ABSTRACT

Student use of mobile computing devices such as laptops, PDAs and Tablet PCs is increasing. Such devices, taken in a higher education context, have the potential for a major impact on pedagogy, on the use of teaching spaces and in the provision of resources for teaching and learning. Opportunities abound, but attempts to embrace Mobile learning (m-learning) should be tempered by practicalities. M-learning raises issues in a number of areas including IT infrastructure development, support provision and teaching practice. Such issues need to be addressed by the institution as a whole and involve IT departments, libraries and faculties.

1 INTRODUCTION

It is necessary that higher education institutions look at the impact of m-learning while it is a relatively new phenomenon. M-learning has already had an impact on provision of learning resources, and in the way students interact with campus facilities. It is reasonable to assume that the use of mobile technology will increase in the future. Institutions need to prepare strategies that enable them to take an active role in realising the potential benefits.

In 2003, the University of Melbourne was one of seven universities in the Asia-Pacific region to win grants from Hewlett Packard to fund initiatives in the use of mobile technology. This paper is informed by the work undertaken as part of these initiatives and identifies challenges to be faced if institutions are to take advantage of this latest development in the area of e-learning. The paper examines the question of sustainability for m-learning support, the impact on provision of services and facilities and the creation of approaches that are robust enough to survive further technological developments in this area.

2 DISCUSSION

2.1 HIGHER EDUCATION CONTEXT

The combination of wireless and mobile computing and student use of increasingly small computing devices is stimulating change in higher education including increased flexibility of learning spaces – libraries, classrooms, cafes, lounges and outside areas have been transformed through the introduction of wireless technologies. A survey of the literature reveals many exciting projects and opportunities for the concept often referred to as mobile or m-learning. Equally a number of issues are raised that need to be addressed if m-learning is to be a viable, sustainable strategy within higher education. In his recent article Alexander (2004) describes a new world of mobile learning that impacts the student, the classroom and the campus through new uses of a wide range of nomadic technologies. Seeing how study, learning and infrastructure are impacted by new technologies is vital for policy and resource allocation.

2.1.1 ENVIRONMENT

In an EDUCAUSE 2004 Conference presentation, “Educating the Net Gen”, Oblinger (2004) reported on recent research on the Net Gen – that group of students born in or after 1982 who have grown up in an environment characterised by mobile devices, the Web, instant messaging and online communities. She sees students as being drivers of institutional IT agendas. Yet a recent survey of
The Evolving Technologies Committee of EDUCAUSE conducted a study in North America that revealed a significant discrepancy between the reported widespread adoption of consumer mobile technologies and the actual perception of wireless services as an "add-on" to the campus infrastructure. (Hitch & McCord, 2004).

In universities, our current generation of learners operates in an "always on" environment. They are digitally literate, mobile and experiential and gravitate towards group activity. The largest discretionary block of time for students is outside of class. Oblinger (2004) says that informal learning is self-directed, internally motivated and unconstrained by time, place or formal structures. With wide area wireless coverage, students learn to combine their mobility with always-on information in new learning spaces.

One classic purpose of a university is the co-location of experts and students, together with physical information (libraries). M-learning can amplify this model as interested persons can contact and hook up with experts and co-learners nearby and around the world, gaining access to digital and physical content. This suggests "swarm" behaviour, where multiple members of a distributed group coalesce on a single point. Experts can put out a digital shingle, awaiting learners, who search for teachers’ profiles. (Alexander, 2003)

Students as well as academics are experiencing a blurring of work and leisure activities. Time spent travelling on buses, trains and planes is used for both business and private pursuits with the aid of mobile devices. In the Academy Internet Newsletter, Jackson (2003) says that we can expect three major components to provide critical impetus to the development of m-learning strategies:

- the ubiquitous availability of high bandwidth communications links, whether via a WiFi hotspot in Starbucks, or through the mobile operators’ 2.5 and 3G networks, enabling delivery of any item of learning material, anywhere;
- an expectation that the introduction of these packet based networks will not just provide an always-on environment, but eventually lead to the same low connection costs experienced in the fixed internet environment; and
- a generally available base of low cost, full colour, multimedia mobile phone, PDA and PC terminals to deliver and process learning tools and content. However, he cautions that availability of suitable content will limit the deliverability of m-learning services in the short term.

