A "TEACHER'S DASHBOARD" FOR A HIGH SCHOOL ALGEBRA CLASS

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Networked Tablet PCs have great potential in classroom settings, including use in small group in-class problem-solving activities. It is possible to obtain substantial amounts of data about student activity during a lesson: what they referred to, notes taken and erased, bursts and lulls of activity. The raw data is necessarily low level: time-stamped pen strokes, deletions, navigation to and from pages, and such. This data can be used, among other ways, to enable a teacher to monitor learning activities as they happen in real-time. We call the display of student activity the *teacher's dashboard*. We describe the use of a dashboard in several sections of a high school algebra class. We found that the teacher came increasingly to rely on this display to see how the students were progressing, and the students felt they were getting more timely feedback. We discuss the challenges in making dashboards that can work in a variety of classroom settings.

1 PROBLEM STATEMENT AND CONTEXT

The SLICE group at the University of Illinois operates an experimental classroom consisting of about 25 networked Tablet PCs (Figure 1). We have used it to deliver many courses. In this paper, we describe its use in a high school algebra class in the 2007-08 academic year.

Networked Tablet PCs have numerous potential applications in the classroom. Many involve better "monitoring" of students – that is, increasing the teacher's ability to gauge the students' progress. These applications usually entail some explicit, scored interaction between student and teacher, such as answering a poll question; we call this "active monitoring." Another type of application is "passive monitoring," in which the teacher does not engage in an explicit interaction with the students, but simply "spies" on them. (Chen's "pulse of the class" system [1] is an example of passive monitoring, though not in the Tablet PC domain.) The major advantage of passive monitoring is that it can help the teacher assess the class without engaging in an explicit interaction, which takes extra time and can require advance planning. A related advantage is that it does not require that the teacher *do anything different*; it just provides an extra "set of eyes" on the class. Thus, it addresses what we believe to be a key problem for Tablet PC-based teaching: allowing teachers to benefit from the technology without changing their established (and successful) teaching methods.

Figure 1: SLICE experimental classroom

The Fall, 2007, and Spring, 2008, semesters presented us with a specific case in point. Two sections of the Algebra II class from University of Illinois Laboratory High School (located next to our Computer Science building) were taught in our experimental classroom at 8AM and 2PM in the fall, noon and 2PM in the spring. Each section had an enrolment of 20-25 students. The

teacher, Craig Russell, had a reputation as an excellent teacher who had a great rapport with his students. Though anxious to try the technology, Craig was too busy to re-work his course. Thus, we had a popular and effective teacher, with no incentive to change his teaching style, who wanted to benefit from the technology with minimal effort on his part. We assume this could describe many, if not most, potential users of Tablet-equipped classrooms.

2 SOLUTION EMPLOYED

Our solution was to employ passive monitoring. We set up a display in the class on which the students' display contents appeared; this was our "teacher's dashboard." The teacher conducted his class as he always had, but was now able to see what his students were doing at all times. He came to rely upon this display more and more.

The students used the Tablet PCs like pencil and paper. The Tablets were pure "slates;" the students' interface was minimized. When students arrived in the lab, they launched the classroom application, calibrated their devices, logged in, and began their work within two minutes time. By the second week of class, this sequence of events was second nature to them.

In the next two sections, we describe what we did in more detail. Our dashboard design for the fall semester proved to be very useful, but it was not without its problems. Above all, it took too much time to peruse all of the student's workspace to discover who might need help. (It took less time than walking around the class, as Craig had done for years, but his expectations changed as well: In the past, he would make no effort to see what *every* student was doing; with the dashboard, he would attempt to do just that.) In the spring semester, we added a sorting capability to make it easier for Craig to find the interesting information in the dashboard.

There is much research yet to be done to make such a dashboard useful in a wide variety of circumstances; we discuss some of the challenges in Section 5.

2.1 Fall 2007 ALGEBRA II classes

We should start by describing how Craig Russell ran his class. Craig had an extensive set of prepared PowerPoint slides and worksheets (PDF documents). These slides were instructional slides, over which he lectured for about twelve minutes. For the remainder of the class period, students solved exercises on the worksheets. The worksheets were automatically loaded onto each student's Tablet PC. These exercises might be done by the class as a whole (under Craig's supervision), by each student individually, or by groups of students. The teacher regularly changed seating assignments to group students who were at the same place in the notes; a group might do exercises different from the rest of the class; in fact, there could be several different sets of worksheets being used simultaneously. Furthermore, Craig would often supply multiple handouts from which the students could choose; Figure 2 illustrates this.

