

**AC 2008-2287: INTERACTIVE LEARNING USING A TABLET PC IN CIVIL
ENGINEERING SOIL MECHANICS**

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Interactive Learning Using a Tablet PC in Civil Engineering SOIL MECHANICS

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Abstract

The authors are part of an initiative at Rose-Hulman Institute of Technology to explore opportunities for the use of tablet PCs equipped with appropriate software as interactive learning devices. Appropriate use of technology is a guiding principle for learning through the ASCE ExCEED model. As a learning tool, the chalkboard offers a broad range of advantages for facilitating learning in a variety of ways. Even so, technology offers opportunities to develop interactive learning tools that can broaden learning activities in the classroom. As a strong proponent of chalkboard-facilitated learning, the author had joined the tablet research team as a skeptic collaborator.

The first author used tablet PCs as the instructor to facilitate nearly all classroom learning in junior-year, civil engineering SOIL MECHANICS course. The instructor and students used pen-based tablets with collaborative note taking software in class to manage lectures, discussions, example problems, classroom learning assessments, practice problems, and spreadsheet-based problem-solving tools. Assessment of learning is being conducted on four levels: (1) assessments of the students' attitudes about using the technology and their learning; (2) independent, institute-level assessment at the beginning, middle, and end of the course; (3) evaluation of student performance on the final exam compared to prior course offerings; and (4) instructor reflection.

The study found that students usually expressed a high acceptance of the learning process, believe both in class and out-of-class learning are improved, and expressed a desire to use the technology in other classes. Final exam test scores indicate no significant change in student performance on exams. The instructor found the technology adds tools to facilitate interaction and immediate assessment of learning and is excited about the prospect of using the technology in more classes. In conclusion, it is recommended use of this technology be considered for similar courses, but only if the instructor is prepared to invest significant time for mastering the technology and for preparation of advance notes for their first offering of the course.

Introduction

Dialogue about the use of technology in engineering education may neglect the fundamental character of effective course-based learning. Clearly, effective learning in engineering courses depends first on the learner, not the technology used to foster learning. The learner must

- value the knowledge,
- be capable, and
- have time and resources that permit them to learn.

The mentor is second only to the learner in impacting learning effectiveness. The mentor's role hinges mostly on the first and last of the above three student needs. The effective mentor

- helps the student strengthen their values;
- improves learning efficiency to reduce time required for learning;
- provides resources that include a course curriculum, reference materials, planned learning activities or lessons, and independent assigned tasks or homework;
- provides their time to individual students or small groups outside of planned learning activities on an as-needed basis; and
- evaluates the student's learning.

One of the important roles of technology in learning is to assist the mentor in their effort to facilitate learning. For example, while simple technology such as chalkboards promise high reliability in a classroom setting, few would argue the value of photographs and videos as appropriate classroom learning tools. Even so, photograph or video presentation constitutes a higher risk of a technology failure. Similarly, students in need of immediate mentoring who are within steps of the mentor's office may be more efficiently mentored face-to-face than by email, but the same students working on the same learning activities off-campus would likely find email a good immediate mentoring option. A final example is a graduated civil engineer who is seeking Master's or equivalent learning for their continued professional or specialization development. If such an engineer is living and working many miles from a college campus, or maintains work hours that conflict with locally available courses; that engineer may have no recourse to continue their education other than through online courses. For each of these examples, the use of technology is an important consideration, but always with respect to its role in assisting the mentor and their role in the learning. Whether a specific technology is appropriate for assisting with the learning process is a matter of comparing the benefit or value of the technology with the cost or risk associated with its use. Ultimately, the goal of any technology implementation should be to improve learning or the learning process with little to no failure of the technology itself.

One tool that holds promise to facilitate improved learning inside and outside the classroom is the use of pen-based computer technology with collaborative learning software. Pen-based technology removes the inherent limitations of a computer keyboard and mouse for note-taking, working example problems, and sharing information between students and the instructor both inside and outside the class. To be effective, pen-based instruction requires (1) a wireless or wired network to permit immediate instructor/student interaction, (2) pen-based hardware for both the instructor and students that is easy to learn and use, and (3) software to facilitate the interaction. While some may consider such technology to be a tool for distance learning, many instructors are finding the technology to be of great value in a traditional classroom setting. This paper reports on the use of such technology in a traditional college environment.

