Table of Contents

mLearning in Education – a summary ................................................. 1

First, there was the Book ........................................................................... 1

Some Considerations for mLearning ............................................................ 3

Linking mLearning to education theory and practice .................................. 3

Technologies - Issues in Delivery of mLearning........................................ 5

The Digital Divide: Access, ICT literacy and Information Literacy .......... 8

Content Issues: Available, Affordable, Appropriate ................................. 9

National Strategies: Integration, Coordination ........................................... 10

Worldwide mLearning: Trials and Trends .................................................. 11

Summary of mLearning in Key Geographies................................................ 11

Conclusion .................................................................................................. 16

Selected examples of mLearning Projects, Activities and Initiatives in Key Geographies ................................................................. 19

Selected Activities and Projects in the United Kingdom............................ 19

Selected Activities and Projects of the European Union ........................... 23

Selected mLearning Projects in United States of America (US) ............... 24

Selected mLearning Projects in Australia ................................................... 27
mLearning in Education – a summary

First, there was the Book

Possibly, the first widespread mLearning device was the book.

We are familiar with the benefits and constraints of books - books enable information to be accessed across time and space, provide a record of what has happened, how it has happened and to whom, and enable learning and knowledge transfer between individuals, organisations, and cultures.

We have moved beyond the book to mobile technologies that utilise the same underlying concepts - but our expectations of technology-enabled learning and its education applications are still being developed and explored.

Mobile Learning is most often referred to as mLearning, and over the last few years has been variously defined by academics and specialists.

For example, Milrad (2003) defines eLearning as ‘learning supported by digital “electronic” tools and media’, and by analogy, he defines mLearning as ‘eLearning that uses mobile devices and wireless transmission’. Quinn (2000) defines it simply as ‘learning that takes place with the help of mobile devices’. Others (Turunen et al. 2003) define mLearning devices more broadly; ‘as a pervasive medium that may assist us in combining work, study and leisure time in meaningful ways’.

For the purposes of this paper, the term Mobile Learning (mLearning) is quite generally applied to using for teaching and learning, mobile and handheld IT devices, such as Personal Digital Assistants (PDAs), mobile telephones, laptops and tablet PC technologies.

Widely used mobile devices include multi-purpose mobile phones with colour screens, web access and email, but may also incorporate PDA functions, digital radio and interactive digital TV.

PDAs and mobile phones are the most commonly used technologies for mLearning, but they exist within the wider domain of possible mobile technologies. These can be broadly defined by two concepts: personal, - where individuals have their own equipment, such as a mobile phone, as opposed to shared devices, and portable, where mobile equipment provides access to static resources. In association with mLearning, the concepts portable and personal have both been consistently applied. Portable solutions provide learning opportunities accessed as a person move through their environment; and personal, allows an individual to access one piece of learning from a variety of ‘static’ locations. Both of these definitions are acknowledged, and to a large extent, generalised in this summary.

Technologically-assisted learning, on which this concept of mLearning depends, builds on a long tradition of distance education, stretching from correspondence study in the 1840s to educational television, mailed-out video and audio cassettes, audio and video teleconferencing, and most recently the use of interactive multimedia, including CD-ROMs and re-usable online learning resources.

It also draws on flexible classroom-based delivery, librarianship and information science, and the independent pursuit of knowledge through conventional research and self-directed inquiry. In considering mLearning, this breadth frequently encourages discussion of definitions of learning, with a common tendency being to refer to “learning”, when what is actually meant is...
“teaching” or “training”. Any attempt to define “learning” in general, and its implications, are not directly addressed in this summary.

There are a number of challenges in discussing the impact of Information and Communication Technologies (ICT) on teaching and learning broadly, and more specifically considering mLearning. The first is the challenge posed by the huge and growing body of literature about mLearning and the associated rapid technological developments underpinning its spread and use.

Today, the volume of information available is so great, and the speed of change so rapid, it is difficult to keep up with developments, even within this fairly specialised area. Partly because of this rapid growth, the quality of information about mLearning is also variable. Anecdotal, speculative, developmental and conjectural claims are frequently presented in the same domain, and often in the same form, as more objective and empirical information.
Some Considerations for mLearning

There are several education implications associated with mLearning which are broadly shared internationally.

Linking mLearning to education theory

Most reviews of technologies and mLearning have been concerned with technologies to address specific curriculum areas or delivery issues. In addition, there has been some theoretical interest in building mLearning into existing education theory. This relates mLearning to an activity-centred perspective, essentially considering new practices against existing education theories. A review of the literature reveals six broad theory-based categories of activity, and identifies a number of examples of the use of mobile technology in each of them.

Behaviourist: activities that promote learning as a change in learners’ observable actions

In the behaviourist paradigm, learning is thought to be best facilitated through the reinforcement of an association between a particular stimulus and a response. Applying this to educational technology, computer-aided learning is the presentation of a problem (stimulus) followed by the contribution on the part of the learner of the solution (response). Feedback from the system then provides reinforcement. In a mLearning context, classroom response systems like “Classtalk” (Dufresne et al 1996) and “Qwizdom” (Qwizdom: Assessment for Learning in the Classroom 2003) fall in this category, as well as examples of content delivery by text messages to mobile phones (BBC Bitesize 2003, 2004).

Constructivist: activities in which learners actively construct new ideas or concepts based on both their previous and current knowledge

In a constructivist approach, learners are encouraged to be active constructors of knowledge, mobile devices embedding them in a realistic context, at the same time as offering access to supporting tools. Compelling examples of the implementation of constructivist principles with mobile technologies come from a brand of learning experience termed ‘participatory simulations’, where the learners themselves act out key parts in an immersive recreation of a dynamic system. Examples include the Virus Game (Collella), Savannah (Facer et al), and the Environmental Detectives (Klopfer and Squire).

Situated Learning: activities that promote learning within an authentic context and culture

Situated learning posits that learning can be enhanced by ensuring that it takes place in an authentic context. Mobile devices are especially well suited to context-aware applications simply because they are easily available in different contexts, and so can draw on those contexts to enhance the learning activity. The museum and gallery sector has been at the forefront of context-aware mobile computing to extend the gallery experience into personalised learning. Examples of mobile systems that situate learning in authentic contexts include the Ambient Wood (Rogers et al 2002), MOBIlearn (Lonsdale, 2003, 2004), and multimedia tours at the Tate Modern (Proctor and Burton 2003) and elsewhere.
Collaborative: activities that promote learning through social interaction.
Mobile collaborative learning has developed from computer-supported collaborative work and learning and is based on the role of social interactions in the process of learning. Many new approaches to thinking about learning developed in the 1990s, most of which are rooted in Vygotsky's socio-cultural psychology (Vygotsky 1978). Mobile devices can support mobile computer-supported collaborative learning by providing other coordination strategies without attempting to replace any human-human interactions, as compared to say, online discussion boards which substitute for face-to-face discussions (Zurita et al 2003; Cortez et al 2004; Zurita and Nussbaum 2004).

Informal and lifelong learning: activities that support learning outside a dedicated learning environment and formal curriculum.
Research on informal and lifelong learning recognises that learning happens all the time and is influenced both by our environment and the particular situations we are faced with. Informal learning may be intentional, for example, occurring through intensive, significant and deliberate learning “projects” (Tough 1971), or it may be accidental and occur as individuals acquire information through conversations, TV and newspapers, observing the world or even experiencing an accident or embarrassing situation. Such a broad view of learning takes it outside the classroom and, by default, embeds learning in everyday life, thus emphasising the value of mobile technologies in supporting it.

Learning and teaching management: activities that assist in the coordination of learners and resources for learning activities.
Education as a process requires considerable learner and resources management. Mobile devices have been used by teachers for activities such as attendance reporting, reviewing student marks and achievements, accessing central school data and coordinating class timetables and locations. In higher education, mobile devices provide course material to students, including assignment due dates and information about timetable and room changes. Examples using mobile technologies in this context include a mLearning organiser developed and tested at the University of Birmingham (Holme and Sharples 2002; Sharples et al 2003; Corlett et al 2004), and the use of mobile phone technologies to support computing students (Riordan and Traxler 2003; Traxler and Riordan 2003).
A blended approach to enabling learning with mobile technologies is necessary as successful and engaging activities increasingly draw on a number of different education theories and practices.
Technologies - Issues in Delivery of mLearning

A connected, mobile society is emerging from the world of the book - with varied information sources and means of communication available at home, work, school and in the community. This has been described as the beginning of the next social revolution. (Rheingold 2003) and with it comes both new capabilities and new expectations.

For example, the legacy concept of the PDA as a device to manage personal information has been extinguished and superseded by a realistic opportunity for learners to experience multimedia via their handset, regardless of whether the device is considered primarily a phone or a handheld computer.

There is considerable interest in exploiting the almost universal appeal and abundance of mobile devices for their educational use. The Internet is increasingly considered as, and is being used as, an educational tool accessible via these devices. Devices have become more portable, affordable, effective and easy to use and increasingly connect users to a wide range of information services and educational opportunities. They are more cheaply priced than desktop computers, and therefore represent a less expensive method of accessing the Internet, although the cost of connection can be higher.

The ubiquitous nature of mobile devices provides opportunities for increasing participation and access to ICT and education, and in particular to utilising services delivered via the Internet.

Increasing access to mobile technologies

There were 91 million mobile phone subscribers at the end of 2004, an estimated 1.5 billion mobile phones subscribers by June 2005, and over 3 billion subscribers predicted by the end of 2010 (Informa, 2005). The Mobile Technologies and Learning Report (Atwell, 2005) states that, in mid-2005, there were more than three times the number of cellular phones per person than personal computers (PCs), and today’s most sophisticated phones have the processing power of a mid-1990s PC, and it is increasing.

A high proportion of UK residents already have mobile phones (75% of the general population, 90% of young adults; (Crabtree et al 2003)) that can handle both voice calls and the display of textual information.

Many newer phones also have the ability to connect wirelessly to the Internet. PDAs are also becoming more widespread (BBC 2004), being distributed by employers eager to keep their workforce productive whilst on the move. Laptops, though already a well-established technology, have new appeal when combined with the connectivity of newer mobile phones - a laptop can now use a mobile phone to dial-up the Internet and offer a truly mobile web experience. Furthermore, kiosks and information screens are appearing around the UK, and both researchers and industry recognise the potential of these “ambient” approaches to provide rich information spaces.