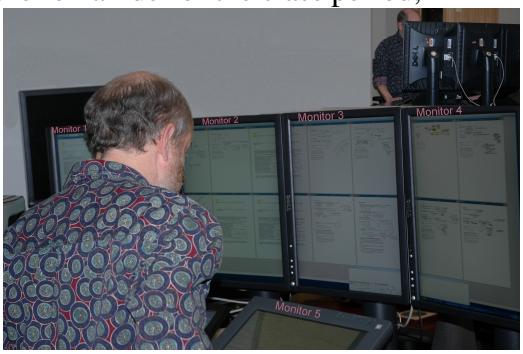


Figure 3: The dashboard

The exercises occupied a significant portion of the class time. In a sense, the teacher was already engaged in "active monitoring," and our job was to enhance his monitoring capabilities.

The dashboard consisted of four monitors, providing total screen space of 48" wide by 16" high, with resolution 4800 x 1600 (Figure 3). This provided a small but readable display of every student's screen. While students were doing exercises, Craig would peruse the dashboard, looking for who were experiencing difficulties. The system allowed him to zoom in on a student for easier reading. In many cases, he would walk to the student's desk to offer help.
Craig came increasingly to rely upon the dashboard. (In one case where the dashboard was inadvertently disconnected at the start of class, he had all the students restart their machines so that he could use the dashboard, an interruption that no high school teacher would tolerate

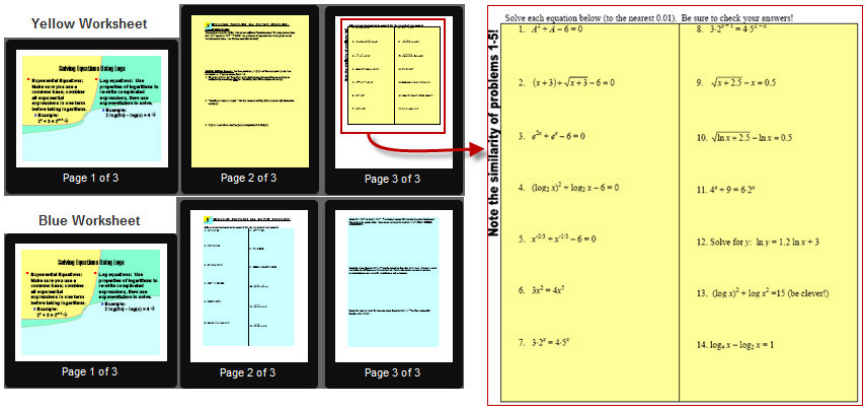


Figure 2: Worksheets loaded on to student tablet.

without a very good reason.) To the students, of course, the impact of the dashboard was entirely indirect. In the evaluation section, we discuss the impacts we were able to measure

Technical note: The note-taking application system used in the study was called NuPaper Classroom®; we used the NuPaper Dashboard™ implementation. The Department of Computer Science was provided with a beta-test license to test the system.

3 THE SPRING, 2008, ALGEBRA II CLASSES

The spring semester featured a continuation of one of the Algebra II classes from the fall (the 2PM section) and a new section at noon; the other section was moved back to the traditional classroom. Based on the fall semester experience, we made some changes to the dashboard.

The major problem with the first dashboard design was that it took time to scan the screen images to determine what was noteworthy from an instructional viewpoint. The

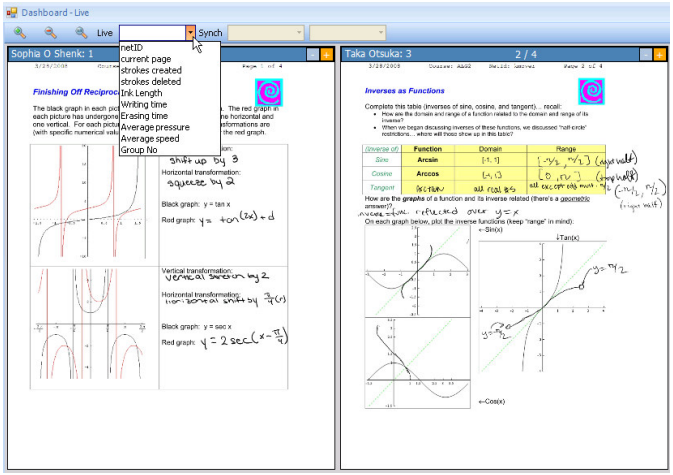


Figure 4. Example of sorting options on the dashboard: student id, current page, strokes created, strokes deleted, ink volume, writing time, erasing time, average pressure, average speed, and group number.

environment was as favorable as one is likely to find – small classes with an experienced teacher who knew his students well – and yet Craig still found this challenging.

To alleviate the problem we augmented the dashboard with a sorting mechanism. We observed that Craig knew his students and the prepared worksheet so well that he often knew what to look for. Sometimes it would be specific students, at other times it would be a specific group (if, for example, he had given one group a particularly difficult problem), and sometimes it would be all the students working on a particular exercise page. The NuPaper® designers added a mechanism whereby he could sort the display by a variety of criteria such as student id, current page, strokes created, strokes deleted, ink length (total amount of ink in pixel space), writing time, erasing time, average pressure, average speed, and group number. The sort order he used most was the sort by group number, where he could compare students working at the same table (figure 4).

