

Integrating Pedagogy, Infrastructure, and Tools for Mobile Learning

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INTRODUCTION

With the advent of the Web, students are empowered with environments that support a wide variety of interactions. These include engagement with authentic tasks, using a range of learning resources, and engaging with teachers and/or other students in knowledge-building communicative interactions. However, the concept of the fully wired world where students can learn anytime/anywhere is still unrealized. Instead, the growth of wireless networks has been substantial, with some countries limiting the construction of wired environments in preference to wireless connectivity. Thus, student learning environments and student expectations for convenience and flexibility are evolving to include wireless solutions along with wired Internet access at home or university.

A key issue associated with the growth of wireless services is the corresponding trade-off of service quality compared to wired computing (Associated Press, 2005). The availability of services is perceived as more important than high bandwidth and high security. The growth of wireless networks in the past 10 years has been spectacular, with a raft of technologies and standards arising to provide connectivity (Fenn & Linden, 2005). There is one note of caution: one of the leaders of research into wireless technologies, Cornell University in the USA, believes that due to competing technologies, even a fully wireless campus is still some time away (Vernon, 2006). This is due to:

- limitations in the interoperability of different wireless systems;
- high power requirements of the 802.11 wireless standard necessitating powerful (heavy) batteries for PDAs and smart phones;
- lower security than wired links; and
- potential interference, resulting in frustrated users.

Therefore, the concept of the fully wired or wireless connected world is still unrealized and will remain so for some time to come. Instead, the creation of local wireless hotspots has been suggested as a more cost-effective method (in the long term) for providing greater connectivity *and flexibility*

to students (Boerner, 2002). Local wireless networking is already providing wireless links for students at cafés, shopping centers, airports, schools, and universities.

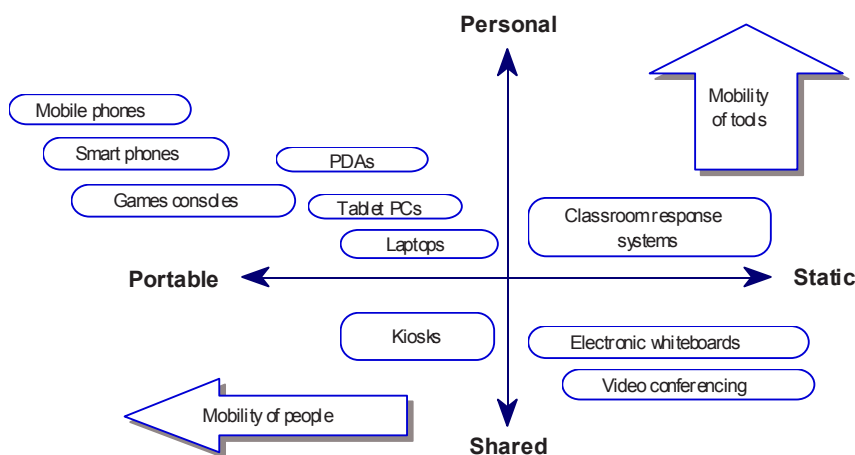
American students now have very high expectations that wireless will be available in all locations on a campus (Green, 2004). In Hong Kong, government statistics list the ownership of mobile devices as having reached an extraordinary level of 122.6% of market penetration (Office of the Telecommunications Authority of Hong Kong, 2005). Students may have a multitude of mobile devices, from mobile phones, iPods, digital cameras, and personal digital assistants (PDAs), to laptop computers. It would be remiss of teachers if they did not attempt to make the effort to utilize such pervasive technologies for teaching and learning as students increasingly try to “cram learning into the interstices of daily life” (Sharples, Taylor, & Vavoula, 2005, p. 58).

