Mobile Learning and Handheld Devices in the Classroom

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Introduction

Mobile learning (or m-learning) is defined by Clark Quinn [Quinn 2000] as

> *… the intersection of mobile computing and e-learning: accessible resources wherever you are, strong search capabilities, rich interaction, powerful support for effective learning, and performance-based assessment. eLearning independent of location in time or space.*

The Mobilearn project, with partners from nine European countries, the United States and Australia, has a similar vision [Mobilearn 2003]:

> *A new m-learning architecture will support creation, brokerage, delivery and tracking of learning and information contents, using ambient intelligence, location-dependence, personalization, multimedia, instant messaging (text, video) and distributed databases. Field trials cover "blended learning" (as part of formal courses); "adventitious, location-dependent learning" (during visits to museums); and "learning to interpret information sources and advice" (acquiring medical information for everyday needs). The high connectivity and functionality may lead to new group behaviors, akin to the SMS phenomenon.*

Do these visions make sense? Do they have a chance of success?

These questions are difficult to answer. In general, predictions of the effects of technology are far too ambitious in the short term, far too modest in the long term, and miss the real point. E-learning itself is just getting off the ground and is still tied to traditional pedagogical models, while many fundamental issues concerning the ownership and distribution of content need to be solved before m-learning can take off. Some skepticism is in order.

Nonetheless, there is an important area where the move to mobile devices has been going on for years: formal classroom education, particularly in quantitative subjects. This trend started with the introduction of Casio graphing calculators in 1986 and is poised to become stronger and more significant with the availability of hand-held networked devices that are networked and that have the capabilities previously associated with desktop computing.

This paper examines how hand-held devices are being used in classrooms, what pedagogic possibilities they present, and some issues that are being faced.

Pedagogical Effectiveness

There are two basic requirements for the adoption of new technology by formal educational systems:

1. The technology must be pedagogically effective and viewed as an improvement
2. The technology must be available and accessible

In mathematics and science, at least, there is widespread belief that microprocessor based technology is pedagogically effective and can lead to improvements in learning. Indeed, technology in the classroom has been *mandated* by curriculum standards for over a decade.

For example, the 1989 standards published by the U.S. National Council for the Teaching of Mathematics for grades 9 – 12 make the following explicit assumptions [NCTM 1989]:

- *Scientific calculators with graphing capabilities will be available to all students at all times.*

- *A computer will be available at all times in every classroom for demonstration purposes, and all students will have access to computers for individual and group work.*

The 2000 release of NCTM *Principles and Standards for School Mathematics* [NCTM, 2000] includes an entire section devoted to the principle that

> *Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning.*

This is elucidated in the NCTM *Standards* with the observation that

> *When technological tools are available, students can focus on decision making, reflection, reasoning, and problem solving.*

The same underlying constructivist pedagogical principles are deeply ingrained in science education standards, and the use of Calculator-Based Laboratory (CBL) and Microcomputer-Based Laboratory (MBL) data collection has been heavily promoted by leaders in educational technology [Soloway et. al.1999]. The ability to collect, manipulate and visually display real-time data adds a significant dimension to the educational experience. So does the ability to collaborate and find "just in time" learning resources. The effectiveness of problem-based learning techniques, aided by technology, is witnessed by many articles and case studies, for example, those cited in the "what are they" portion of [Concord Consortium 2003] and in [E-learning Centre 2003]. These benefits are not restricted to mathematics and science.

The interest in mobile learning in traditional classroom settings is motivated by a search for more effective educational and instructional approaches, especially in areas where current methods are viewed as lacking. In [Tatar et. al. 2003] a team of researchers from SRI international argues that "m-learning" (as described by Clark Quinn and in the Mobilearn vision earlier) is still based on a content retrieval and delivery model of instruction, whereas properly using mobile networked technology in the classroom can change the traditional instructional paradigms. The following table, excerpted and re-formatted from the cited article, shows these changes in the column labeled "C-learning:"

Emerging research architectures

Feature	M-learning	C-learning
Paradigm	Lecture, seminar	Hands-on projects, collaborative groups
Use of medium	Media designed to deliver information	Tools designed to support inquiry
Student input	Writing free-form text	Constructing graphs, animations, questions
Communication	Mostly online discussion with little support from shared non-textual referents	Face-to-face discussion supported by shared attention to data, drawings, graphs, and text

Availability and Access

If pedagogic effectiveness were the only criterion for the adoption of technology, the same (or better) results could be achieved with desktop computers. But availability and access are major problems for desktops. “A computer in every classroom” is a long way from “a computer in every backpack.” In the United States, for example, virtually all public school buildings, and almost all public school classrooms (87%), had Internet access in 2001. Yet there were still 4 – 5 students per connected computer.

This difference between availability of handheld devices (calculators) and desktop computers is clearly acknowledged in the NCTM assumptions from the year 2000 quoted above: It is assumed that calculators are available to *all students at all times* but that computers are available for demonstrations.

It is no wonder, then, that graphing calculators have had a far greater effect on mathematics and science education than have microcomputers. As characterized in [Demana and Waits, 1992], graphing calculators provided low cost, portable user friendly alternatives to computers. Graphing calculators, not microcomputers, have become standard in high school and college mathematics and science classes.

Technological Advances and Their Implications

Graphing calculators induced a change in the classroom from non-reliance on technology to pedagogy based on technological exploration. This change was accentuated by the introduction of “probeware” that allowed real-time data collection. But handheld technology is changing again in three significant ways.

