AC 2010-784: THE PEN IS MIGHTIER THAN THE KEYBOARD: IMPLEMENTING DIGITAL INK IN THE ENGINEERING, HUMANITIES, MATHEMATICS, AND SCIENCE CLASSROOMS

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The Pen is Mightier than the Keyboard: Implementing Digital Ink in the Engineering, Humanities, Mathematics, and Science Classrooms

Abstract
The use of digital ink devices in the engineering, mathematics, and science classrooms offers a promise of improved student learning and faculty teaching. To this point, however, assessment of the impact of digital ink technologies (both hardware and software) has only begun. Our project focused on student note-taking strategies during course lectures. The use of tablet PCs and DyKnow Vision software provided faculty the opportunity to share prepared notes while students could annotate those notes during class. Our results regarding the impact on student note-taking strategies indicate that students must re-imagine their traditional classroom role, from scribe to reflective learner.

Measuring the Impact of Digital Ink on Students' Note-taking Strategies

Recent developments in educational technology have provided instructors with an effective tool to implement in their classrooms. Tablet PCs and pen slates provide a stylus that allows the user to input data (in the form of digital pen strokes) through a variety of applications, such as ink annotations in word processing software and handwriting in notebook software. While these innovations offer a promise of improved student learning and faculty teaching, researchers are only beginning to measure these impacts in any systematic way.

Since 2003, faculty members at our institution have been implementing digital ink through tablet PCs and slates in engineering, humanities, mathematics, and science courses. As these implementations have been developed, we have conducted assessments of the projects and reported these results to the faculty, as well as presented some of the findings at professional conferences and in conference proceedings. This paper is an attempt to synthesize the multi-year results and offer findings on the impact of digital ink implementations on student learning, particularly in an area that is significant in the college classroom context: students' note-taking strategies.

Research into Student Note-taking Strategies

No image better characterizes the college classroom than row upon row of students bent over notebooks transcribing both the professor's lecture and the equations, diagrams, and notations that appear on the whiteboard at the front of the room. Such may be our conventional ideal of the college classroom, but from the perspective of pedagogy, no system may be less effective for student learning. As Kenneth Kiewra of the University of Nebraska Lincoln has noted, "notetaking during lectures is occasionally no more effective than not recording notes . . . because of the often incomplete notetaking styles of college students"[1] A better procedure, Kiewra suggests, is to "supply learners with a set of notes prepared by the instructor, rather than have them [students] record and review personal lecture notes. Under such conditions, students would not have to divide their attention during acquisition between listening and notetaking and could subsequently review a far more complete set of notes than they would review typically."[1]

Such an approach is used in many classrooms on our campus. Instructors prepare skeletal notes that students fill in as the class proceeds. Included in the notes are the equations, drawings,

diagrams and other visual content that may appear on the whiteboard or on an overhead for students but are often difficult for students to transcribe accurately and quickly. Despite the adaptation of the prepared lecture notes, there still remains a large gap between the faculty members' preparation of the notes and students' annotation of them, given that the paper technology of distribution means that once the notes leave the professors' hands, they can have no further input on them.

We have closed this gap at our institution through the use of tablet PCs and DyKnow Vision™ software in the classroom. Via DyKnow Vision™ software, a faculty member can share with students prepared notes or material written/drawn on the fly. As students listen to the lecture, they have on the monitors of their computers the faculty member's notes, and the students can supplement these notes with their own annotations. Since the digital pen offers flexibility in comparison to a keyboard, students may input their annotations in a variety of forms, i.e., handwritten text, freehand drawings, etc. At the end of class, students save their notebooks with their annotations included. These notebooks supply students with an important resource they use as they review material and study for quizzes or exams.

Assessment Context and Methodology

The introduction of tablet PCs and DyKnow Vision software to the classroom context at our institution began in 2004 in computer science, physics, and technical communication courses. Since that time, the tablet PC technology has improved immeasurably (processor speed, pen calibration, device reliability), and now courses using the hardware/software combination are taught in applied biology, biomedical engineering, chemistry, chemical engineering, computer science, electrical engineering, Japanese language, mechanical engineering, physics, software engineering, and technical communication. Beginning in 2006, as a result of funding from two external grants, we developed assessment tools that would allow us to measure the impact of tablet PCs and DyKnow on student learning and faculty teaching.

Three surveys were designed to assess student perception of the hardware in combination with the software for the course over the quarter. The surveys were the same for all courses. The precourse survey served as a baseline for each course while the mid-course survey tracked change from the first to fifth week. The post-course survey assessed technology usage and learning following students' usage of tablet PCs and DyKnow at the end of 10 weeks.
The pre-course survey contained 11 items. These addressed issues such as experience with various hardware devices, home internet connection, interest in the tablet PC, note-taking preference and reference to notes, and confidence in learning objective ability. In addition, each instructor developed a set of learning outcomes specific to the course, and students were surveyed on their self-efficacy with the outcomes both pre- and post course. The mid-course survey contained 6 items identical to the pre-course survey. These items included comfort with various hardware devices, enjoyment of the tablet PC, and note preference and reference. The post-survey consisted of 14 items. Eight of the items were identical to the pre-course survey addressing comfort with various hardware devices, enjoyment of the tablet PC, note preference and reference, and confidence in learning objective ability. Additional items on the post-course survey included those assessing technology used by both the instructor and student during class, satisfaction with learning, favorite and least favorite DyKnow tools, and open comments.

