Evaluating the Symbiosis of DyKnow Software and Pen-Based Computing in the Rose-Hulman Classroom

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1. ABSTRACT

At Rose-Hulman Institute of Technology we have developed curricula that use DyKnow software and pen-based computing in courses drawn from seven different disciplines: Computer Architecture (computer science); Design for Manufacturing (mechanical engineering); Engineering Chemistry; Introductory Physics; Mechanical Systems (mechanical engineering); Operating Systems (computer science); Technical Communication; Signals and Systems (electrical engineering); and Software Requirements and Specifications (software engineering). As a component of the development of these pedagogies, we have focused on the assessment and evaluation of the impact of a symbiosis of hardware (pen-based computing) and software (DyKnow Vision) on teaching and learning. Assessment has been developed at two levels for this project. One level of assessment is the development of classroom assessment techniques, or CATs. The second level of assessment includes both formative and summative assessment components measured through a mixed methods design. In this paper we describe both the implementation of the hardware/software combination in these courses and the assessment of impact of the combination on student learning. We also provide results from the first year of our two-year assessment project.

2. PROBLEM STATEMENT AND CONTEXT

Rose-Hulman Institute of Technology is a private, primarily undergraduate institution of roughly 1850 students offering majors in engineering, mathematics, and science only. At Rose-Hulman we have developed curricula that use DyKnow software and pen-based computing in courses drawn from seven different disciplines: Computer Architecture (computer science); Design for Manufacturing (mechanical engineering); Engineering Chemistry; Introductory Physics; Mechanical Systems (mechanical engineering); Operating Systems (computer science); Technical Communication; Signals and Systems (electrical engineering); and Software Requirements and Specifications (software engineering). Pen-based technologies provide educators a fresh opportunity to increase the visual dimension of many different types of courses. When the opportunity to use pen-based computing and DyKnow came up, Rose-Hulman faculty were very interested in exploring the hardware/software combination given the highly graphical nature of their engineering and science subjects. In the Mechanical Systems course, for instance, the instructor presents diagrams and models frequently in class; likewise, in Signals and Systems, the instructor requires that students work on problem sets during the class session.

While pen-based computers may allow us to enhance the visual dimension of a course (an inherently laudable goal when dealing with graphically intensive courses in engineering and the sciences), these technologies are their most powerful when they simultaneously facilitate collaboration, promote active learning, encourage note-taking, and provide frequent opportunities for formative assessment. We outline these five dimensions of the hardware/software symbiosis below as they have been implemented during the first year of a two-year project.

Visual dimension: Instructors spend much of their preparation time for class developing models of systems. In the traditional classroom (without pen-based computing and DyKnow), they were required to copy these models onto a classroom whiteboard and/or display them on overheads or laptop computer projectors. Students would have either have to copy out the models into their own notes or annotate a hard copy of the models distributed by the faculty member.

Collaboration: Completing sets of problems is an important feature of highly mathematical engineering courses. In the traditional classroom, the instructor can work a problem for the students on the whiteboard for the students to copy down. The instructor can also ask students to work the problems on their own. The instructor may not, however, be able to check every student's work by circulating through the classroom. Students who are having trouble completing the problem may also be reluctant to ask for help.

Active learning: Technical courses often require the delivery of large amounts of data to students. The challenge in conveying large amounts of facts in the traditional classroom setting is that some students may become passive receivers of information rather than active learners. Active learning can occur when students work in small groups, when they share their individual work with the rest of the class, and in other purposeful learning situations.

Note-taking: Taking notes is an important component of the technical classroom. Students usually take notes with pen and paper, then refer back to these notes when it is time to study for an exam. Unfortunately, the sheer amount of information contained in notes, as well as the time that separates the note-taking from studying for an exam, can affect the productivity of the students' work.

Formative assessment: It is sometimes the case that an instructor wonders if students truly understand class material. Formative assessment allows an instructor to evaluate students' understanding in the immediate classroom setting, rather than waiting for a midterm or final exam to reveal that students haven't been able to grasp complex material. Classroom assessment techniques (CATs) provide instructors with immediate feedback on student learning. Basing our project on the work of Angelo and Cross (1993), we have identified CATs appropriate to each course and then adapted them into the pen-based computing/DyKnow environment. We have also made use of CATs that are already features within DyKnow, like the participant status and polling features. Each instructor can use CATs to gauge student learning in real time and make pedagogical adjustments as needed.

