

## M-EDUCATION: MOBILE COMPUTING ENTERS THE CLASSROOM

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### ABSTRACT

*Experts now predict that someday the number of wireless-enabled handheld computing devices will exceed desktop PCs. This paper explores the potential impact of this trend on education. Several examples of current and anticipated usage in learning, instruction, and classroom management are given. Finally, the challenges of adopting and deploying mobile education are considered.*

**Keywords:** mobile education, m-education, handheld computers, pedagogy, post-secondary

### INTRODUCTION

In 1993, Apple Corporation introduced the Newton Messagepad, a pen-based handheld device with general purpose computing capabilities (1). The Newton was pricey (\$1150 at introduction), the handwriting recognition less than accurate, and the desktop connectivity complicated. But the Newton could communicate. It had a standard serial port, infrared port, and a standard PCMCIA expansion slot that could accept a modem or a network card. An optional keyboard was even available. As a platform for education, the Newton showed serious promise. Later models, such as the Newton eMate were made available to schools at a reduced price of \$500. Still pricey, but approaching the realm of affordability. Apple's Newton was a case of "too little, too early", especially for the educational market.

With the release of the 3Com Palm Pilot 1000 in March 1996, the potential for small form factor mobile computing devices to revolutionize education moved from dream to affordable reality. The Pilot 1000 personal digital assistant (PDA) had an even smaller form factor than the Newton, easily synchronized with the desktop, and sold for a retail price of \$370 (7). Memory was limited to 128 KB. A standard serial port offered the only communication available. For a PDA, the Palm Pilot was the first viable substitute for paper-based organizers. Palm sales skyrocketed, breathing new life into nearly moribund handheld computer market that had over-promised and under-delivered.

Before long, the Palm product line evolved, adding memory resources, an infrared port, and modem communication. In May 1999, 3Com Corporation introduced the Palm VII, the first PDA with wireless access to the Internet—all at a price far lower than a desktop PC. This convergence of wireless communication, low cost, and a small form factor marked the beginning of a new era in mobile computing. With the advent of truly portable PDAs, users now had a serious alternative to luggable laptops. And with the introduction of Microsoft Windows CE 3.0 in June 2000, users had a choice in Internet-enabled handheld operating systems. Some educators began to take notice, experimenting with PDAs in the classroom in an attempt to create computer-supported collaborative learning environments (4). Some have gone even further.

Elliot Soloway, for instance, is so convinced that wireless handhelds are the solution to the low density of computers in primary and secondary education classrooms that he and his colleagues have begun to lobby for universal access:

“K-12 will take computing technologies seriously only when they are as available as pencils. When computing technology is literally ready-at-hand, when students whip out handheld devices from their backpacks and desks instead of pencils and paper, only then will education and educators move to using the technology in a routine, day-in, day-out manner” (9, p. 20).

This raises an interesting research question: If low-cost wireless handhelds become ubiquitous and replace laptops as the primary mobile computing platform, what is the implication for education? This paper explores the potential of mobile education as it affects learning, instruction, and classroom management. Examples of current and anticipated usage are given. Finally, the challenges of adopting and deploying mobile education are considered.

### THE PROMISE OF MOBILE EDUCATION

The computing revolution that has changed modern life has yet to make a significant impact on the classroom. Unlike business, where information workers have easy access to computer technology, today’s primary, secondary, and post-secondary students would be hard pressed to find a computing device within easy reach. A 1999 National Center for Education (5) survey found that 90% of U.S. K-12 classes had less than five computers per room. Seat time statistics are even more abysmal. According to one study, K-12 students averaged less than 15 minutes “seat time” per week per student in front of a computer (9). Low computer density coupled with low usage would indicate that the current role for computers is peripheral to K-12 instruction, rather than an integral part of the learning process.

The picture in post-secondary education is similar. Some colleges (Bryn Mawr, 2002) report ratios as low as 6 students to 1 computer. Others (Wellesley College, 2002) report ratios as high as 10 students to 1 public access computer. Some colleges report statistics on percentage of laptop ownership. An exceptional few report that all students are required to own a computer (3, 11). Data on the number of students per computer in each classroom and the average usage per week are not readily available. Regardless, except in courses taught in computer labs, it would appear that universal access is not currently a reality in higher education.

Today’s handhelds are much more than connected personal organizers. These devices have enough computing power to serve as a ready platform for mobile education (m-education) (10). In the classroom, wireless handhelds could be used to enhance student learning or facilitate instruction and classroom management (8). Assuming universal, mobile/wireless computer access for each student and faculty member, we see numerous opportunities for enhanced in-class learning, facilitated instruction, and course management:

#### **Enhanced Learning**

- *Anonymous Participation.* Students not entirely comfortable with their understanding of the material could submit questions to the instructor or respond to instructor questions

without others in the classroom knowing. This would provide a forum for the “dumb questions” students are usually too apprehensive to ask.