Improving mobile functionality

The Nokia N770 Internet Tablet, “smartphone”, (mobile phones with PDA functionality) has now dropped the cellular GSM connection in exchange for WiFi and Voice over IP (VoIP), combined with a high resolution screen (800 x 480 px - 5.5” x 3.1” size) running the Linux based, Internet Tablet 2005 operating software with Opera Browser with Flash player.

Potentially, as an intelligent thin client, it could be a device to deliver web or Internet-based
learning materials, although its current battery life (three hours while browsing) could limit universal school application.

Nokia has teamed with Google to include Google Talk with the latest software upgrade to the Nokia N770. Google Talk is Google’s response to Skype and brings Instant Messaging and VoIP to the N770 thus allowing free Internet telephony.

At the end of 2004 and during 2005 Nintendo and Sony both released handheld gaming platforms of immense internal processing power and ability for audio-visual rendition. Within four months Nintendo had sold more than 6 million units of its DS system retailing for just £99 in the UK, proving that it is now possible to have wireless rich media handheld computing on a mass scale at an affordable price.

Like the gaming platforms, the general purpose systems such as those using Symbian, Palm or Windows Mobile operating systems now provide sufficient processing capability and wireless connectivity to move away from traditional handheld computing applications to include built-in cameras and audio recording capability providing the more diverse and rich media experiences typically found on high-end multimedia desktop computer systems.

The term “Portable Internet” is sometimes used to describe a platform for high-speed data access using Internet Protocol (IP), which covers:

- advanced wireless technologies like Wi-Fi, WiMax, IMT-2000, ultra wideband and radio frequency identification (RFID) tags. These operate at long, medium and short ranges;
- new techniques that make more efficient use of the available spectrum, including spread spectrum, smart antennae, agile radios and mesh networks.

Short-range technologies, such as Bluetooth, ZigBee and RFID allow low-power connectivity within a range of 30 metres.

Medium-range technologies can communicate at least 150 metres from a hotspot (Wi-Fi, or IEEE 802.11b) and up to several kilometres, depending on environment and regulatory factors.

Finally, long-range technologies such as WiMAX (IEEE 802.16) and IMT-2000 (3G) have ranges that extend up to 50 kilometres from a base station, and to near-nationwide coverage when offered as a networked service. Also in this category fit solutions based on high or low-altitude platform stations (HAPS/LAPS) that can serve a whole town and satellites that can serve a whole region.

Wireless connectivity is critical to effective mLearning developments. Internet-enabled portable devices based on these technologies may hold considerable future promise - particularly in places where fixed-line infrastructures are difficult to install. Adequate regulatory and policy measures need to be in place to encourage operators, private sector investors and users to expand services and launch innovative new projects. Governments have a key role to play in this, for example through policies for licensing that are conducive to fostering new services, and through pro-competitive policies which can still maximise benefits for users.

**Summary of types of mobile Internet connectivity**

*Global systems for mobile communication (GSM):* designed for voice communications, but adapted for small amounts of data transfer.
High speed circuit switched data (HSCSD): designed to allow GSM to transfer data at rates of up to four times the original network data rates.

General packet radio services (GPRS): designed to give increased data rates as well as charging based on amounts of data transferred rather than the time spent transferring the data.

Third generation (3G) mobile: designed to offer a consistent set of services to mobile computer and phone users. Increased data rates (up to a theoretical maximum of 2Mbps) should allow a far wider range of services, including video conferencing.

Enhanced data GSM environment (EDGE): designed to co-exist with GSM. It should allow GSM operators who don’t have licences for the 3G spectrum to provide users with data rates that would, in some cases, challenge 3G data rates (up to a theoretical maximum of 554Kbps).

Public access WLAN: designed to enable users to access the Internet in localised “hotspots” via a wireless local area network (WLAN) access card and a personal digital assistant (PDA) or laptop. While data speeds are relatively fast compared with mobile telecommunication technology data rates, their range is short.

Linked public access WLANs: designed to link a number of public access WLANs to give high speed access in, for example, the centre of a town.

Public access WLAN and mobile telecommunication convergence: access technology allowing users/devices to move between a telecommunications technology (eg GPRS, 3G) and public access

WLAN to gain the highest available data rate, depending on geographical location: Currently being discussed, it is likely that devices will become available for seamless roaming between technologies.

Selected examples of technologies that could be usefully applied in mLearning

Podcasting: likely proliferation of audio content to mobile devices, link to broadcasts from free to air media, FM radio, or organisation specific broadcast (eg lectures, professional development).

Audio and video Blogging: “mBlogging” – Audioblog.com simplifies posting of audio and video content to blogs.

Integrated location and communication capabilities: GPS, GIS, RFIDS, sensors and other technologies into mobile devices to support experimental learning.

Search and visualisation technologies: easier and quicker access to content on mobile devices.
The Digital Divide: Access, ICT literacy and Information Literacy

Despite the sweeping changes noted in many contexts worldwide, it must be recognised that, although widespread, the impact of ICT, let alone mLearning, has not been universal. To the extent that some individuals and groups do not have adequate access to, or the capacity to use, networked digital technologies, they are effectively “locked out” of significant economic, cultural, social and intellectual activities.

In reality there are multiple digital divides which must be attended to in order for the benefits of the knowledge economy to be reaped both individually and collectively. These issues are not specific to mLearning but have become widely acknowledged since ICT has been associated with education.

Neither the confidence nor the competence to use digital technologies is universal within the Australian community or in its education sectors.

In order to avoid the phenomenon of “information have”s and “have nots”, a coherent national strategy is required to achieve ICT literacy for the general population. The ability to make use of online resources entails more than simply ICT literacy; it also necessitates the ability to be discriminating about the information that is encountered online.

This emphasises the potential benefits of implementing a national strategy that incorporates both ICT literacy and information literacy.
Content Issues: Available, Affordable, Appropriate

A significant issue for mLearning concerns easy access to available, affordable and appropriate information/content. With the increasing use of mobile devices to access learning materials, educators need a range of learning materials available to provide to users. Much existing learning material was developed for large screen displays on desktop computers and is therefore frequently inappropriate for use on mobile devices with small screens.

Also, existing learning materials were typically developed in large sections which may not be suitable for mLearning where smaller information packets are more appropriate.

Learning objects suit the mLearning approach and can provide just-in-time learning for students and/or can be linked to form complete sequences, lessons or courses taken for credit.

A requirement for successful mobile delivery is that learning objects should be able to be provided as independent components so learners can complete their learning in short spaces of time.

Learning materials for mobile devices must also contain visually rich information that is appropriate for display on a mobile device’s screen. Graphical strategies such as spatial organisers, graphical outline, pictures and illustrations minimise the amount of reading required on a small screen.

In Australia, despite the online content generated, owned or sponsored by Governments and their various education departments and agencies, together with the federated online resource developments of The Learning Federation, limited national networks and fragmented local access continue to place useful information beyond the reach of many potential users, both in the community and in some schools.
National Strategies: Integration, Coordination

The nature of self-directed learning and of digital, and particularly mobile technologies, is such that - especially in combination - they inevitably raise issues and challenges that cannot be met by any one portfolio, or any one level of Government. Accordingly, a range of Government departments and agencies, in particular those with an education, communication or cultural mandate, require “whole of Government” responses to develop a national elearning and associated mLearning strategy. Such an approach would have the dual purposes of enhancing Australia’s competitiveness and ensuring a robust, well-informed democracy, important in an era of increasing information. This requires not only bipartisan support but also integration of both from State/Territory and Australian Governments.

The transition to effective mLearning requires integrated planning. Educational authorities and institutions must evaluate not only content, but existing curriculum frameworks to ensure new resources are relevant to mobile technologies; telecommunication infrastructure optimised; teachers and school leaders trained for mobile delivery and to adapt the culture of the organisation.

One of the challenges that all organisations will still have to face after implementing mLearning is how to keep up with the rapid changes in the technology and expanding technical capabilities of students.
Worldwide mLearning: Trials and Trends

Worldwide, the field of mLearning is characterised by a proliferation of pilots and trials that allow mobile technologies to be tested in a variety of learning contexts. These initiatives are increasingly collaborative, on a larger scale, and are being managed by national authorities (or larger consortia) rather than by individual university faculties or local education organisations. The European Commission has, and continues to fund, a significant number of mLearning development projects - largely because of potential capacity to support policy delivery, together with its significant implications for economic development and unification.

The focus on mLearning is creating an environment of evolving practices in education. Sustained deployment of mLearning will be refined through sharing outcomes of the pilot activities and trials, ongoing evaluation, and the reporting and analysis of implications that arise.

The current trends in mobile computing are towards devices that are even more embedded, ubiquitous and networked than those currently available.

The capabilities of mobile phones, PDAs, games consoles and cameras will likely further merge within the next five to ten years to provide a networked, multimedia device that is always with you.

In the short space of five years, mLearning has already moved from being a theory, explored by academic and technology enthusiasts, into making a real and valuable contribution to the provision of learning opportunities. However, despite pockets of excellence, significant research examples and its demonstrated capacity for strategic change in education delivery, effectively blending of mLearning into current education strategies and practice remains fragmented, rather than widespread in education delivery.

Research has revealed a rich vision for current and potential developments in education, moving away from the initial simplistic view of mLearning as a potentially isolating activity. Exploring mLearning as a rich and collaborative experience, whether in classrooms, homes or the streets of a city. It challenges some existing theories of learning, but shared mLearning activities will help evaluate and identify the most relevant applications of mobile technologies in education.

Summary of mLearning in Key Geographies

United Kingdom (UK)

Overview

Over the last decade a national approach to education delivery and ICT developments has created significant research and application of elearning across the UK. More recently, UK government, education organisations and universities have combined to stimulate and support the development of mLearning through a number of UK specific managed and funded initiatives. These activities often partner schools with corporate technology and/or Higher Education researchers for specific projects. In addition, UK education personnel have been active participants in and provided leadership for several European Union and European Commission (EU) mLearning projects and initiatives.
Kate Anderson, Director of Research at the Learning and Skills Development Agency, said in 2005: ‘The concept of learning in a fixed place is being challenged by these new technologies. Although books and printed communication will still be fundamental to learning, to reach certain people - particularly the young who have been put off by traditional education - we need to devise ways of reaching them using modes of communication that are familiar and fun. The mLearning projects demonstrate now speedily the technology and content is moving to enable this to become the normal way of learning for many young people.’