2.1.2 PEDAGOGICAL CONTEXT

Chen et al., (2002), note that the principal pedagogical considerations to be taken into account are the urgency of the learning need; the need for knowledge acquisition; the mobility of the learning setting; the interactivity of the learning process; the situatedness of the instructional activities and the integration of instructional content. McLean (2003) cites Singh as explaining the pedagogical processes necessary to support the new m-learning paradigm. Notable in Singh’s requirements is the need to move from courseware to performance-ware.

"The stand-alone learning content model needs to transform to a context-driven, task-sensitive, performance-support model. Examples include guide tasks, instructions, job-aids and reference-ware. In addition, standards need to be defined to interchange performance objects which are delivered within the context of a job task, with learning objects which focus on modular course content.” (p. 10). McLean sees the Macquarie University’s Learning Activity Management System as a useful way of achieving this. LAMS is the first example of the application of technology to learning activities as distinct from content development. Therefore, it is the ideal vehicle to link with the use of mobile devices. The size of the knowledge object is the key. No-one is going to take a 2 hour course on a PDA. On the other hand, delivering a smaller learning object, say, a refresher or a discrete piece of knowledge, is where the power of m-learning excels. Similarly, mobile devices are well suited to providing:

- Extension of e-learning programmes to mobile workers.
- Stimuli for other learning activities – pre-seminar/conference prompts and tasks can establish participant entry knowledge levels. Post event communications can reinforce seminar inputs and test for acquired knowledge.
- Immediate time/location-based learning needs. Online decision support, diagnostic aids and treatment protocols, e.g., “Talking Pictures“ at the Tate (Bluetooth enabled)
Extension of public sector life-long learning programs to the general public.

Alexander (2004) reports that at the University of Minnesota, Duluth, PDAs are also used for quizzes and simulations, as well as for traditional applications that require spreadsheets, word processors, and Web browsers. Students appreciate the easy access to data, including preloaded multimedia content.

In a JISC Technology and Standards Watch Report on wearable technology, de Freitas and Levene (2003) identify several limitations of mobile devices that need to be considered when developing educational applications. An obvious one is their small screen size, which can be very limited, for example on mobile phones. Solutions to this problem necessitate innovative human-computer interface design. They also have limited performance, in terms of processor capability, available memory, storage space and battery life. Such performance issues are continuously being improved but, to counter this, users’ expectations are also growing. Although currently there is a problem of slow “anywhere” internet connectivity; 3G technologies promise to improve the situation. Wireless LAN connectivity, such as 802.11, provides simple and reliable performance, but only for localised communication.

2.1.3 SUPPORT SERVICES/SCAFFOLDING
Cases of successful integration of mobile technologies into e-learning share a common factor – planned support for the innovation in the form of technical expertise, help services and training to support both students and teachers. For example, Shepard (2002), describes Cleveland State University’s provision of help desk, desktop support, and training areas. He also included his university’s security administrator in his support team to make sure they avoided developing programs or processes that would compromise data security by allowing users to download data to a device that could be easily carried off site. Their support also extended to preparing support policies, the standards for their selected hardware platform, desktop personal information managers, synchronisation software, and approved software.

De Freitas and Levene (2003) state that standard software tools are widely available, although the different platforms are not always compatible. This is not a major problem, since communication occurs through standard web and email protocols. Current personalisation and collaboration tools are mainly based on static profiling, while what is needed is a more dynamic and adaptive approach. There are still outstanding issues regarding content management and delivery of e-learning materials, since these technologies, that we assume will be XML centric, are still evolving.

Infrastructure issues (3G networks, bandwidth and protocols), security issues, as well as form factors and usability of mobile devices (power, data input and output) are receiving much attention. (Alexander, 2004; Dix et al, 2000; Pirhonen, Brewster and Holguin, 2002). According to Carroll, Kjeldskov, Tobin and Vetere, (2003), these factors alone are insufficient to ensure successful use. Carroll et al describe an alternative, user-centred approach that involves examining the ways that mobile technologies can add value to users’ lives.

