IRRODL

THE INTERNATIONAL
REVIEW OF RESEARCH IN
OPEN AND DISTANCE LEARNING

Special Issue: Mobile Learning

Vol 8
No 2

creative commons

June 2007

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Guest Editorial

Mobile Learning

Mohamed Ally
Athabasca University, Canada

This special IRRODL issue on mobile learning is timely because of the proliferation of mobile technology in society, globalization, and the need to re-examine how learning materials are designed and delivered for the new generation of learners. In today's world, people are on the move and are demanding access to learning materials and information anytime and anywhere. At the same time, there is increasing use of mobile technology in different sectors of society to meet the needs of people on the move. In business, there is increasing use of mobile technologies for individuals to conduct their business anywhere and anytime. In healthcare, medical staff are using mobile technologies to access just-in-time information and to enter information in real time. People working in the field away from the central office use mobile technologies to access information and to communicate with other workers. Also, younger generations of learners are using mobile technologies for entertainment and socialization. These learners are using mobile devices to access information and multimedia materials and to communicate with friends. These new generations of learners do not see technology as something foreign. They readily accept technology and consider technology to be part of their lives. Moreover, the use of mobile technology is a 21st Century skill that students and workers must have to function in society.

Because of the increasing use of mobile technologies in society and by the younger generation, learners will demand course materials be delivered on mobile technologies to be accessed from anywhere and at anytime. At the same time, today's and tomorrow's learners will be nomadic and continuously on the move. As learners move from one location to the next, they must be able to use the infrastructure in the different locations to access learning materials. Hence, learning materials must be designed for easy access by the nomadic learners using mobile technology regardless of where they are located and which network infrastructure they are using to access information.

Despite mobile learning being a relatively new area in the delivery of instruction, many initiatives and research studies have been conducted to investigate the use of mobile technology in learning. For example, MOBIlearn, which is a worldwide European-led research and development project, explored the context-sensitive approaches to informal, problem-based, and workplace learning by using key advances in mobile technologies. In addition, there are papers published on how to design learning materials for delivery on mobile technology (Ally, 2005; Patten, Sanchez & Tangney, 2006; Sharples, Taylor & Vavoula, 2007).

The papers in this special theme issue examining mobile learning will help educators and trainers to be better prepared for the use of mobile technology in education and training. The papers in this special issue also help to clarify what is meant by mobile learning, discuss what has been

achieved so far in the use of mobile technology in learning, and describe the use of different mobile technologies in education and mobile learning applications around the world.

The paper by Agnes Kukulska-Hulme looks at mobile usability in educational contexts. She claims that the successful development of mobile learning is dependent on human factors in the use of new mobile and wireless technologies. Also, the majority of mobile learning activity continues to take place on devices that were not designed with educational applications in mind, and usability issues are often reported. Kukulska-Hulme's paper reflects on progress in approaches to usability and on recent developments, with particular reference paid to usability findings reported in studies of mobile learning. One of the areas frequently ignored in research studies on learning technology is the user of the technology. Kukulska-Hulme examines the requirements of education as well as the needs of students participating in distance education – discipline-specific perspectives and accessibility issues. She also summarizes usability findings from research studies of mobile learning and reports on two mobile learning projects. This paper sets the stage for reading the other papers in this special issue.

John Traxler's paper addresses the global use of mobile technology in society and how mobile devices are transforming the way people learn and communicate. He claims that with increased popular access to information and knowledge anywhere, anytime, the role of education – especially formal education – is now being challenged, and that the relationships between education, society, and technology are now more dynamic than ever. Traxler examines this relationship in the context of mobile learning and the sustainability of mobile learning. Most learning in the workplace is done through informal learning. Traxler's paper provides information on how mobile technology can be used in informal learning.

Torstein Rekkedal's and Aleksander Dye's paper draws on experiences from three European projects conducted between 2000 and 2007. The titles of these projects are "From e-Learning to m-Learning, Mobile learning – the next generation of learning, and Incorporating mobile learning into mainstream education." Rekkedal and Dye's paper reports on the use of specific mobile technologies in distance education and the benefits of using these technologies. It provides feedback received from students and tutors on the use of mobile technology in education and lists specific recommendations for educators to follow when implementing mobile learning. This paper is helpful for distance educators who would like to use mobile technology in open and distance education.

As technology evolves, it is important to keep up with the changes to benefit learning. The paper by Jason Caudill examines different mobile technologies and how these technologies can be used in mobile learning to benefit learners. One of the challenges for educators and researchers is to come up with an acceptable definition of mobile learning that everyone can use to guide research in mobile learning and the development and implementation of mobile learning. Caudill's paper explores the definition of mobile learning and clarifies the difference between e-Learning and m-Learning. One of the unique features of mobile learning is the mobility of learners. This paper examines the use of wireless technology to enhance mobility in mobile learning.

As educational organizations increasingly use distance education to reach out to students and deliver instruction to students, it is important to use technology to connect to students to make sure students complete their courses and program of studies. In their paper, Bharat Inder Fozdar and Lalita Kumar report on how the use of mobile technology can help in student retention in open and distance learning. Also, the use of mobile technology allows educational organizations to reach more learners and to connect to learners who already have the mobile technology.

An increasing trend in mobile learning is the use of instant messaging to connect to students and to promote collaboration. James Kadirire's paper explores the use of instant messaging in mobile learning. He claims that the use of instant messaging in mobile learning gives students a sense of online community. In his paper, Kadirire describes a prototype instant messaging system that can be used in education to allow learners to form a community of learning when taking distance education courses. He claims that use of instant messaging as a support tool is practical since it is affordable and students and educators will use this feature because of the low cost.

Kristine Peters reports on a comparative study that looks at the use of mobile technology in commerce and learning. She examines the latest mobile technology for learning and how mobile learning can meet the needs of the new generation of students. Peters suggests that "m-Learning lends itself to new methods of delivery . . . that are highly suited to the 'just enough, just in time, and just for me' demands of 21st Century learners." The 'just enough, just in time, and just for me' is applicable to the workplace where workers need the right information at the right time and customized based on the worker characteristics.

One of the major benefits of the use of mobile technology is the education of learners on the move. R. A. Aderinoye, K. O. Ojokheta, and A. A. Olojede discuss how mobile learning can be used in nomadic education programs. The current school system in Nigeria is not viable to reach all learners in different locations. They explore how the use of existing infrastructure and mobile technology can help to educate Nigeria's nomadic population. This paper is a good example of how mobile technology can be used to educate people on the move.

Yuhsun Edward Shih and Dennis Mills present an innovative model for mobile learning and examine the challenges of using mobile technology in education. They claim that mobile communication technologies are rapidly evolving to include local area wireless connections using Wi-Fi, Third Generation (3G) mobile communications, and Worldwide Interoperability for Microwave Access (WiMAX), and related mobile computing devices such as smart phones, pocket PCs, tablet PCs, and various Personal Data Assistant (PDA) handheld devices. The paper describes a model to facilitate mobile learning design and to achieve better mobile learning outcomes.

One of the major issues for educators in remote locations and developing countries is access to the Internet. In the research notes section of this special issue on mobile learning, researchers look at accessibility of the Internet in Asia. Jon Baggaley and Batchuluun Batpurev compare the browser loading times of webpages created using common Web development techniques and report on the results obtained. They make recommendations on techniques for accessing the Internet. In a second study related to Internet access, Jon Baggaley, Batchuluun Batpurev, and Jim Klaas compare the loading times of webpages with the complexity of the Internet routes linking the Web users and the Web servers hosting them. They make suggestions on how to use existing infrastructure to improve online delivery and distance education.