Some current mLearning areas of interest

- Where are the boundaries between learning and entertainment? Does it matter? To what extent can games and activities delivered through mobile technologies be educational? Several current projects are exploring these questions.
- Will mLearning become a solitary activity possibly adversely affecting young people’s social skills? ‘The sharing of mobiles and messages by friends, both remotely and when they are together, highlights their potential as collaborative learning tools.’ (Jill Attewell, LSDA)
- In the UK, thousands of mobile handsets have been purchased as learning tools. User trials have successfully helped a wide range of hard-to-reach learners in many different contexts. The debate has moved on: the issue now is to understand the different learning models that best incorporate it, to analyse the costs and benefits and support broad application in both education and corporate sectors, to best use mobile elements in their learning strategies.

European Union (EU)

Overview

Each EU Member State is responsible for its own education system, but all are influenced by and learn from each other’s experiences in the use of technology for education and training. Hence, European Commission initiatives such as the eLearning Initiative and the eLearning Programme play a central role in building networks of co-operation that share experiences over Europe. They also help to meet the common objectives of education and training systems agreed by the EU Member States and aim to design a truly pan-European system of quality lifelong learning.

Successful integration of ICT into education and training systems is a main concern of EU leaders and a declared policy priority for 2005/2006. Social cohesion and competitiveness of Europe are seen to depend increasingly on the ability to exploit the potential of ICT for learning. Some documented main benefits of ICT when applied to learning include facility of access, flexibility, learner orientation and better opportunities for collaboration. ‘Learning enhanced by the use of the Internet and new mobile and multimedia technologies should be available to all.’

Two key themes form the basis for the EU’s strategy in the field of mLearning:

- **Enhancing Education and Training**
  It is an EU priority to take advantage of ICT to speed up necessary changes in education and training systems and to break down barriers between different forms of learning. E-learning and mLearning should be available to all.
• **Skills for the Information Society**
  Europeans need to develop new skills to adapt to rapidly changing working and living environments. Actions in this field range from promoting ICT-related skills, to measures aimed at removing obstacles to technology systems and to the free movement of EU workers around the internal market.

**Some current mLearning areas of interest, in EU**

Much initial debate had focused on the definition of mLearning. Is it about mobile learners? Is it about small personal devices? Is it about communication and collaboration? Is it about context sensitivity? Is it an adjunct to e-learning? In the short space of five years, mLearning has moved from being an idea explored by academic and technology enthusiasts, into a real and valuable contribution to learning.

The focus is increasingly moving from the devices to examine the learner experience, making use of whichever devices and technologies surround learners, in an attempt to empower and enrich their learning, wherever and whoever they are. The question is no longer whether mLearning works for learners, particularly hard-to-reach learners, but rather how best to fit it into the education blend.

**United States (US)**

**Overview**

US Secretary of Education, Margaret Spellings, provided a national economic development rationale in 2005, as an endorsement of investment in education technology generally, stating, ‘ICT can provide a powerful platform to help transform and strengthen education to meet the workforce needs of the 21st century.’

Although mobile networks and services in the United States are just at the beginning of broadband and broad-scale adoption, mobile technologies have already had a major impact. Bluetooth technology makes it possible to create personal area networks (PANs) among physically proximate devices, connecting headset device to phones, which can in turn connect to a computer, a PDA, and any other nearby Bluetooth-enabled device. Instant messaging (IM) enables real-time and often simultaneous connections among co-workers, friends, and family wherever there is access to a wireless communication network. Apple iPods have managed to make pocket-sized mass storage devices unmistakably trendy.

Until the early months of 2005, there would have been no strong reason for looking beyond notebook and handheld computers - at least not in North America. However, with the expansion of 3G (third-generation) networks and the increasing availability of “smartphones”, users in Asia and Europe were finding that their broadband connectivity and their computing needs can be met through a single device. And increasingly, that device is a mobile telephone.

US mobile users are starting to experience mobile multimedia, with the growing adoption of GSM telephones with Multimedia Messaging System (MMS) functionality, but the US. wireless service providers still do not offer the kind of broadband distribution capacity needed to ensure a high-quality experience for mobile users.

Nevertheless, advancements in embedding rich media players, such as the Web-ubiquitous Macromedia Flash, in handsets and computers have gone a long way towards mitigating
bandwidth limitations by enabling rich, engaging presentation layers on a wide variety of mobile devices, regardless of the form.

The heightened interest in mobile possibilities for teaching, learning, and research in USA can be attributed to a number of factors: the continuing expansion of broadband wireless networks; the explosion of power and capacity of the next generation of cellular telephones; and the fact that mobile telephones, a familiar tool for communications, are already fully integrated in contemporary life and social practice.

Unlike other mobile devices used in education, devices such as PDAs or tablet computers, require very little extra effort to get people to adopt and use mobile phones. This situation allows more things to be done with the mobile phones to which they are already attached and with which they are already reasonably competent and confident.

Nevertheless, when it comes to mobile adoption, the United States is relatively behind the curve. The broadband, multimedia connectedness taken for granted by the typical Korean or Nordic citizen is something that most US citizens are not likely to see for some time. As a result, US educators are finding themselves in the awkward position of knowing that the mobile revolution is coming, without really being able to implement learning, be confident about what it’s going to look like or knowing what the possibilities for mLearning may be.

US government support for mLearning initiatives has been relatively limited, with key individuals and specific university faculty research therefore being critical in developing current theories and applications. While it has been expected that colleges and public universities stay abreast of rapid changes in the application of information technology, typically they have very limited budgets. In addition, students familiar with the potential of mobile technologies and communication, increasingly expect staff to apply innovative technology in the classroom and integrate it into the curriculum. Studies and initiatives with wireless technology use in the classroom have examined the processes and methods to successfully integrate PDA networked technology into the IT curriculum at some public universities. Universities which required students to use PDAs for courses found that the skills of IT department had to be expanded to effectively implement them in curriculum delivery. Academic staff has similarly been required to address significant change.

Activity in the K-12 sector has been consistently managed through the national Consortium for School Networking (CoSN) which has provided significant national leadership and integration for ICT in learning broadly, in addition to a specific focus on mLearning developments. Activities include competitive grant programs which placed Palm handhelds in classrooms as early as 2000-2001 with subsequent evaluation focused on gathered user surveys, site visits, and site-based evaluations implemented by PEP awardees and their teams, with guidance from researchers.

The CoSN site disseminates information about national initiatives and links to specific information about K-12 mLearning developments and key activities, including:

- **About Palmtops** site: information about handheld industry, which includes Palm OS and Pocket PC.
- **Brighthand** site: reviews of handhelds, smart phones, forums include one on the use of handhelds in education.
- **Computing Unplugged** - publication: news items and feature articles on handheld devices.
• **Concord Consortium** web page: older articles and resources about the Ubiquitous Computing project.

• **Donna McGauley's Palm Resources** site: instructions for creating mobile classroom, lesson plans, tips, tutorials and links to recommended applications.

• **EduPalm Web Page**: advice, recommendations and links to a variety of resources.

• **Geek.com** site: reviews, ordering, newsletter about emerging technologies - including handhelds.

• **GoKnow**: sells programs developed by Hi-CE researchers, professional development, consulting services and lists of articles on handheld technology in schools.

• **Handheld Computing in Education**: Rutgers University - links to recommended software and hardware and recent research projects on using handhelds to enhance student learning.

• **Handheld Computers in High Schools**: teacher-created site for handheld resources and use.

CoSN also provides product reviews, research publications and case studies to disseminate mLearning practice. This information includes:

• **TEEMSS Research Report** from Concord Consortium: examines the feasibility and educational value of probeware (used in conjunction with handhelds) in middle school science education.

• **Freedom to Learn Evaluation Report** from Michigan State University: evaluates the impact of a 1-to-1 wireless computing project in 15 districts, K-12, during the 2002-2003 academic year.

• **IPAQ Handheld Computer Evaluation Report, Broward County, Florida**: case study and internally evaluating first-year mLearning implementation in grades 4-12, in four schools.

• **Preliminary Reports on mCLASS Assessments**: large-scale reading and literacy assessment tools implemented in Texas and New Mexico. Preliminary evaluations from both states statewide implementations of a pilot program using a handheld versions of reading tests to assess primary-grade students in 100 schools; and Using handheld computers to support assessment: A Look at New Mexico’s Reading First initiative.

Extensive CoSN Product reviews and information include:

• **Handheld Hardware**: Reviews of a wide range of handheld computers and graphing calculators, sold to K-12 market.

• **Handheld Software and Other Products**: The list of handheld software publishers is long with links provided to key distributors and resource sites. Information and descriptions of many applications, peripherals and handheld devices.

**Some current mLearning areas of interest in US**

The big issues that have emerged in research and discussion include identifying that essentially it’s the learner that’s mobile and that network solutions are not necessarily supportive of mobile individuals’ learning. There are concerns about how mLearning can both complement and conflict with formal education and defining the most effective ways to provide “just-in-time” fragments of information to mobile learners. The importance of context, constructed by learners through interaction and how learning is interwoven with everyday life, are areas
currently being researched. The ethical problems of ownership and privacy in relation to mobility have yet to be addressed in terms of education system responsibilities.

Australia

Overview

Current mLearning initiatives within the education and training sector of Australia are characterised by fragmentation. Several universities and education faculty staff have pockets of research, initiatives and enthusiasm; however their work is essentially focused on the Higher Education sector, providing limited awareness of research outcomes or benefit to K-12, VET or life-long-learning developments.

The Australian Government has taken no significant interest in developing or optimising networks or mobile systems to support mLearning. Market forces have been allowed to fragment potential interoperability, which would maximise benefits for learners nationally. Dr Marcus Bowles, director of the Institute for Working Futures, states that Australia’s telecommunications companies are stifling the economic benefits of mLearning by defending market share and confining mobile data transmissions to high-cost cellular networks. In the over-regulated and under-planned Australian market, Dr Bowles says the private sector and local governments are resorting to building their own networks to resolve the problems.

“Switching across any network is impossible in the Australian market because it’s all been cut up”. The development of mLearning in Australia is being constrained by network and mobile telecommunication inadequacies.

- The Learning Federation initiative in the K-12 sector is creating resources and learning objects which have generic qualities appropriate for mLearning delivery in that they are a national resource, are significantly visual rather than text-based, and can be delivered in small segments to support individual learning needs. In terms of content, use of these resources can be maximised through integration with mLearning applications.