2.1.4 PROFESSIONAL DEVELOPMENT
Clearly, teachers and instructors need to be highly proficient in the use of the technology for students to receive the most beneficial instruction. It is integral that teachers and instructors be provided with an ongoing professional development program that caters not only for training but also for fostering a supportive and motivated outlook towards using technology. One-off training sessions and workshops tend to be inadequate for this purpose, and can sometimes lead to the failure of the intervention as a whole. Professional development programs should contain connections to student learning and curriculum specific applications, hands-on technology use and active participation. A variety of collegial learning experiences needs to be provided along with sufficient time for teachers to further develop their skills. Administrative support, adequate resources and continuous funding are also important (Rodriguez and Knuth, 2000). Furthermore, a strong network of technical support within the institution is another requirement for effective professional development.

2.2 THE TRIAL OF MOBILE COMPUTING AT THE UNIVERSITY OF MELBOURNE
The emergence of mobile technology and the potential impact on teaching and learning was identified as an issue by the University of Melbourne. Early in 2003, several suppliers were approached by
representatives of the Faculty of Law and the Information Division with a view to establishing a partnership whereby a clearer picture of the use of mobile technology in an educational setting could be obtained.

The integration of mobile technology in campus life suggests a range of opportunities, both actual and potential, to enhance teaching and learning activities, but little was known about the patterns of usage adopted by users of the technology. The literature suggests mobile technology can be used effectively on and off campus, within the classroom, for collaborative work, and for communication between students and staff. What might that look like? The future also was considered. What applications, both currently available and under development, might enhance the use of mobile devices? Applications that are “location aware” were considered. Thus, it was noted that there were a number of emergent threads that were particularly relevant to the use of mobile devices in an educational context.

Investigating potential uses of the technology was the overall aim of the project and this aligned well with developments on campus in the area of wireless networking, and with the institution’s high-level strategic goal of enhancing teaching and learning with technology. An application was prepared for Hewlett Packard’s Applied Mobile Technology Solutions Grant. The University of Melbourne was one of seven universities in the Asia-Pacific region to be successful. The University received A$240,000 worth of equipment, including 26 Hewlett Packard Tablet PCs and 57 Hewlett Packard iPAQ handheld computers, for trials in the faculties of Law, Medicine and the department of Information Systems (Faculty of Science). The Information Division was to provide professional development support for aspects of the project.

2.2.1 MEDICINE
In the Faculty of Medicine, Dentistry and Health Science, the Department of Rural Health chose to trial the use of Hewlett-Packard Tablet PCs in a rural clinical setting. Final year students spend two weeks in a small rural community with minimal IT support. The Tablet PCs potentially offered a means to access medical databases, create and use logbooks, make notes and create reflective journals. The ease of use of Tablet PCs was seen as an attractive aspect of the technology. The Tablet PC’s ability to utilise pen-based input, had potential to overcome personal and cultural barriers that may exist when a keyboard-equipped laptop is used in a clinical settings. This, combined with handwriting recognition was seen as a useful tool for clinical activities, and wireless connectivity options would help to facilitate these processes.

The Tablet PCs addressed a number of perceived needs. A portable and easy to use element of technology was seen as an essential tool in a rural clinical setting – a setting that quite often lacks the infrastructure, learning support and wireless connectivity options that exist on campus. In addition, access to medical databases, literature and other point-of-care information can be limited in remote areas. To counter this, a number of University of Melbourne information resources and other medical databases were “loaded” onto the Tablets for use in the rural placement programme and this has given students access to information resources that may well have otherwise been inaccessible.

2.2.2 LAW
The Law faculty recently moved to purpose-built facilities incorporating well-equipped teaching spaces and wireless networking. This was the setting for the trial of the use of the latest mobile technology - iPAQ “Pocket PCs”.