In beginning the implementation of pen-based computing and DyKnow software, we considered the features of both the hardware and software that could facilitate change in these five areas.

3. SOLUTION EMPLOYED

The solutions employed on our campus relate to the five dimensions of the hardware/software combination.

Visual dimension: Dr. Archana Chidanandan: "The classroom in which my course is taught does not have any white board space. I like to write and draw while teaching. Also, I like to have students work in pairs or individually and write solutions on the board to share with everyone. Since the setup of the current classroom makes this impossible, I have used DyKnow to accomplish it. I can have my slides available through DyKnow and insert blank pages for me to write/draw. I also allow students the opportunity to write stuff that I want them to share with me and/or the rest of the class. I also like that I can have them submit their work, grade it, and return it all through DyKnow."

Collaboration: Dr. Mario Simoni: "I wanted to use the Wacom slates and DyKnow so that I could go over derivations and problems in class and have the students focus on what I was doing and the meaning of it, rather than trying to copy everything down from the board. The students are using the slates to work problems and then submit them to DyKnow. I then use their submissions to illustrate common mistakes to the class and how to avoid such mistakes. In general, I think the slates are having a positive impact on student learning. When the class is working on a problem on the devices, I walk around the room and see them engaged in the material. I don't think that they would be so engaged if I were simply to lecture over the same material. That alone could be achieved with worksheets. I think the real benefit of the slates is the ability to submit their work and critique it in class where everyone can see it and have a record of it. Learning requires feedback and the sooner the students can get feedback on their thoughts the better the potential for learning to occur. The DyKnow/slates combination makes it possible for the whole class to get feedback on a given concept so that everyone can benefit."

Active Learning: Dr. Patrick Ferro: **"**I decided to implement pen-based computing for the current academic year based on feedback from last year, during which time the course was taught using PowerPoint. Last year, the students were generally disinterested and falling asleep from listening to my PowerPoint lectures. I thought that I could increase the interaction if I punctuated information slides with interactive slides. DyKnow was a natural answer for this, as it allowed me to keep the information intensive slides from PowerPoint but it brought interactivity to the presentation. At this stage, I feel that the effort has mainly been a success from the standpoint of comparing the classroom dynamics to last year. The number of people sleeping and/or totally tuned out has dropped."

Note-taking: Dr. David Fisher: "I decided to use the pen-based system in my course so that students could have a better resource for storing high quality electronic notes. Most students need more time than 50 minutes to absorb the material in Mechanical Systems. I felt like having better notes via DyKnow that incorporated their notes with mine could be a better system. Also, by making all of the material electronic I could save screen capture recordings of the lectures. These recordings are posted to my course website (www.rose-hulman.edu/~fisherds)."

Formative assessment: Dr. Rebecca DeVasher: "I was interested in implementing DyKnow and tablet PCs to help me to use classroom assessment techniques. Classroom assessment techniques offer a way to reach out to the students who are struggling with a particular concept, and also a way to reward students who understand the material. I find that this course tends to have students with diverse backgrounds in chemistry. I find that I have to help out many students with weaker backgrounds, and still feel the urgency to challenge those with stronger backgrounds. The classroom assessment techniques, and the features that the pen-based technologies offer, allow me to better address the needs of each individual."

Summative assessment: In addition to the formative assessment instructors have developed through CATS, summative assessment is used to measure success in implementing pen-based technology in classes in various disciplines and is collected quantitatively and qualitatively. Quantitative data is collected through self-report surveys, while qualitative data is collected through focus groups and open-ended items on self-report surveys.

The quantitative dimension of the summative assessment of the project is comprised by two surveys: pre-course and post-course. The pre-course survey serves as a baseline for each course while the post-course survey assesses technology usage and learning following students' usage of a pen-based computing device (either a tablet PC or a Wacom slate) and DyKnow. The pre-course survey contains 6 items: 1) previous use of computer devices (a desktop, laptop, and pen-based computing device); 2) frequency of use for each of these devices; 3) perceived usefulness of each device to complete specified tasks, such as "taking notes" and "preparing for tests"; 4) interest in using a pen-based computing device; 5) knowledge of and confidence in a series of course-specific learning objectives; and 6) tools used to take notes.