Rose-Hulman Institute of Technology (RHIT) is investigating the use of pen-based technology in a variety of courses across the engineering, math and science curriculum (Devasher et al., 2007). In addition to the existing campus wireless network, the institute is using Hewlett Packard® tablet PC computers and DyKnow® software (Berque, 2006; DyKnow, 2006) in the study. In collaboration with this effort to date, the first author has implemented pen-based technology to

facilitate learning in a required junior-level, civil engineering SOIL MECHANICS class, a senior/graduate level FOUNDATION ENGINEERING technical elective, and in a required sophomore-level MECHANICS OF MATERIALS course. This paper examines the use of pen-based technology and collaborative learning software in the SOIL MECHANICS course.

Course Development

The first author, hereinafter referred to as the instructor, joined this institute project with some trepidation. As a graduate and former assistant mentor in the American Society of Civil Engineers (ASCE) Excellence in Civil Engineering Education (ExCEED) program (Estes, et al., 2005; ASCE, 2008), the instructor is an outspoken institute proponent of the tenets of ExCEED, including appropriate use of technology in the classroom. In fact, the instructor's campus reputation in this regard was one significant reason the project PI contacted the instructor about joining the project. The adoption of this technology-based instruction process for most all of the class meetings seemed to the instructor to be a significant departure from his ExCEED roots. Similarly, the project PI was interested in having a critical examination of the technology from a possible skeptic. The instructor only agreed to join the project with the understanding that implementation of the technology would not have to be on a daily basis, and frequency of use would be determined by the instructor as the class proceeded.

To prepare for course implementation in the fall 2007 term, the instructor worked half time on the project during the summer of 2007. Training was simplified by the project leadership, as this pen-based learning project was in its second year and formal training of new faculty participants was well-planned and thorough. Advance preparation included hardware and software training, numerous practice sessions with other faculty participants in the project, and significant revision of lesson plans used previously for the course. The instructor planned to implement the technology both in the required junior level SOIL MECHANICS course, as well as in the senior/graduate level FOUNDATION ENGINEERING elective course. For both courses, the instructor sought an electronic text to facilitate not only advance preparation of course notes, but also to permit access to the text during class to address unanticipated questions or threads of discussion that lead to topics not captured in the slides prepared in advance. After some searching, the instructor identified a two-volume public domain geotechnical engineering handbook of excellent quality for the purpose of the two courses (Samtani and Nowatzki, 2006a and 2006b), and was thus able to simply direct the students to download a copy and make their own choices about printing and binding their text, or simply working from the electronic version.

The instructor resolved to maintain as many of the tenets of ExCEED in the development of course notes for the revised class, and to seek out opportunities to enhance student learning in ways that could not be achieved using simpler technology. Creation of board notes featuring multiple colors used in an organized structure was thus an objective, as was regular use of questioning techniques, physical demonstrations of behavior, and regular classroom assessment of understanding. As the instructor became more familiar with the collaborative note-taking software during course preparation, it became clear that example problems worked by the instructor could be replaced with posed example problems that would then be worked during class by the students and submitted for in-class review. The ability to build collaborative groups described in the next section allowed the instructor to plan more group work for class time. In

addition, it became evident during early course notes preparation that with the collaborative note-taking software, the instructor could save time by building some mundane parts of board notes in advance to allow more time annotating the notes, discussion of concepts, and student problem-solving. As the instructor became more familiar with the software, excitement about the potential to improve learning increased.

As the first day of class arrived, the instructor was confident learning would not be impaired by use of the technology and was excited about the potential opportunity to explore new types of learning during class. The instructor was less than confident about the subtleties of efficiently controlling the learning using the software, and about reliability of the technology day after day. For this reason, the instructor prepared all of the slides for the first few weeks of class on overheads as a backup and arrived for class prepared to use traditional chalk board notes supplemented with overheads in the event of a technology failure or author's failure to use the software efficiently.

Learning Environment

The class consisted of thirty 50-minute lecture periods and ten 160-minute lab periods. The pen-based technology described herein has only implemented in the lecture periods, but was used in all lecture periods throughout the 10 week term. The classroom setting was a traditional lecture-style classroom featuring white boards, forward-facing student seating, an LCD projector, and two dozen Hewlett-Packard tc4400 tablet PCs for each student to use, but only during the class meeting. For this project, the instructor was issued a tablet PC identical to the tablet PCs in the classroom. Section 1 of the class was comprised of 16 students, with 15 students in section 2. The instructor would normally combine these students into a single class, but felt strongly about each student having a tablet PC of their own, so the class was divided into two sections. In retrospect, this was good, because it permitted the instructor to double his experience in the use of the software and hardware and steepened the learning curve for mastering the technology.

