Abstract
A course transformation grant was awarded by the university to implement the PC Tablet, wireless access, and WebCT in a senior level soils and foundations class for the fall semester 2003. The course is housed in the Department of Civil and Architectural Engineering Technology (CAET), the School of Engineering, Technology, and Computer Science (ETCS), Indiana-Purdue University Ft. Wayne (IPFW). The grant was a university “pilot” project as a first step in investigating more widespread use of mobile technology across the university curriculum. Each of the 18 students enrolled in the course received a COMPAQ Tablet for their use for the semester. The instructor was also provided a Tablet. Seven specific transformation initiatives were identified, and seven specific impacts on student learning were predicted with the use of mobile technology. The project assessment was defined by a series of detailed surveys throughout the semester, culminating in an extensive student survey that measured the impact of the Tablet on student learning. As the semester evolved, other issues related to the use of the Tablet were identified and became part of the final evaluation.

This paper presents the results of the course transformation project assessment and makes recommendations related to the use of the PC Tablet for this particular course, for the department, for the school, and for the university community in general. Many issues related to effective implementation of mobile technology were discovered which will prove invaluable to university administrators as they evaluate potential models for more widespread implementation.

Introduction
Mobile technology represents the latest evolution of personal computing. These devices include notebooks, tablets, and PDA’s. Wireless access is usually associated with use of mobile technology. The university administration and a core group of faculty believe it is necessary to integrate some form or multiple forms of this technology into the undergraduate education experience. A committee was formed to study the implementation of mobile technology in the classroom and the use of the wireless network to enhance the learning environment. The committee recommended that the level of integration would be approached using a three phase plan. The first phase would use a select group of individual courses representing various schools in the university that would integrate mobile technology. Based on results from the first phase, the second phase would integrate mobile technology in select departments or schools. The third phase would include the entire university in the use of mobile technology. In all phases, each student involved would be required to have a mobile computing device to be either leased or purchased. The exception would be in the first phase where the university would provide the devices for student use. An important consideration is that the specific mobile technology has not been specified.
The university is prepared to begin Phase I of the implementation in Spring 2004. In August 2003, I offered to prepare a template to be used for a call for proposals for Spring 2004. The course used as a model was Properties and Behavior of Soils course, a senior level course in the construction engineering technology program. The course is a combined introduction to soil mechanics and foundation design with lab. As a member of the committee, I became quite enthusiastic at the direction the university was taking in this effort, and I offered my course to be a “pilot” for the Phase I courses to be offered in the spring. The soils class was offered fall semester 2003. A complete course transformation occurred in a short 2 week period before class. The committee voted unanimously to accept my proposal. The university was in the process of establishing a campus-wide wireless network, and my classroom received priority to establish wireless connections by the beginning of the semester. For the mobile technology, I bypassed the notebook and requested the COMPAQ Tablet for each of my students and myself. The university purchased 19 tablets, loaned to each of the 18 students in the course to be returned at the end of the semester. I was provided with a Tablet for my use beyond the semester. The total cost to the university for the COMPAQ Tablets was $38,000.

The impetus for this project took many different tracks, but ultimately I was interested in creating an environment that enhanced the learning experience and created an excitement that would involve all students in the course. A study by Kolar, Sabatini, and Fink concluded class dynamics were much better with laptops in the classroom and certain learning exercises were much more effective. They also found that instructor commitment and subject matter are important factors in the effectiveness of this mobile technology[1]. A study at West Point also concluded that mobile devices offered different opportunities for learning both in the classroom and outside of the class and represent the latest evolution in personal computing[2]. This desire for a new environment was the catalyst that led to the selection of the Tablet as the most appropriate mobile device. The technology is new, something that would appeal to students. Several other factors related to history of the course also influenced the selection decision. The laboratory work is all accomplished with 3 person teams, and it is difficult to have all students on a team fully participate in the work. Typically, any computer work is taken on by one student. The others may be involved with other aspects of the lab work. Several labs involve real time data analysis, something we were never able to accomplish before. Computers are outside the lab. With the Tablet, real time data analysis can be accomplished with all students participating. Also, some labs require shared data, more efficiently accomplished with the Tablet.