In summary, this special issue on mobile learning addresses some of the issues and challenges of mobile learning, and provides suggestions and recommendations for mobile learning and for research on mobile learning. It sets the stage for further work to make mobile learning more accepted and effective in the education system. Different sectors of society such as business, government, and entertainment are using mobile technology to provide services and to interact with their clients. These sectors understand the mobility of their clients and are changing their systems to meet their clients' needs. Education is behind the other sectors in the use of mobile technology to deliver learning materials and interact with students. To accelerate the use of

mobile technology in education, researchers and educators need to work with manufacturers of mobile devices to develop mobile devices for use in the education sector. This is critical since most of the available mobile technology was developed for use in business and other sectors.

References

Ally, M. (2005). Multimedia information design for mobile devices. In M. Pagani (Ed.) *Encyclopedia of Multimedia Technology and Networking.* Idea Group Inc. Hershey, PA.

Patten, B., Sanchez, I. A., Tangney, B. (2006). Designing collaborative, constructionist and contextual applications for handheld devices. *Computers & Education, 46,* 294-308.

Sharples, M., Taylor, J., & Vavoula, G. (2007). A Theory of Learning for the Mobile Age. In R. Andrews and C. Haythornthwaite (Eds.) *The Sage Handbook of Elearning Research* (pp. 221-47). London: Sage.

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Mobile Usability in Educational Contexts: What have we learnt?

Agnes Kukulska-Hulme
The Open University, UK

Abstract

The successful development of mobile learning is dependent on human factors in the use of new mobile and wireless technologies. The majority of mobile learning activity continues to take place on devices that were not designed with educational applications in mind, and usability issues are often reported. The paper reflects on progress in approaches to usability and on recent developments, with particular reference to usability findings reported in studies of mobile learning. The requirements of education are considered as well as the needs of students participating in distance education; discipline-specific perspectives and accessibility issues are also addressed. Usability findings from empirical studies of mobile learning published in the literature are drawn together in the paper, along with an account of issues that emerged in two mobile learning projects based at The Open University, UK, in 2001 and 2005. The main conclusions are: that usability issues are often reported in cases where PDAs have been used; that the future is in scenario-based design which should also take into account the evolution of uses over time and the unpredictability of how devices might be used; and that usability issues should be tracked over a longer period, from initial use through to a state of relative experience with the technology.

Keywords: Usability; mobile devices; PDAs; flexible learning; empirical studies; scenario-based design

Introduction

Mobile learning is proving to be a fertile ground for innovation, but it is important to realise that the success of mobile learning will depend on human factors in the use of the new mobile and wireless technologies. It is only now that the challenges of mobile learning on a larger scale, and with diverse populations of students, are beginning to be understood. This paper draws together what is currently known about user experience, educational requirements, and changing needs in the field of distance learning, and makes suggestions regarding ways of improving the study of mobile learner experience. As Wagner (2005) has pointed out, " . . . complicated key controls and difficult-to-read screen presentations will be tolerated only under certain very limited conditions. The rest of us aren't willing to risk having a bad experience. For broad and long-term adoption, the experience really does matter" (¶ 23).

The past few years have witnessed the development of a substantial body of literature reporting pilot projects in learning with mobile devices, and a surge of conferences pertaining to mobile

learning research. The papers describe mobile systems and software that have either been purpose-built for education or that use off-the-shelf solutions originally intended for business use. In spite of careful designs and preparations on the part of the researchers and practitioners running the projects, issues of usability are known to arise in both situations, preventing learners from engaging fully with their educational tasks.

We have reached the stage in mobile learning research where the considerable body of evidence from various projects and trials can enable us to begin to review in a more global way what has been learnt to date about the usability of mobile devices in education. Admittedly, this is a vast topic and it is not possible to generalise from a range of user experiences that span different technologies, contexts of use, study modes and learning objectives. Nevertheless, there is much to be learnt from being aware of the kinds of usability issues that have arisen in the past. The aim of this paper is two-fold: first, to reflect on progress in approaches to usability and on recent developments in the field, and second, to review usability issues reported in a range of studies of mobile learning. In doing so, it is important to pay attention to the particular needs of students participating in distance education, many of whom would consider themselves to be the original 'mobile learners,' used to carrying their course materials around with them and accessing them in flexible ways. For these students, learning with mobile devices represents another step in the right direction but it also presents some specific challenges.

Accounts of mobile usability issues that pertain to education can be found in many sources, most notably in specialist conference series such as *Mlearn*, *IADIS Mobile Learning*, and *WMUTE*, in themed journal issues and in published case studies (e.g., JISC, 2005). A systematic review of all the available sources would be a valuable exercise; for the purposes of this paper, a number of recurring issues are identified and highlighted as a step towards a systematic review. In the meantime, those who design future studies, those involved in the design and implementation of mobile learning, and the designers of new mobile devices and software can begin to benefit from this evolving collective experience.

As well as examining usability issues reported in specific studies, it is helpful to see them against the background of the state of play in mobile usability and in relation to requirements that might be specific to education. The next two sections address these two aspects in turn.

Mobile Usability

Mobile usability can be regarded as an emerging specialism within the more general field of usability, which has also been evolving. Human-computer interaction researchers recognize that to produce computer systems with good usability, it is important to understand the psychological, ergonomic, organizational and social factors that determine how people operate. Nielsen (1993) explained usability in terms of a system’s overall acceptability, which included its social acceptability and all practical aspects such as reliability, cost, compatibility and usefulness. Subsequently, Preece, Rogers and Sharp (2002) have focused on "creating user experiences that enhance and extend the way people work, communicate, and interact" (p. v). Dix and colleagues (2004) remark that "users no longer see themselves as cogs in a machine . . . it is not sufficient that people can use a system, they must want to use it" (Dix, Finlay, Abowd, & Beale, 2004, p. 156).

Although researchers in human-computer interaction are forging ahead in developing their visions for helpful and engaging interactions however, the reality for many computer users remains quite different. Influential authors like Cooper (2004) and Nielsen (2005) continue to

point out the usability shortcomings of current computer software and technology. Shneiderman (2002) has stated that too often computer software is "just too hard to figure out" (p. 24). Yet Shneiderman also believes that new computing methods can produce "more usable, more reliable computer software and user interfaces that yield much improved user experiences" (p. 26).

How do mobile technologies fit into this picture? Are mobile devices bringing us closer to the ideals of usable computing – or distancing us away from them? The user interfaces on mobile devices are often relatively simple, but each manufacturer has a different interface. Devices are also continually being replaced with new models, even before users have got to know them well:

> "In many markets, mobile phones have a product life cycle of 12 months or less. Some subscribers are able to put their new phones to immediate and full use. For others, the learning curve is so steep that they move on to a replacement without having learned to exploit the functionality available in the first one" (Gilbert, Sangwan, & Han Mei lan, 2005, p.1).

Furthermore, hardware limitations that have long been overcome in desktop systems are back on the usability agenda when mobile devices have to be charged regularly, run out of memory, and may be unreliable. New factors have also come into play: the very nature of mobile interaction is that it is frequently interrupted or fragmented, may be highly context-dependent, and takes place in physical environments that may be far from ideal.

In his book devoted to handheld usability, Weiss (2002) remarked on the "general lack of usability on most handheld devices" (p. xiii), whilst Nielsen's verdict on mobile usability in 2003 was that "the latest mobile devices . . . still lack key usability features required for mainstream use" (Nielsen, 2003, p. 1). Recent developments have been characterised by an increasing awareness of contexts of use and how these might evolve. For example, Turel (2006) argues that the emergence of mobile value-added services has introduced a broad range of new use contexts, requiring a new conceptual model of mobile usability. Similarly in relation to mobile data services, Gilbert and colleagues (2005) propose a dynamic perspective of users' out-of-the-box (initial use) experience, embracing differences over time in both the 'external' and 'internal' contexts among users, such as user location, demographics, or lifestyle characteristics.