- *Collaborative Review.* Writing assignments or practice exercises could be peer-reviewed using collaborative editing software.
- *Concept Illustration.* Difficult to grasp concepts could be visually illustrated using animations or video that could be played in full or slow motion. Students would be able to interact with the illustration to test their understanding of the concept being presented.
- *Data Collection.* Handhelds outfitted with the appropriate peripherals could be used for in-class and field data collection.
- *Educational Games.* Multi-player exercises designed to reinforce or discover concepts may be used to leverage student interest in participative competition. Television-style question and answer games with participant monitoring would ensure that all class members get a chance to be involved.
- *Increased Levels and Timeliness of Feedback.* Real-time quizzing and assessment would provide immediate feedback during concept acquisition. Universal computing would guarantee access to drill and practice applications that could be employed to increase the quantity of feedback.
- *Individualized Content.* Lecture notes or slides could be dynamically reformatted based on the student’s preferred learning style. Content could be adapted to the student’s ability level.
- *Intelligent Agents.* Virtual representatives (software agents) could be authorized by students to perform background tasks, schedule team meetings, and negotiate resources needed for class work.
- *Just-in-time Learning.* During a lecture or class activity, students could research unfamiliar terms or flag content for later review.
- *Note Dissemination and Annotation.* Using one-to-many synchronization software, instructors could download class notes to each student. Digital notes would enable easy student highlighting and margin comments. Rather than focusing on capturing every word spoken by the instructor, digitally distributed notes would allow students to focus on key concepts. Electronically distributed notes coupled with text-to-speech translation would be especially useful to sight-impaired students.
- *Note Transcription.* As an aid in note taking, handhelds could be used to do student handwriting recognition or instructor voice recognition. Networked intelligent whiteboards could be used to capture instructor board annotations and drawings. Notes could be stored in either a voice or text format. Voice-to-text translation could provide a complete classroom transcript for the hearing-impaired.
- *On-line Searches of Reference Material.* With always-connected handhelds, students could investigate reference material in class. Site tracking utilities could identify the mostly frequently visited web pages. Instructor-guided searches would provide students with a role model for finding and filtering information.
- *Simulation.* Individual and collective simulation exercises become possible with portable, connected computing devices. Highly Interactive Computing in Education, for example, has developed “Cooties” to demonstrate disease propagation (9).

### **Facilitated Instruction and Course Management**

- *Appointment Scheduling.* Group calendaring software would facilitate teacher-student and student-student appointment setting.
- *Assignment Distribution and Due Date Reminders.* Using “push” technology, students at River Hill High School in Maryland are provided their daily assignments and due date reminders, direct to their handheld (6). These digital reminders minimize the need to waste class time on answering such questions as “What’s the next assignment” or “When is the next exam?”
- *Assignment Submission.* Using networked dropbox software, students could submit assignments electronically. Instructors could provide feedback by inserting hyperlinked comments into the student’s original document. Grading would be paperless.
- *Brainstorming.* Large group and small group brainstorming could be facilitated by collaborative tools that simplify aggregation, summarization, and group evaluation of ideas. Handhelds could be used as a shared whiteboard space for diagrammatic brainstorming.
- *Case Method.* Handhelds bring the point of access for case study background material into the classroom. Video and audio clips of key players in a case narrative could be viewed individually by the case study groups.
- *Electronic Name Cards.* With automated participant recognition, the instructor handheld could display the name of students raising their hands or called on to answer in-class questions. Further, the instructor handheld could maintain student background information to facilitate building rapport.
- *End-of-class Formative Evaluations.* Handhelds allow easy data capture of end-of-class assessment. This information could be used as part of a continuous instructional quality improvement program.
- *E-text and E-supplementals.* Handhelds provide a capable platform for e-text and supplemental readings distribution. Advances in Digital Rights Management address copyright issues. Books can be filtered and viewed at multiple levels from summary to detail. Text can be fully hyperlinked within the text itself or to other works and on-line resources. For sight-impaired, text-to-speech translation would allow handhelds to read aloud to the student.
- *In-class Polling.* Both open and anonymous polling becomes possible with handheld technology. Results can be instantly aggregated and graphed. As group decision support software research has demonstrated, anonymity invites additional participation from class members reluctant to participate openly. Polling could be used for pre-assessment of material or post-assessment to determine the level of understanding.
- *Roll Taking and Class Participation Monitoring.* Handhelds with unique computer IDs could be used to take attendance on a non-intrusive basis. Student participation, as well as student time on task, could be accurately tracked.

### **ISSUES IN ADOPTING M-EDUCATION**

With the adoption of any new technology, there are challenges to deployment. Wireless handhelds are no different. Key issues include: (a) the limitations of the handheld environment, (b) pedagogical integration, (c) the student/teacher behavioral impact, and (d) privacy, security, and intellectual property rights.

### **Handheld Platform Limitations**

Although handhelds are by far more robust than desktop PCs, rarely causing program crashes, they are by no means fault tolerant. To achieve additional robustness, hardware designers have scaled down desktop application and operating environment complexity. This guarantees that handhelds will not be as full-featured as desktop machines, limiting their usefulness for some pedagogical applications.