Collaborative learning was facilitated using DyKnow® collaborative learning software. To make use of DyKnow during class, the instructor and students logged in to the designated server. The instructor began each class Session as a faculty user, after which the students joined the Session as student users. In the case of this course, the instructor prepared lesson plan slides in advance which would be comparable to overhead transparencies featuring blank spaces for additional annotating. As the Session proceeded, the instructor selected the appropriate slide to be used. Upon selection, that slide became available as a Panel to all of the student users logged into the Session. The instructor then made use of the tablet PC pen to annotate the Panel with board notes and sketches, selecting from a variety of pen, highlighter, and drawing tools available in the software. As the Panel was annotated, the instructor's pen strokes were recorded on all of the computers logged into the Session. Slides could be selected in any order, so the lesson could be nonlinear through the prepared slides. At times, the instructor also inserted blank slides to provide additional board notes or sketches, or to permit a quick cut and paste from a text book or internet source for additional instruction. An example of an annotated DyKnow panel is provided as Figure 1.

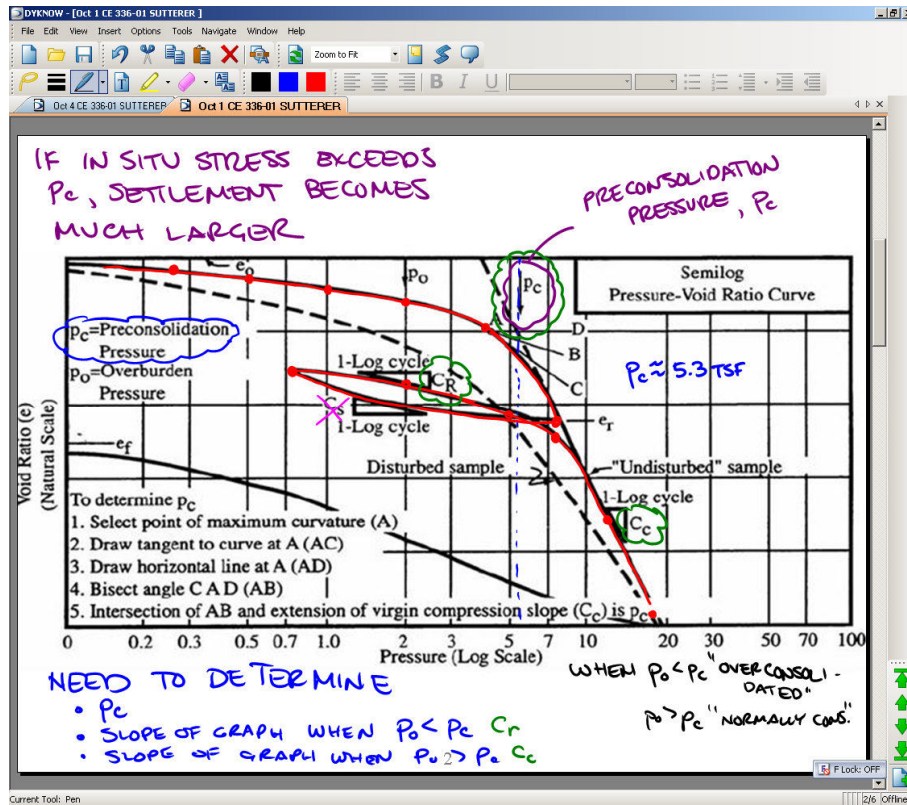


Figure 1. An example of an instructor-annotated DyKnow panel.

Sometimes the copying of the instructor’s board notes was necessary for fundamental learning. In such cases, it was better if the instructor’s pen strokes were not recorded by all participants in the Session. This was achieved using Private Ink, which only appeared on the instructor’s tablet PC. Because the instructor’s tablet PC was being displayed in the front of the room using an LCD projector, the instructor could use Private Ink to annotate slides that should be copied by students. Students could view the projection of the instructor’s Private Ink in the front of the room, but the Private Ink annotations did not appear on their own computer, so those Private Ink notes had to be copied by the students in order to be saved, in much the same way students copy down traditional board notes. In Figure 1, Private Ink annotations are in the color purple.