- The Flexible Learning Network has a separate, established collaborative production and digital delivery system to meet the specific needs of their learner groups.

Combining the knowledge and expertise of these significant existing resource developments would maximise benefits, share practice more effectively across Australian education cross-sectorally and stimulate development of mLearning expertise to position Australia significantly in mLearning internationally.

The vision is clearly defined; mLearning is at the intersection of mobile computing and eLearning: accessible resources wherever you are, always networked, powerful processing, strong search capabilities, rich interaction, support for effective learning, and performance-based assessment. It is eLearning independent of location in time or space. What is less clear is where we are now and how we can deliver on the mLearning vision.

Conclusion

While this review has identified largely government supported mLearning initiatives, it must be acknowledged that there may be relatively little that national governments acting alone can do either to encourage or to support mLearning beyond providing funding to stimulate research and collaboration through project delivery. Empowering learners, amplifying their capacities and strengthening the quality and availability of information provision requires governments to
work with businesses, researchers, professional associations, education and training institutions, information providers, communities of interest and others, to provide the best possible conditions for the emergence of a society of learners. Such conditions start with a commitment to the ideal of access to, and strong support for the intrinsic value of learning not only for economic competitiveness but also for personal satisfaction and growth.

The Internet does not belong to any single group and, because it is simultaneously everywhere and nowhere, it does not lend itself to conventional terrestrial legal and political mechanisms. It is vital however, to create a sense of trust in the technology for learning purposes and to protect the interests of the relatively powerless and marginalised against the large players who might seek to exploit the digital domain unfairly or to compromise learners’ access to needed information. Governments and other authorities have only limited power to “control” the digital domain through traditional means.

Education can benefit from using emerging mobile technologies to deliver learning matched to the increasingly “neomillennial” learning styles of their students. Based on “mediated immersion”, these learning styles include:

- Fluency in multiple media and in simulation-based virtual settings, often multi-tasked;
- Communal learning involving diverse, tacit, situated experience, with knowledge distributed across a community and a context as well as within an individual;
- A balance among experiential learning, guided mentoring, and collective reflection;
- Expression through nonlinear, associational webs of representations;
- Co-design of learning experiences personalised to individual needs and preferences.

Many teachers will find this shift difficult, although professional development can accommodate neomillennial learning styles to continue teaching effectively, as the nature of students evolves.

Despite the rapid mLearning developments in Europe and the UK, in Australia currently and particularly outside urban areas, few mobile devices are ubiquitously connected, having instead only dialup capability; meaning intermittent connection. This is a component of the two major issues. The first is the problem of having managed learning through an intermittent connection; the second is cross-platform solutions necessary to enable all learners to have access to all materials independent of particular technology or system preferences.

Device-independent delivery has stimulated work in advanced information representations that separates content elements from format. One example is eXtensible Markup Language, (XML) allowing content to be separated from how it appears on each different device. Unfortunately, national delivery networks represent a different scale of problem.

Education authorities are increasingly embracing certain aspects of the digital revolution to ensure that everyone has at least minimal levels of access and competence, recognising that new paradigms of teaching, learning and information provision are likely to prevail in the future. At least 20 mobile providers have formed a consortium (5 January 2005) to develop a new standard (Super 3G) for the transmission of data over mobile networks.

The new standard will be up to 10 times faster than 3G, to an extent, still in its infancy. It is reported that the development of the technology could conclude by 2007, with commercial launches after 2009. It is thought that Super 3G could allow for services not available over 3G, including continuous video broadcasting and full movie downloads.
It is inevitable that the speed of change with regard to mobile communication devices in particular and technology in general is set to continue and a great deal of “new” technology will be widespread by the time it reaches the education market.

Finally, mLearning is a collection of pieces to be fitted to a learning need, not a single solution. There have already been guidelines developed to support effective implementation of relevant systems and policy. When elearning first became widespread, one of its biggest constraints was the assumption that it could become a solution to all learning problems; that teachers were no longer required, and that anything could be taught using it.

We now know that this is not the case, and that good teachers, communication, collaboration and stimulating activities are essential, as they are with mLearning. The first step into mLearning seems to be the most important. In a majority of trials and project activities, the organisations have continued to do their own mLearning long after the trials have finished. The key starting point for them on their m-journeys was taking that first step: trying it out, defining effective solutions for their learners in the local context.
Selected examples of mLearning Projects, Activities and Initiatives in Key Geographies

Much of this project information is not original work, but is acknowledged with thanks, as having been drawn directly from project websites (both current projects and those completed).

Selected Activities and Projects in the United Kingdom

PDAs to Support Teaching and Learning

As early as 2002-2003, Department for Education and Skills (DfES) sponsored a handheld computing pilot with 150 teachers at 30 schools (Perry 2003). The foci of the project were managing teachers’ workloads and identifying support for teaching and learning. A number of features of mobile technologies met with universal participant approval. These included pragmatic features such as the small size and longer battery life than laptops. The storage capacity of PDAs was generally rated as highly favourable, along with ease of synchronising data with other devices. The relatively low price of PDAs was also cited. The qualities consistently disliked included the small screen, unstable data storage and complexity of synchronising with PC’s and printers.

Large EU mLearning projects including the UK

In May 2003 the potential of mobile devices for revolutionising the way people learn was the focus of the MLEARN 2003 conference organised by the Learning and Skills Development Agency (LSDA) on behalf of two mLearning projects - “m-learning” and “MOBIlearn” - both supported by the European Commission’s Technology Enhanced Learning (TEL) Unit in the Information Society Technologies programme. Over 200 delegates from 13 countries experienced a range of new research, ideas and mLearning technologies which had been disseminated and developed at that time.

Ideas, innovations and technologies presented from projects included:

- encouraging disaffected young people (some of whom are homeless) to become involved in learning through games, quizzes and mini soap operas on mobile phones and PDAs (UK);
- the use of mobile messaging to motivate students and make revision fun (UK);
- multimedia guides to galleries and museums incorporating movies, images, music, Internet access and email facilities on handheld devices (UK and Italy);
- context-aware, location-based learning content provided anywhere, anytime to anyone;
- mobile collaboration and ad-hoc networks to support organisational learning;
- incorporating video clips onto handheld devices to train people in hospitals (Sweden);
- integrating learning through mobile phones into traditional classroom teaching (Germany);
- learning a foreign language through mobile phones (Finland and UK).
The Learning2Go Project

Conducted in Wolverhampton, using the Fujitsu Siemens Pocket Loox 720. The Pocket PC platform was chosen because of the similarity of the applications to PCs, the ease of creating and viewing e-books, its onboard camera and its high quality VGA Screen in full 640x480 resolution using se_vga, making web browsing a viable experience. The project also uses content through a device running Flash. Phase 2 of the project has 1000 devices in use.

Mobile phones for language learning

Two mobile language learning systems for mobile phones were implemented and tested in 2003 (Thornton and Houser 2004). SMS was used as part of an English language course, where students were sent frequent vocabulary messages, which also act as reminders to revise. The lessons proved effective and were well received by the students. The system takes advantage of “push” technologies and promotes regular study. Researchers did note, however, that students were postponing study until they would have the time to concentrate on the task.

Skills Arena (2004)

A mathematics video game developed and implemented using the Nintendo Game Boy Advance system to supplement conventional curricula and teaching methods. Drills in subtraction and addition are presented as a game with advanced scoring and recordkeeping, character creation and variable difficulty level. Students can select the name and physical traits of their character, which they use to compete in “matches” against computer-generated opponents, ranked by difficulty and by increasing the speed at which the problems are displayed on the screen.

BBC Bitesize (2003, 2004)

An initiative to provide revision of learning. Promoted as a crossplatform environment, it was initially difficult to get the Java game running on all phones. The SMS service was originally free, but excessive demand forced the BBC to charge for the messages, leading to a significant decline in popularity.

CTAD: materials for mLearning

Content varying from simple text messages to more complex, interactive multimedia - designed to be delivered on handheld computers that can provide animations, sound and colour. Materials are related to attractive paper based resources such as fliers, scratch cards and “z” cards, to be used in conjunction with the mobile devices, such as for engagement activities, signposting or drill and practise activities.

The Curriculum Online programme

Developed as part of the Government’s vision to use ICT to raise educational standards in schools. Curriculum Online is providing teachers with easy online access to a wide range of digital materials to support their teaching across the curriculum. A central element of the project is a dedicated portal launched in January 2003 where teachers can search for digital material from accredited suppliers that meets their specific requirements. Funding in the form of e-learning credits that can only be used to purchase eligible Curriculum Online software has also been released to schools.
The Department for Education and Skills (DfES) evaluation of Curriculum Online

DfES has contracted the National Centre for Social Research (NatCen) and the University of Bristol to conduct a four-year evaluation of Curriculum Online to assess:

- the educational impact of Curriculum Online in schools;
- the operational effectiveness of the programme and the impact that it has on the education publishing and multimedia industry (ie suppliers of educational material).

The educational impact of Curriculum Online is being measured through a series of surveys and by qualitative research in schools.

Joint Information Systems Committee (JISC)

Significantly focused on Higher Education and Further Education, JISC has funded and managed several mLearning initiatives, frequently located in schools. Different trials investigated different approaches to using mobile devices. In some cases using mobile phones already owned by learners. In others, high-level phones, or PDAs were provided. The learning was sometimes supplementing activities already underway; in others the learning activities were constructed around the mobile devices. In almost all of these scenarios, it was found that the learning worked best for both the learner and teacher when it spanned the mobile device, and other media or group activities. Typically it was combined with group activities, paper-based materials, other ICTs, and everything else the teachers would normally do.

These findings are supported by other studies exploring the different approaches to learning and what opportunities wireless and mobile technologies can offer. The JISC innovative practice guide (Knight 2005) suggests distinguishing between these learning perspectives:

- learning as acquiring competence;
- learning as achieving understanding (both individually, and collaboratively);
- learning as social practice.

All of these have a place in the mLearning blend and JISC applies its project outcomes to maintain a broad range of digital services including; supporting open access, legal information, resource guides, managed learning environments and digital repository programs.