Other design trade-offs revolve around portability. The small form factor of handheld computers limits memory capacity, screen size, processor speed, secondary storage, and usability. Stylus-based input is slow and cumbersome. Auxiliary keyboards help but now the student must carry two devices instead of one. Battery power becomes an issue when students fail to carry spares or recharge their batteries. Secondary storage, except for those who can afford microdrives, is limited to the capacity of flash memory expansion cards.

Of course, applications are smaller. For the Palm platform, most applications are designed to run in less than 8 megabytes, with 16 megabytes the maximum. For the Pocket PC, the limit is between 32 and 64 megabytes. This precludes running desktop-strength RAM-intensive applications that require 128+ megabytes. While some popular desktop applications have been migrated to the handheld environment, most have not. This has led to a shortage of application software. As second generation handhelds (2G) become available with their increased memory and speed, and as developers target applications for the handheld market, the current shortage should abate.

### **Integrating Handhelds into Instruction**

As educators who teach in desktop PC labs know, integrating computers into instruction has been a challenge. There is no reason to believe integrating handhelds will be any less difficult. In many PC labs, educators have wrestled with maintaining student attention. Students often sit near the back of the class so that they can read personal email, surf the web, play games, or live chat with their friends. The handheld environment will be no different. Students may just as easily perform the same kinds of distracting activities.

As discussed earlier, software availability is a real issue. The literature has shown there are several classroom experiments underway in which academic software applications and software infrastructure are being explored (4). Some of this software has moved into the commercial or shareware market (e.g. Slide Show Commander). Much has not. Obtaining the kinds of software that maximize the capabilities of handhelds as an instructional medium is a long term proposition. The same is true of content formatted for the limited display capabilities of handhelds. Many of these displays are only 2.8 to 3.8 inches with a maximum of 65,000 colors and 240 x 320 pixel resolution. Reformatting text and video for these hardware limitations is not just a simple conversion process. Image clipping, image resolution reduction, and text rewriting are required.

Finally, there is the issue of electronic cheating. Handhelds with wireless communication capability make beaming answers to classmates all too easy. As educators have found, today's calculators with infrared communication often have to be banned from the classroom or testing

center to avoid cheating. Without adequate safeguards, handhelds could be the platform of choice for swapping answers and plagiarizing.

### **Sociological Implications of Computational Democratization**

What happens when computer rights are universal or when each student has the same computing power as everyone else in the class, including the instructor? The democratization of information has often been cited as a key reason for the downfall of the Soviet Union and for the flattening of corporate hierarchies in the 1990s. If the advent of universal information has led to radical social change, what does universal computing portend? What happens when everyone has the same intellectual tools? How does that change the classroom? These questions remain to be answered. We can only speculate that democratization of computing may have as much impact on modern civilization as the democratization of information has had.

### **Legal Issues Surrounding Handheld Use**

Probably the biggest hurdle to acceptance of handhelds as a primary educational delivery platform is the same hurdle educators have faced in moving education content to the Internet – intellectual property rights. As paper-based copyright laws are adapted to the digital age and as digital rights management software addresses copyright infringement, content will eventually migrate to the handheld. In the interim, content must be self-generated. This can be time consuming and often serves as a deterrent to adoption. However, as the accelerating growth in distance education demonstrates, educators will eventually find a way to overcome the legal obstacles to content distribution.

As with any tool, appropriate use is critical in insuring the well-being of those in close proximity to the tool user. Many college campuses prohibit the viewing of pornographic web sites on public access PCs, as this may be deemed offensive to students sitting nearby in the lab. Wireless handhelds represent a ready opportunity to propagate obscenity, libelous remarks, and computer viruses. Appropriate use policies and content filtering may need to be addressed before any large scale handheld deployment.

Finally, as students move about with their handhelds, mobility will “stretch enterprise security resources to the farthest reaches of the planet” (2). The danger of mobile intruders becomes a real concern. Without adequate security, wireless handheld networks become an easy target for computer viruses, stolen “connect” time, or personal identity theft.

## **CONCLUSION**

Experts now predict that someday the number of wireless enabled handheld units will exceed desktop PCs, making handhelds the single largest computing platform. This poses both an opportunity and a challenge for educators. Mobile education offers the promise of ending the digital divide that separates the technological “haves” from the technological “have nots”. Affordable, convenient, connected hardware could democratize computing, providing universal access for all. Computer-supported learning would take on new meaning. Academic communities would become universally internetworked, not just at the organizational level but at the individual level. Collaboration, instant feedback, and personalization would become the

norm. Information would literally be at your fingertips. Such a vision is not only possible; it is a reality in schools and colleges experimenting with mobile education today.

Technology aside, large scale adoption of m-education is not without hurdles. Ubiquitous computing changes the culture. Public policy and the legal environment continue to lag product introduction. Even so, today's wireless handhelds may have just as much impact on the classroom of the future as universal textbooks had on the classroom of the past.

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