As part of the Hewlett Packard Grant, the Faculty of Law received 33 iPAQ Pocket PC h5550s. The group of students chosen to make use of the mobile technology were from the Juris Doctor programme. These students are generally professionals returning to study and have various levels of familiarity with technology in professional settings. The student cohort is small, around 25.

The faculty identified a need to investigate the benefits of mobile technology to the traditional Socratic methods employed in Law education. The nature of teaching in Law means that there is an opportunity for incorporating the use of tools such as iPAQs with “live” access to the Web and to legal resources during classroom interactions. The potential transformation of learning environments and spaces and the way in which they are used was considered, as well as different information seeking behaviours that might emerge.
Provision of electronic legal resources in an IPAQ-friendly format was also an issue - would widespread use of such devices have potential impact on the way in which such legal resources were formatted for delivery?

There was also potential for collaboration on documents, including sharing and working on documents with multiple authors. It was recognised that this has wider application for small group work and lessons learned here would have application in collaborative group work generally. Also, tools to assist in time management and tracking were seen as important for this group of professionals.

2.2.3 INFORMATION SYSTEMS
The Department of Information Systems in the Faculty of Science chose to work with both IPAQs and Tablet PCs. A state of the art facility called the Interaction Design, Evaluation and Analysis (IDEA) Laboratory is to be used to support phases of the project. Human computer interactions were studied in a variety of settings, and new applications of emerging technologies, involving mobile technology, were considered. Students developed scenarios, conducted analyses of feasibility and built prototypes of innovative applications.

The use of mobile technology in teaching was investigated. Postgraduate and senior undergraduates were involved in the project. Undergraduate students used IPAQs for assignments that involved the application of mobile technology. Masters Students undertook research into human usability using the devices. In addition, a number of research projects were established to look at location-aware aspects of device use.

2.2.4 INFORMATION DIVISION
The Information Division's role in the project was to provide professional development support. To this end, a range of resources was created that introduced Tablet PC and IPAQ users to the functionality of these devices. In the case of Tablet PCs, the pen-based input and digital ink aspects were particularly addressed. Involvement in this project was seen as furthering the Information Division's goal of supporting the enhancement of teaching and learning with technology and the mobile technology involved was seen as a powerful tool that has great potential for effective and innovative use in higher education.

2.2.5 OBSERVATIONS
It is not the purpose of this paper to analyse the findings of the various elements of the Mobility project, and it should be noted that the trial is still underway. It is, however, possible to make a number of useful observations.

In Law, there is an increased willingness to use technology. The convenience and ease of use of the IPAQ devices for accessing and sharing information contribute to this. There is also evidence that the devices are being used to support professional practice.

The IPAQ's screen size, processing power and battery life (especially when accessing the wireless network) are seen as limiting factors and the addition of a mobile telephone function would be welcome. Electronic resources suitable for hand-held use are not widely available from legal publishers and Law supplied content in an appropriate form through in-house means. As reported in the literature, the Law trial confirms that device effectiveness is limited by design issues and physical constraints. Completion of the project holds much promise in providing material that will inform policy, and purchasing decisions in the Faculty of Law.

In the Department of Rural Health, a functional evaluation of the Tablet PCs was undertaken to establish their usefulness in the clinical setting. Issues emerged with the usefulness and effectiveness of the handwriting recognition function. It was noted that a Tablet PC was more useful for taking notes that remain as handwritten notes, albeit electronic and shareable. The Tablet PCs used by the Department of Rural Health were not all equipped with the optional docking station. The lack of a CD ROM drive (in particular) highlighted the usefulness of hardware to achieve docking functionality. Access to wireless networking infrastructure was also an issue.

A key area of functionality for Tablet PCs is wireless access to the Internet. This is not always available at small rural hospitals. Access to traditional network access points is also required. This
observation is the catalyst for developments in the wireless networking infrastructure available at rural locations.

Overall, students are finding the Tablets a useful resource for their studies although it is early days yet. Developments in wireless infrastructure will no doubt expand potential use of devices in a rural clinical setting. It was observed that there were differing levels of engagement with the particular technology among academics. It might be observed that this is true in a general sense also, and, as noted, the University has a key strategic aim to develop and support the use of technology in teaching and learning.