Futurelab - Various Partnerships, Research and mLearning projects

Working in partnership with industry, policy and practice, Future lab is a not-for-profit organisation, committed to sharing the lessons learnt from research and development in order to inform positive change to educational policy and practice. Futurelab:

- incubates new ideas, taking them from the lab to the classroom;
- offers hard evidence and practical advice to support the design and use of innovative learning tools;
- communicates the latest thinking and practice in educational ICT;
- provides the space for experimentation and the exchange of ideas between the creative, technology and education sectors.

Futurelab has ICT research projects in several areas. It also maintains a program of innovative prototype development, seminars, reports and research, in partnership with schools and UK universities. The Literature Reviews, undertaken with key academic researchers in the
investigated area, provide valuable summaries of current issues and initiatives. One example is the extended Literature Review in Mobile Technologies and Learning by Laura Naismith, Peter Lonsdale, Giasemi Vavoula and Mike Sharples, University of Birmingham. The outline states that “Mobile technologies are a familiar part of the lives of most teachers and students in the UK today. The challenge for educators and designers, however, is one of understanding and exploring how best we might use these resources to support learning. That we need to do this is clear – how much sense does it make to continue to exclude from schools, powerful technologies that are seen as a normal part of everyday life? This review provides a rich vision of the current and potential future developments in this area”. Some recent Literature Reviews include:

- **Teaching with Tangible Technologies**: University of Bath, University of Nottingham;
- **14-19 and Digital Technologies**: Oxford University;
- **E-Assessment**: University of Durham;
- **Games and Learning**: University of Bristol.

### Development of Data-input Software – (adaptive intelligence)

Developed and patented by a specialist UK SME to provide a solution that has the adaptive intelligence to learn the user’s language traits and behaviours, comprehend the user’s input topics and intentions, understand its context and suggest appropriate words/phrases accordingly. The solution has simultaneously:

- Increased users’ word-per-minute data entry ratio, reduced keystrokes per character, errors and typing time;
- Improved accessibility (ergonomics and ease of interaction) with computer and mobile devices PC, laptop, PDAs, smartphones.

### TOPILOT project (2004)

Developed a low-cost multimedia open access, distance learning service for young people in the community of occupational travellers, such as circus, fairground and barge workers across the UK, for whom school and college terms are too rigid, particularly in the mobile summer period. The project set up a mobile school-based telematics network using multimedia learning equipment for both primary school and vocational training. The equipment with mobile GSM is available to travelling learners, with results supported by school tutors. Costs will be kept low by cheap narrow-band tutor/learner communication.

### UltraLab and m-Learning (Anglia Ruskin University)

*m-Learning* was a €4.5m, 3 year pan-European research and development programme supported by the European Commission’s Information Society Technologies (IST) Programme. The project started October 2001 and ended September 2004, coordinated by the Learning and Skills Development Agency (LSDA). Participant organisations included universities and commercial companies based in three EU countries - Britain, Italy and Sweden. Prototype products and services developed for m-Learning have delivered information and learning experiences via technologies that are inexpensive, portable and accessible to the majority of EU citizens. The target audience included young adults aged 16 to 24, who are unemployed, under-employed and/or homeless and who are not currently taking part in education or training. The
products and services were designed to capture the interest of the young adults and to assist them in the development of life long learning objectives. Learning themes therefore focused on themes such as football and music, with “bite-sized” learning modules designed to develop aspects of literacy and numeracy.

Selected Activities and Projects of the European Union

EU strategy for Technology Enhanced Learning

A Strategic Objective of the Information Society Technologies research priority is supporting research to define the value that information technologies and new media add to learning processes. The principal objective is to increase the efficiency of learning for individuals and groups. The research work in various projects will integrate technological, cognitive, pedagogical and organisational aspects and lead towards interactive systems and open platforms to enable distributed learning, learning from experience, collaborative learning and personalised learning. In addition, European Commission programmes such as eTEN and eContent promote the use of ICT for education and training.

The MOBIlearn Project

A worldwide European-led research and development project exploring context-sensitive approaches to informal, problem-based and workplace learning by using key advances in mobile technologies. The MOBIlearn project is the largest research project in mLearning to date, exploring new ways of using mobile environments to meet the needs of self-learning and collaborative learning. The MOBIlearn project outcome, mLearning architecture, will support creation, brokerage, delivery and tracking of learning and information contents, using ambient intelligence, location-dependence, personalisation, multimedia, instant messaging (text, video) and distributed databases. Field trials will cover “blended learning” (as part of formal courses); “adventurous, location-dependent learning” (during visits to museums); and “learning to interpret information sources and advice” (acquiring medical information for everyday needs). The project contributes to the economic development of mLearning at the international level as participants include public bodies, mobile operators/device manufacturers, software and learning technologies production companies, publishers/content providers, and participants in standards initiatives. The University of Southern Queensland (USQ) and education.au have participated in a MOBIlearn project in 2004. (see Australian projects and initiatives)

ACTeN (Anticipating Content Technology Needs) Initiative

An EU Commission funded project (launched 2002) to initiate a European e-content network by bringing content experts from all countries, to collect information and exchange their best practices; stimulate the development of a European e-content industry with a particular emphasis on cooperation between EU and candidate countries. A collaborative initiative for two years, that brings together 11 educational, research, and commercial partners from 10 EU and accession countries. Networks for e-content were developed through market monitors, business roundtables, workshops contests and scholars conferences. In order to deliver immediate value to the industry and decision making bodies such as the European Commission, results from regular events were disseminated as reports, national profiles, and via the project website.
Networks and access

The European mobile communications sector has been notably successful through the development of the second generation (GSM) mobile telephony with European users having fully embraced the services that this technology provides (65% of the EU population currently subscribe to GSM). As the technology evolves from 2G (mainly GSM) to 2.5 (GPRS) and to 3G (UMTS) the scope of the services and applications that can be provided is significantly enlarged, to an extent which is not yet fully understood in terms of possibilities and potentialities. In order to ensure a coherent and harmonised development of European-wide consumer appealing services and applications, the European Commission - under the Information Society Technologies (IST) Programme - has launched an initiative to support developing/trialling/validating of new multimedia rich services and applications on a Pan-European basis. The initiative:

- supported trials of applications and services;
- provided focused, “networked” sets of relatively small initiatives (3-4 projects);
- supported (through co-financed expenses) the develop/trial/validation of new services;
- addressed 2.5G and 3G services and applications;
- managed quick initiatives, flexible to match market conditions and timings;
- aimed at pan-European services, to ensure openness of services (use of open APIs/middleware for seamless network roaming);
- involved current developers of Internet applications on fixed lines to work on mobile platforms;
- involved content providers (eg publishers, sport associations, compatibly with IPR issues);
- exploited synergies with existing industry initiatives;
- was of short duration (18 months or less).

**M-learning project**

Originated from an EU Commission three-year pan-European research and development programme, aimed at helping young adults aged 16 to 24, who were considered most at risk of social exclusion in Europe. The group consisted largely of disaffected learners who had not succeeded in the education system. They were not involved in any education or training and were unemployed, under employed, or even homeless. What many had in common was access to a mobile phone, inexpensive, portable and accessible to the majority of EU citizens.

**Selected mLearning Projects in United States of America (US)**

**iPods enter Duke Classes**

The entire Duke University class graduating in 2008 received Apple iPod digital devices as part of a university initiative to encourage creative uses of technology in education and campus life. This mix of pop culture, information technology and pedagogy has generated enormous interest from other educators as well as news media. Examples of how some Duke courses are using the devices include: catching quotes, recording and reviewing lectures, recording and analysing news events, speeding the collection of data in labs, assisting language learning, using iTunes to illustrate engineering principles and to assist class discussions.
Environmental Detectives

The MIT *Games-to-Teach* project seeks to further explore the development of “augmented reality educational gaming” (Klopfer and Squire 2005). Augmented reality educational gaming builds on recent developments in handheld gaming, where context-sensitive data and social interactions are used to supplement real world interactions.

Individual Academic leadership – Research and Resource development – Elliot Solway

For the past 25 years, Elliot Solway has worked to improve K-12 education through the use of computing technologies. A recent venture, *GoKnow, Inc.*, is demonstrating how handheld computers can transform K-12 classrooms by enabling 1:1 computing for each and every child. *GoKnow* provides administrators, teachers, students and their parents/guardians with a complete, handheld-centric solution. *GoKnow*’s award-winning handheld software including *FreeWrite*, *Sketchy*, *Cooties*, *Fling-It*, and *PAAM*, are based on 15 years of classroom-based research at the University of Michigan. For the past six years, Elliot and his colleagues in HI-CE have worked in 28 middle schools in Detroit, with over 10,000 students.

Research Centre for Education Technology (RCET), Kent State University

Research activities have been designed to explore students' use of mobile computing devices and effects on their motivation to learn, engagement in learning activities, and support for learning processes, with a special focus on mainstreamed special needs students. Preliminary data was collected from students in four elementary and two 7th grade science classes in Northeast Ohio. It included usage logs, student work samples, student and teacher interviews, and classroom observations. Findings highlight the personalisation of learning afforded by such devices both in terms of individuals and individual classroom cultures, as well as their usefulness in extending learning beyond the classroom, and suggest that increased motivation due to mobile device use leads to increases in the quality and quantity of student work. Findings also indicate that the use of mobile computing devices may help lesson the gap in academic achievement between special needs and regular students. Findings indicate that handhelds provide students with both private and public workspaces, and opportunities to show conceptual understanding of what has been learned in a wide variety of ways.

1:1 Initiative

In the US, laptop computers were once seen as the way to realise 1:1 student to computer ratios. While Maine’s Governor Angus King spearheaded Maine’s 1:1 Laptop Initiative in 2002, he has subsequently publicly stated (April 25, 2005) that laptops are too expensive and lower-priced alternatives are needed in order to truly scale 1:1. The broad range of “sublaptops”, from small screen palmtops to 7” screen notepads, are emerging that can do 80% of what a laptop can do at 10-20% of the TCO (total cost of ownership). Thus, after spending considerable sums to build its computing infrastructure, with 2-3 computers per room, a computer lab or two, as well as wired and wireless networking, a school can now spend a relatively small amount of money to fill out that infrastructure and provide each and every child with their own, small mobile, networked, computer to use for all learning activities and for their own personal activities as well. This development is currently underway.
Consortium for School Networking (CoSN)

MLearning research in the US for K-12 is significantly focused through CoSN, the main national organisation in education technology leadership for K-12 strategically aiming to improve teaching and learning. This integrated approach through CoSN provides products and services to support and nurture leadership development, advocacy, coalition building, and awareness of emerging technologies. Activities for mLearning are part of that work.