Students in the Session saved the faculty member’s annotations, their own Panel annotations, and their own Private Notes attached to that specific Panel. Private Notes are a separate Panel prepared by each student that looks like a notebook page and is provided for additional notes beyond those provided by the faculty member. These additional notes are possible because students are not preoccupied with copying the faculty member’s board notes, as they would if the faculty member were using a chalk board. Private Notes are an opportunity for students to think about what is being presented and summarize their understanding in additional notes to capture the faculty member’s commentary in a way they understand.

The above information-sharing and note-taking features are essential, but only collaborative in the sense that the students are being provided the instructor’s notes while adding their own. This collaborative learning software include many features not used by the instructor in this first

application in class, but additional collaborative tools useful to the faculty instructor and students includes

- Panel submission of student work on examples during a Session for the whole class to review
- Replay Panel, which replays a selected panel pen-stroke by pen-stroke so the sequence of panel construction can be reviewed
- A Polling feature that permits immediate assessment of learning during a Session
- A Grouping feature that gives designated groups control of each others' panels to facilitate group problem solving during class

The Replay Panel feature was of particular interest to the students. As noted above, this feature allowed students to reply the pen strokes on a panel in sequence. Many students reported using the feature outside of class time when reviewing worked example problems and simply to assist in studying.

The instructor particularly appreciated the use of student submittals during class. An example is shown in Figure 2. Student submittals were examples worked by the students during class time, submitted immediately to the instructor's tablet PC, and then displayed for review by the whole class. Many students reported working examples themselves was highly beneficial, especially when they could subsequently observe their classmates' work along with their own to understand subtleties in problem solution or their own mistakes. The instructor also found this tool extremely useful, as it allowed him to roam the room to assist students individually, encouraged

(1) A normally consolidated layer of clay extends from the ground surface to 9 feet below the surface. The next deeper layer is a very dense sand. The clay has a $C_c = 0.24$ and $c_v = 10$ ft²/yr. A footing will be placed on top of the clay layer. The footing is 3 feet square and will carry a column load of 14850 lbs. How much will the footing settle? To facilitate more accurate settlement computations, break the soil profile into three equal layers. The clay has a total unit weight of 113.7 pcf and ground water is just below the ground surface, so assume GW depth = 0 feet.

Layer	H (ft)	Before Footing			After Footing			
		midpoint pt (psf)	midpoint u (psf)	midpoint po (psf)	midpoint Δpt (psf)	midpoint pt (psf)	midpoint u (psf)	midpoint po=pf (psf)
A	3	170.6	93.6	77.0	733.3	903.9	93.6	810.3
B	3	511.7	280.8	230.9	264.0	775.7	280.8	494.9
C	3	852.8	468.0	384.8	134.7	987.4	468.0	519.4

used 2:1 approx.

footing surface
 clay
 dense sand

e_0 omitted → would normally be provided or computed, so assume $e_0 = 1.10$

$$S_c = \frac{C_c}{1 + e_0} H_0 \log_{10} \left(\frac{P_f}{P_0} \right) \quad P_f = P_0 + \Delta p$$

$$S_{cA} = \left(\frac{0.24}{1 + 1.10} \right) (3) \log_{10} \left(\frac{810.3}{77.0} \right) = 0.35045 \text{ ft}$$

$$S_{cB} = \left(\frac{0.24}{2.10} \right) (3) \log_{10} \left(\frac{494.9}{230.9} \right) = 0.11337 \text{ ft}$$

$$S_{cC} = \left(\frac{0.24}{2.10} \right) (3) \log_{10} \left(\frac{519.4}{384.8} \right) = 0.04466 \text{ ft}$$

$$\sum S_c = 0.508 \text{ ft} = \boxed{6.10 \text{ in}}$$

Figure 2. An example of a panel submitted by a student during class for immediate review by the class.

students to help each other, and permitted immediate identification of misunderstandings or matters that required additional instruction.

In addition to the in-class activities, students loaded DyKnow on their personal laptop computers to permit review of notes, printing, and additional annotation of their files. Use of the software did not require pen-based technology, though usage is often simplified using a pen. On several occasions, students who had taken ill joined the class from their residence hall. In those cases, they even completed in-class example problems on their own, despite missing the instructor's oral presentation and some instructor annotations in Private Ink.

