

# Programming Handheld Devices to Enhance Learning

*Educational software on Pocket PCs is producing a more mobile and interactive learning environment at Wake Forest University*

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Software engineers on the information systems research and development (R&D) team at Wake Forest University (WFU) have developed an application that turns a Pocket PC into a Web server, a real-time quizzing device, a presentation controller, and a class communications device. Available to other educational institutions for downloading, this application, called ClassInHand, gives faculty powerful tools for enhancing existing instructional methodologies and exploring new pedagogical possibilities.

## Emerging Super-Mobile Computing

In its strategic planning for computing, the WFU information systems staff focuses on how technology can continue to support an exciting and engaging learning environment for students and faculty. Issuing a laptop computer to every student has increased communication, facilitated research, encouraged collaboration, and helped students become comfortable in a technology-driven world. We've found, however, that students are reluctant to carry laptops to their classes because of the added weight in already heavy backpacks and because they fear breaking this expensive piece of equipment.

The recent emergence of Pocket PC and palm-sized devices compelled us to consider the potential benefits of these super-mobile, wirelessly connected handheld devices for our students and faculty. The information systems R&D



team began working with handheld devices in the spring of 2001, with the goal of determining whether such devices have a place in the classroom. The team chose the Hewlett-Packard iPAQ to work with because of its powerful Pocket PC operating system and the expansion pack architecture that lets faculty and students use the existing 802.11-based wireless campus network.

## Developing the Right Tools

The R&D team first tested the Pocket PC's capabilities with the device's standard software load, including PocketWord, PocketExcel, Pocket Internet Explorer, and personal information management software. Except for note-taking and access to Web resources, these applications seemed to provide little functionality of pedagogical interest.

To test the operating system's robust-

ness, the team decided to develop a Web server for the Pocket PC. Ideas began to emerge immediately. Team members met with several well-respected, forward-thinking faculty members to discuss opportunities for in-class feedback through Web forms that faculty and students could submit to this "personal server." The faculty members encouraged further development to support their own objectives of increasing interactivity, feedback, and participation in class.

Science instructors in particular were interested in the potential for these super-mobile computers and the Web-server software to facilitate administration of ConcepTests, a methodology popularized by Eric Mazur at Harvard University. The method consists of explaining a concept to students, then posing a question that requires them to apply the concept rather than just recite

its definition. After providing multiple-choice answers, the instructor polls students, using colored index cards or a similarly quick device by which students show their answers. The instructor tries to assess quickly whether the majority of students have answered correctly. If they haven't, the instructor directs students to seek the correct answer by discussing the question with another student. The instructor then polls students again. In most cases, discussions enable students to converge on the correct answer. This quizzing and polling application seemed perfect for the Pocket PC Web server.

Instructors also supported the idea of developing software that would let them control presentations from the Pocket PC so that they needn't remain tethered to a desktop or laptop com-

puter to advance slides and read their content. Though a remote mouse would be a partial solution, they liked the idea of having a single device to control presentations and receive feedback.

The R&D team produced its first Pocket PC software application, Pocket-Classroom, in the fall of 2001. It included

- presentation control for PowerPoint slide shows;
- a Web server built especially for the Pocket PC environment;
- a text feedback feature enabling students to submit free text to the Web server through a form in their browser; and
- a feedback meter enabling students to submit numbers through a browser form, with submissions

forming a continuous graph on the instructor's Pocket PC screen.

In the summer of 2002, the team enhanced the software, renaming it ClassInHand and adding

- a quizzing or polling feature,
- enhancements to facilitate saving text feedback for later review, and
- enhancements to enable jumping to a particular PowerPoint slide.

The software's individual features deserve detailed discussion.

### **Presentation Control**

Microsoft PowerPoint has become a convenient tool for faculty members who wish to enhance their lectures with illustrations or simulations. Several available products let a presenter download PowerPoint slideshows to the Pocket PC. Although this model offers the convenience of carrying a Pocket PC rather than a laptop for presentations, it tethers the Pocket PC to the projector and eliminates some of PowerPoint's features. With ClassInHand, the presentation remains on the laptop or desktop computer connected to the classroom projector, and the Pocket PC becomes an enhanced, mobile remote control device. The ClassInHand software on the Pocket PC communicates through the wireless network with special agent software on the instructor's laptop or desktop computer, included as part of the ClassInHand installation. The instructor can use the Pocket PC from anywhere in the room to browse to a presentation on the desktop or laptop computer, initiate it, and control the slideshow. Both the slide text and the speaker notes appear on the Pocket PC screen.

These presentation controls let the instructor move around the room and maintain eye contact with students without having to look back at the projection screen to see the contents of the slide. A new feature introduced in the fall of 2002 lets the instructor jump easily to a particular slide, a task that in PowerPoint itself requires an awkward sequence of steps.

