TABLET PC'S IN MATHEMATICS: VLC PROJECT[1]

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The VLC Project

The VLC project at UNCW (http://aa.uncw.edu/vlc/) is a pilot implementation of a Virtual Learning Community (VLC) to facilitate learning across various disciplines in science and mathematics at UNC Wilmington. The main goals of traditional Learning Communities are to link together courses or coursework to achieve greater coherence of learning materials and to increase interaction with faculty and peers. There appears to be sufficient evidence that Learning Communities help to improve student's understanding of science and mathematics while fostering the transfer of knowledge across disciplines. (http://www.evergreen.edu/washcenter/resources/acl/iii2.html). In a VLC we envision achieving the same goals without the restriction and expense of housing the students in a common dorm. Instead, we provide an environment in which outside class interactions with students are replaced with rich online interactions and pen-enabled communication tools.

The VLC project at UNCW involved chemistry-II and calculus-I courses sharing certain common themes. The sixteen students participating in the program agreed to take both courses in the same semester. We had hoped to have a larger number of students, but the class size was limited by the equipment available through the grant.

The lectures for the two courses were scheduled back to back in the same classroom while the chemistry labs met at a different time of the day in a traditional laboratory facility. The rationale for choosing these two courses was purely a logistic one. Since it was difficult to determine willing participants from the entering freshmen class, students were recruited in the fall semester from the chemistry I course. This was a course with large student enrollment and it was one in which students had taken common exams graded on a common scale. In the selection process, we were able to collect data such as grades in the chemistry-I tests, SAT scores and high school GPA's and thus compose a predictor for comparative performance of students in the project. It was determined from the data that this appeared to be an average class with a slightly larger proportion of minorities as compared to the general population in the larger chemistry-I section.

Both of the instructors in the project agreed to take on an extra load by simultaneously teaching a traditional section of the respective courses in their disciplines. Some

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of the students applied to participate in the project but were unable to get into the VLC classes because of the limitations of class size. Instead, they agreed to enroll in the regular calculus section taught by the mathematics instructor in the project. We also collected data on these students and found no significant difference in their performance predictor.

All students and faculty involved in the project were provided with a tablet PC and all of the technology required for full participation. Both courses included a number of labs some of which were used in the coordination of core themes. In particular, the calculus labs included data acquisition experiments in mechanics, chemical kinetics, and the mathematical modeling of molecules and ideal gases. Two virtual TA's, one graduate and one undergraduate student, assisted in the projects by helping the students with academic materials and answering questions about technology. The tablet PC's used by the faculty and the students were loaded with discipline dependent software packages including Maple 10. They were also equipped with all of the software required to conduct paperless classes and rich internet communication.

In the summer prior to implementation, the development team spent a considerable amount of time and effort in evaluating and selecting commercially available software packages to use in conjunction with the project. The software evaluation process included the following categories:

- Office and Pen-enabled collaborative tools
- Lecture capturing and publishing Software
- Virtual Meeting software
- Discipline specific, pen-driven software.

At the end, the selection of some of the software packages we used was highly influenced by the availability, the cost, and the willingness of the manufacturers to provide licenses for the limited duration of the project.

Office tools

UNCW is a "Microsoft" campus, in which all faculty has full license to all MS Office tools, so it was natural to decide on picking Microsoft Office software, including Word, Excel, PowerPoint and OneNote as standard software.

OneNote was used often by the instructors for lectures in the classroom and by the students for note-taking. OneNote has several advantages over similar handwriting software programs. The package has excellent handwritten recognition, a convenient organizational folder structure, and outstanding "touch and feel" electronic pen resolution. We found the OneNote environment to be completely natural for lectures rich in mathematical symbols, tables and graphs. To the user, it seemed no different than using a regular paper tablet, except that the projection was completely digital, and the user had a large variety of "inkwells" and stroke widths available. The OneNote program fails completely in recognition and conversion of mathematical symbols and does not have a clearly distinguishable pointer. We include below a pair of screen captures of actual lectures, involving both preloaded graphics as well as spontaneously handwritten notes:

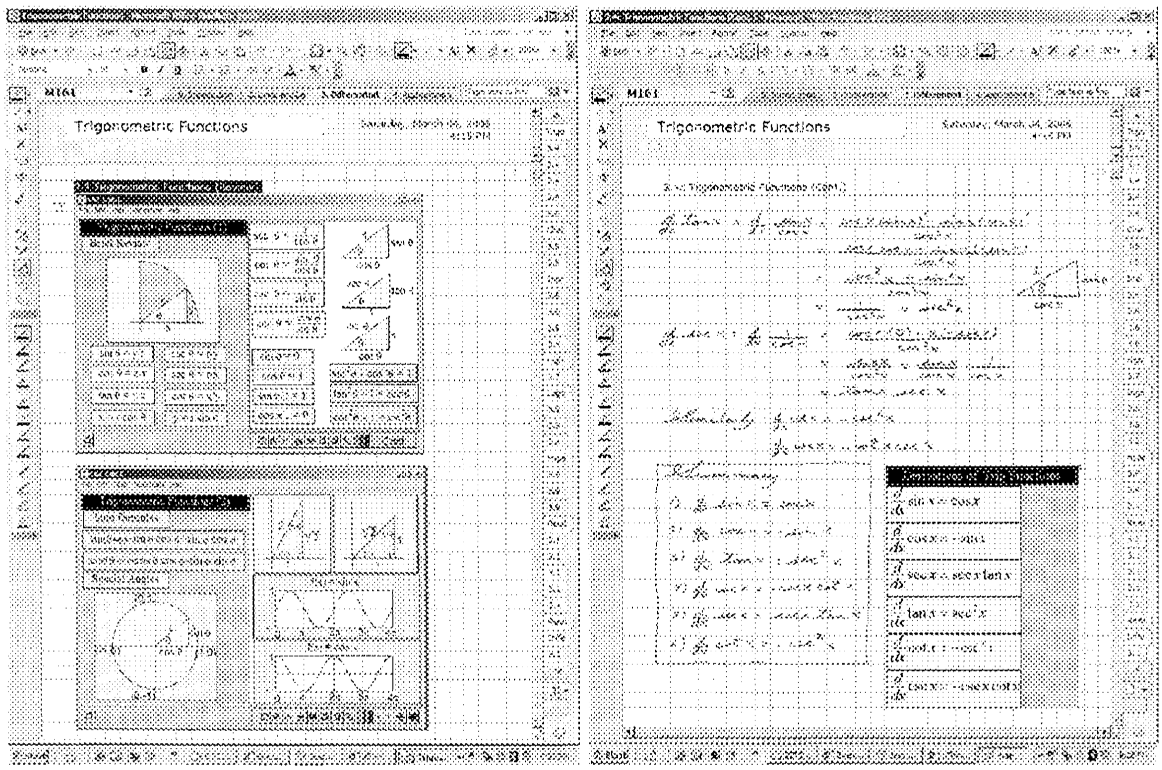


Figure 1. Sample Pages of OneNote Lecture.

In lectures which included more elaborate, or "sequentially-revealed" graphics, as shown in the left panel of Figure 1, students were provided with the fully revealed graphics ahead of time. This way, students did not have to spend the time frantically drawing the picture (incorrectly) and writing the equations at the expense of paying attention the content and what the instructor was saying. The clear advantage of using pre-prepared OneNote documents to paper handouts was the zero cost of using color slides and the easy accessibility to the pre-packaged materials over the web. Also, OneNote provides a tool that automatically imports the graphics from any environment into the background of the page. As a result, students can annotate the slides without fear of erasing the original picture. The combination of the ease with which one can import a graph from a program like Maple, together with the natural environment of an electronic writing tablet, makes software like OneNote ideal for conducting electronic board lectures in mathematics. Another advantage of this mode of teaching is that students were able to incorporate graphs and Maple demonstrations performed by the instructor into their digital notes.

As illustrated in Figure 2, it is interesting to observe that in the math classes, students seem to prefer handwritten notes; whereas in the chemistry class, they appeared to be more comfortable annotating the instructor lectures. Perhaps hidden in this observation, there is a cultural message about how little progress mathematics instructors have made in conveying to the students a visual appreciation for mathematics.