Outcomes

Evaluation of the findings is still under way, plus the course will be taught using the technology in the fall of 2008, so the findings reported in this study are preliminary. The effectiveness of learning using pen-based technology with DyKnow was assessed in four different ways: (a) student surveys, (b) institute assessment, (c) student performance on tests, and (d) instructor reflection. Institute administered standard teaching evaluations were also administered for the class, but have not been considered in assessment of the effect of the technology at this time.

Student Surveys

Students were surveyed by the instructor three times during the term to determine their impression of learning effectiveness. The surveys included other questions relevant to the class, and also questions to assess their overall feelings about use of the technology, independent of their learning. Students were also asked to provide comments for improving the class, including insights on what they would change and what they liked. The results of four key questions on the student surveys, identified in italics below, are shown on Table 1.

Which of the following best describes your current feelings about the use of DyKnow in this class? Table 1 shows that over 80% of the class did not have negative feelings about the use of the technology, though they felt less positive about its use by the end of the term than at the beginning.

How do you think the use of DyKnow in this class has affected your learning during the class meeting? The second question indicated that 90% of the class believed the technology did not reduce their learning during class, and over 30% felt it improved their learning during class time.

How do you think the use of DyKnow in this class has affected your learning outside the class meeting? The response to the third question in the table was surprising. An average of 49% of the class felt the use of this technology improved their learning outside of the scheduled class meeting time. This response was unexpected. Students reported the ability to access the instructor's hand written notes along with their own private notes reassured them they had a good record of the materials covered in the class. The Replay Panel feature was also mentioned frequently as a feature that helped them better understand sequential processes demonstrated by the instructor's panel notes. Students who had some reservations about use of the technology in the classroom sometimes deferred to using handwritten notes in lieu of Private Notes, but still joined the Session because they found the Session notes acquired to be of great value.

Table 1. Results from Student Feedback Surveys during the course

	After two weeks		After four weeks		After seven weeks	
	No.	%	No.	%	No.	%
Which of the following best describes your current feelings about the use of DyKnow in this class.						
I do not like it at all	1	3%	1	4%	1	3%
Not my preference, but I can manage with it	3	10%	4	15%	3	10%
Neutral. I neither like nor dislike it	3	10%	7	27%	9	31%
I prefer this, but the traditional way is fine too.	14	47%	8	31%	8	28%
I really like DyKnow and would like to see it used in more classes.	9	30%	6	23%	8	28%
	30		26		29	
How do you think the use of DyKnow in this class has affected your learning during the class meeting?						
I believe it has reduced my learning	3	10%	2	8%	3	10%
Neutral - neither reduced nor improved my learning	18	60%	16	62%	15	52%
I believe it has improved my learning	9	30%	8	31%	11	38%
	30		26		29	
How do you think the use of DyKnow in this class has affected your learning outside the class meeting?						
I believe it has reduced my learning	1	3%	1	4%	4	14%
Neutral - neither reduced nor improved my learning	12	40%	14	54%	11	38%
I believe it has improved my learning	17	57%	11	42%	14	48%
	30		26		29	
Please rate your experience using DyKnow on your own computer to access notes, etc.						
I really like it and have had no significant problems	9	30%	6	23%	6	21%
I prefer it, but would do fine without it as well	12	40%	6	23%	5	17%
Neutral - I have no strong opinion either way	3	10%	7	27%	11	38%
I do not prefer it, but don't mind doing it this way	6	20%	6	23%	5	17%
I do not like it at all	0	0%	1	4%	2	7%
	30		26		29	

Please rate your experience using DyKnow on your own computer to access notes, etc. The response to the fourth question was mixed and is still being evaluated. The author is examining responses to this question in other classes and will review data from next year's class. It is possible that no clear conclusion can be drawn from this response, other than that the students had a wide range of impressions about use of DyKnow on their own computers.

Student Performance on Tests

The instructor creates new term tests each time the course is taught. Old tests are made available to the students prior to testing. For this course, the instructor also added another term test. In previous years, students were administered two term tests and a final exam. This year, students were administered three term tests and a final exam. This modification in the testing was planned before the instructor joined the project in response to feedback from prior assessments. Consequently, it is not possible to reliably compare student performance on term tests with previous years.