### **Web Server Features**

The university's experience with laptops indicates that increased commu-

## **Computing Technology at Wake Forest University**

Wake Forest University (WFU), consistently ranked as one of America's "most wired" universities and research schools, has received national recognition for its use of computing technology to support the institution's core mission of face-to-face teaching and learning. The university's comprehensive technology plan provides students with powerful hardware and software, an award-winning campus network, innovative online services, specialized technical support, and student programs. This plan ensures that students have many opportunities to enhance their academic and campus experience through technology.

Upon enrollment, first-year students receive IBM ThinkPads and HP color ink-jet printers. The computers are upgraded after two years and become the property of the student upon graduation. Through a network login ID, students have access to e-mail, software packages, and network services and resources.

Students also benefit from an extensive online information system that includes class schedules and grades, university-wide activity calendars, the WFU libraries' information system, and an electronic version of the student newspaper, *Old Gold and Black*. The WFU information network hosts databases and directories, an alumni directory, class registration services, an online ridesharing board, a used-textbook exchange, and customizable links to news, weather, and research sites.

WFU has a 622-megabit-per-second connection to the Internet. Each residence hall room is equipped with one Ethernet connection per resident, and there are more than 20,000 additional active network jacks in classrooms, libraries, study lounges, and offices to ensure that students can be online nearly anywhere on campus. A help desk and resident technology advisors assigned to each residence hall provide full-time support.

nication among faculty and students has been one of the greatest payoffs of its ubiquitous-computing program. The ClassInHand software goes a step further, turning the Pocket PC into a unique avenue of communication for the instructor. With this architecture, only the instructor needs special software; students use the browser on their laptop, handheld, or desktop computer. The instructor can start and stop the Web server by simply tapping on the ClassInHand screen, exercising quick, easy, and complete control over access to materials placed there for students.

The ClassInHand Web-server screen displays the IP address of the instructor's Pocket PC, which the instructor provides to students. When students type this address into their browser or choose it from their previously bookmarked sites, they access the home page on the instructor's handheld Web server. The standard ClassInHand software installation includes all links and Web pages needed for the quiz, text feedback, and feedback meter functions.

Although the Web server's primary function is to support these features, instructors can use it much as they use a traditional Web server. An instructor can easily add materials to the Web server by creating them on a laptop in Microsoft Word, saving them in either HTML or PDF format, and synchronizing them to a folder that is part of the ClassInHand installation. By starting the mobile Web server, the instructor gives students access to these documents through their browsers. This gives instructors a simple way to make links for class use or provide other information to students without calling on a server administrator for assistance or developing server management skills. One WFU instructor is using this feature successfully to have students download and save MS Word or PDF documents from the ClassInHand server. This is a fairly simple task if the student is using a laptop or desktop computer; it's a little more complex using a Pocket PC device because of Internet Explorer's reduced feature set for the Pocket PC.

The Web server has been adapted to the mobile environment by selective implementation of customary Web-server

features. Security was carefully considered at every stage of development. As a result, attacks by viruses such as Nimda and Code Red return a "File Not Found" message and cause no harm. Unlike typical Web servers, the ClassInHand server doesn't let students access a directory listing of its contents, so they cannot determine what files are on the instructor's Pocket PC.

### **Text Feedback**

The text feedback form is a standard HTML form with a text box in which students may enter questions, comments, or free-text answers to instructors' questions. Submissions are, by default, anonymous; students may include their names if they wish or if asked to by the instructor. Submissions show immediately on the instructor's Pocket PC screen. This could be particularly helpful in large lecture halls, where it may be difficult to hear students' questions, or in distance-learning environments, where instructor and students are not face to face.

Students' text submissions are also saved in a text file that instructors can access later. WFU faculty members use this feature in two different ways. First, at the beginning of class they collect students' responses to a question that will reveal whether the students have done the out-of-class reading. In this case, students include their names to receive credit. The instructor leaves the classroom with a file on the Pocket PC rather than a handful of papers. Second, instructors solicit responses from students at the end of class on the most confusing topic presented during the lecture.

With anonymity, students have more freedom to comment honestly about the learning environment. They have not used this feature inappropriately.

### **Feedback Meter**

The feedback meter displays a number scale from -10 to +10 on the students' Web form. Instructors direct students to submit values indicating agreement or disagreement, comprehension or confusion, or whatever the instructor wishes to measure. As students click on the number line, the instructor sees each number

submitted immediately in a moment-to-moment graph on the Pocket PC screen. This functionality is particularly useful in collecting feedback over time, say, for identifying characteristics students are asked to observe within a piece of music, a series of photos, a film, or a reading. Instructors can assign different characteristics for students to identify by specific numbers on the scale, then watch the graph on the Pocket PC screen to see whether they are submitting the right values at the right times.

### **Quiz**

The quiz feature is a polling application designed to present a question and collect and aggregate students' responses in bar graph form on the instructor's Pocket PC. Instructors can choose whether to let the students see these results. ClassInHand uses the same wireless communication mechanism and agent program for displaying the results to the class as those used for the presentation feature.