The post-survey consists of 12 items. Three of the items are identical to the pre-course survey addressing frequency of use of each device, perceived usefulness of each device, and ratings of knowledge of and confidence in learning objectives. Additional items in the post-course survey are as follows: 1) desire to use the current model tablet PC or the latest model tablet PC for future courses (two questions); 2) preference for the tablet PC over a laptop; and 3) desire to utilize the tablet PC in and out of the classroom (two questions).

Students are also asked what hardware device they used with DyKnow (two questions), satisfaction with their learning experience, and preferred note taking tool (two questions). In addition to the pre- and post-course surveys, a focus group has been implemented. The focus group consists of 9 items focusing on student experiences with the tablet PC and DyKnow combination. The survey instruments were implemented with the courses taught during the fall quarter 2006 (PH 113 Physics, RH 330 Technical Communication, and CSSE 371 Software Requirements and Specifications). The survey was implemented again with RH 330, ME 317 Design for Manufacturing, and CHEM 201 Engineering Chemistry in the winter quarter 2006-07. All of these courses implemented DyKnow with HP 1000 and 1100 tablet PCs, except for RH 330 in the winter quarter, where Wacom Slates were used instead.

The student responses from the surveys are analyzed and are presented in several ways. First, frequency of student responses are calculated overall. Second, an ANOVA is conducted to compare each course participating in the assessment to examine the effect of the tablet PC on student learning. Finally, a paired sample T-test is conducted to compare pre- and post-course ratings within courses. The course instructors distribute paper versions of the pre- and post-course surveys to students during the first and last weeks of the quarter for all sections.

A full report on the pre- and post-course common item comparisons is not possible within this paper. We wish, however, to highlight a few compared items that reveal interesting results. One finding of particular importance is the low level of student satisfaction with the tablet PC and DyKnow overall. Even lower are the students' ratings of their desire to use the current tablet PCs in the future. We believe this result stems from the fact that the tablet PCs students use in class are models 1100 and 1000 Compaq Tablet PCs, technology that is quite outdated at this day and time. As much as we can, we are trying to bring out students' perceptions of the tablet PC/DyKnow combination's usefulness to learning without allowing students to be distracted by the age of the device. Our hope is that we can deploy the assessment components with up-to-date devices in the coming year.

Students were asked to report their previous experience using a tablet PC, the type of hardware they utilized with DyKnow, and their preferred tool for taking notes. Interestingly, the majority of CSSE 371 indicated previous experience with the tablet PC while the majority of students in RH 330 and PH 113 indicated no previous experience with the tablet PC. The tablet PC was the most frequently utilized device for running DyKnow regardless of course. The majority of students in all courses prefer using a pen and paper for taking notes.

Qualitative data for the project was collected with 3 open ended questions regarding the ways the tablet PC/DyKnow combination impacted note taking; these questions were included on the post-course survey. In addition to these items, a sample of students enrolled in RH 330, CSSE 371, and PH 113 participated in a focus group. Students were asked to comment on the tablet PC/DyKnow relationship in areas of classroom interaction, taking class notes, class assignments, peer review, and general likes/dislikes. Some of the responses from both assessment measures are summarized below by topic.

Classroom Interaction: One benefit to using DyKnow with the tablet PCs in class was the ease of allowing the professor to see who was paying attention in class through panel submissions. An additional

benefit mentioned by students included a quicker the pace to the lecture since the notes were already available and multiple-choice quiz questions could easily be posted and answered.

Students did report paying less attention in class compared to traditional courses not using the tablet PC and DyKnow since the technology made it easy to multi-task and still catch back up with the provided notes. Since students were required to pay attention to the tablet PC, the instructor did not expect that students would be actively taking notes. This made it easier for students to play games or access the internet instead of paying attention in class.

Class Notes: During the focus groups, students almost unanimously reported a decrease in their note taking with DyKnow throughout the quarter. Some students felt they did not need to take notes for their course while other students preferred the greater flexibility of taking notes with pen and paper. Students did not care for the multitude of pages DyKnow created when taking notes, did not like the constraint DyKnow placed on their note-taking style and organization, and felt they needed to take notes themselves so that they would pay attention in class and not become so easily distracted. Students did report feeling that having the same notes as the professor helped their learning in class because they were easier to refer to later.