The surveys were placed in each class's course management system page. Students logged on during class during the first, fifth, and final weeks of the quarter to complete the surveys. All data collection was coordinated by the Office of Institutional Research, Planning, and Assessment. The student responses from the surveys were analyzed then presented in several ways. First, frequency of student responses was calculated overall. Second, an ANOVA was conducted to compare survey ratings across courses within the year. Third, a paired t-test was run to compare ratings within each course across the quarter. Finally, an independent t-test was run to compare ratings between experimental and control courses.

Assessing Students' Note-taking Strategies

From 2007 and moving forward, we decided to make note-taking a particular focus of the assessment work. We decided this based on instructors' observations regarding how the hardware/software interaction changed the classroom. In particular, students often complained in the open-ended portion of the surveys about the ways in which instructor-prepared notes distributed through DyKnow changed the students' practices in class. "What am I supposed to do in class," a student might ask, "if I'm not spending my time writing down every word the instructor says?" Our hypothesis regarding note-taking was developed based on research into students' note-taking strategies by educational psychologists who examine these practices in a variety of settings.[2-7]

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 1 (results drawn from two of the courses involved with the study), there was in one class a decrease in the number of students supplementing instructor notes between the 1th and 5th weeks followed by an increase between the 5st and 10th weeks. There was also a decrease in the percentage of students reporting referring to their notes while doing homework, working on projects, and before exams/quizzes ("all of the above") with a slight increase between the 5th and 10th weeks. In the second class, students' annotations continued to decrease throughout the ten-week quarter. We credit these decreases/increases to a period of learning and adaptation on students' part; students may initially not see the value of actively annotating instructor's notes through the tablet and DyKnow. Clearly, however, the annotation behavior of students is not predictable, except as a function of the faculty member's willingness of model the new note-taking practice and to make it an explicit part of his/her classroom pedagogy. At this point we are at the very beginning of drawing out the implications of these data, and we plan to align the results from all the courses in future publications.

Figure 1: Note-taking Preference and Note-taking Reference

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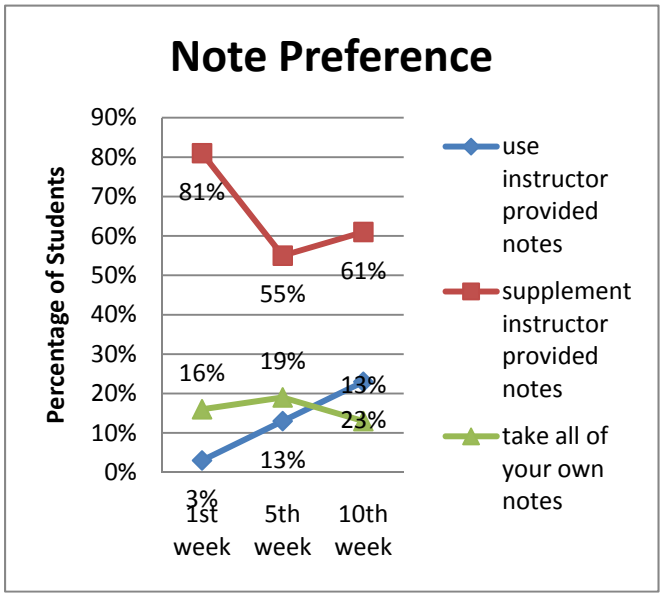