1. Handheld devices are becoming microcomputers. Pocket PC and Palm OS devices exhibit computing power and versatility comparable to those of desktop (or notebook) systems at prices approaching those of graphing calculators.

2. Mobile computing devices are networked. Significant WiFi infrastructure is already being installed at colleges and universities, and cellular technology can provide ubiquitous uninterrupted access to the Internet.

3. Handheld devices are accepting handwriting as input. “Digital ink” and handwriting recognition technology allows natural and more versatile input, something that is quite important in educational applications.

These changes mean that a single handheld device can do it all. For the same price as a graphing calculator a school district can buy handheld devices that can be used by students

- For word processing
- For online information search and retrieval (including ebooks)
- For testing in all subjects
- For computation
- For data acquisition
- For visually displaying and processing information
- For genuine access to diverse languages and cultures

These are all things that are currently done in traditional classroom settings. As has been demonstrated with current handheld technology, the combination of access to information and the means to conveniently process it (visually, computationally or verbally) enables discovery and problem based learning.

In addition, ubiquitous connectivity and visual displays open the door to multi-student games and simulations [PlaySpace 2001] as well as collaboration of the type that "digital natives" [Prensky 2001] find quite natural. Continual access to the Internet changes the way that people search, discover and retrieve information, if for no other reason than convenience. According to [SBIS 2003, Benchmark 48], "three out of four Internet users in the EU prefer online book-searching against the traditional way." The fact is that, as [Prensky 2001] says, "Today's students are no longer the people our educational system was designed to teach." Access to ubiquitously connected, portable and powerful handheld computers has the potential to close the gap between how we teach and who we teach.

Distribution Channels and Control of Content

A major lesson of the last few years of technology is that *connectivity matters.* Not only does connectivity change the way in which people relate to information (and to each other), but it also affects who controls technology.

When new technologies (such as personal computers, graphing calculators and mobile phones) are introduced, it is generally the hardware manufacturers who determine the end user applications. Even if manufacturers make third party development possible, they generally do so via proprietary means that they control. Eventually, however, standards emerge, either because a single manufacturer dominates the market and creates a *de facto* standard or because an industry adopts an open standard. This creates enough platform independence (or platform uniformity in the case of *de facto* standard) that it becomes commercially viable for independent software vendors to develop end user applications. This is the point at which true innovation can occur.

For innovation to have an effect, however, there must be distribution channels that provide access to end users. This is where connectivity comes in and why the Internet is different. In other media, such as print, radio, cinema, music and television, the companies who own the distribution channels (publishers, radio and television networks, film studios, and the recording industry) control the content. On the Internet, this is not the case. Control of intellectual property in a distributed networked environment [ALA 2003], and of the wireless network itself, are some of the major issues affecting the spread of m-learning and the classroom use of networked handheld devices.

Wireless Wars

Wireless connectivity itself seems inevitable. Wireless is more convenient and it costs a lot less to install and maintain a wireless network than a copper or fiber based network. However, there are two competing approaches to providing wireless connectivity. One approach is through mobile telephony. PDA's and mobile phones are merging, so one possibility for the m-learning device is the "smart phone" that is both a mobile phone and mobile personal computer. The other approach is through WiFi, which is already being used by PDA's and Pocket PC's. Although it will not affect the pedagogic or sociological implications, competing choices of this nature are not welcomed by people investing in an organization's technology infrastructure and inevitably slow the adoption process.

Comparing the two choices, the mobile phone approach has the advantage that connectivity is passed from cell to cell. Even with competing standards (CDMA, TDMA, GSM etc.) a GSM mobile phone can effectively be used world wide and can be used without significant interruption while traveling from home to school or to work.

But a serious battle is taking place. In an attempt to control the distribution channels, mobile phone manufactures are selling phones that are “locked” to a specific carrier (e.g. Vodafone, t-mobile, Telstra, Virgin Mobile, Orange, etc.), and in an attempt to control the content, carriers are trying to force end users to access content only through their services. This is not a stable situation. It is already possible to download J2ME (Java 2, Mico Edition) applications to mobile devices via the Internet and smart cards, completely bypassing the cellular channel. It is also hard to believe that consumers will accept a world that is partitioned into non-intersecting carrier-centric communities, each of which requires a separate set of subscriptions to access the same content.

Meanwhile, WiFi is gaining in popularity and “hot spot” aggregators are now offering access somewhat akin to cellular roaming The IEEE Computer Society 802 standards committee has released not only the 802.11 series of WiFi standards but also standards (802.16) for metropolitan area networks with ranges measured in kilometers instead of meters [Geier 2003]. These standards, as well as some competing proprietary approaches, promise to provide the “wireless last mile” [Cherry 2003]. While the mobile phone industry is straightening itself out, it may well be that metropolitan area WiFi advances to the point where a single access point can cover a school (or work) campus and possibly the area in which most people live, shop, work and go to school. There is even the possibility that WiFi roaming will become a reality, although there are many problems that need to be solved along the way [Chai 2003].

Conclusion

Mobile learning has the potential to be significant and even revolutionary, but there are significant problems it faces. In the classroom setting, mobile learning is an extension of a movement that started with the introduction of graphing calculators and that has been changing classroom pedagogy. There is every reason to believe this movement will gain new impetus and wider applicability with the introduction of ubiquitously connected handheld devices that have the power of a personal computer. There may be no other choice if the educational system is to adapt to the learning styles and meet the demands of future generations of digital natives.

Even though fundamental issues (including the control of distribution channels and content) remain unresolved, now is the time for the e-learning and educational technology community to pay serious attention to mobile learning and handheld devices.

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