Handheld Computers to Enhance Active Learning in a Digital Systems Course

Bob Avanzato
Penn State Abington

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 in the fall of 2001 and 2002. 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.

1.0 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 2001 and fall of 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 digital systems course covers topics in number systems, logic gates, Boolean algebra, combinational and sequential logic, state machines, memory concepts, and programmable logic devices. These engineering students 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 supported. The ability to transfer software applications and data from one Palm unit to another using the infrared beaming feature facilitated a collaborative approach to many activities. The Palm devices also possess a serial port, which allows connection to data acquisition systems and other computers.

A second phase of the project occurred during the fall of 2001 offering of the digital systems course. In this phase, 39 students were required to purchase a Palm OS-compatible PDA to be used regularly in the classroom and lab sessions to promote active

leaning. The Palm OS PDA is a low-cost handheld computer, offers an intuitive interface, and has a great deal of software support. In addition to building on the successes of the previous year, students in the fall of 2001 explored the effectiveness of mobile quizzes. Teams of honors students from the 2001 class again investigated innovative uses of handheld computers in a variety of applications including robotics, GPS systems, music, and circuit design.

This paper will 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.

2.0 Handheld Computer Software Tools

This section will describe several of the key 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 i/o, 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 unit. 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 tools allows for the creation of hierarchical 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 critical 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 is 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 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 randomize questions and candidate answers (see figures 7, 8, 9). Although this application was not utilized directly 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

3.0 Student Survey Results

At the conclusion of each of the semesters, the students received a survey on which to comment on the effectiveness of the handheld computer in the course. In the fall of 2000 survey, the students were 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 the 2001 class (37 respondents) was 3.64 and for the 2000 class (21 respondents) the average was 4.0. When asked if the students would recommend the use of the Palm PDA in future offerings of the course, 18 of the 21 respondents in 2000 indicated "yes," three students indicated "not sure," and none indicated "no." In the 2001 survey, 28 of the 37 respondents indicated "yes" to the same question, 6 indicated "not sure", and 3 students responded "no."

In response to the open question: "What is the most positive reason for using a Palm PDA in the course?" 10 students on the 2001 survey specifically indicated the InfoView database application. 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).

4.0 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 and enhanced 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 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.

It is expected that as the power of handheld hardware and networking capabilities increase, and as handheld software applications improve, the opportunities for active learning 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 the next course offering. The issue of mobile access of course materials outside of the classroom also appears promising from the study and will be investigated.

5.0 References

- [1] Avanzato, R.L., "Handheld Computers in the Classroom and Laboratory," Proceedings of the 2001 Annual ASEE Conference, Albuquerque, NM, June 2001.
- [2] Palm, Inc Santa Clara CA; URL: www.palm.com
- [3] Orbworks; URL: <http://www.orbworks.com>
- [4] Avanzato, R.L., "Controlling a Mobile Robot with a Personal Digital Assistant," Proceedings of the 2001 Annual ASEE Conference, Albuquerque, NM, June 2001.
- [5] Handtop, URL: <http://www.handtop.com>
- [6] URL: <http://www.isilo.com>
- [7] URL: <http://www.avantgo.com>
- [8] Quizzler, URL: <http://www.QuizzlerPro.com>

BOB AVANZATO

Bob Avanzato is an associate professor of engineering at the Penn State Abington College. His interests include mobile robotics, fuzzy logic, expert systems, and curricular enhancement. Prior to his position at Penn State, Bob was a senior engineer at the Advanced Technology Laboratories at Martin Marietta where he was involved in digital signal processing and artificial intelligence research and development. (email: rla5@psu.edu)