Current thinking suggests that in mobile learning, user-centred design and attention to contexts of use will lead to better mobile learning usability. Pehkonen and Turunen (2003) have argued that in the case of mobile learning, user-centred design means not only planning learning goals and actions, but also specifying different contexts of use and the requirements of different 'actors,' which might include teachers, students, and even parents. Malliou and Miliarakis (2005), and Evans and Taylor (2005), have also advocated user-centred and scenario-based design. Lessons from the *MOBIlearn* project (O'Malley, Vavoula, Glew, et al., 2003) include a guideline on usability which suggests observing "the usability requirements of all those involved in the use of the system in any way (learners, teachers, content creators) to assure system acceptability" (p. 32). The guideline elaborates that in designing mobile applications and producing mobile content, it is important to consider the context of use and that the learner should be able to receive personalised information "that is valuable to her in the given context" (O'Malley et al., 2003, p. 32).

With many factors impacting on the usability of mobile devices in education, it is not yet clear whether these user-centred and context-sensitive approaches are the necessary and sufficient ways to ensure a high degree of usability in mobile learning. Those who are involved in designing

mobile devices have been noticing that "new solutions are utilized in ways that never even occurred to their designers" (Keinonen, 2003, p. 2) – in other words, you cannot fully predict what users will choose to do – and whilst this is not an entirely new phenomenon, the highly personal and portable nature of mobile devices makes it more likely to happen. Besides, uses may become more elaborate over time: Gilbert and colleagues (2005) have drawn attention to the period after initial use of a mobile service, "during which the scope of use expands to fulfil emergent needs" (p. 207).

Another approach to improving usability is to make the user interface or content adaptable to, or by, the user. Making information personally valuable in a given context, as suggested in the *MOBIlearn guideline* (O'Malley et al., 2003), is one way of adapting to the user. Jäppinen, Ahonen, Vainio, and Tanhua-Piiroinen (2005) have written about the pros and cons of adaptivity in the context of mobile learning: a system that can model the user and automatically regulate and organise its functioning is very appealing, but at the same time this property can make the system less controllable and predictable for the user. Malliou and Miliarakis (2005) put their faith in the adaptability of the mobile system in the MoTFAL project: "it should adapt to the learners' evolving skills and knowledge" (p.122) as part of a set of requirements that are specified to assure its usability.

Returning to the idea that people must want to use a system (see Dix, et al., 2004, above), we can hypothesize that people may acquire a mobile device for a specific purpose but its subsequent use may depend on, and evolve according to, their wants or needs. As noted earlier, they may never discover all the features of their device before moving on to another one, because what they want, or what someone else thinks they want, is a new device. What has not been well researched to date is how people get to know the features and possibilities of their mobile device and its applications over time. How that happens may be determined not only by the individual's effort but by their social networks – and by the extent to which mobile services and content are 'pushed' in their direction by various providers. In educational contexts, where mobile devices may be loaned out to students for a limited period of use, it may also be determined by (non-)ownership of the device. The impact of the education context on mobile usability is explored in more detail in the next section.

Requirements in education

The reasons underpinning the use of mobile technology in education have been explored by Kukulska-Hulme (2005a), who identified the three main motivations as being: improving access, exploring the potential for changes in teaching and learning, and alignment with wider institutional or business aims. Where the emphasis is on changing teaching and learning, practitioners and researchers are interested in collaborative learning, students' appreciation of their own learning process, consolidation of learning, and ways of helping learners to see a subject differently than they would have done without the use of mobile devices. Just-in-time learning and support for managing learning are also key interests. There is awareness that the new technologies may have a role in reducing cultural and communication barriers, and that they are altering attitudes and patterns of study.

The diversity of reasons for use of mobile technologies in education makes it difficult to make any generalisations about requirements. Nevertheless, there are attempts to characterise these requirements, including in relation to interface design and usability. Nielsen (2001) has remarked that although general usability standards apply equally to e-learning, there are additional considerations, for example the need to keep content fresh in learners' minds so that they do not

forget things whilst trying to accommodate new concepts. User-centred system design and evaluation have traditionally been driven by the concept of a 'task.' To a certain extent, it is possible to list the kinds of tasks that learners engage in. For example Rekkedal (2002) has suggested that mobile learners in distance education need to be able to perform tasks such as studying the course materials, making notes, writing assignments, accessing a forum, sending and receiving e-mail, and communicating with a tutor. The process of learning, however, is not always easily broken down into tasks, and something like 'studying course materials' is no more than a label that conceals great complexity in how the materials might be studied. Ryan and Finn (2005) have commented on the difficulty of task analysis in relation to mobile learning 'in the field,' in the course of their attempts to define the generic requirements of users who typically operate out in the field (e.g., geologists, archaeologists, journalists, technicians, police). It is also very challenging to design and evaluate tools that support learners' development and interactions with others over time.

Conventional approaches to usability tend to be limited to metrics relating to time taken to complete a task, effort, throughput, flexibility and the user's attitude. Syvänen and Nokelainen (2005) have attempted to go beyond this by combining technical usability criteria (such as accessibility, consistency, reliability) with pedagogical usability components such as learner control, learner activity, motivation and feedback. Kukulska-Hulme and Shield (2004; Shield and Kukulska-Hulme, 2006) have also argued that usability needs to be understood differently when it is being evaluated in the context of teaching and learning, and that the concept of pedagogical usability can be helpful as a means of focusing on the close relationship between usability and pedagogical design. Exploring this concept raises the question of whether there are aspects of pedagogical usability that are discipline-specific; this is examined by Kukulska-Hulme and Shield (2004) in relation to the discipline of language learning. In websites that support language learning, usability might depend on whether the site uses the first or target language, and on its ability to support multimodal and intercultural communication. The ways in which language experts conceptualise user interfaces may also be specific to the culture and sub-cultures of their discipline. These aspects can be hard to quantify and measure, but it does not mean that they are less important.

Discipline-specific perspectives can be identified in a number of mobile learning projects. For example, in the accounting project reported by Roberts, Beke, Janzen, et al. (2003), screen size on the personal digital assistant (PDA) was found to be an important issue because of the particular needs of the discipline, namely data entry and spreadsheet requirements. Polishook's (2005) research into the possibilities for student music composition on PDAs showed that for some individuals, the small, poorly lit low-resolution screens, tiny dialogue boxes, and the need to connect extra wires, stood in the way of productive use for music composition.

Educational activity can sometimes be better understood by system designers when it is seen as an example of a 'rich context' involving different people, the spaces they meet in and the physical artefacts they use (Dix et al., 2004). Collaboration and co-construction of knowledge are nowadays seen as being the defining characteristics of learning, in contrast to cognitive models that previously concentrated more on the individual learner without much consideration of their social and physical environment. In relation to mobile learning, Luckin, du Boulay, Smith et al. (2005) have defined a learning context as an 'ecology of resources' and have shown how technology can link different resource elements within and across learning contexts.

What have we learnt from empirical studies of mobile learning?

Many published studies and conference papers mention aspects of usability, either because it was something that was specifically evaluated, or more often, because usability issues arose during a project or trial and seemed worth mentioning. Sometimes testing the usability of a system is a milestone that will determine whether the system is going to be developed further; for example, Hitz and Plattner (2004) state that if the usability tests on their prototype *PaperLink* system yield satisfactory results, they will proceed to a generic mobile implementation.

Usability is typically considered from the point of view of issues or problems encountered by users, but good usability essentially means that learning can proceed without obstacles and might even be enhanced by the availability of certain features. In Kukulska-Hulme (2005b), a dozen case study accounts of mobile learning were analyzed from a usability perspective and positive aspects were also identified. For example, Trinder, Magill, and Roy's (2005) case study highlighted the advantage of the immediate readiness of PDAs – the fact that they can be switched on and used straight away with no 'boot up' time – making them ideal to grab a few moments' useful working time at times and in locations where even a laptop would not be useful. Trinder and colleagues also claimed that among their learners, the ability to beam items between PDAs encouraged collaboration and communication. In a similar vein, Corlett and Sharples (2005) report the finding that a keyboard was fundamental to making full use of the pen *Tablet* device. Bradley, Haynes, and Boyle (2005a) give a number of recommendations to make multimedia content on PDAs usable in a local history tour and for learning Java programming, for example increasing the contrast of images and using audio commentary rather than text. Ryan and Finn's (2005) approach – mentioned earlier in relation to field-based learning – also falls into the category of studies that focus on planning-in good usability features rather than eliminating bad ones once they have occurred.