The wireless complement to the Tablet allowed many new experiences to develop. As an adjunct to wireless, the course utilized WebCT for the first time. Power point lecture notes were provided, special projects were presented, and homework solutions posted on WebCT. The Tablet was loaded with Microsof Office, which allowed students to download lecture notes. The Tablet then allowed students to take additional notes on the lecture slide with their Tablet pen. Using the Journal program, example problems that I presented in class could be taken on the Tablet and saved with lecture notes. Another important factor in the selection of the Tablet related to the term project, which involved a geotechnical analysis of a problem site off campus. Site plans and boring logs were presented on WebCT, which students could download. They could then take their Tablet to the site and take notes and sketch existing conditions and possible solutions on the loaded plans.
Perhaps the most important factor in selection of the Tablet related to the learning communities that were readily established by the students outside the classroom where wireless access was available. Observation over the years has been that students go their own way after class and find it very difficult to meet as a group. However, with the Tablet, many group activities were observed taking place in the ET building lobby. Finally, the “fun factor” was achieved!

Specifically, but not inclusive of all requirements, each student was expected
1. To learn about the use of the tablet and how to access the wireless network.
2. Have access to lecture notes on WebCT, which can be accessed via wireless. Lecture would provide additional information and solve example problems. Students can write and sketch lecture notes on the tablet and save with the prepared Power Point notes. This would be used to evaluate if note taking is an efficient use of mobile technology.
3. To become proficient in the use of EXCEL to solve, graph, and present problems and lab data.
4. To learn the use of appropriate geotechnical software.
5. To produce a significant amount of individual work, along with group submissions.
6. To be active participants in the study associated with the pilot project, with results to be published and presented.

The COMPAQ Tablet specifications include a 1.0 GHz processor, 512 MB memory, and 30 GB hard drive. No drive units are provided with the Tablet. Software was loaded by the Information Technology Services Department. Some students purchased external USB flash drives to transfer files or utilized the network to store data to their server space or to print. These specifications and limitations proved important in evaluation of the transformation.

**Description of Course Transformation**

1. Course conversion to WebCT.
2. Microsoft Office software suite will allow real time data plots required of some laboratory procedures. Previously the students would have to go to department computer lab on second floor to plot data, and then return to lab to continue work. Also, usually only one student would work with the data. All students will participate.
3. Geotechnical software will be loaded on tablets for student use and will be utilized in real time in both lecture and lab. This is a critical new component of the course and will be integrated with lecture material and classroom instruction. (If funds available for purchase)
4. Power Point presentations will be required of all students, not only group, but also individual presentations.
5. The use of spreadsheets to calculate and program will be required of individuals as well as lab groups.
6. Students will utilize the tablet as an alternative to traditional note taking and time management – ideally in all classes they will take.
7. Mobile technology will be used in a field problem that will be their design project.
Impact on Learning
1. Students work in lab groups and typically write group reports. A professional geotechnical proposal is also submitted with presentation. Usually one student will work with the data and one will create the presentation. With the transformation, all students will participate in all aspects of the lab and projects, resulting in additional individual grades.
2. Real time data plots can occur in lab.
3. Students will visit their design project site and utilize their tablet to record field measurements and sketches.
4. Students will program sophisticated soil behavior under loading using EXCEL. This is typically a major accomplishment that provides lifelong confidence in their ability to problem solve.
5. Implementation of soil mechanics and design software not previously used in class.
6. More productive lecture time with active participation.
7. Confidence in computer skills, which translates into confidence in ability to work with new situations in industry.

Assessment Methodology
Student attitudes towards new technology used in a learning environment are an important factor in the assessment of student learning. An extensive survey was developed to assess student attitudes toward the Tablet and use of the Tablet in the classroom, laboratory, and outside of class. Significant research has been conducted to study student attitudes toward the integration of information technology in the classroom. Many of the survey questions were taken from these previous surveys. Doolen, Porter and Hoag used a survey to measure six areas related to PDA usage – anxiety, confidence, liking, usefulness (general), usefulness (course), and enthusiasm. This PDA study used constructs from a Computer Attitude Scale developed by Loyd and Gressard and items from a survey that measures enthusiasm developed by researchers at the Texas Center for Educational Technology. The questions related to WEBCT, wireless, student purchase or lease of the technology, and specific use of the Tablet were developed by the author. The following list of questions indicates the attitude measured for each group of questions.