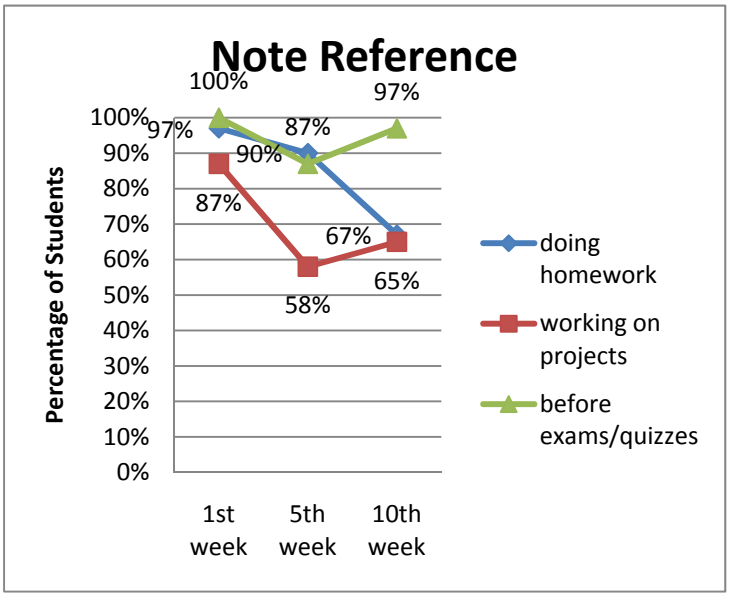

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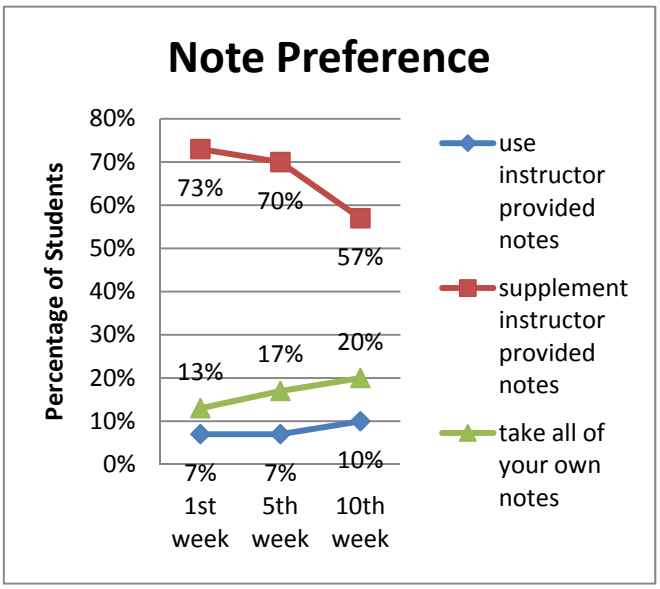

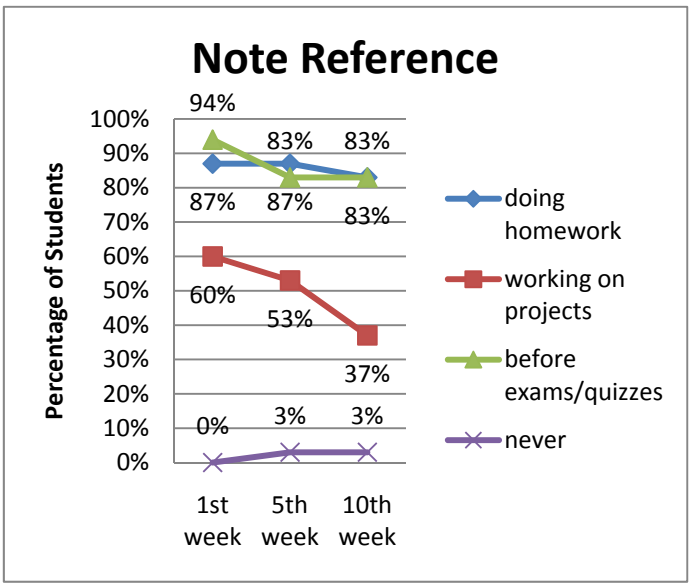

Conclusions

Based on the assessments of the impact of tablet PCs and collaboration-facilitating software, we can make preliminary conclusions regarding the implications of this technology on faculty

teaching and student learning. First, we find that students must be taught how to approach their time in class from a new perspective. Most Rose-Hulman students are successful because they developed effective note-taking strategies in high school. To ask these students to then abandon these successful strategies and replace them with a new strategy can be difficult. In open-ended comments to multiple surveys, students indicated that they believed the DyKnow notebook made them "lazy," since they believed they had lost their primary occupation while in class. In reviewing student comments, some faculty members have attempted to shift the emphasis of their in-class time, from note transcription to problem solving.

Second, students generally believe that a faculty member's effectiveness with the new hardware/software interaction determines their own learning. Student comments often cited the ease (or lack of ease) that their instructor demonstrated with the technology. These students did not demand that the faculty member's use was flawless, and they understood when technical difficulties lay beyond his/her control. Overall, however, students were more willing to see a positive impact with the new technology if the faculty member demonstrated a clear pedagogical rationale for the change and modeled for students' effective usage. As one student in a civil engineering course commented, "tablets are great as long as they get used in a way that allows students to stay active and engaged in the material."

Finally, the impact of the hardware/software interaction on faculty is profound. As a result of re-imagining how content should be presented in this new environment, faculty may undergo a complete rethinking of their pedagogy. More than just a different way to present content (as a replacement for PowerPoint), the use of DyKnow Vision and tablet PCs creates more opportunities for faculty-student and student-student interaction, though software features such as class polls, panel submission, and group work (see the DyKnow Vision homepage—www.dyknow.com—for a full listing and description of the software's features). Faculty have commented that the possibilities for increasing engagement encourages a rethinking of course approaches and has resulted in course reorganization, such as the inverted classroom approach mentioned earlier.

We continue to collect data and conduct analysis for this project. We plan to report more completely on our findings in a formal journal article in the near future.

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