Interactive Learning Using a Tablet PC in Soil Mechanics
Kevin Sutterer, Rose-Hulman Institute of Technology

Abstract
The author is currently part of an initiative at his institute 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 author used tablet PCs to facilitate nearly all classroom learning in junior-year Soil Mechanics. 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 by the author.

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 institute assessment findings were consistent with student feedback, suggesting learning was equal or improved by the technology. Final exam test scores indicate no significant change in student performance on exams. The author has discovered 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.

Key Words
Education Methods, Innovative Teaching Methods, Technology in the Classroom
Interactive Learning Using a Tablet PC in Soil Mechanics

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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 chalk boards 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 expand 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. In addition to the existing campus wireless network, the institute is using Hewlett Packard® tablet PC computers and DyKnow® software in the study. In collaboration with this effort to date, the author has implemented pen-based technology to facilitate learning in a junior-level 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 required junior-level soil mechanics course.

**Course Development**

The faculty member 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\textsuperscript{1,5}, the faculty member is an outspoken institute proponent of the tenets of ExCEEd, including appropriate use of technology in the classroom. In fact, the author’s reputation in this regard was one significant reason the project PI contacted the author about joining the project.

To prepare for course implementation in the fall 2007 term, the faculty member 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 faculty member 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 author 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 author identified a two-volume public domain geotechnical engineering handbook of excellent quality for the purpose of the two courses\textsuperscript{6,7}, and was thus able to simply direct the students to download their free copy and make their own choices about printing and binding their text, or simply working from the electronic version.

The author 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 author became more familiar with the collaborative note-taking software during course preparation, it became clear that example problems worked by the faculty 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 author 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 faculty member can save time by building some mundane parts of board notes in advance to allow more time for discussion of concepts and questioning. As the author became more familiar with the software, excitement about the potential to improve learning increased.

As the first day of class arrived, the author 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 author 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 author 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 faculty member 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 author 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 author to acquire double training in the use of the software and hardware and steepened the learning curve for technology mastery.

Collaborative learning was facilitated using DyKnow collaborative learning software. To make use of DyKnow during class, the faculty and students log in to the designated server. The faculty member begins a class Session as a faculty user, after which the students join the Session as student users. In the case of this course, the faculty member prepared lesson plan slides in advance which would be comparable to overhead transparencies featuring blank spaces for additional annotating. As the Session proceeds, the faculty selects the next slide that will be used, and upon selection that slide then becomes available as a Panel to all of the student users logged into the Session. The faculty member then makes 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 is annotated, the faculty member’s pen strokes are recorded on all of the computers logged into the Session. Slides may be selected in any order, so the lesson can be nonlinear through the prepared slides. The faculty member can also insert a blank slide and provide board notes and sketches identical to board notes presented in a traditional sense on a chalk board.

Sometimes the copying of a faculty member’s board notes is necessary for fundamental learning. In such cases, it would be better if the faculty member’s pen strokes were not recorded by all participants in the Session. This is achieved using Private Ink, which only appears on the faculty member’s tablet PC. Because the faculty member’s tablet PC is being displayed in the front of the room using the LCD projector, the faculty member can use Private Ink to annotate slides that should be copied by students. Students can view the projection of the faculty member’s Private Ink in the front of the room, but the Private Ink annotations do not appear on their own computer, so those Private Ink notes must be copied by the students in order to be saved.

Students in the Session save the faculty member’s annotations, their own Panel annotations, and their own Private Notes that are 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 faculty member’s notes while adding their own. This collaborative learning software include many features not used by the author in this first application in class, but additional collaborative tools useful to the faculty member 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

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 faculty member’s oral presentation and some faculty member 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) faculty 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 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 are shown on Table 1.
The first question in 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. The second question shows 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. The response to the fourth question was mixed and is still being evaluated for the project.

<table>
<thead>
<tr>
<th>Table 1. Results from Student Feedback Surveys during the course</th>
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<tr>
<td>Which of the following best describes your current feelings about the use of DyKnow in this class.</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>I do not like it at all</td>
</tr>
<tr>
<td>Not my preference, but I can manage with it</td>
</tr>
<tr>
<td>Neutral. I neither like nor dislike it</td>
</tr>
<tr>
<td>I prefer this, but the traditional way is fine too</td>
</tr>
<tr>
<td>I really like DyKnow and would like to see it used in more classes.</td>
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</table>

The response to the third question was surprising. An average of 49% of the class felt the use of this technology improved their learning outside of the scheduled class meeting. 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.

Institute Assessment
Institute assessment is being conducted for all classes being taught using the technology, and the analysis of the findings was still under way at the time of this report. The assessment coordinator has reported to the author that student satisfaction with the technology was high at the start of the term and decreased somewhat as the term progressed. They also reported student confidence using the technology increased continuously throughout the term.
Student Performance on Tests

The author 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 author 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>
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<tr>
<th>Table 2. Summary of Final Exam Scores</th>
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<tr>
<td></td>
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<tr>
<td>Average</td>
</tr>
<tr>
<td>Fall 2005: 80</td>
</tr>
<tr>
<td>Fall 2006: 76</td>
</tr>
<tr>
<td>Fall 2007: 77</td>
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<tr>
<td>Standard deviation</td>
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<tr>
<td>Fall 2005: 11</td>
</tr>
<tr>
<td>Fall 2006: 11</td>
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<tr>
<td>Fall 2007: 11</td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>Fall 2005: 47</td>
</tr>
<tr>
<td>Fall 2006: 45</td>
</tr>
<tr>
<td>Fall 2007: 31</td>
</tr>
</tbody>
</table>

Faculty 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 author held great concerns about successful implementation in the course.

The author 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 recognized that only a small portion of student learning occurs during class time and 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 to keeping the lessons running smoothly. The author has admittedly not been strong in the past in the use of questioning techniques to keep the students engaged with learning, and as with organization of the board notes, confident use of the technology took precedent over focused questioning techniques. Students reported a higher level of engagement than in some of the instructor’s past classes, however, whenever they were working together on example problems, so the instructor sought as many opportunities as possible to engage students in that way. 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 author often, upon recognizing on 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 author also noted that careful preparation of advance slides contributed greatly to organization of the course. Finally, the author 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 author, 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 author 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 author’s confidence in the software and hardware increased. In a recent conversation with a colleague from another institute, the author 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 faculty support for the technology was positive. Initial implementation has led the faculty member to incorporate the technology into other courses. Early data indicates the benefit of using the technology is greater than the cost.

Acknowledgements

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References


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