The Department of Information Systems investigate opportunities to use mobile technology as the platform for location and context aware guides for places such as museums. Other innovative applications include a means whereby mobile device users can negotiate opportunities to collaborate, communicate, and interact, through their devices. It is apparent from such work that there are a number of opportunities for the development of innovative applications for portable and personal devices.

2.3 GUIDELINES FOR SUSTAINABLE M-LEARNING

Following are a set of guidelines for the implementation and support of sustainable mobile technologies and m-learning. These guidelines are based on our experience through the Hewlett Packard mobility project and reflections on issues emerging from the literature.

2.3.1 PEDAGOGY

Teaching and learning principles should be made an integral part of any approach. At the University of Melbourne, for example, the document, *Nine Principles Guiding Teaching and Learning in The University Of Melbourne* should be examined - both to clarify effective, research-based principles, and to inform a vision that considers how these principles may be applied using technology. In order that technology be accepted, and successfully implemented, it must be seen as a servant of pedagogy.

The presence of a variety of mobile devices in the teaching space presents a number of challenges. An effort must be made to raise the awareness of the possibilities that mobile devices offer and to seek "insertion" points for the use of the technology into the practice of teaching. This effort need not imply the creation of specific resources suitable for mobile devices, but should encompass an awareness of issues in the creation of documents that are suited to a range of devices and are suitable for collaboration and sharing by students.

Mobile devices, while representing a number of opportunities in enhancing the way students learn, can also be sources for innovation. Examples are content "beamed" to all students and "clicker" applications in lectures.

2.3.2 FLEXIBLE SPACE

As a teaching and learning principle, James and Baldwin (2002) note students should have opportunities to work together both inside and outside of the classroom. Observation suggests that students embrace group activity, whether facilitated or not. Increasingly, mobile technology is being utilised in such group work. Mobile technology has potential to impact on the design and use of existing spaces and the development of new spaces for students. With the emergence of powerful portable devices such as the IPAQ, there is potential for a significant change in the way that computing facilities for students are offered. Portable devices (in the case of IPAQs, perhaps equipped with a keyboard) can be used for a range of activities normally associated with student computer lab access: email, simple word processing, Internet/Web access. The use of mobile devices should reduce the requirement for desktop computers for these applications. Instead, resources can be diverted to computers that are powerful and are suitable for tasks beyond the capacity of many mobile devices, such as digital manipulation, multimedia creation, and complex document preparation. This can result in space that is flexible, wireless enabled and capable of supporting a range of technology-facilitated student activities. Such a space is well suited to collaborative learning and provides an environment that is rich in communication, collaboration and flexible access to information, both electronic and paper-based.
2.3.3 WIRELESS DEVELOPMENT
Increased development of the wireless infrastructure should be closely aligned with observed usage of the technology. Swarming behaviours, technology choice, patterns of use of devices can all inform developments in this area. This presupposes clear lines of communication between areas responsible for network infrastructure, technical support, education support and those investigating the impact of emerging technology.

While ubiquitous wireless access is highly desirable, it is not absolutely necessary. Frequent access to wireless "clouds" can be used to good effect with the spaces between being bridged by a student-based, information-laden, pedestrian network. These wireless clouds can be used to advantage in the provision of resources. As noted by Alexander (2003) “Leading the way in developing wireless practices are members of a community anchored in such locations, including reference librarians in a library, and students living in a dorm.” Network access is increasingly broadband and as a consequence, fast. The wireless network should not be seen as a poor cousin to the wired network and it should be constantly developed to make best use of developments in this area.

2.3.4 CONTENT FOR PORTABLE DEVICES
To maximise the use of handheld devices (in particular), content should be considered from the point of view of how it will look on a range of devices. This is already a consideration in terms of general guidelines for accessibility of teaching and learning materials. Developments in the use of XML for the separation of structure from content are useful in this regard. The small screen size on a number of mobile devices should be a consideration, as should the relatively limited computing power available. Some things to consider:
- materials made available from the Learning Management System are suitable for access on a range of devices;
- the use of XML to structure content is investigated/encouraged;
- cross platform content types such as e-books are utilised;
- limitations of mobile devices are considered in the development of m-content;
- multiple access points for content are available (Wireless, Bluetooth and infrared methods of content dissemination should be considered);
- the creation of mobile-friendly content is a component of professional development;
- the multimedia capability of mobile devices is considered.