CoSN technology leadership initiatives include:

- Accessible Technologies for All Students (www.accessibletech4all.org);
- Cyber Security for the Digital District (www.securedistrict.org);
- Data-Driven Decision Making (www.3d2know.org);
- Safeguarding the Wired Schoolhouse (www.safewiredschools.org);
- Taking Total Cost of Ownership to the Classroom (www.classroomtco.org); and
- Developed the Council of School District Chief Technology Officers (CTO Council).

CoSN’s membership includes a blend of education and technology leaders, policy makers, and influencers from the public and private sectors.

CoSN launched the Data-driven Decision Making Initiative: Vision to Know and Do, in February 2003, building upon its role in providing key K–12 school district managers with the knowledge and skills necessary for effective leadership, including ICT. This initiative is a:

- respected source of up-to-date, unbiased information for educators on collecting, understanding and using data effectively;
- practical mechanism for educating school leaders about data-driven decision making and its applications in elementary and secondary education; and,
- nationally recognised framework for sharing knowledge among educators and transferring knowledge between the educational and vendor communities.

Data collection, analysis and reporting have become critical components of the national education policy initiative No Child Left Behind (NCLB). School districts must collect more data, in more detail and disaggregate them to track student progress. State-level systems and support are being developed for collecting and integrating student assessment data with demographic information.

CoSN reports include:

- A Guide to Handheld Computing in K-12 Schools; The second report by CoSN's Emerging Technologies Committee. Based upon extensive research and interviews with educators, administrators, and industry experts, the report evaluates handheld computers and their applications in education and administration, assesses their strengths and weaknesses, offers advice about implementing handhelds in K-12 schools, and reports on lessons learned by early adopters. Much of the report focuses on ways in which handhelds are used in K-12 education, administration, and decision making. Growing numbers of schools are evaluating handhelds because their low cost makes them a viable solution for one-to-one computing initiatives which many educators believe are essential for technology to be integrated effectively into K-12 education. Also, when handhelds have wireless capability and are networked, their mobility makes possible anywhere, anytime learning.
• *Why Wireless?* (2005) The report, developed with input from several wireless technology providers and many educators, explores the ways in which eight different districts are using wireless LAN technology. It outlines some of the most compelling reasons schools give for purchasing wireless LANs including:

- **Mobility:** Wireless networking allows users of laptops, notebooks, PDAs, tablet PCs and wireless Voice Over IP (VoIP) telephone devices to roam freely on campus while remaining connected to the school's network;

- **Flexibility:** With frequently-changing needs, schools face the need to move classrooms and reconfigure computer networks. With WLAN technology, it is possible to connect buildings, to change lab locations and classroom setups frequently and easily without the need for hard-wire drops;

- **Savings:** Eliminating the need to wire and rewire provides financial savings for schools. Space savings are possible as well, with wireless mobile labs taking the place of the older, hard-wired labs.

- **Expandability:** By adding on to existing networks - rather than replacing the wired with the wireless - districts expand their options without losing their initial investment in infrastructure.

**Security Report:** A potential drawback to wireless technology. It has influenced security measures to be built into the IEEE’s 802.11 standard. However, it is almost universally accepted that wireless networks are considerably less secure than wired ones. A number of vulnerabilities could allow hackers to gain access to a school’s wireless network. While the goal is most often to gain free Internet access, the same security holes can potentially be used to access confidential student information, alter records, or inflict malicious damage of other types.

The IEEE's 802.11 task group is developing specifications for a new security standard to be called 802.11i. In the meantime, the CoSN report outlines a variety of interim options for schools including improved encryption schemes, requiring that access to sensitive data be limited to wired users, the implementation of firewalls, and the use of Virtual Private Networks.

**Selected mLearning Projects in Australia**

**University Research Grants from Global IT Corporate**

Hewlett-Packard (HP) in 2003 awarded two Australian universities grants totalling $420,000 for initiatives to positively transform the teaching and learning environments through the use of mobile technologies. The University of Melbourne and the Northern Territory University received the HP grant, titled HP Applied Mobile Technology Solutions in Learning Environments. The universities used HP’s mobile technologies, including tablet and handheld PCs, to explore and develop the innovative application of mobile technologies in the teaching and learning environments.

The grant also includes cash to help with the cost of academic staff assigned to the project, as well as a funded trip to the United States where one delegate from each university presented a paper on their project. The University of Melbourne project investigated the interactive learning and research habits of students in Law, Medicine and Science faculties, both on and off campus. By providing students with mobile technologies, the University aimed to better
understand how technology can be effectively used to improve the student learning experience. Northern Territory University used the grant to trial three different learning scenarios, including on-campus teaching of information technology subjects; a mobile education unit that delivered training direct to remote, primarily indigenous, communities; and supporting university programs for remote high schools.

In 2004 HP similarly funded Curtin University (WA) for a mLearning project.

**CoolCampus Initiative, Monash University (2004)**

The last decade has seen the power and capability of computing devices and communications networks increase dramatically. Many researchers believe that this is making possible a new computing paradigm - *pervasive* or *invisible* computing - where computing technologies will recede into the background. The Faculty of Information Technology at Monash University established the *CoolCampus* Initiative in an effort to connect its existing pervasive computing research activities and to generate more opportunities for its pervasive computing researchers to collaborate with and engage university and industry partners. Many universities have similar approaches to investigating developments through such a named and promoted initiative to develop an ICT and learning priority area of the university or of a key faculty.

**“Always On” MLearning - transforming school cultures**

Funded by an ARC grant to University of Tasmania and DET Victoria and Tasmania.

Research investigating the changes and implications for school culture in transforming learning by using handheld devices in Primary, Grade 6 classes. This project extended an existing similar project to a one month trial in Victoria which subsequently developed into secondary schools in the Yarra Valley.

**Mobility in Science classes, University of Tasmania**

Supported by ASISTM grant, science classes in four high schools in Northern Tasmania implemented 120 handheld devices in a research trial monitored and reported by Education Faculty researchers.

**TxtMe Project, Swan TAFE, WA (2004)**

This project targeted 15-19 year old students who had not previously succeeded in traditional classroom-based learning, and examines the option of mLearning for vocational education and training (VET) providers. The project was funded by the Australian Flexible Learning Framework as a New Practice in Flexible Learning project, developed collaboratively between stakeholders in five TAFE Colleges in WA.

The project arose from the realisation that the VET sector could harness emergent technologies as a strategy to create learning environments that more fully engage young learners in the learning process. The research focused on the need to understand how young people communicate and learn, using mobile technologies. The research team investigated the potential that using these learning technologies presents. A range of blended teaching and learning strategies were supplemented with the use of an SMS portal which enabled practitioners to plan and organise activities with an “on-time” component in place.

Learning experiences were “scaffolded” with message swarms within which students were encouraged to interact with each other and return prompted practitioner messaging. A range of
activities that brought students to a common working space, enabled practitioners to explore the core concepts familiar to the user of the mobile phone, encouraged them to participate in focus group sessions, interactive online surveys, contribute to MP4 capture and to record their thoughts and feelings towards the use of this “private space” by the practitioner. Learning technologies which work in an interoperable manner were utilised to support the learner’s inclusion in activities such as email, chat and bulletin boards.

**mLearning: Hand-Held Innovations - FlexibleLearning Network**

This Queensland-based project was inspired by the ongoing advances of handheld mobile technology and the potential of this technology to provide a valuable addition to the flexibility of training delivery. Its focus has been to provide new directions in the way in which handheld technology is used in the delivery of training in the workplace through the development of innovative resources and teacher support materials including Learning Objects that are best suited to handheld delivery.

**Using Communication Technology in VET (2004) - Flexible Learning Network**

A Queensland TAFE Institute incorporated online and mobile technologies into a “blended learning” approaches for the delivery of hospitality courses. The VET training and workplace training support strategies have been applied in several industry areas. The potential for workplace “just-in-time” or formal assessments of competencies can be supported by the flexibility offered through mobile devices.

**mLearning Network - Institute of TAFE Tasmania, and Swan TAFE, WA**

The mLearning network provides a community of practice aimed at furthering the ongoing knowledge and development of mLearning in Australia and as a hub to foster mLearning connections internationally. Its fundamentals are based around the new and emerging mobile technologies, including but not limited to mobile phones, Pocket PCs, Palm PCs, PDA’s, Tablet computers plus other mobile devices and their potentials for the flexible delivery of learning. Its aim is to build a unique network of like-minded practitioners from private and public practice to enable the sharing of innovative mLearning concepts, ideas and experiences, that provide support for best practice mLearning.

**The Institute for Working Futures**

Collaborated with the Australian Flexible Learning Framework to manage several mLearning research projects. The director believes outcomes could significantly benefit the national economy - if the mobile telecommunications could be integrated.

**Flexible Learning Toolboxes redeveloped**

The sustained development of the Flexible Learning Toolbox project has recently launched a repository of learning objects which trainers can download for free use with their learners. Contents of initial Toolboxes have been redeveloped as learning objects. The content has been “disaggregated” or segmented for easy download and delivery. The learning object approach has been found in European mLearning research to be most effective for mLearning content delivery. Learning objects supporting a range of industries, including Automotive, Security, Infection control and Panel Beating amongst others, are currently available in the repository.
Other Flexible Learning Network initiatives


The project examined the practical and cost effective application of handheld mobile technology (PDA) for the delivery of flexible learning in the workplace. Specialist applications were developed through a joint collaboration between the learning institution, industry, staff and the learners as well as key stakeholders from many industry sectors.

• **QTI m-Player**: Question and testing interoperability player for mobile devices. Selected businesses and registered training organisations (RTOs) around Australia will be the first in the world to use mLearning in a secure environment. It will allow the vocational education and training (VET) system to create assessing instruments for teachers and trainers to test students anywhere and anytime using mobile devices.

• **National New Practices in Flexible Learning**: TAFE, NSW New England Institute:

- Explored three initiatives for handheld devices:
  - self-induction offsite - safety requirements of building sites, via dial-up to a website;
  - training and assessment in calibration skills for chemical mixing, using web interaction;
  - GPS (Global Positioning System) for personal interpretation of points of interest at sites, e.g., zoo and botanical gardens.

• **Access and General Education Centre**: TAFE NSW are in research trials engaging clients with mLearning initiatives including an interactive Mobile Film Festival, email SMS broadcast activities as well as Mo-blogging and Video-blogging for workplace assessment, general education and Indigenous culture and story telling.