Examples of usability issues that are being reported in the research literature can be summarised under the following headings:

Physical attributes of mobile devices

Sharples, Corlett, Bull, et al. (2005) report that students expressed discontent about the size and weight of their PDAs, their inadequate memory and short battery life. The memory was considered too small to hold the course resources, additional PDF and media files, added software, games and music files. Bradley, Haynes, and Boyle (2005b) report that limited storage space was an issue on the PDAs used in their project; but they also mention that the size of the PDA was viewed positively by students, who appreciated being able to have a quick look at the PDA while walking, just before an exam, rather than having to carry a book or A4 papers; in those circumstances the small screen of the PDA did not seem to present a problem.

Screen size was identified as the biggest drawback to using PDAs in an outreach project described by Sugden (2005), noting especially that for sight impaired learners "the environment is impossible" (p. 116). In a project reported by Rekkedal (2002), the students "expressed very different views" concerning reading from a small screen. It seems that a small screen may be an issue, but not always. Current opinion is that learners' age may be a factor (van 't Hooft, 2006) and that in the future, virtual screens and keyboards may help overcome the small screen issue (Ally, 2006).

Content and software applications

"Learning how to work with a PDA takes more time than people first think, despite the apparent similarity to Windows applications," according to researchers in the Manolo Project (2005). In a slightly different context, Hackemer and Peterson (2005) note that whilst students were comfortable with their handheld's built-in functions, additional applications proved problematic, as most of the available software lacked formal usability assessment and documentation; this resulted in very few students being willing to explore applications in order to understand how they could be used. Smørdal and Gregory's (2005) study showed up problems in cutting and pasting material from one application to another, which limited the usefulness of the PDA as a communication device.

Selecting from a list of options can be a way to make it easier to interact with a mobile device, and, indeed, Cacace and colleagues (Cinque, Crudele, Iannello, & Venditti, 2004) report that drop-down lists and checklists proved useful in a mobile medical training context. On the other hand, Waycott and colleagues' study in a museum setting (Waycott, Jones, & Scanlon, 2005) identified that choosing from a list of pre-written messages on the screen of the PDA did not necessarily facilitate peer-to-peer communication. The applications and circumstances of use were very different.

Network speed and reliability

In Smørdal and Gregory's (2005) study the slow transmission of webpages on GSM-connected PDAs resulted in a negative experience. A JISC case study (2005) in the use of wireless *Tablet PCs* at a London college identified occasional weak signals and slow access to documents as negative aspects of wireless connectivity within the college. Roberts and colleagues (2003) list wireless network reliability as one of the five key lessons that emerged from a mobile learning pilot project in accounting involving some 300 college students: "For maximum success, the technology has to work reliably. While small screen size and the lack of a keyboard were noted as PDA limitations, they did not generate the level of dissatisfaction among PDA students that the poor wireless WAN network functionality did" (p. 33). On the other hand, with regard to speed, Cinque and colleagues (Cinque, Cacace, Crudele et al., 2005) report that their medical and nursing students tended to prefer a smaller device, with colour display, to a faster one, noting that "usability seems more important than performance" (p. 115).

Physical environment

Corlett and Sharples (2005) report several usability issues that arose in their pen *Tablet* project, including difficulties in using the device out of doors due to excessive screen brightness. Bradley, Haynes and Boyle (2005b) noted that amongst their participants there were some concerns about personal security (the risk of being mugged), and about possible radiation from devices using radio frequencies. Manolo Project (2005) case studies in environmental sciences report the need to use rain covers on PDAs outdoors in rainy or humid conditions, and the need to consider the risk of loss and theft of equipment on field trips.

Issues that appear to have a bearing on usability include device ownership and duration of use. In the study reported by Sharples and colleagues (2005) the lack of device ownership meant that since students were required to return their handhelds at the end of the year, they did not want to invest in additional memory modules that would have overcome the memory limitations of their

PDA. Waycott and colleagues (2005) also comment that in case studies involving PDAs, "where participants were prepared to invest effort in learning how to best use them for their own purpose, they could benefit from this investment as they were using the PDAs over a long period of time" (p. 124).

The impact of usability issues on academic and technical staff are also mentioned in the literature. Luckin et al. (2005) have described the substantial overhead of staff time in terms of technical support, account administration and finding workarounds for features that did not work as required. The Manolo Project (2005) has also emphasized the need for various types of support, including technical support, in its published summary of lessons learned from the project.

Finally, in consideration of learners with disabilities, Dodd, Pearson, and Green (2005) have warned against new teaching methods becoming dependent on inaccessible mobile technology:

Existing devices, exemplified by PDAs, inherently small and used in badly lit, noisy, and moving environments, amplify the demands placed on vision, hearing and mobility skills. . . Current solutions focus on adapting existing commercial products to incorporate impairment-specific devices using Braille keyboards, and screen reading/ magnification technology. Whilst this solves accessibility problems for a narrow band of users, it does not provide the coordinated approach necessary to support disabled users with more than one physical impairment (Dodd, Pearson, & Green, 2005, p. 49).

This last point has particular implications for distance education, as relatively large proportions of disabled students participate in this form of education. The next section reviews the experiences of distance students in relation to the usability of mobile technologies.

Usability of mobile devices in distance education

As noted by Ally (2005a), the use of mobile technology in distance education could provide more flexibility for learners, a view that has also been put forward by Rekkedal (2002). Ally also makes the point that mobile learning requires organizational change and careful planning: existing course materials must be converted and new ones developed for delivery on mobile technology; it is necessary to establish a telecommunication infrastructure, train staff and faculty, and so forth.

Most experiences of mobile learning to date relate either to conventional teaching contexts – i.e., in face-to-face teaching in universities, colleges, and schools, or to informal learning in public spaces such as museums and gardens – but there is some experience specifically in distance education. For example, work on mobile learning has been ongoing at the Norwegian Knowledge Institute – NKI Distance Education – for some years now (Fagerberg, Rekkedal, & Russell, 2002; NKI Distance Education, 2004). Researchers at Birmingham University's Centre for Educational Technology and Distance Learning (subsequently rebranded as CLIC) continue to work on distance and continuing education issues (CLIC, 2006), as do researchers at Athabasca University (McGreal, 2005; McGreal, Cheung, Tin, & Schafer, 2005; Ally, 2005b).

In this section, the focus is on two projects at The Open University in the UK, both of them concerning the use of mobile devices by students on the Institute of Educational Technology's Masters programme in Online and Distance Education (MAODE). This is a distance learning programme delivered online, making use of Web resources and conferencing. Students enrolled in the programme are typically studying part-time and involved in other professional activities. In

terms of age, they are mostly in their 40s and come from a variety of cultural backgrounds. The first project summarised here investigated students' use of PDAs that were given to them, whilst the second project investigated their use of their own mobile devices. This parallels developments in the field of mobile learning, in that early projects tended to be based around activities that involved giving or lending mobile devices to students to try out; more recently, due to increased device ownership, there is a growing interest in investigating how mobile devices that are already owned by distance learners could be incorporated into their learning, or how the learners themselves are already using the devices on their own initiative.

1. PDAs for reading course materials

During 2001, a study was conducted to evaluate the use of PDA devices by students on the Masters course H802: *Applications of IT in Open and Distance Education* (Waycott & Kukulska-Hulme, 2003; Waycott, Jones & Scanlon, 2005). The idea was to give students the option of reading some of their course materials on a PDA. Students could choose to read on a PDA or only the print version, or both. As part of this project, cognitive, ergonomic, and affective aspects of PDA use were investigated in some detail (Kukulska-Hulme, 2002).