Conversely, the instructor does not return final exams from one year to the next, and is careful about preventing student acquisition of final exams. Although the instructor often changes the final exam from one year to the next, the fall 2005 and fall 2006 final exams were identical, so the same exam was also administered to the class in fall 2007 to permit comparison of student performance over three years. A formal rubric was not used to grade the final exam each year,

but comparison of grading marks from 2006 exams by the instructor indicated the grading in 2006 and 2007 was relatively consistent. Student exams from 2005 were not available for examination. The average and standard deviation of the final exam grades is shown in Table 2. Comparison of the fall of 2007 with the prior years suggests no significant change in the final exam score associated with incorporation of the pen-based technology. The drop in scores from 2005 to 2006 could not be explained. It is possible the rubric used for grading in the fall of 2005 was different, resulting in a slightly higher average score on the exam.

Table 2. Summary of Final Exam Scores

	Fall 2005	Fall 2006	Fall 2007
Average	80	76	77
Standard deviation	11	11	11
n	47	45	31

Institute Assessment

The second author facilitated independent assessment and thus supplied the insights in this section of the paper. One of the first things students were asked to respond to on the institute-administered survey was the number of RHIT courses in which they had used the laptop, tablet PC, and Wacom® Slate (another pen-based technology) and their level of comfort in using each device. As can be seen from Figure 3 below, the vast majority of students in SOIL MECHANICS had never used a tablet PC or a Wacom Slate prior to the fall 2007 quarter. Interestingly, there was a positive correlation between laptop use and comfort and tablet use and Wacom use. The more courses a student had used a laptop in, the more comfortable they were with the device.

After rating their interest on each survey, students were asked to explain their rating. Following the week 1 rating where students reported a slight interest in the tablet, students were unsure what benefit the tablet would have on their learning. Some were skeptical while others were excited. A few of the student comments can be seen below. In order to best present the progression of student opinions across the quarter, the same four students are used as examples

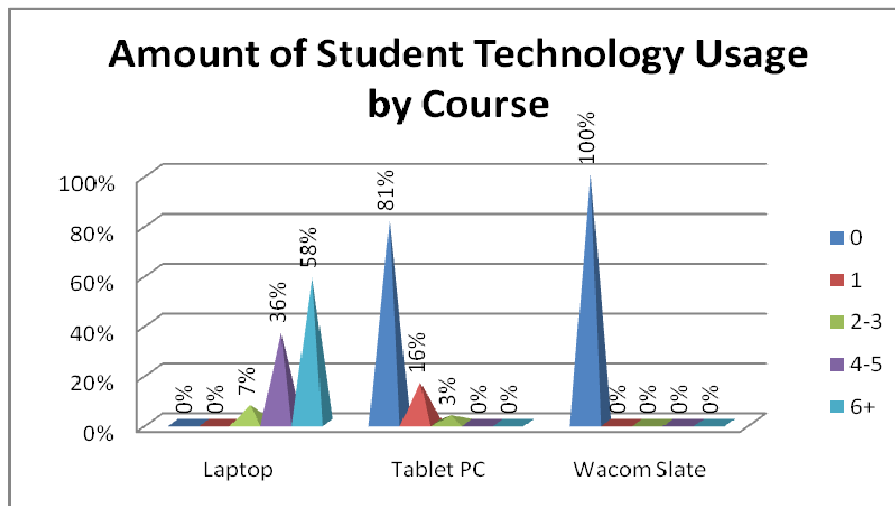


Figure 3. Number of courses in which students used technology during class.

for each week. The students used as examples were chosen based on 3 criteria; the made a comment on each survey, the comment was coherent, the comment represented comments echoed by a number of other students in the course.

“For some things it is important to have a hard copy, or to physically write something down. Aside from those, tablets are great as long as they get used in a way that allows students to stay active and engaged in the material.” Student A

“It looks pretty neat.” Student B

“My previous experience with the tablet was a poor one. The tablet was extremely slow. Also, I was focused on the computer screen instead of the professor’s movements. Hence, I missed meanings of statements.” Student C

“I’m getting my first chance to use it in a class and I want to see what all the fuss is about.” Student D

Following the week 5 rating where students reported moderate enjoyment of the tablet, students were split in their responses. Some did not enjoy the tablets while others found them quite useful. A few of the student comments can be seen below.