**Australian Participation in EU MOBILearn project (EU)**

University of Southern Queensland and education.au limited

Participants in this significant EU project which explored new ways to use mobile environments to meet the needs of learners, working by themselves and with others. State-of-the-art mobile devices were available. A new mLearning architecture was designed to support creation, brokerage, delivery and tracking of learning and information contents, using ambient intelligence, location-dependence, personalisation, multimedia, instant messaging (text, video) and distributed databases.

Field trials covered “blended learning” (as part of formal courses); “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 behaviours, akin to the SMS phenomenon. The economic benefits of this project will be substantial at European level, and will be realised quickly because of the involvement of key stakeholders. These include public bodies, mobile operators, software and learning technologies production companies, mobile devices manufacturers, publishers and content providers, and participants in standards initiatives.
In the MOBIlearn project, one of the most important and challenging technical tasks was the development of multi-device, adaptive user interfaces - interfaces that will run on and adapt to the characteristics of multiple display devices and networks as well as multiple users and user tasks.

WP5 is in charge of this task, which consists of two related but very different streams of work:

• the physical and graphical human interface design, according to usability criteria and following a user-centred approach
• the technical challenge of connecting the interface with the different services delivered through MOBIlearn.

To allow WP5 activities to develop the Adaptive Human Interface Subsystem to be integrated into the overall MOBIlearn architecture, a suitable technical framework was identified that provides:

• an effective way to describe the structure and components of the user interface for a service
• an efficient and effective approach for adapting the interface at run time, according to different kinds of user- and environment-dependent constraints.

The MOBIlearn project developed a significant and innovative mLearning architecture. This has elements (layers) that reflect the needs of each constituency including end-users, pedagogical experts, 3G mobile operators, mobile device manufacturers (phone and PDAs), market analysts, content providers with large digital repositories and technology providers. The project will foster architectural integration and upgrades to satisfy new methodologies for mLearning environments. These will include practical implementations and trials using learning materials in selected contexts, for example, business administration and management education for the mobile worker, art and cultural heritage information access for the learning citizen or basic medical knowledge for everyday life.

Therefore, MOBIlearn did not attempt to address all the emerging areas of mLearning, but explored the chosen aspects in terms of all its different components (pedagogy, technical and human interaction, business). Australian participation in this major international project strengthens national mLearning understanding and has established key personal networks with great potential benefit for subsequent mLearning developments nationally.
The mLearning activities of the following authors, researchers and project leaders have been quoted here and have significantly informed the content of this overview. Their contribution is gratefully acknowledged.

**Attewell, Jill;** Manager, Technology Enhanced Learning Research Centre, Learning and Skills Development Agency, (LSDA) UK.

**Burton, Jane;** Curator of Interpretation, Tate Modern, UK.

**Colazzo, Luigi;** Department of Computer and Management Sciences, University of Trento, Italy

**Corlett, Daniel;** Project Manager, Centre for Educational Technology and Distance Learning, University of Birmingham, UK.

**Facer, Keri;** Research Director, Futurelab, UK.

**Informa,** - publication providing specialist information to the global academic and scientific, professional and commercial communities via publishing, events and performance improvement activities.

**Katz, Heather;** Senior Instructional Technologist, Research and Intelligent Decision Systems Inc. USA

**Klopfer, Eric;** School of Architecture and Planning, Massachusetts Institute of Technology

**Laouris, Yiannis;** Medical Doctor and Systems Engineer, President of Cyprus Neuroscience and Technology Institute, Cyprus.

**Milrad, Marcelo;** Senior Researcher, School of Mathematics and Systems Engineering, Växjö University, Sweden. Also Co-Director, Centre for Learning and Knowledge Technologies

**Proctor, Nancy;** Antenna Audio, company providing audio and audio-visual interpretation to museums, exhibitions, historic sites and visitor attractions worldwide.

**Quinn, Clark;** Formerly University of Pittsburgh, University of New South Wales, then led the development of an intelligently adaptive learning system, now independently supports initiatives in learning technology through OtterSurf Labs

**Ragus, Marcus;** Institute of TAFE, Tasmania, Natural Resources, AUS.
Rheingold, Howard: Author and writer about technologies and online communities. Appointed lecturer at UC Berkeley and Stanford Universities, USA.

Riordan, Mark: Head, Technology Department, Institute of Art, Design and Technology (IADT). University of Dublin

Rogers, Yvonne: Professor, School of Informatics and the School of Information Science, adjunct professor Cognitive Science, Indiana University.

Sharples, Mike: Professor Learning Sciences, University of Nottingham

Soloway, Elliott: Dept of EECS, College of Engineering, School of Information, School of Education, University of Michigan, USA.

Squire, Kurt: Assistant Professor, Educational Communications and Technology Division of Curriculum and Instruction, University of Wisconsin-Madison

Traxler, John: Formerly National ICT Research Centre. Currently, Centre for Learning and Teaching, Wolverhampton University, UK.

Turunen, Hanne: Researcher, Hypermedia Laboratory, University of Tampere, Finland

Vygotsky, Lev: (1896 – 1934), Soviet developmental psychologist. Work received widespread recognition in the 1960s with access to English translations. Vygotsky proposed the intellectual development of children is a function of human communities, rather than of individuals. His philosophies remain influential within the fields of developmental psychology, education, and child development.
GLOSSARY

ORGANISATIONS AND INITIATIVES

ARC Grants; (Australian Government) Australian Research Council, provided funds for research and researchers under the National Competitive Grants Program (NCGP). These programs are grouped into Discovery, Linkage and Centres.

ASISTM grant; Australian School Innovation in Science, Technology and Mathematics Project (Australian Government). Aims to bring about permanent improvements to the ways in which science, technology and mathematics are taught in schools by enabling schools to link with industry, science organisations, universities and others to explore ways to encourage a culture of innovation, attract greater numbers of quality students into teaching, improve coordination between primary and high school curricula and provide positive role models for students.

Australian Flexible Learning Framework; Provides Australia’s vocational and technical education (VTE) system with e-learning skills, professional development opportunities, products, resources and support networks. Collaboratively funded by the Australian Government and all States and Territories at AUD$15 million annually.

BBC – British Broadcasting Corporation; UK Public service provider of news, radio, TV, research and education support. Digital services include content, podcasts, email.

CoSN; Consortium for School Networking; US national non-profit organisation with a focus on education technology leadership for K-12 to strategically improve teaching and learning. CoSN provides products and services to support and nurture leadership development, advocacy, coalition building, and awareness of emerging technologies.

Department for Education and Skills (DfES); Established by UK government to create opportunity, release potential and achieve excellence for all in education and training.

European Union and European Commission (EU) - provides information, daily news, statistics, policies, programs and legislation for European community countries. Includes significant unification and education initiatives; specific Technology Enhanced Learning (TEL) Unit in the Information Society Technologies programme.

IEEE, Institute of Electrical and Electronics Engineers, Inc.; leading worldwide professional association for the advancement of technology. Defines technical standards, provides technical information and reference services.

Joint Information Systems Committee, JISC; Supports further and higher education by providing strategic guidance, advice and opportunities to use Information and Communications
Technology (ICT) for teaching, learning, research and administration. Funded by all UK post-16 and higher education funding councils of UK.

**LSDA - Learning and Skills Development Agency, UK.** April 2006 evolved into two separate organisations; Policy and strategic work to the Quality Improvement Agency for Lifelong Learning (QIA) and research, training and consultancy projects delivered by the Learning and Skills Network (LSN).

**No Child Left Behind (NCLB);** Federal education plan initiated by George W. Bush, August 2001 supported by the U.S. Department of Education as a policy initiative to provide "a new era in education." Depends on assessing student achievement and recording data to measure and provide accountability.

**RTOs** - Registered Training Organisations; Australian agencies accredited to provide quality training in a range of industry areas.

**The Le@rning Federation - (TLF)** an initiative of the state, territory and federal governments of Australia and New Zealand, employs emerging technologies to produce world-class online curriculum content for schools.

**TECHNOLOGIES**

**Generic**

**API - Application Programming Interface:** The interface that a computer system, library or application provides to allow requests for services to be made of it by other computer programs, and/or to allow data to be exchanged between them.

**Audio and video Blogging:** “mBlogging”, (see Blog). Added video and audio to become multi-media blogs, including posting photos from their phone. Audioblog.com simplifies posting of audio and video content to blogs.

**Blog:** A **weblog**, (shortened to blog), a website with journal or diary entries displayed in reverse chronological order. Offers commentary or news on a particular subject; some function as more personal online diaries. A typical blog combines text, images, and links to other blogs, web pages, and other media related to its topic.

**Blended learning:** Combines multiple approaches to pedagogy or teaching. Includes self-paced, collaborative or inquiry-based study. Blended learning can combine 'blended' use of virtual and physical resources. Examples include combinations of technology-based materials and traditional print materials.
Bluetooth technology; An industrial specification for wireless personal area networks (between mobile devices (PDAs, mobile phones, laptops, PCs, printers and digital cameras) via a secure, globally unlicensed short range radio frequency.

Broadband; Refers to a signal or circuit which includes or handles a relatively wide range of frequencies. Broadband is always a relative term, the wider the bandwidth, the more information carried. In data communications a modem will transmit over a telephone line a bandwidth of several megabits per second, handled by ADSL, which is described as broadband.

e-assessment; Using information technology for any assessment-related activity. This definition includes the use of a word processor to on-screen testing. Due to its obvious similarity to e-learning, the term e-assessment is becoming widely used as a generic term to describe the use of computers within the assessment process. E-assessment can be used to assess cognitive and practical abilities. Cognitive abilities are assessed using e-testing software; practical abilities are assessed using e-portfolios or simulation software.

EDGE- Enhanced data GSM environment: designed to co-exist with GSM (see GSM) and allow GSM operators who don’t have licences for 3G spectrum to provide data rates that could challenge 3G data rates.

ICT - Information and Communication Technologies; Application of digital elements to teaching and learning. Currently in almost all schools and is of growing influence in the teaching and learning process.

Interactive multimedia; refers to the use of several media where learners are able to process information through multiple sensory channels including auditory, visual and kinesthetic manipulation. The advantages of interactive multimedia in learning include visualizing abstract and concrete ideas by creating images, diagrams, or animations, reducing cognitive load in learning, facilitating mental representation of external objects, and improving cognitive learning for low spatial ability learners.