All 65 students enrolled in the course were supplied with PDAs; most were new to using this type of device. The study aimed to assess the benefits and constraints introduced by PDAs, and examine how this new tool influences students' reading strategies; annotating and note-taking were included in the investigation. *WordSmith*, a document editor and viewer, was used to present course materials on the PDA. The document viewer mode enabled users to read and search the text in several ways. Participants received the manufacturer manuals, and were also provided with further instructions tailored to their needs. They did not have access to any specific technical support during their use of mobile devices. The model of mobile learning in this project was that of individual learners accessing materials on their individual devices, and to a certain extent, using their own initiative to explore the features and capabilities of the device, although they could share their problems and questions in the online conference.

The conference for this project was opened up to students in the run-up to the distribution of PDAs; this became a focal point for early adopters (i.e., those students who were already users of other handheld computers, or who were immediately interested in the technology). Once the PDAs were distributed, the conference was accessed by a wider circle of students. Numerous hardware, software, synchronisation, and compatibility problems were discussed, and students made comparisons between the PDA and other devices they were familiar with, including their desktop computers. A number of issues emerged during the evaluation period, for example, in relation to reading; skim-reading on a PDA could be slower than skim-reading in print; what students noticed when reading print could also be different from what they noticed when reading on the PDA. When the font was enlarged on the PDA, scanning could be harder. Taking electronic notes and annotating the text could also be difficult on the PDA. Observations that accompanied this study showed that some users had difficulty gripping the very thin stylus and inadvertently pressed buttons at the bottom of the device. It was also noted in this project that the sensitivity of the screen seemed to vary from one PDA to another, and in some cases it was necessary to re-calibrate the screen so that it responded to the stylus. Even with limited use of the PDAs, it was clear that scratches could start to develop on the screen, making it less sensitive and, perhaps, less usable over time.

The project concluded that three main issues needed to be considered in future projects of this kind: (1) usability of the hardware (considering that the PDA used in the project was a relatively

inexpensive model; the screen contrast was very low and required great concentration); (2) usability of the software (the application used for reading texts was not designed for reading); and (3) usability of the text (the text had not been designed with a PDA in mind).

2. Survey of how MAODE alumni use mobile devices

This project ran in 2005 and its participants were registered alumni of the same Masters in Online and Distance Education (MAODE). The alumni had completed at least one-third of the programme, and in some cases all of it. Fifty-seven (n = 57) alumni completed an online questionnaire and nine were subsequently interviewed. The purpose was to gather both numerical and qualitative data on the breadth of their use of mobile devices: which did they use, for what activities, and how? Participants were asked whether they had used a mobile phone, smartphone, PDA, and MP3-player (for example, an *iPod*). For each device, they were asked whether they had used it for teaching, work, learning, social interaction, and entertainment (including quizzes and games). For each activity they selected, they were asked to give an example. Informal uses (with friends, family, or interest groups) could be included when responding about 'teaching' and 'learning.' There was also a catch-all question about any other uses; in addition, participants were asked how often they carried out specific activities with a mobile device, such as reading an e-book, browsing a website, or making a video clip (for more complete accounts of this project, see Kukulska-Hulme & Pettit, 2006; Pettit & Kukulska-Hulme, 2006).

A review of the data from the survey shows that the use of PDAs generated the greatest number of spontaneous comments relating to usability. These were not always negative comments. Forty-six percent of the respondents had used a PDA. In relation to uses connected to their work, respondents commented that they used the PDA in preference to a laptop while travelling by train because the battery lasted longer than the one in their laptop, and because a PDA was more comfortable to use in 'airline seats,' that typically do not have a proper table. A separate keyboard was used by three of the respondents. In relation to their use of the PDA for learning, comments included: "trying to download documents to read but finding the screen far too small"; "preferring print rather then the PDA, to read and scribble on on the train"; and "trying to use blogs on the PDA but finding the formatting not good enough." Positive aspects of learning-related usability were using time productively while waiting, and being "always up to date." In relation to social interaction, one respondent regretted not having Wi-fi and another had tried conferencing on the PDA but found it "too clunky, too hard to write on."

Although the data only offered a small selection of comments mentioning aspects related to usability, there was some indication that the PDAs did present some usability issues, particularly in the context of learning. On the other hand, when looked at from the point-of-view of productive use, respondents reported using their PDAs in a rich variety of ways; included in these reports were activities such as brainstorming, mindmapping, reading e-books, downloading academic articles, accessing email, keeping a list of library books to take out, loading copies of software manuals, Web browsing, and use of multiple media (i.e., photos, video, music).

Conclusions

The paper presented a review of current usability issues in the use of mobile devices in the context of education, almost exclusively in relation to adult learners. In doing so, a broad interpretation of usability has been adopted, encompassing not only technical but also pedagogical considerations, which are often closely intertwined. As we have seen, the field of mobile usability is in a state of evolution, as it reflects and, indeed, takes forward some of the

developments in the field of usability as a whole. Similarly, there is ongoing discussion of what are the important issues with regard to mobile technology uses in education. In a general review, it is not possible to make definitive statements about usability based on what is often reported in an ad-hoc way in the literature, however some interesting points emerge that can guide our thinking in the future.

The majority of mobile learning activity continues to take place on devices that were not designed with educational applications in mind. It is noticeable that usability issues are often reported where PDAs have been used, which suggests that PDAs might be the object of more usability problems than is the case for mobile phones, for instance. If that is, indeed, the case, then one possible explanation is that devices, such as mobile phones and mp3 players, are more likely to be personally owned by, and hence more thoroughly familiar to, their users; Antoniou and Lepouras (2005) assert that owners' familiarity with their mobile phone avoids many potential usability problems for mobile learning in a museum setting. There is also some evidence to the contrary. For example, it was noted earlier in this paper that users may not know their mobile phone all that well because they are always moving to a newer model; but this may be more applicable to some sectors of the population than others. Another explanation for the extent of reported usability issues in connection with PDAs is that PDAs may feature in more mobile learning studies, as phones and other devices have not so far been researched in learning contexts to quite the same extent (but this is changing). Furthermore, the pace of change in technological developments means that the PDAs used in earlier studies do not necessarily present the same challenges as more recent equipment. Arguably, some usability issues may have been overcome: McGreal and colleagues (2005) take the view that the technological capacity of PDAs "has increased dramatically in the past three years. Screens are bigger and better; systems have more memory; they have more multimedia capabilities; and there are more refined methods for inputting data" (p. 50). It is likely that users' experience with the devices is much improved as a result, although we do not yet have sufficient evidence.

It looks like the future is in scenario-based design, but this should also take into account the evolution of uses over time and the unpredictability of how devices might be used. Discipline-specific perspectives ought to be brought into play, and accessibility must continue to be considered alongside usability. Findings will always be context-dependent to a considerable extent, but it should be possible to accumulate knowledge about user experience in particular physical environments and situations of use. Some sets of mobile learning guidelines have already been published and they include some mention of usability. Generic requirements for certain types of user are also being elaborated. One final point to make is that rather than testing for usability at just one or two specific points in the life of a project, it would also be beneficial to find ways of tracking usability over a longer period of time, from initial use through to a state of relative experience.

References

Ally, M. (2005a). Use of Mobile Devices in Distance Education. Paper presented at *Mlearn 2005*, October 25-28. Cape Town, South Africa.

Ally, A. (2005b). Multimedia information design for mobile devices. In M. Pagani (Ed.) *Encyclopedia of Multimedia Technology and Networking.* Hershey, PA.: Idea Group.

Ally, M. (2006). Mobile Devices Usability. Posting on the *CIDER Mobile Learning SIG forum*, June 11, 2006. Retrieved February 14, 2007 from:

http://cider.athabascau.ca/CIDERSIGs/mobilelearning/mlearndiscussion/talkback/1150066275

Antoniou, A., & Lepouras, G. (2005) Using bluetooth technology for personalised visitor information. Proceedings of the *IADIS international Conference on Mobile Learning*, June 28-30. Qawra, Malta.