Anxiety
1. Working with the Tablet made me feel very nervous*
2. I get a sinking feeling when I think of trying to use the Tablet in class*
3. The Tablet makes me feel uneasy*
4. The Tablet makes me feel confused*
5. I feel comfortable working with the Tablet*
6. The Tablet makes me feel uncomfortable*
7. The Tablet frustrates me**
8. I was confused by the Tablet**
9. Working with the Tablet makes me feel tense**
10. I have avoided tools like Tablet because they are unfamiliar to me**
11. I have avoided tools like Tablet because they are intimidating to me**

Confidence
12. I am not good with technology such as Tablet*
13. Generally I would feel OK about trying a new problem on the Tablet*
14. I don’t think that I would do advanced computer work*
15. I am sure I could do work using Tablet*
16. I have a lot of self-confidence when it comes to working with Tablet*

Liking
17. I will do as little work with computers or Tablet as possible*
18. Once I start to work on the Tablet or the computer, I find it hard to stop*
19. I do not enjoy talking with others about technology like Tablet*
20. Figuring out problems using Tablet does not appeal to me*
21. I like computers, but I don’t like Tablet**
22. It was fun having the Tablet in class**

Usefulness (general)
23. I will use computers many ways in my life*
24. Learning about Tablet is a waste of time*
25. Learning about Tablet is worthwhile*
26. I expect to have little use for Tablet in my daily life*
27. I can’t think of any way that I will use Tablet in my career*
28. Anything that a Tablet can be used for, I can do just as well some other way*
29. Working with Tablet will not be important to me in my life’s work*

Usefulness (course)
30. Using Tablet did not have a positive effect on my learning**
31. The Tablet was helpful to me in learning class concepts**
32. Using Tablet during lectures made it easier to understand the material**
33. Using Tablet during lectures made it easier to do my homework assignments**
34. The Tablet should be used more often in this class**
35. Tablet should not be used in this class**

Enthusiasm
36. I would like to learn more about the Tablet***
37. The challenge of learning to use the Tablet is exciting***
38. I would like to spend more time using a Tablet***

Tablet Proficiency
39. I used the Tablet in all my classes
40. Note taking was efficient using the Tablet
41. The use of the Tablet, wireless connection, and web CT was a productive way to deliver course content
42. I never became proficient at note taking using the Tablet

Usage for Other Students
43. The Tablet should be required of all students in the department
44. The Tablet should be required of all students in the School of Engineering, Technology and Computer Science
45. The Tablet should be required of all students at the University
46. I would be willing to purchase a Tablet on a payment plan if required by the University instead of leasing a Tablet
47. I would be willing to lease a Tablet on a payment plan if required by the University instead of purchasing a Tablet
48. I prefer a lease with option to purchase plan
Effectiveness of WebCT

49. I enjoyed using WebCT with this class
50. WebCT enhanced learning in the class
51. WebCT is an efficient means of communicating course information

Wireless Access

52. I enjoyed wireless access with the Tablet
53. Wireless access should always be provided with Tablet use

Use Outside Class

54. I used the Tablet outside of class
55. I used the Tablet at my place of employment

1. Please describe the benefits of the Tablet for use for this class.
2. Please describe benefits of the Tablet outside of this class (e.g. other classes, home, at your work).
3. Did you introduce the Tablet to your employer? If so, what interest did he/she take related to their company?
4. Please describe problems with use of the Tablet?
5. Other comments?

Questions shown with a single asterisk * are taken from Loyd, et.al., those with a double asterisk ** are taken from Doolen et.al., those with a triple asterisk are from the Texas Center, and those questions without an asterisk were developed by the author. Eighteen students participated in the class and fourteen survey responses were received along with general responses from the last five open questions. The surveys were anonymous and no attempt was made to correlate response to demographic information or to student outcomes in the course. A five-point Likert scale (strongly disagree, disagree, neutral, agree, strongly agree) was used for all survey items except the general questions.

Results and Discussion

Using EXCEL, the results of each of the questions were summarized and are grouped together to measure one of the eleven attitudes.

ANXIETY

Tablet Creates Anxiety

Figure 1

Comfortable With Tablet

Figure 2
CONFIDENCE

Little Confidence

High Confidence

Figure 3
Figure 4

LIKING

Does Not Like

Does Like

Figure 5
Figure 6

USEFULNESS (GENERAL)

Little Use

Usefull

Figure 7
Figure 8

“Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition Copyright © 2004, American Society for Engineering Education”
USEFULNESS (COURSE)

Figure 9

Figure 10

ENTHUSIASM

Figure 11

TABLET PROFICIENCY

Figure 12

Figure 13
Usage for Others

Effectiveness of WebCT

Require Wireless Access

Figure 14
Figure 15
Figure 16
For seven of the attitudes measured, two graphs are provided for each attitude. The first graph relates a negative response to the attitude, and the second graph relates a positive response to the attitude. For a negative response to an attitude that is disagree or strongly disagree and for a positive response to an attitude that is agree or strongly agree, the conclusion that can be made is a positive response to the attitude. For example, in figures 7 and 8, general usefulness of the Tablet is measured. Figure 7, the first graph, evaluates little usefulness and there is a strong disagreement with this measure. Figure 8, the second graph, measures usefulness and there is strong agreement with this measure. Therefore, the conclusion is the students find the Tablet to be useful, in general. With two graphs, a positive response will always be weighted to the right side response (disagree) for the first graph and will always be weighted to the left side response (agree) for the second graph.

