HANDHELD COMPUTERS TO ENHANCE ACTIVE LEARNING IN A DIGITAL SYSTEMS COURSE

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ABSTRACT

Penn State Abington has integrated the student use of handheld computer technology to foster active and collaborative learning experiences in the classroom and laboratory in a sophomore-level introductory digital systems course over a period of three semesters. The handheld computer provided each student with access to useful course material and tools, which enhanced the learning experience in and out of the classroom. Additionally, teams of students explored innovative uses of handheld computers in a variety of applications including robotics, GPS systems, music, and circuit design. Based on data from a student survey, the handheld computer was judged to be a useful educational tool.

INTRODUCTION

Penn State Abington has integrated the student use of handheld computer technology to foster active and collaborative learning experiences in the classroom and laboratory in a sophomore-level introductory digital systems course in the fall of 2000, 2001, and 2002. Penn State Abington has also integrated handheld computers into the Information Sciences and Technology (IST) undergraduate curriculum, robotics instruction, and a French language course.[1] The handheld computer is an inexpensive, personal digital assistant (PDA) that supports database, spreadsheet, document viewing/editing, graphics, programming, personal organization, and web-browsing software.

Through support from Palm, Inc,[2] Palm PDA technology was introduced into an introductory digital systems engineering course for 24 students in the fall of 2000 at Penn State Abington. The Palm OS PDA offers an intuitive interface, and has a great deal of software support. Each student was provided a Palm III-series handheld computer. A textbook was also a required purchase for the course. The digital systems course covers topics in number systems, logic gates, Boolean algebra, combinational and sequential logic, state machines, memory concepts, and programmable logic devices.

Engineering students in the 2000 course investigated, evaluated and developed handheld software tools for enhancing active learning and instruction in both the lecture and laboratory components of the course. Databases, simple CAD tools, C programming, image capture, web-based tools, and robotics applications were explored. Electronic quizzes and distribution of notes and web resources were also investigated. The ability to transfer software applications and data from one Palm handheld unit to another using the infrared beaming feature facilitated a collaborative approach in many classroom activities. The Palm devices also possess a serial port, which allows connection to data acquisition systems and other computers.

The second phase of the project occurred during the fall of 2001 and the fall of 2002 offerings of the digital systems course. In this phase, each student was required to purchase a Palm OS-compatible PDA to be used regularly in the classroom and lab sessions. Students typically purchased Palm handhelds in the $100 to $250 price range. Successes from the first phase in 2000 were now incorporated into the course. No textbook purchase was required in 2001 and 2002 courses, since the course content was now largely contained in the PowerPoint slides and handheld resources. Teams of honors students from the 2000, 2001, and 2002 classes researched and evaluated innovative uses of handheld computers in a variety of applications including robotics, GPS systems, music, and circuit design.

The objective of this paper will be to provide an overview of several key software tools and handheld applications developed for enhancement of the digital systems course. Results from a student survey assessing the effectiveness of the handheld computer in the course will then be described.

HANDHELD COMPUTER SOFTWARE TOOLS

This section will describe several of the successful software applications for the handheld computers utilized in the digital design course. The first tool to be presented will be PocketC,[3] a low-cost C-language compiler for the Palm OS. Pocket C supports much of the functionality of C and provides support for graphics, serial port, and sound. Software can be directly entered or modified on the Palm OS unit. Programs can also be transferred from a desktop PC to the Palm device. In one activity, students in a conventional classroom were able to create and modify simple software programs to generate truth tables for a variety of Boolean functions for analysis. In another classroom activity, students devised software tools to perform base conversions. In this way the classroom was temporarily transformed into a computer lab. The PocketC product was also used to support student design projects such as a simple digital circuit CAD program, a music sound generator, robot arm controller, and an autonomous robot.[4] Figure 1 displays a Palm screenshot of sample PocketC program text as it would appear in the Palm memo application. Figures 2 and 3 illustrate PocketC program segments that provide communication over the Palm serial port to a microcontroller for a robotics application. The PocketC tool on the handheld allowed students to access, modify, and develop small programming applications in a variety of environments and facilitated the rapid prototyping of projects.

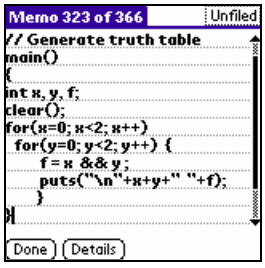

Figure 1

Figure 2

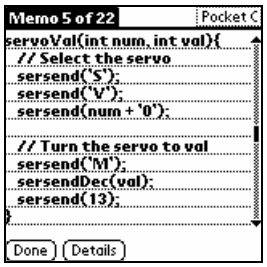

Figure 3

The second tool to be described is InfoView[5] database tool. The InfoView database tool allows for the creation of hierarchical informational databases that can be quickly accessed on the handheld computer. The product supports the display of text, simple images, and tables. Links are activated by a simple tap of the stylus on the touch-sensitive screen of the handheld. A database of key digital design course concepts was developed by the author for use by the students in the classroom and laboratory (see figures 4 and 5). Access to this database enabled students to engage more productively in the classroom in design work and team quizzes. This mobile database was also used by students in the laboratory to access reference materials on integrated circuits (figure 6). The vendor also provided several databases that proved useful in the course. Finally, the students found the informational database to be very useful for studying and reviewing class material in a variety of environments.