Bradley, C., Haynes, R., & Boyle, T. (2005a). Design for Multimedia m-Learning: Lessons from two case studies. Paper presented at *ALT-C 2005*. University of Manchester.

Bradley, C., Haynes, R., & Boyle, T. (2005b). Adult Multimedia Learning with PDAs: The user experience. Paper presented at *Mlearn 2005 Conference*, October 25-28. Cape Town, South Africa.

Cacace, F., Cinque, M., Crudele, M., Iannello, G., & Venditti, M. (2004). The Impact of Innovation in Medical and Nursing Training: a Hospital Information System for students accessible through mobile devices. Paper presented at *Mlearn 2004*, July 5-6, Rome, Italy. Retrieved February 14, 2007 from: http://www.crudele.it/papers/00269.pdf

Cinque, M., Cacace, F., Crudele, M., Iannello, G., & Bernaschi, M. (2005) Mobile learning in a hospital environment. Paper pubished in the proceedings of the *IADIS international Conference on Mobile Learning*, June 28-30. Qawra, Malta.

CLIC (2006). *Centre for Learning, Innovation and Collaboration, formerly the Centre for Educational Technology and Distance Learning.* University of Birmingham, UK. Retrieved February 14, 2007 from: http://www.clic.bham.ac.uk/

Cooper, A. (2004). *The Inmates are Running the Asylum: Why high-tech products drive us crazy and how to restore the sanity.* Indianapolis, IN.: Sams Publishing.

Corlett, D., & Sharples, M. (2005). Tablet technology for informal collaboration in higher education. In J. Attewell & C. Savill-Smith (Eds.) *Mobile Learning Anytime Everywhere: Papers from Mlearn 2004*, (pp. 59-61). London: LSDA.

Dix, A., Finlay, J., Abowd, G. D., & Beale, R. (2004). *Human-Computer-Interaction.* 3rd edition. Harlow, UK.: Prentice-Hall.

Dodd, R., Pearson, E., & Green, S. (2005). A systematic approach to mobile accessibility. *ALT-C Conference abstracts*, September 6-8, 2005. Manchester University.

Evans, D., & Taylor, J. (2005). The role of user scenarios as the central piece of the development jigsaw puzzle. In: J. Attewell and C. Savill-Smith (Eds.) *Mobile Learning Anytime Everywhere: Papers from Mlearn 2004*, (pp. 63-66). London: LSDA.

Fagerberg, T., Rekkedal, T., & Russell, J. (2002). Designing and Trying Out a Learning Environment for Mobile Learners and Teachers. Paper published on the *NKI Distance Education – Electronic College.* Retrieved February 14, 2007 from: http://www.nettskolen.com/forskning/55/NKI2001m-learning2.html

Gilbert, A. L., Sangwan, S., & Han Mei lan, H. (2005). Beyond Usability: The OoBE dynamics of mobile data services markets. *Personal and Ubiquitous Computing, 9*(4), 198-208.

Hackemer, K., & Peterson, D. (2005). University of South Dakota Palm Initiative. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A handbook for educators and trainers* (pp. 157-163). London: Routledge.

Hitz, M., & Plattner, S. (2004). PaperLinks – Linking printouts to mobile devices. In J. Attewell & C. Savill-Smith (Eds.) *Mobile Learning Anytime Everywhere – a book of papers from MLEARN 2004* (pp. 105-108). London: LSDA.

Jäppinen, A., Ahonen, M., Vainio, T., & Tanhua-Piiroinen, E. (2005). Adaptive Mobile Learning Systems: The essential issues from the design perspective. In J. Attewell & C. Savill-Smith (Eds.) *Mobile Learning Anytime Everywhere – a book of papers from MLEARN 2004* (pp. 109-111). London: LSDA.

JISC (2005). *Case Studies of Innovative Practice: Wireless and Mobile Learning.* Project led by Agnes Kukulska-Hulme at The Institute of Educational Technology, The Open University, UK. Retrieved February 14, 2007 from: http://www.jisc.ac.uk/whatwedo/programmes/elearning_innovation/eli_oucasestudies.aspx

Keinonen, T. (2003). Introduction: Mobile distinctions. In C. Lindholm, T., Keinonen, & H., Kiljander (Eds.) *Mobile Usability: how Nokia changed the face of the mobile phone* (pp. 1-8). New York: McGraw-Hill.

Kukulska-Hulme, A. (2002). Cognitive, ergonomic, and affective aspects of PDA use for learning. Proceedings of *2002 European Workshop on Mobile and Contextual Learning*, June 20-21. University of Birmingham.

Kukulska-Hulme, A. (2005a). *Current uses of wireless and mobile learning – Landscape study on the use of mobile and wireless technologies for teaching and learning in the Post-16 sector. JISC-funded project.* Retrieved February 14, 2007 from: http://www.jisc.ac.uk/uploaded_documents/Current%20Uses%20FINAL%202005.doc

Kukulska-Hulme, A. (2005b). Mobile Usability and User Experience. In A. Kukulska-Hulme & J. Traxler, J. (Eds.) *Mobile Learning: A handbook for educators and trainers* (pp. 45-56). London: Routledge.

Kukulska-Hulme, A. & Pettit, J. (2006). Practitioners as innovators: emergent practice in personal mobile teaching, learning, work and leisure. Paper submitted to the *2006 Mlearn Conference*, October 22-25. Banff, Canada.

Kukulska-Hulme, A., & Shield, L. (2004). Usability and Pedagogical Design: Are language learning websites special? Paper presented at *ED-MEDIA 2004 World Conference on Educational Multimedia, Hypermedia and Telecommunications.* June 22-26. Lugano, Switzerland. Retrieved February 14, 2007 from: http://www.aace.org/DL/index.cfm?fuseaction=ViewPaper&id=16072

Luckin, R., Brewster, D., Pearce, D., du Boulay, B., & Siddons-Corby, R. (2005). Whether it's m-learning or e-learning, it must be ME learning. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A handbook for educators and trainers* (pp. 116-124). London: Routledge.

Luckin, R., du Boulay, B., Smith, H., Underwood, J., Fitzpatrick, G., Holmberg, J., Kerawalla, L., et al. (2005). Using Mobile Technology to Create Flexible Learning Contexts. *In A. Jones, A. Kukulkska-Hulme, & D. Mwanza (Eds.) Portable Learning: Experiences with Mobile Devices. Journal of Interactive Media in Education 22*. Retrieved February 14, 2007 from: http://jime.open.ac.uk/2005/22/

Malliou, E., & Miliarakis, A. (2005). The MOTFAL Project: Mobile technologies for ad hoc learning. In J. Attewell & C. Savill-Smith (Eds.) *Mobile Learning Anytime Everywhere: Papers from Mlearn 2004* (pp. 119-122). London: LSDA.

Manolo Project (2005). *Guidelines for Integrating e-, w-, and m-Learning. Project deliverables – lessons learned.* Retrieved February 14, 2007 from: http://www.spinlab.vu.nl/manolo/

McGreal, R. (2005). Mobile devices and the future of free education. Paper presented at the *ICDE World Conference 2005*, October 24-28. New Delhi: International Council for Distance Education.

McGreal, R., Cheung, B., Tin, T., & Schafer, S. (2005) The Athabasca University Digital Reading Room: Library resources for mobile students. Paper published in the proceedings of the *2005 IADIS International Conference on Mobile Learning*, June 28-30. Qawra, Malta.

Nielsen, J. (1993). *Usability Engineering.* Boston MA.: Academic Press.