2.3.5 PROFESSIONAL DEVELOPMENT
Professional development is a key element in the effective use of mobile technology. A clearly articulated, conceptual basis for professional development should encompass the development of knowledge in the use of technology in teaching and learning, as well as the acquisition of skills. Some things to consider when structuring approaches to professional development:
- staff should be aware of student use of mobile technology;
- uses in teaching and learning interactions should be demonstrated and suggested;
- the use of mobile technology should be embedded in an e-learning context;
- emerging trends should be identified, and impacts discussed;
- the focus is on technology as a tool for education;
- a combination of approaches should be used in professional development delivery;
- support for professional development should be underpinned by robust technical support infrastructure;
- support and professional development should be clearly differentiated;
- the expectations of users should be addressed;
- technical support interactions should be seen as opportunities for professional development.

2.3.6 SUPPORT
The support of personal, mobile devices represents a challenge to existing support resources. The ubiquity of mobile devices brings with it the need for support. Issues of “just-in-time” and “on-the-spot” support need to be addressed. It should be noted that support will be sought, regardless of the communicated levels of available support. In fact, enhancement of the infrastructure and environment in order to facilitate the use of mobile devices is sometimes seen as encouragement to use such
devices (which, in a sense, it is). With this encouragement then, is the implication that other needs will be met. This is particularly true of the support area, and this expectation needs to be planned for and managed.

Some issues to consider:

- the institution must clearly establish the level of support that will be available to users of personal technology and this information should be clearly communicated to all stakeholders - for example, a "recommended list" of devices that qualify for a higher level of support;
- support staff become investigators of new technologies;
- expertise is developed in the use of a range of mobile devices;
- service desk personnel (libraries, IT, student facilities, etc.) are familiar with mobile technology and able to offer "low-level" support and guidance towards other support resources;
- accept that support will be sought;
- support is closely aligned with professional development.

3 CONCLUSIONS

At present, it is primarily the type of access device and availability of suitable content that will limit the deliverability of m-learning services but this will undoubtedly change. Perhaps a more central concern for the use of mobile devices in educational contexts is the need to provide stable pedagogies that can migrate for the benefit of the learner according to the device, location and learning outcomes and objectives.

The social and educational benefits of mobile devices include the greater mobility and flexibility for the learner by potentially increasing the capacity of the learner to learn “anytime, anywhere” according to subject specificity and selected pedagogical models and approaches. This has particular benefits for lifelong learners, distance and part-time learners, as well as campus-based learners, providing greater flexibility by facilitating collaborative learning within ‘communities of practice’ (Wenger 1998).

Through improving access to digital content, opening up campus spaces to information, and setting the stage for ad hoc learning groups, campuses are entering the wireless, mobile world making m-learning work for higher education’s core missions of teaching and research.

A close alignment of objectives with implementation can help to embed the use of technology (and not just mobile technology) into teaching and learning. There should be a clear articulation of what is intended and how it is being implemented. At the University of Melbourne, in its strategic plan, there is a focus on the goal of creating and maintaining “…superb learning environments for undergraduate and postgraduate students” and enhancing “the quality of learning and educational outcomes in the University by “developing flexible course structures and delivery options;…” (The University of Melbourne, 2004). The guidelines discussed above will only support a sustainable m-learning environment if they are aligned with the institution’s core strategic aims and they need to be embedded in appropriate policies, plans and strategies.

We are seeing an increasing use of what is essentially personal technology and regardless of the actions of institutions, it would be reasonable to assume that usage of powerful, portable computing devices will increase. Mobile computing is fast becoming, if not already, ubiquitous. That being the case, any approach that does not take a holistic, institution-wide approach is in danger of being totally unprepared for a student driven phenomenon.

4 REFERENCES