4 EVALUATION

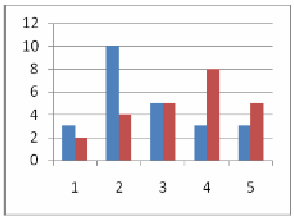
In each of the Algebra II classes we hosted, the students spent some time being taught by Mr. Russell before moving to the laboratory classroom. The fall classes were in their regular classrooms for about a month before moving to our classroom; the noon class, which used our classroom only in the spring, was the continuation of a class that met in a regular classroom in the fall. Thus, all students had some experience being taught by Craig Russell both with and without the dashboard. We present the evaluation results for the Fall section of the 2PM class, and the noon class in the spring. We asked a number of survey questions; for space reasons, we will give responses only for these two:

6. How often do you feel the instructor offers you one on one attention during class?
7. How often do you feel the instructor is able to identify that you were struggling with a particular topic?

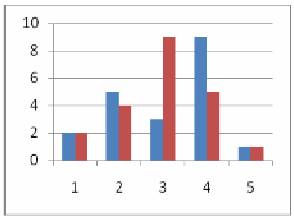
In both cases, the possible answers were 1 (not at all), 2 (rarely), 3 (sometimes), 4 (often), and 5 (almost all the time); thus, higher-numbered responses are better.

The circumstances of the two surveys were very different. For the 2PM class, we administered the survey in December, and asked them to answer the questions twice, once as they felt in December, and once as they *would have answered* in September. For the noon class, we administered the survey twice, when they first started using the Tablet PCs (again, this is after a semester with Mr. Russell in a conventional classroom) and again in May. The following graphs present the count of before-and-after responses; the bars on the left (in blue) are "before" responses, and bars on the right (red) are "after" responses.

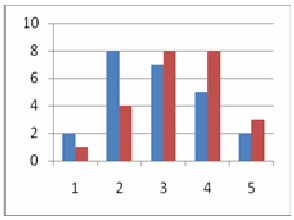
2PM class – question 6



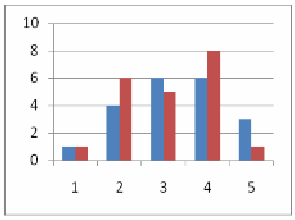
2PM class – question 7



12PM class – question 6



12PM class – question 7



The 2PM class shows a strong effect, while the noon class's responses are more mixed. This is most likely due to the different circumstances in which the surveys were administered. It is not clear to us which numbers are more believable. The true before-and-after surveys, as were done in the noon class, seem more objective, but that is not necessarily true; the problem with surveys administered four months apart is that the students become used to a certain level of attentiveness from the teacher, and their answers reflect this; in other words, their definition of the term "often" changes. The 2PM surveys offered students the opportunity to provide a head-to-head comparison of two classroom situations – with the dashboard and without; their responses indicate that they felt a definite change in their teacher's ability to respond to their problems quickly, and their feeling on this is surely meaningful.

5 FUTURE WORK

As noted earlier the circumstances in these classes were ideal for the dashboard, in a number of ways: The classes were small; the teacher's pedagogical approach was already highly interactive; and we had sufficient space and hardware to provide a large dashboard. We believe the "teacher's dashboard" is a facility that can, and will, be of benefit in a wide variety of classes. However, each of the advantages we enjoyed points to a challenge for researchers:

- In larger classes, we would have the technical problem of providing space for all the screen displays. (In [2], we described a system that alleviates this problem, in which the instructor outlines a portion of the screen in which students are to answer the exercises; this smaller area could then be scaled to create a readable display of many more students.) More fundamentally, it would become that much harder for the teacher to find the interesting information among all the student writing.
- In a less interactive class, the teacher would have a somewhat different problem: determining, from the students' *note-taking* – rather than their problem-solving – whether they were following the material or needed help (or were simply disengaged).
- We expect that few classrooms will be equipped with a 48 x 16-inch display. Indeed, it is likely that the only computers in the classroom will be the Tablet PCs. The teacher would be able to view a dashboard, but it would be much smaller than the one available to Mr. Russell.

These issues point to a combination of user interface design, visualization, and analysis of ink. Concerning the latter, we do not anticipate that computers will be able to understand student writing in the foreseeable future – this is a much harder problem than analyzing ordinary text, which is already extremely difficult. Rather, we think that the computer might analyze certain physical characteristics of student writing that would indicate uncertainty or disengagement or confidence or whatever. This kind of analysis might be accurate enough to act as a filter, narrowing the teacher's search for actionable data.

6 ACKNOWLEDGEMENTS

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[1] Milton Chen. 2003. **Visualizing the Pulse of a Classroom**, *Proceedings of ACM Multimedia*, 2003.

[2] Kamin, S., Hines, M., Peiper, C., and Capitanu, B. 2008. A system for developing tablet pc applications for education. *ACM Technical Symposium on Computer Science Education*, *SIGCSE Bull.* 40, 1 (Feb. 2008), 422-426.