“It seems more efficient for getting a point across. We are not wasting time on as many simple things.” Student A

“I’m pretty neutral; tablets really aren’t that special compared to a laptop.” Student B

“I like to type my notes on the page and sometimes for examples I have to switch over to writing. It’s an inconvenience.” Student C

“I prefer taking notes by hand. It allows me to pay more attention to the lecture just by actively writing. Involving computers just complicates things that you can do with a whiteboard.” Student D

Following the week 10 rating where students again reported moderate enjoyment of the tablet, most students found benefits to the tablet PC in their learning. The same students’ comments can be seen below.

“More convenient. Submitting problems keeps everyone engaged... not just one student as seen in a typical classroom.” Student A

“It’s like a computer and a notebook... combined!” Student B

“Re-emphasized the material taught in class. I understood the material better by seeing it and taking a few notes rather than scribbling things down.” Student C

“It took away from learning from the lecture. I felt less engaged.” Student D

Students in SOIL MECHANICS were asked to rate their level of comfort with, interest in, and distraction due to the technology across the quarter. The summary of these ratings are shown in Table 3, with a rating of 6 being completely comfortable with the technology. There were two statistically significant differences in student ratings across the quarter.

- Student comfort with the tablet PC significantly increased from the 1st to 5th weeks and from the 1st to 10th weeks. The increase from the 5th to 10th week was not statistically significant.
- Student interest and enjoyment significantly increased from the 1st to 5th weeks and from the 1st to 10th weeks. The increase from the 5th to 10th weeks was not statistically significant.

Table 3. Tablet Means across the Quarter (6 Point Rating Scale)

Item	SOIL MECHANICS		
	1 st Week	5 th Week	10 th Week
Laptop Comfort	5.64	5.68	5.76
*Tablet PC Comfort	3.86	5.29	5.39
*Tablet Interest/Enjoyment	4.29	5.00	5.18
Tablet Distraction	3.11	2.57	2.68

Note: * indicates significant difference

On each of the three surveys, students were asked to indicate their preferred method for taking notes and the situations when they refer to their notes. As can be seen in Figure 4 below, there was an increase in the number of students using instructor provided notes with the largest increase between the 5th and 10th weeks and a decrease in the number of students supplementing instructor provided notes with the largest decrease between the 1st and 5th weeks. There was a decrease in the number of students reporting referring to their notes while doing homework with the largest decrease between the 5th and 10th weeks.

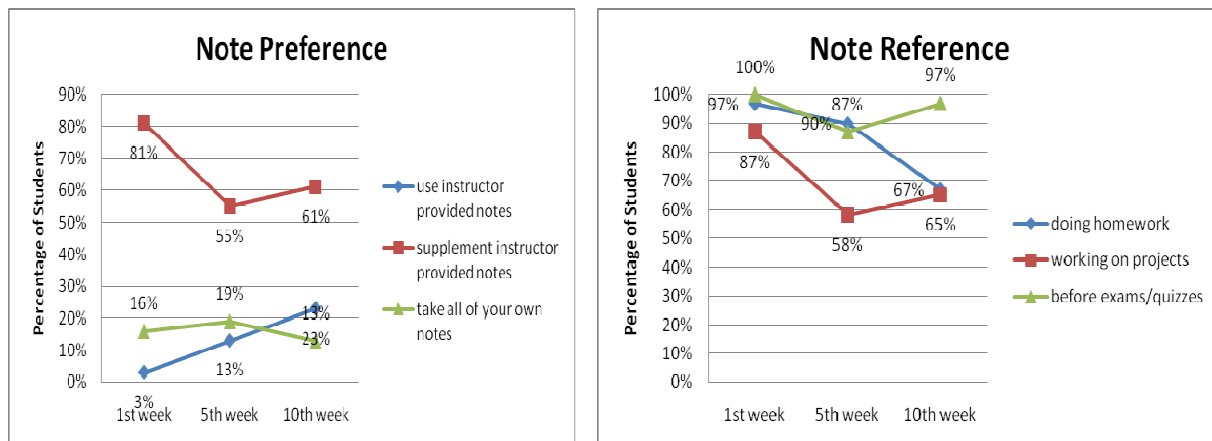


Figure 4. Preferred method to take notes and frequency of referring to

Comparing SOIL MECHANICS student ratings of learning objectives pre- and post-course revealed an increase in student ratings of confidence in their ability to complete each objective. This is summarized in Table 4. All 5 of these increases were statistically significant. Since a control group did not rate these items, there is no way to know if the increase is due to the implementation of the tablet PC and DyKnow or simply to student learning. The shift away from the blackboard to the tablet PC and DyKnow did not prevent student learning.