Nielsen, J. (2001, January 16). Jakob Nielsen on e-learning. Article published on *Elearning Post.* Retrieved February 14, 2007 from: http://www.elearningpost.com/articles/archives/jakob_nielsen_on_e_learning/

Nielsen, J. (2003, August 18). Mobile Devices: One generation from useful. Alertbox posting on *useit.com: Jakob Nielsen's Website.* Retrieved February 14, 2007 from: http://www.useit.com/alertbox/20030818.html

Nielsen, J. (2005, October 3). Top Ten Web Design Mistakes of 2005. Posting in *Jakob Nielsen's Alertbox.* Retrieved February 14, 2007 from: http://www.useit.com/alertbox/designmistakes.html

NKI Distance Education (2004, October). *Mobile Learning – The Next Generation of Learning, White Paper*. Retrieved February 14, 2007 from: http://whitepapers.silicon.com/0,39024759,60133005p-39000592q,00.htm

O'Malley, C., Vavoula, G., Glew, J.P., Taylor, J., Sharples, M., & Lefrere, P. (2003). *MOBIlearn WP4 – Guidelines for Learning/Teaching/Tutoring in a Mobile Environment.* Retrieved February 14, 2007 from: http://www.mobilearn.org/download/results/guidelines.pdf

Pehkonen, M., & Turunen, H. (2003). Preliminary guidelines for the design of the mobile learning activities and materials. In *EUROPRIX Scholars Conference, Conference Papers and Presentations*, November 13-14. Tampere, Finland: European Academy of Digital Media, MindTrek Association. Retrieved February 14, 2007 from: http://www.mindtrek.org/liitetiedostot/materiaalit_editori/75.doc

Pettit, J., & Kukulska-Hulme, A. (2006). Going with the grain – mobile devices in practice. Paper submitted to the *ASCILITE 2006 Conference*, December 3-6. Sydney, Australia.

Polishook, M. (2005). Handheld Composing: Reconceptualizing artistic practice with PDAs. In A. Kukulska-Hulme & J. Traxler, (Eds.) *Mobile Learning: A handbook for educators and trainers* (pp. 133-138). London: Routledge.

Preece, J., Rogers, Y., & Sharp, H. (2002). *Interaction Design: Beyond human-computer interaction.* New York: John Wiley.

Rekkedal, T. (2002). *M-Learning for PDAs: Enhancing the flexibility of distance education.* Powerpoint presentation delivered to *Ericsson Education*, November 22. Dublin, Ireland. Retrieved February 14, 2007 from: http://learning.ericsson.net/mlearning2/project_one/presentation/torstein1911.ppt

Roberts, J., Beke, N., Janzen, K., Mercer, D., & Soetaert, E. (2003). Harvesting Fragments of Time: Mobile learning pilot project. Final Report. *McGraw-Hill Mobile Learning Pilot Project Consortium*, May 1. Toronto, Canada.

Ryan, P., & Finn, E. (2005) Field-based mLearning: Who wants what? Proceedings of the *IADIS International Conference on Mobile Learning.* June 28-30. Qawra, Malta.

Sharples, M., Corlett, D., Bull, S., Chan, T., & Rudman, P. (2005). The Student Learning Organiser. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A Handbook for Educators and Trainers* (pp. 139-149). London: Routledge.

Shield, L., & Kukulska-Hulme, A. (2006). Are language learning websites special? Towards a research agenda for discipline-specific usability. *Journal of Educational Multimedia and Hypermedia, 15*(3), 349-369.

Shneiderman, B. (2002). *Leodardo's Laptop: Human needs and the new computing technologies.* Cambridge, MA.: MIT Press.

Smørdal, O., & Gregory, J. (2005). KNOWMOBILE: mobile opportunities for medical students. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A handbook for educators and trainers* (pp. 99-105). London: Routledge.

Sugden, D. (2005). Exploring the physical frontiers of e-learning. The use of personal digital assistants (PDAs) in outreach centres. *ALT-C 2005 Research Proceedings*, September 6-8, University of Manchester.

Syvänen, A., & Nokelainen, P. (2005). Evaluation of the technical and pedagogical mobile usability. In J. Attewell & C. Savill-Smith (Eds.) *Mobile Learning Anytime Everywhere: A book of papers from MLEARN 2004* (pp. 191-195). London: LSDA.

Trinder, J., Magill, J., & Roy, S. (2005). Expect the Unexpected: Practicalities and problems of a PDA project. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A handbook for educators and trainers* (pp. 92-98). London: Routledge.

Turel, O. (2006). Contextual effects on the usability dimensions of mobile value-added services: a conceptual framework. *International Journal of Mobile Communications, 4*(3), 309-332.

van 't Hooft, M. (2006). *Usability issues.* Posting on the CIDER Mobile Learning SIG forum, May 26, 2006. Retrieved February 14, 2007 from: http://cider.athabascau.ca/CIDERSIGs/mobilelearning/mlearndiscussion/talkback/1148656719

Wagner, E. D. (2005). Enabling Mobile Learning. *EDUCAUSE Review, 40*(3), 40-53. Retrieved February 14, 2007 from: http://www.educause.edu/apps/er/erm05/erm0532.asp?bhcp=1

Waycott, J., & Kukulska-Hulme, A. (2003). Students' Experiences with PDAs for Reading Course Materials. *Personal and Ubiquitous Computing, 7*(1), 30-43.

Waycott, J., Jones, A., & Scanlon, E. (2005). PDAs as Lifelong Learning Tools : An activity theory based analysis. *Learning, Media and Technology, 30*(2), 107-130.

Weiss, S. (2002). *Handheld Usability.* Chichester, UK.: John Wiley.

SOME RIGHTS RESERVED

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Defining, Discussing, and Evaluating Mobile Learning: The moving finger writes and having writ… .

John Traxler
University of Wolverhampton, UK

Abstract

Since the start of the current millennium, experience and expertise in the development and delivery of mobile learning have blossomed and a community of practice has evolved that is distinct from the established communities of 'tethered' e-Learning. This community is currently visible mainly through dedicated international conference series, of which MLEARN is the most prestigious, rather than through any dedicated journals. So far, these forms of development and delivery have focussed on short-term small-scale pilots and trials in the developed countries of Europe, North America, and the Pacific Rim, and there is a taxonomy emerging from these pilots and trials that suggests tacit and pragmatic conceptualisations of mobile learning.

What has, however, developed less confidently within this community is any theoretical conceptualisation of mobile learning and with it any evaluation methodologies specifically aligned to the unique attributes of mobile learning.

Some advocates of mobile learning attempt to define and conceptualise it in terms of devices and technologies; other advocates define and conceptualise it in terms of the mobility of learners and the mobility of learning, and in terms of the learners' experience of learning with mobile devices.

The role of theory is, perhaps, a contested topic in a community that encompasses philosophical affiliations from empiricists to post-structuralists, each with different expectations about the scope and legitimacy of theory in their work. The mobile learning community may nevertheless need the authority and credibility of some conceptual base.

Such a base would provide the starting point for evaluation methodologies grounded in the unique attributes of mobile learning. Attempts to develop the conceptualisations and evaluation of mobile learning, however, must recognise that mobile learning is essentially personal, contextual, and situated; this means it is 'noisy' and this is problematic both for definition and for evaluation.

Furthermore, defining mobile learning can emphasise those unique attributes that position it within informal learning, rather than formal. These attributes place much mobile learning at odds with formal learning with its cohorts, courses, semesters, assessments, and campuses, and with its monitoring and evaluation regimes. This raises concerns for the nature of any large-scale and

sustained deployment and the extent to which the unique attributes of mobile learning may be lost or compromised.

Looking at mobile learning in a wider context, we have to recognise that mobile, personal, and wireless devices are now radically transforming societal notions of discourse and knowledge, and are responsible for new forms of art, employment, language, commerce, deprivation, and crime, as well as learning. With increased popular access to information and knowledge anywhere, anytime, the role of education, perhaps especially formal education, is challenged and the relationships between education, society, and technology are now more dynamic than ever.