Class Assignments: Students were split in their opinions of how DyKnow and the tablet PC changed how they work on class assignments. Some students did not feel the technology made any difference over a regular computer. Other students felt it was a "hassle" because they could not see the notes and work on the assignment on one machine at the same time. Not being allowed to take the tablet PCs out of the classroom was another issue that contributed to student responses.

Students found working in teams to be more difficult with the tablet PC and DyKnow. They found it difficult to put content on 1 tablet PC and had difficulty moving around with the tablet PC because of the low battery life of the machine and the lack of reliable wireless access. Interaction between students with DyKnow was poor, but the interaction between students and the instructor was considered good.

General Student Likes and Dislikes: Students thought the concept of the tablet PC was "awesome" and had a lot of potential to be useful in class. The actual execution of the concept was not seen so favorably however. Specifically, students found the tablet PCs useful for drawing pictures and graphs in physics.

Students did not like the inaccurate stylus and having to recalibrate it each time they used the tablet PC. They also found the resolution, speed of the machines, and difficulty connecting to their network drives and server undesirable. Some students could not access the VPN on their machine. One of the features students would like in the tablet PC is for it to be thinner so that when they write on it, they feel more like they're writing on paper. One of the most frequently mentioned dislikes was the ease with which students could distract themselves from class content. Students felt the tablet PCs were "forced" into their classes and the curriculum would have worked just as well without using them.

Improving student classroom experiences with the tablet PC and DyKnow can be achieved a number of ways according to students. Using a Wacom slate with students' current laptops, having touch screen laptops, or using up-to-date tablet PCs were three alternative suggestions to the current tablet PC implementation. Changing from DyKnow software to Microsoft One Note software was a second suggestion. Students did not feel adding DyKnow to the tablet PC added to its functionality. Creating a digital database of subject specific resources, having the ability to search digital notes, having an index for notes, and creating OCR were all features students would like when using tablet PCs and DyKnow software in the future.

4. EVALUATION

At this point, we are finishing the first year of this two-year assessment project, so our conclusions regarding the impact of tablet PCs and collaboration-facilitating software are preliminary. Currently we see some indications from the data regarding the impact of these devices on student learning.

First, students are aware that they are using devices that are outdated and slow. Although they acknowledge this fact, they can also imagine the potential for the technology in its latest form. Second, students may not readily give up their note-taking role in class or see it as a positive change. Faculty must also recognize that when students are no longer required to copy extensive formulas and equations from the whiteboard, they will need to be engaged in different activities. Such a transformation of the classroom is something that both students and faculty alike will need to adjust to. Third, students recognize that adding technology to a course may provide them with additional opportunities to become distracted. While it is possible to limit students' access to the Internet while using tablet PCs and DyKnow, we have opted not to do so with this project. Students at our institution do not have the option to take online courses, but they felt that this combination of technologies could be used in such a manner. They seemed not to be in favor of this option.

5. FUTURE WORK

The surveys were conducted again during the 2006-07 academic year at the end of the winter quarter for students enrolled in Engineering Chemistry, Design for Manufacturing (mechanical engineering), and Technical Communication. Beginning in summer 2007, a new set of courses will be targeted for the project; we will make changes to the survey instrument before it is implemented during the 2007-08 academic year.

6. ADDITIONAL RESOURCES

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Rose-Hulman Tablet Project hompage: http://www.rose-hulman.edu/irpa/tablet

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Sudipa Mitra-Kirtley is a professor in Physics and Optical Engineering. She has been keenly interested in interactive classroom lecturing for over a decade now. In 1995 she was one of the first faculty members to bring in the studio mode of teaching to Rose-Hulman. In 2003, she was involved in writing a grant to HP for acquisition of iPAQs and tablets for educational practices. Ever since then she has been using tablets in her physics classes. She has won an award from the Women and Hi-tech organization in Indiana, presented numerous talks at conferences, and co-authored several publications in this area.

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Julia M. Williams is the author of articles on writing assessment, electronic portfolios, and ABET that have appeared in the IEEE Transactions on Professional Communication, Technical Communication Quarterly, Technical Communication: Journal of the Society for Technical Communication, and the International Journal of Engineering Education. She is also the recipient of a Tablet PC Technology, Curriculum, and Higher Education 2005 award from Microsoft Research to assess the impact of tablet PCs and collaboration-facilitating software on student learning.