The development of similar reference databases with equivalent content but in an HTML format is also underway. The advantage of an HTML format would be platform independence and flexibility. Several commercially available products, such as iSilo[6] and Avantgo[7], are capable of displaying HTML documents on handheld computers.

Figure 4

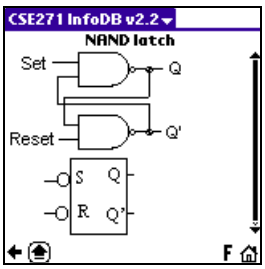

Figure 5

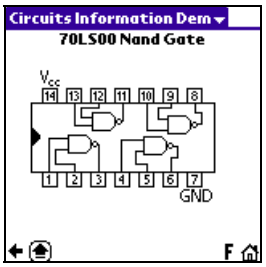

Figure 6

The third handheld application to be discussed is the practice quiz software, Quizzler.[8] This product allowed students to review multiple-choice questions on their handheld computers. The author developed a database of over 170 multiple-choice questions for use with this product. Although the course exams were primarily problem solving and design oriented, the practice quizzes were found to be very useful for exam preparation and review. For one, the quizzes provided a useful overview of course material, and second, the practice quizzes could be conveniently accessed in any environment. This product allows for the arrangement of questions into categories, and will also randomize questions and candidate answers (see figures 7, 8, 9). Although this quiz application was not utilized a great deal in the classroom environment, the students found the application to be very useful in the learning process outside of the classroom, as evidenced by the survey results discussed in the next section.

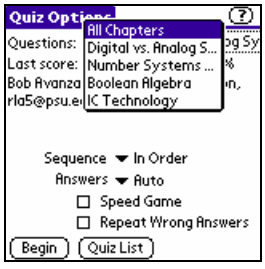

Figure 7

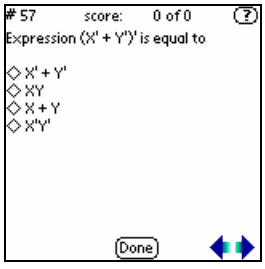

Figure 8

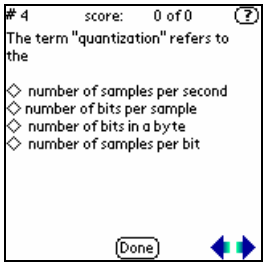

Figure 9

STUDENT SURVEY RESULTS

At the conclusion of each of the three semesters, the students received a survey on which to comment on the effectiveness of the handheld computer in the course. The students were each asked how they would rate the overall effectiveness of the Palm PDA in the classroom on a scale from 1 to 5 (1=not useful; 3=moderately useful; 5=extremely useful). The average response for overall effectiveness for the 2000 class (21 respondents) was 4.0. The average response for the 2001 class (37 respondents) was 3.6, and for 2002 class (13 responses) the average response was 4.0 for the same question.

When asked if the students would recommend the use of the Palm PDA in future offerings of the course, 18 of the 21 respondents (86%) in 2000 indicated "yes," three students (14%) indicated "not sure," and none indicated "no." In the 2001 survey, 28 of the 37 respondents (76%) indicated "yes" to the same question, 6 students (16%) indicated "not sure," and 3 students (8%) responded "no." In 2002, 10 of the 13 students (77%) indicated "yes," and 3 of the 13 students (23%) indicated "not sure."

In open-ended questions, students were asked to state the most positive reason and the most negative reason of using a Palm PDA in the course. Nine students (out of 21) in 2000 emphasized the access to reference data, especially circuit information, as a positive reason. The most common negative aspect (3 students out of 23) claimed that entering data directly onto the Palm was slow and difficult.

In 2001, 10 students (out of 37) specifically indicated the InfoView database application as the most positive aspect. Thirteen students specifically identified the Quizzler practice quiz application as very positive. Five students indicated that familiarization with handheld technology was the most beneficial aspect. Negative aspects on the use of the Palm in the 2001 class included "high cost" (8 students); "distracting" (2 students); "not used enough in class" (5 students); "difficult to use" (1 student); "lectures were not available on the PDA" (1 student); and "could not use handheld on the test" (2 students).

In 2002, there was a similar emphasis on InfoView reference and Quizzler quizzes as positive aspects. High cost (2 students out of 13) and lack of additional application software (3 students) were included as negative aspects.

SUMMARY AND CONCLUSIONS

Based on the survey data, the overall response from students has been positive. From the instructor's point of view, the use of handheld computers has improved opportunities for active learning experiences in the classroom, and has also exposed the students to many important engineering issues of handheld technology. The overall performance of the class in examinations was judged by the instructor to be at least equivalent to, or better than, previous semesters without the use of handhelds. Student access to handheld information and mobile tools allowed the instructor to engage the students with more challenging problems and creative classroom assignments. For example, in a 2002 class, a low-cost handheld data acquisition device[9] with a temperature sensor was successfully used to collect data by students in the classroom, thereby demonstrating the breadth of applications that can be accessed by way of a handheld computer in a standard classroom. The handheld also provided a suitable technology on which to base small research projects and innovative application development projects for students.

It is expected that as the power of handheld hardware and wireless networking capabilities increase, and as handheld software applications improve, the opportunities for active learning and assessment in the classroom will also improve. The successful handheld computer tools and resources generated in this integration effort will be used as a foundation for improvements in future course offerings. We are attempting to pursue solutions that are platform independent to allow students with handhelds from a variety of vendors to participate. Also, the issue of mobile access of course materials outside of the classroom appears promising from this study and will be investigated further.

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BIOGRAPHICAL INFORMATION

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