ClassInHand offers many functions within the quiz feature that make it easy for both faculty and students to manage and use. Its functionality lets faculty members

- set up questions and their multiple-choice responses prior to class, when a detachable keyboard can greatly facilitate text entry on the Pocket PC;
- edit test questions or responses;
- include a graphic to serve as a question or to supplement a text question;
- dynamically control which questions students can see at any particular time by tapping check boxes on the Pocket PC screen;
- export test results into a time-stamped file;
- clear results in preparation for asking the same question in another class or in the same class after further discussion;
- view results on the Pocket PC, refreshing as often as desired while students are submitting responses; and
- show results to the class when desired.

ClassInHand functionality lets students

- browse easily to a question, using links on the instructor's ClassInHand Web-server pages; and

- submit answers through a Web form rather than navigating through complex client software.

The quiz function is strictly anonymous and is not intended for grading assessment. It is a tool that can help instructors determine the effectiveness of their explanations and if necessary plan more appropriately for subsequent lectures. It can also let students discover right away whether they understand the concepts being presented. Both students and faculty benefit from determining learning effectiveness immediately, as opposed to finding out days or weeks later on graded assessments.

### Testing ClassInHand in WFU Classrooms

The software was first piloted in a physics classroom in the fall of 2001. Because the quiz feature wasn't yet included, the instructor adapted the feedback meter to gauge whether students understood the concepts he had presented. He asked a question and assigned each of the possible answers to a number on the scale. By watching the graph on his Pocket PC screen as students submitted their responses, he could tell whether they were choosing the correct answer. This gave him a quick assessment of the students' level of understanding, and he was able instantly to adjust his teaching plan to either review the concept or proceed to something new.

The instructor requested that the Department of Information Systems issue iPAQ Pocket PCs to his students for use in this pilot. He felt that these small, wireless, instant-on handheld devices would be less intrusive than a classroom full of open laptops and would save the precious minutes of class time it would take to boot up laptops. Students were much more willing to carry the smaller device to class, and the instructor was pleased with the interactivity the software permitted in this class of approximately 100 students. Although the small screen can hinder Web surfing in general, it was not a problem for the ClassInHand Web pages because they were designed with this environment in mind.

However, the Pocket PC presented some obstacles that interfered with a

good assessment of the software. Students weren't familiar with the concept of volatile memory: if the battery on the device fully discharged, they lost files and software they had installed. Students who lost their wireless driver software were temporarily unable to connect to the network to access the instructor's handheld Web server. Others experienced problems getting IP addresses through the dynamic host configuration protocol, because this process is less robust on the Pocket PC operating system than on laptop and desktop operating systems. Some students indicated at the end of the semester that they didn't have enough time to become comfortable using the Pocket PC during the four-week pilot. These problems, coupled with the decision to issue Pocket PCs to only half the students in the class because of cost constraints, contributed to lower participation than we expected during class.<sup>1</sup>

Technical problems and device usability issues aside, the instructor offered the R&D team valuable feedback on the software itself. This led to development of the quiz feature introduced in the fall of 2002, as well as improvements in saving feedback files. These features greatly increase the software's utility without increasing the level of technical expertise instructors need to manage it.

The new version underwent beta testing in a chemistry class of 40 students in the fall of 2002, where the quiz feature was used at least once in each class meeting. It generated very positive comments from both instructor and students. The software has been the catalyst for a change in the instructor's teaching style, and he is convinced that his students are learning more about chemistry than students in past classes have. Each student has a Pocket PC and a keyboard, and participation is 100 percent. Classes are lively, and students become quite animated when discussing quiz questions with each other before the instructor reveals the polling results.


Classes in sociology, education, and health and exercise science are also using the software. In the latter classes, students use ClassInHand for course-required in-class presentations. The instructor distributes some of the class

materials by having students download them from the ClassInHand Web server to their Pocket PCs. In the sociology and education classes, only the instructor has a Pocket PC; students use their laptop browsers to access the instructor's ClassInHand Web server.

### Assessment and Future Enhancements

The ClassInHand software simplifies classroom technology management for both faculty and students. It has been designed to ensure that tasks such as starting and stopping the Web server, adding class materials to the server, creating and managing quizzes, and making presentations require only screen taps and basic file-creation skills rather than extensive technical training for instructors. Students need only a browser, so they don't have to load or learn special client software.

The WFU information systems staff is continuing to monitor the pilots and interview both faculty and student participants to assess the software's effectiveness and the value of super-mobile devices in the academic environment. At the same time, the R&D team is investigating new features for ClassInHand and considering other software development that will take advantage of the great mobility of wirelessly connected handheld devices.

To download the software and learn more about ClassInHand, please visit <http://classinhand.wfu.edu/> or contact Anne Bishop, director of information systems research and development. 

### Endnote

1. For the complete text of a study conducted in conjunction with this pilot, see <http://www.wfu.edu/~jld/studies/Dominick%20SMC%20Study%202001%20-%20Draft.pdf>.

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