Table 4. Means for SOIL MECHANICS Student Learning Objectives
(Rating Scale: 6 point scale ranging from 1 = completely unconfident to 6 = completely confident)

Learning Objective	Confidence*	
	Pre	Post
Design a subsurface investigation for a structure.	2.67	4.27
Evaluate results from geotechnical laboratory tests for errors and validity.	2.67	4.07
Use data from a subsurface investigation to determine parameters for design of a shallow foundation.	2.57	4.00
Analyze the geotechnical aspects of a shallow foundation system.	2.47	3.90
Design geotechnical quality assurance/quality control program for a typical civil engineering project.	2.70	3.90

Notes: * all differences are statistically significant.

Finally, students were given the opportunity to provide general comments about the tablet PC, DyKnow, and the course. These comments included incorporating DyKnow into more CE courses, enjoying the convenience of not having to “frantically” copy all of the notes, and desire for audio to accompany the slides. One student even felt “as long as you pay attention, it is probably the best way to take notes.” Replacing the standard freshman laptops with tablets was also suggested.

Some of the aspects students did not care for include the difficulty they experienced trying to delete items from the slides, the slow speed with which DyKnow responds, and the temptation for distraction. Ironically, one student felt DyKnow should not be used as “students spend too much time on other programs other than DyKnow and don’t have copies of the notes.”

Instructor Reflection

As noted previously, the author was uncertain about the likelihood of successful use of this technology before the course began. The simplicity of chalk board or whiteboard notes holds great appeal for instructors, and student familiarity with learning through use of high quality board notes is reassuring. Networks and wireless systems are notorious for failing at the worst possible times, and certainly the instructor was concerned about this possibility. Although the DyKnow collaborative note-taking software now seems simple to use, the instructor held great concerns about successful implementation in the course.

The instructor entered the course determined to always project a positive, low stress perspective about the technology to the students. When occasional glitches were encountered with a student

login or wireless failure on a specific tablet PC, the instructor calmly suggested an acceptable solution, took time to show concern for the student's frustration, and proceeded with the lesson, emphasizing time had been built in for unforeseen events and that the class was still on schedule. In fact, the instructor had designed the course to cover more material in class more quickly than in previous years, so when some time was lost during class, assignments remained consistent with those made during previous years, and at the end of the term the course actually had covered several topics better and in greater depth than previously.

The instructor's goals to follow the tenets of ExCEED met mixed success. Construction of well organized "board" notes on the DyKnow slides improved over time, but the instructor admits some inconsistency in this regard because effective use of the software and hardware took precedent over perfect board notes to keep the lessons running smoothly. The instructor has admittedly not been strong in the past in the use of questioning techniques to keep the students engaged with learning. As with the presentation of board notes, confident use of the technology took precedent over focused questioning techniques. Even so, students reported a higher level of engagement in this class than in some of the instructor's past classes. This may be because the instructor sought as many opportunities as possible to engage students with in-class problem solving and group work. Organization of board notes and use of effective questioning techniques improved as the instructor gained familiarity with and confidence in the use of the learning technology.

The course meetings were more enjoyable from one day to the next for the instructors and students. Use of the collaborative note-taking software allowed a wider variety of activities to facilitate learning. The instructor often, upon recognizing on a given day that the students were especially tired or less focused, would change the lesson to make use of a different learning tool to wake up the group. The instructor also noted that careful preparation of advance slides contributed greatly to organization of the course. Finally, the instructor is now finding that many lesson plans can be built more quickly using this technology than for more traditional courses.

Despite the positive experience of the instructor, an important caution is the amount of time that has been invested in advance and during the term to become proficient with this technology. Although the official summer work on the project was half time, the instructor worked nearly full time for most of the summer to prepare. During the fall term, preparation of slides was time consuming at first, though this improved as the instructor's confidence in the software and hardware increased. In a recent conversation with a colleague from another institute, the instructor advised that this technology not be explored by a tenure track faculty unless significant technical support for the specific technology is available on campus.

Conclusions

Pen-based technology in conjunction with collaborative note-taking software was used successfully for facilitating a junior-level soil mechanics course. Student and instructor support for the technology was positive. Initial implementation has led the instructor to incorporate the technology into other courses. Early data indicates the benefit of using the technology is greater than the cost.

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