In this article the approach adopted for the design of m-learning tools and infrastructure is predicated on the idea that there will be intermittent wireless connectivity with limited bandwidth (e.g., grainy video at best). Students in Hong Kong (like most places) lead busy lives, and access to always-on Internet connections may not be possible or desired. Instead, the concept of flexibility of learning—learning at a time most suitable to the student—is seen as a primary driving factor for our work. What follows is a description of a framework for development of learning tools and institutional infrastructure designed to take advantage mobile devices and the flexibility offered by m-learning.

MOBILE DEVICES AS SEMIOTIC TOOLS

Tools were once seen as some form of some physical object (e.g., a screwdriver, the pulley, a hammer, or the cogs on a bicycle). The purpose of tools was to enhance human strength and/or human capabilities. Traditional learning included the humble pen-and-paper or an abacus. However, humans have also created semiotic tools (Vygotsky, 1978), which are intangible tools to mediate cognition. These semiotic tools include language, numbers, algebraic notation, mnemonic

Figure 1. Classification of mobile technologies (Adapted from Naismith, Lonsdale, Vavoula, & Sharples, 2005, p. 7)



techniques, graphs, and diagrams—most of which may be expressed in the form of media elements that are easily stored, retrieved, and manipulated by computers (Kennedy, 2001). Since Vygotsky's time, technical tools (computers, PDAs, mobile phones, smart phones) have come to encompass devices that can utilize and manipulate signs (intangible tools) to enhance human cognitive processes (Duffy & Cunningham, 1996; Jonassen & Reeves, 1996). Current mobile devices function as computer-based cognitive tools, helping people to store, organize, structure, communicate, annotate, capture information, play, and engage in increasingly complex tasks, blurring the distinction between tangible (hardware) and intangible (software and signs) tools—one without the other is meaningless.

The feature set of mobile devices is improving rapidly as the power of the central processing unit (CPU) increases, following Moore's Law as desktop computers have for past decades (Zheng & Ni, 2006a). The future looks bright with the convergence of personal digital assistants, mobile telephones, and digital imaging into devices described as smart phones (Zheng & Ni, 2006b). The growth of computing power in such devices offers many opportunities for learning. Already such devices are endowed with features and facilities in the realm of science fiction just a few years ago, running a variety of operating systems with support for the .NET framework from Microsoft, Java, multimedia capability, and storage capacity in the multi-gigabyte realm, rapidly overcoming limitations described only a few years ago by Csete, Wong, and Vogel (2004). For example, connection speeds have risen dramatically.

However, if the potential of mobile tools for learning is not to be wasted, there is a pressing need to develop appropriate learning tools that can provide structure to the student experience. Such learning tools need to be pedagogically

sound, offer high levels of interactivity, and be compliant with the available infrastructure. It has been shown that placing content on the Web or storing it in a learning management system (LMS) is not sufficient for learning to occur (Ehrmann, 1995; Reeves, 2003; Rehak & Mason, 2003). It is even more disadvantageous to do so in a mobile environment with limitations on screen size, battery life, and processing power, notwithstanding the rapid development of functionalities and features. Some examples are the virtual keyboard (<http://www.virtual-laser-keyboard.com/>) and more powerful batteries that enable faster, power-demanding CPUs and hard drives to be used for longer periods of time (<http://www.medistechnologies.com/>).

DEVELOPING FOR THE MOBILE LEARNER

Vavoula and Sharples (2002) suggested that mobility is an intrinsic property of learning. They argue that learning has spatial (workplace, university, home), temporal (days, evenings, weekends), and developmental components (the learning needs/life skills of individuals which change depending upon age, interest, or employment). Figure 1 is a diagrammatic representation of this view.

In Figure 1 there are two arrows. The horizontal arrow indicates increasing mobility of people (right to left), while the vertical arrow indicates increasing mobility of the device. In the work described in this article, the focus is on the top left quadrant, with high mobility for people and devices. Applications (mobile learning tools or m-learning applications) that support mobility of devices and people have a number of criteria that differ widely from the desktop environment. In Table 1 the basic design elements suggested by Zheng

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