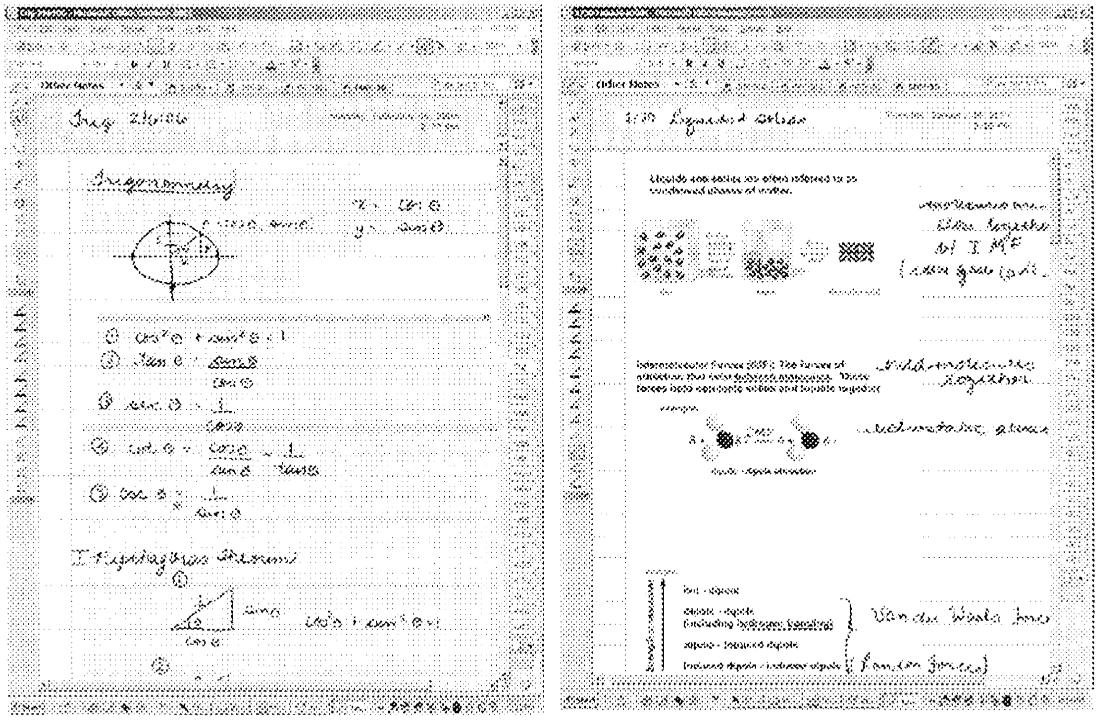
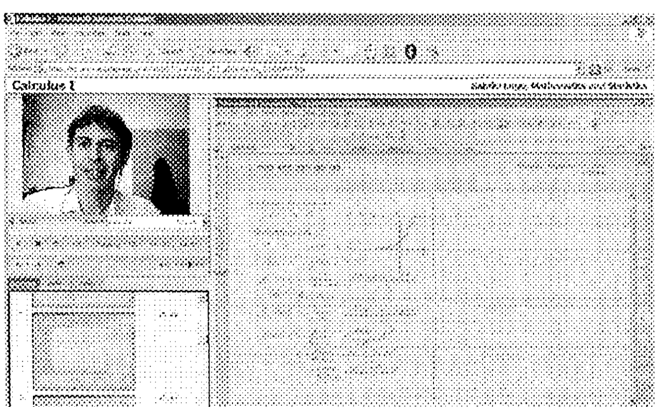


Figure 2. Sample Pages of Student Notes.

Lecture Capture Software



There are a number of multimedia lecture capturing packages comercially available. Again, influenced by already established contacts between our university's Information and Technology division with specific manufacturers, we decided to use the Apreso package (www.apreso.com). Such packages, in conjunction with the handwriting tools mentioned in the previous section, make it a "no brainier" to publish a course in the web, even if the course is of a traditional pen and paper type. The Apreso software is linked to a calendar compatible with MS Outlook, in which one enters the complete schedule for a course or a set of courses to be recorded for the semester. The Apreso server is a standard desktop computer networked directly to the monitor screen of the classroom instructor's machine, which will automatically turn itself on according to the instructor's schedule. In addition, a standard video camera and sound system can be wired to the system so that all classroom activity is recorded, synchronized with the computer screen, compressed, and saved. The program then packages all the audio, analog and digital video, and creates a web-ready link to stream the information over a low bandwidth connection. At the user end, the student has the option to display in full screen, either the analog video from the camera, the computer monitor output synchronized with the audio, or both. There is also a feature that allows the student to jump to automatically created "keyframes" after the entire lecture has been streamed to the local computer.

Other Software

As mentioned earlier, many other educational software tools were tested and tried in this project. Because of space limitations we are not able to elaborate at length on the strengths and weaknesses of these tools. The Virtual Meeting package called Centra (www.centra.com) used in the project worked very well. The voice over IP synchronization with the whiteboard was excellent, though as with all the other web conference programs we tried, sharing programs such as Maple as awkward and slow.

In terms of pen-driven software applications to mathematics it is worth mentioning a program called MathJournal by xThink (http://xthink.com/). This is the best mathematics package yet available that accepts handwritten input. Math Journal features a pen-driven calculator, 2D and 3D graphics, matrix computations, limited symbolic computation, and does conversion to MathML. The developers of this program are making fast progress in adding features and removing bugs. We envision that sometime in the near future we will see an implementation of Maple which will accept pen-scripted input.

There is also a tool under development by Microsoft called MS Equation Writer. This tool is free and it does a great job in basic recognition of basic handwritten mathematics equations.

Assessment

Though our grant assessment team has not yet published the results of the numerous surveys and other data collected to measure the success of the project, we can at least report that the students in the experimental group performed significantly better than those in the control group. In the first two hourly exams, the mean and standard deviation of the scores was almost identical for both groups in both the math and the chemistry courses. However, the mean class score in the last two exams and in the final exam for the experimental group was over one standard deviation above that of the control group. It is interesting to note that the top 5 scores as well as the lowest score occurred in the experimental class. Of course, it is too early draw any conclusions about what made the difference in the better grades. One factor is clear: The experimental class had virtually perfect attendance and initial analysis of the surveys indicates that the students had substantial face to face and electronic communication amongst themselves.