The overall response from the students in this pilot course transformation using the PC Tablet was quite positive. Additional comments provided by the students provided insight into problem areas not addressed by the questionnaire. Also received were very positive comments not addressed in the questionnaire. These comments, in addition to results presented in this paper, will provide the university committee some guidance in determining future action with regard to use of mobile technology in the classroom. The following list summarizes the most significant results and observations.

- The instructor must commit time and resources to make productive use of the technology.
- Students felt very little anxiety in use of the Tablet. (Figures 1 and 2)
- Students achieved a high degree of confidence in use of the Tablet for coursework. (Figures 3 and 4)
- Students enjoyed working with the Tablet. (Figures 5 and 6)
- Students found the Tablet useful in general and in accomplishing course objectives. (Figures 7, 8, 9, and 10)
- Students displayed a high degree of enthusiasm for the Tablet. (Figure 11)
- Students became proficient with the Tablet, particularly note taking. (Figures 12 and 13)
- Students are noncommittal in recommending use of the Tablet for other students in a larger group setting - department, school, or university. (Figure 14)
- WebCT was an effective tool used with the Tablet. (Figure 15)
- Wireless access should always be provided. (Figure 16)

My observations of student behavior with the Tablet both in and out of class concur with the results of the student questionnaire. I was very pleased with the enthusiasm for the course, which was driven, in part, by the technology. Student participation in computer work and in the lab was universal, and I observed the learning communities established with each group and between groups.

An example of Tablet usage that provided a variety of applications for the student was the final laboratory project which involved a geotechnical site evaluation for residence halls on campus. The students were provided with a site map detailing the site investigation locations and also were given access to all boring logs via WebCT. The boring logs could be printed off for hard copy or they could be accessed in real time via wireless at the site. Lab work consisted of evaluating existing soils for index properties, classification, standard proctor density, unconfined compression, and consolidation. An example of a specific course enhancement that was desired...
as part of the transformation occurred with the consolidation lab. The lab is conducted over a six
day period, 24 hrs/ day. Each lab group was responsible for one 24 hr loading cycle, and the
group data was combined for all groups to complete one consolidation evaluation. A significant
advantage was gained for the students in both time and learning when data is plotted in real time.
It is very likely the load cycle can be completed in hours versus 24 hrs, which means the lab
group would not have to be involved for the 24hr period. This time determination is made from
a log time – deformation graph. In previous classes, one person from the group would go to a
second floor computer lab to plot a data point in EXCEL, then print out results and share with
the lab group. Usually the same person did computer work. The other members would not get
involved. With the Tablet, all group members worked with EXCEL and achieved a better
understanding of the principles involved in consolidation. Also, since lab group data was shared
with other groups, data could be posted to WebCT for all to have immediate access. The Tablet
created a learning community within the laboratory and encouraged all students to be involved
with computer applications specific to each lab. Wireless access provided an exciting tool for
student access to site information, which created an exceptional learning environment. Results
similar to this project were observed throughout the course.

A majority of students used the Tablet in other courses and several used the Tablet at their
workplace. In effect, the students introduced new technology to their employers, and several
expressed interest in the benefits of the Tablet in their workplace. This was an unanticipated
outcome of the project. The student response was neutral when asked to recommend use beyond
this class. I understand the implication of students recommending new technology at cost to
other students. Three options for student access were proposed – the preference was a lease with
option to purchase.

Several problem areas were identified. The most significant was speed of the Tablet, screen size
for possible CAD interface, and lack of built-in drive units. Also, our classroom did not provide
a power source which became a significant problem when students attended this class in the
evening after having spent all day in other classes. Wireless access is not universal and is a
necessity with mobile technology.

The hardware configuration for Tablets has already improved and will continue. Docking
stations can solve the screen size issue with professional software. The university has a plan to
implement wireless campus-wide and is aware of the power issue. I believe the problem areas
can be addressed adequately, including financial consideration for the student.

Recommendations

• Continue with individual course transformation projects at university expense
• Workshops for instructors
• Implement department integration 2004-2005
• Determine financial options for students
• Provide technology to instructors willing to commit to transformation
• Proceed with wireless access, with student space and selected classrooms given priority
• Provide power to student and classroom space
References

Biography
C. WAYNE UNSELL is Chair, Department of Civil and Architectural Engineering Technology.