude Questionnaire (CAQ v5.22) was used to measure the gain on attitudes about computer importance, computer enjoyment, study habits, empathy, motivation/persistence, creative tendencies, school, computer anxiety, Discourse use, mobile ownership, mobile knowledge, and mobile Importance for the pre-calculus gatekeeper course. Gain results are shown in figure 6. Test results using the modified CAQ v5.22 in our DOL gatekeeper course indicate a fair amount of anxiety across all platforms. Also gains in perception and acquired knowledge show that technology ownership has a direct impact on the first two dimensions of learning in the presence of technological infusion. Most evident are the fluctuating gains in computer enjoyment, email use, e-classroom application (Discourse), and computer usage. Tablet PC users exhibit consistent satisfaction across all these areas. We speculate that the tablet PC strikes the right balance in portability, functionality, and performance such that the user uses it more and is more productive with it than any of the other platforms used in this study. This is especially applicable in urban environments were the student is challenged with selecting mobile/ubiquitous computational tools to help offset the many demanding situations imposed by the density of communications, transportation, and social networks that surround them.

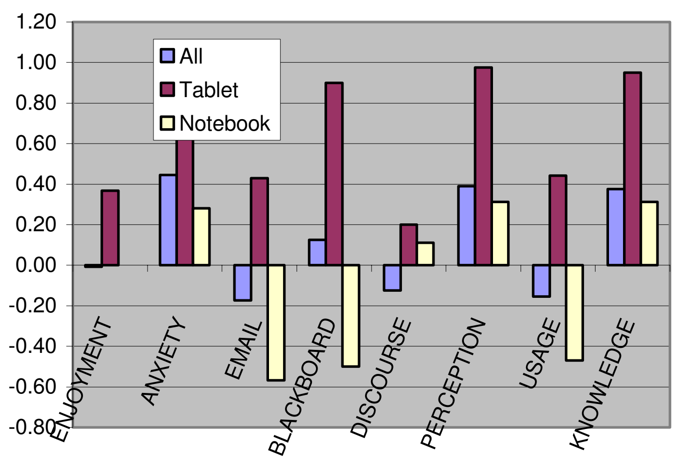


Figure 7. Graph illustrating gains for pre-calculus students for various technology factors.

Conclusion

In this paper, we presented a course module specifically designed to introduce mobile technology to engineering freshman. Freshman students were given a broad overview of device usage, connectivity to the network, and low-level network design. Our effort to infuse mobile technology into the course was highly successful in stimulating the student curiosity, perception, usage, and interest in the curriculum. Results reveal that the length of time of ownership and student classification or maturity has a positive impact on our student's attitudes and perceptions about mobile technology. Furthermore mobile platforms that offer a balance between size, weight, functionality and performance appear to have the greatest impact on student attitude and academic performance.

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