Internet Tablet; handheld device in several brands, provides easy broadband access over Wi-Fi connection or via mobile phone communication, telephone calling and instant messaging. Provides Hi-resolution widescreen display and intuitive user interface.

Learning Objects; modular digital resources, uniquely identified and metatagged, that can be reused to support learning. Provides educational content in small “chunks” able to be re-assembled for various learning environments.

MMS - Multimedia Messaging System; Delivers rich media formats for mobile devices. A standard allows sending messages that includes multimedia objects (images, audio, video, rich text) and not just text messages as in Short Message Service (SMS).
Open-source software; is computer software with source code available under a copyright license that permits users to study, change, and improve the software, and to redistribute it in modified or unmodified form. It is the most prominent example of open source development and can support distributed learning by reducing cost of purchasing licenced proprietary software.

“Pervasive Computing”; Sometimes called ubiquitous computing. Concept of embedded computing into the environment and everyday objects to enable users to move around and interact with information and computing naturally and casually. One of the goals of pervasive computing is to enable devices to sense changes in their environment and to automatically adapt and act based on these changes based on user needs and preferences.

PDA – Personal Digital Assistant; handheld devices originally personal organisers providing calculating, clock, calendar, computer games, accessing the Internet, sending and receiving E-mails, radio or stereo, video recording, recording notes, an address book, and a spreadsheet. Newer PDAs have colour screens and audio capabilities, enabling them to be used as mobile phones.

Podcasting - providing audio content to mobile devices, link to broadcasts from free to air media, FM radio, or organisation specific (eg lectures, Professional Development).

“Push” technologies; are prearranged updating of news, weather, or other selected information on a computer interface through periodic and generally unobtrusive transmission over the World Wide Web.

QTI m-Player: Question and testing interoperability player for mobile devices. around Australia will be the first in the world to use mLearning in a secure environment

RFID Radio Frequency Identification tags; operates at long, medium and short ranges; new techniques that make more efficient use of the available spectrum, including spread spectrum, smart antennae, agile radios and mesh networks.

Smartphone; mobile phone with PDA functionality; any electronic handheld device integrating the functionality of a mobile phone, personal digital assistant (PDA) or other information appliance. Often achieved by adding telephone functions to an existing PDA or putting "smart" capabilities, such as PDA functions, into a mobile phone.

“Sublaptops”; Range from small screen Palmtops to 7” screen notepads. They can do 80% of what a laptop can do for 10-20% of the total cost of ownership.

Super 3G; new standard for the transmission of data over mobile networks, provides services not available over 3G, such as continuous video broadcasting and full movie downloads.
**SMS- Short Message Services**: Available on most digital mobile phones (and other mobile devices, e.g. a Pocket PC, or occasionally even desktop computers). Permits the sending of short messages (also known as text messages, or more colloquially SMSes, texts or txts) between mobile phones, other handheld devices.

**VoIP; “Voice over IP”**: routing of voice conversations and signals over the Internet or through any other IP-based network.

**VPN - Virtual Private Network**: A private communications network usually used within an organisation to communicate over a public network. VPN message traffic is carried on public networking infrastructure, using standard (often insecure) protocols, or over a service provider's network providing VPN service guarded by well-defined Service Level Agreement (SLA) between the VPN customer and VPN service provider.

**WiFi**; is a brand originally licensed by the Wi-Fi Alliance to describe the underlying technology of wireless local area networks (WLAN) based on the IEEE 802.11 specifications. Wi-Fi is now so pervasive, and the term so generic, that the brand is no longer protected. Initially for laptops and in LANs, is now increasingly used for Internet access, gaming, and basic connectivity of consumer electronics such as televisions and DVD players.

**Wireless network**: A telephone or computer network using radio as the carrier or physical layer. Allows users of laptops, notebooks, PDAs, tablet PCs and wireless Voice Over IP (VoIP) telephone devices to roam, connect between buildings, change locations and classroom setups frequently and easily without permanently-wired systems.

**Wireless technology**: Is generally used for mobile IT equipment. It encompasses cellular telephones, personal digital assistants (PDA’s), and wireless networking. Other examples of wireless technology include GPS units, garage door openers, wireless computer mice and keyboards, satellite television and cordless telephones.

**XML - eXtensible Markup Language**: Special-purpose markup language, capable of describing and containing many different kinds of data. Its primary purpose is to facilitate the sharing of data across different systems, particularly systems connected via the Internet. It allows content to be separated from how it appears on each different device.

**ZigBee** and RFID Short-range technologies allow low-power connectivity within a range of 30 metres. The technology is intended to be simpler and cheaper than other WPANs such as Bluetooth.

**PROPRIETARY DEVICES AND NETWORK SYSTEMS**

**Apple iPod** – Portable media player designed and marketed by Apple Computer. Provide a simple user interface designed around a central scroll wheel, stores media on a built-in hard
drive, while the smaller iPod shuffle uses flash memory. Like many digital audio players, can serve as an external data storage device when connected to a computer.

**Flash; Adobe Flash** (formerly **Macromedia Flash**), or simply **Flash** - refers to both the Player and to a multimedia authoring program used to create content for web applications, games and movies. The Flash Player, is a client application available in most dominant web browsers.

**Fujitsu Siemens Pocket Loox 720** - proprietary handheld device with similar applications to PCs. Features an integrated camera, Voice over IP and VGA display e-mail and files whilst on the move. Choice of wireless technologies including Bluetooth, Wireless LAN, creates and views e-books.

**GSM - Global System for Mobile Communications**; popular standard for mobile phones worldwide. Its ubiquity makes international roaming common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. Differs significantly from its predecessors in that both signaling and speech channels are Digital call quality therefore considered a **second generation** (2G) mobile phone system.

**GPRS - General packet radio services**: designed to give increased data rates as well as charging based on amounts of data transferred rather than the time spent transferring the data.

**3G mobile - Third generation mobile networks**: designed to offer consistent services to mobile computer and phone users, allows a wider range of services, including video conferencing.

**GIS; Geographic Information System**- A computer system capable of integrating, storing, editing, analysing, sharing, and displaying geographically-referenced information. In a more generic sense, GIS is a tool that allows users to create interactive queries (user created searches), analyse the spatial information, and edit data.

**Google Talk** is a service offered by Google. A response to Skype and brings Instant Messaging and VoIP free Internet telephony. Unlike some other instant messaging services, Google Talk uses an open protocol.

**GPS: Global Positioning System**: The only fully-functional satellite navigation system, is a constellation of over two dozen GPS satellites broadcasting precise timing signals by radio to GPS receivers, allowing them to accurately determine their location (longitude, latitude, and altitude) in any weather, day or night, anywhere on Earth.
HAPS/LAPS solutions based on high or low-altitude platform stations can serve a whole town and satellites that can serve a whole region. Potential capability to serve a large number of users, either in dense urban areas or over a wide geographical area.

**HSCTS** - High speed circuit switched data, designed to allow GSM to transfer data at rates of up to four times the original network data rates.

**IM - Instant messaging**: enables real-time and often simultaneous connections among co-workers, friends, and family wherever wireless communication networks exist.

**IPAQ Handheld Computer** – Proprietary mobile messenger provides phone, e-mail, global communications connectivity, productivity, and mobility with high-end features such as GSM and EDGE technologies, and multiple messaging capabilities.

**Java**: An object-oriented programming language developed by Sun Microsystems in the early 1990s. Unlike conventional languages which are generally designed to be compiled to native code, Java is compiled to a bytecode which is then run by a Java virtual machine.

**Linked public access WLANs**: designed to link a number of public access WLANs to give high speed access in, for example, the centre of a town.

**Linux**: Is a Unix-like computer operating system. A prominent open source development with free software and all of its underlying source code available for anyone to freely use, modify, and redistribute. Initially developed and used by individual enthusiasts on personal computers, since gained the support of major corporations for use in servers and the desktop market.

**Nintendo**: a multinational corporation became one of the most powerful in the handheld console market. Nintendo's main competitors for gaming are Sony and Microsoft. Produce handheld gaming platforms of immense internal processing power and ability for audio-visual rendition.

**Nokia N770 Internet Tablet**: Portable device provides instant messaging, internet calling, internet browsing, email, instant wireless access to the Web, streaming of files, Internet radio, News Reader, play videos and music with an ultra sharp widescreen display that's specifically designed for viewing online content.

**Opera Browser**: an Internet suite which handles common internet-related tasks, including visiting web sites, sending and receiving e-mail messages, managing contacts, and online chat. Used in mobile phones, smartphones, Personal Digital Assistants, game consoles and interactive televisions.

**Palm handholds**: The Palm corporation produces a number of Personal Digital Assistant (PDA) which run the Palm operating system. Have become more advanced, including the
ability to become hard drives on computers via USB cables, and to merge with smartphones, providing e-mail, SMS, and instant messaging.

**PANs – Personal Area Networks**: a computer network used for communication among computer devices (including telephones and personal digital assistants) close to one person. The reach of a PAN is typically a few meters. PANs can be used for communication among the personal devices themselves (intrapersonal communication), or for connecting to a higher level network and the Internet (an uplink).

**Public access WLAN**: provides Internet in localised “hotspots” via a wireless local area network (WLAN) access card and a personal digital assistant (PDA) or laptop. Data speeds are relatively fast compared with mobile telecommunication technology, but range is short.

**Public access WLAN and mobile telecommunication convergence**: access technology allowing users/devices to move between a telecommunications technology (eg GPRS, 3G) and public access

**Skype**: a proprietary peer-to-peer Internet telephony (VoIP) network, competes against existing open VoIP protocols. Acquired by eBay in October 2005, has experienced rapid growth in both popular usage and software development, for both its free and paid services. Notable for features, including free voice and video conferencing, and its ability to use peer-to-peer (decentralised) technology to overcome common firewall and NAT problems.

**Symbian OS**: An operating system, designed for mobile devices, with associated libraries, user interface frameworks and reference implementations of common tools, produced by Symbian Ltd.

**WiMax**: Worldwide Interoperability for Microwave Access, defined by the WiMAX Forum in 2001 to promote conformance and interoperability of the standard IEEE 802.16. Described as a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL.

**WLAN**: aims to gain the highest available data rate, depending on geographical location. Currently being discussed, it is likely that devices will become available for seamless roaming between technologies.