The paper explores and articulates these issues and the connections between them specifically in the context of the wider and sustained development of mobile learning.

Keywords: Mobile learning; distance learning; definition; conceptualisation; evaluation

Introduction

The use of wireless, mobile, portable, and handheld devices are gradually increasing and diversifying across every sector of education, and across both the developed and developing worlds. It is gradually moving from small-scale, short-term trials to larger more sustained and blended deployment. This article draws on recent publications, projects, and trials in order to explore the possible future and nature of mobile education. The article then examines the relationship between the challenges of rigorous and appropriate evaluation of mobile education and the challenges of embedding and mainstreaming mobile education within formal institutional education.

Mobile learning has growing visibility and significance in higher education. Evidence for this growing visibility and significance is as follows. First, there is the growing size and frequency of dedicated conferences, seminars, and workshops, both in the United Kingdom and internationally. The first of the MLEARN series, MLEARN 2002 in Birmingham, for example, was followed by MLEARN 2003 in London, with more than 200 delegates from 13 countries, by MLEARN 2004 in Rome in July 2004, by MLEARN 2005 in Cape Town in October 2005, and by MLEARN 2006 in Banff, Alberta in November 2006. Another dedicated event, the International Workshop on Mobile and Wireless Technologies in Education (WMTE, 2002), sponsored by IEEE, took place in Sweden in August 2002 (http://lttf.ieee.org/wmte2002/). The second WMTE (http://lttf.ieee.org/wmte2003/) was held at National Central University in Taiwan in March 2004, in Japan in 2005, and in Athens in 2006. Both these series report buoyant attendance. There are also a growing number of national and international workshops. The June 2002 national workshop in Telford on mobile learning in the computing discipline attracted 60 delegates from UK higher education (http://www.ics.ltsn.ac.uk/events). The National Workshop and Tutorial on Handheld Computers in Universities and Colleges at Telford (http://www.e-innovationcentre.co.uk/eic_event.htm) on June 11, 2004, and subsequent events on January 12, 2005 and November 4, 2005 (http://www.aidtech.wlv.ac.uk) all attracted over 90 delegates. The International Association for Development of the Information Society (IADIS) (www.IADIS.org) now run a conference series, the first taking place in Malta in 2005, the second in Dublin in 2006, and the third in Lisbon in 2007. Secondly, there have also been a rising number of references to mobile learning at generalist academic conferences, for example the Association for Learning Technology conference (ALT-C) every September in the UK (http://www.alt.ac.uk).

The mobile learning currently exploits both handheld computers and mobile telephones and other devices that draw on the same set of functionalities. Mobile learning using handheld computers is obviously relatively immature in terms of both its technologies and its pedagogies, but is developing rapidly. It draws on the theory and practice of pedagogies used in technology enhanced learning and others used in the classroom and the community, and takes place as mobile devices are transforming notions of space, community, and discourse (Katz & Aakhus, 2002; Brown & Green, 2001) and the investigative ethics and tools (Hewson, Yule, Laurent, & Vogel, 2003). The term covers the personalised, connected, and interactive use of handheld computers in classrooms (Perry, 2003; O'Malley & Stanton, 2002), in collaborative learning (Pinkwart, Hoppe, Milrad, & Perez, 2003), in fieldwork (Chen, Kao, & Sheu, 2003), and in counselling and guidance (Vuorinen & Sampson, 2003). Mobile devices are supporting corporate training for mobile workers (Gayeski, 2002; Pasanen, 2003; Lundin & Magnusson, 2003) and are enhancing medical education (Smordal & Gregory, 2003), teacher training (Seppala & Alamaki, 2003), music composition (Polishook, 2005), nurse training (Kneebone, 2005), and numerous other disciplines. They are becoming a viable and imaginative component of institutional support and provision (Griswold, Boyer, Brown, et al., 2002; Sariola, 2003; Hackemer & Peterson, 2005). In October 2005, the first comprehensive handbook of mobile learning was published (Kukulska-Hulme & Traxler, 2005), but accounts of mobile distance learning are still infrequent.

There are now a large number of case studies documenting trials and pilots in the public domain (Kukulska-Hulme & Traxler, 2005; JISC, 2005; Attewell & Savill-Smith, 2004). In looking at these, we can see some categories of mobile learning emerging (Kukulska-Hulme & Traxler, *in press*):

- **Technology-driven mobile learning –** Some specific technological innovation is deployed in an academic setting to demonstrate technical feasibility and pedagogic possibility

- **Miniature but portable e-Learning –** Mobile, wireless, and handheld technologies are used to re-enact approaches and solutions already used in 'conventional' e-Learning, perhaps porting some e-Learning technology such as a Virtual Learning Environment (VLE) to these technologies or perhaps merely using mobile technologies as flexible replacements for static desktop technologies

- **Connected classroom learning –** The same technologies are used in classroom settings to support collaborative learning, perhaps connected to other classroom technologies such as interactive whiteboards

- **Informal, personalised, situated mobile learning –** The same technologies are enhanced with additional functionality, for example location-awareness or video-capture, and deployed to deliver educational experiences that would otherwise be difficult or impossible

- **Mobile training/ performance support –** The technologies are used to improve the productivity and efficiency of mobile workers by delivering information and support just-in-time and in context for their immediate priorities (for an early account, see Gayeski, 2002)

- **Remote/ rural/ development mobile learning –** The technologies are used to address environmental and infrastructural challenges to delivering and supporting education

where 'conventional' e-Learning technologies would fail, often troubling accepted developmental or evolutionary paradigms

Mobile distance learning could fall into any of these categories (with the exception of the 'connected classroom learning'); how it develops will depend in part on the affordances of any given situation. These affordances might include:

- Infrastructure, meaning power supply, postal services, Internet connectivity, etc.
- Sparsity, giving rise to infrequent face-to-face contact, lack of technical support, etc.
- The wider policy agenda including lifelong learning, inclusion (of rural areas for example), assistivity, participation, and access
- Mobile distance learning within a framework of blended distance learning and the affordances of other delivery and support mechanisms

Defining Mobile Education

In spite of the activity cited above, the concept of mobile education or mobile learning is still emerging and still unclear. How it is eventually conceptualised will determine perceptions and expectations, and will determine its evolution and future. There are different stakeholders and factors at work in this process of conceptualising mobile education and the outcome is uncertain.

There are obviously definitions and conceptualisations of mobile education that define it purely in terms of its technologies and its hardware, namely that it is learning delivered or supported solely or mainly by handheld and mobile technologies such as personal digital assistants (PDAs), smartphones or wireless laptop PCs. These definitions, however, are constraining, techno-centric, and tied to current technological instantiations. We, therefore, should seek to explore other definitions that perhaps look at the underlying learner experience and ask how mobile learning differs from other forms of education, especially other forms of e-Learning.

If we take as our starting point the characterisations of mobile learning found in the literature (the conference proceedings from MLEARN and WMTE for example), we find words such as 'personal,' 'spontaneous,' 'opportunistic,' 'informal,' 'pervasive,' 'situated,' 'private,' 'context-aware,' 'bite-sized,' and 'portable.' This is contrasted with words from the literature of conventional 'tethered' e-Learning such as 'structured,' 'media-rich,' 'broadband,' 'interactive,' 'intelligent,' and 'usable.' We can use these two lists to make a blurred distinction between mobile learning and e-Learning. This distinction, however, is not only blurred but in part is also only temporary. Many of the virtues of e-Learning are the virtues of the power of its technology (and the investment in it) and soon these virtues will also be accessible to mobile devices as market forces drive improvements in interface design, processor speed, battery life, and connectivity bandwidth. Nevertheless, this approach underpins a conceptualisation of mobile learning in terms of the learners' experiences and an emphasis on 'ownership,' informality, mobility, and context that will always be inaccessible to conventional 'tethered' e-Learning.

Tackling the problem of definition from another direction, we see that mobile devices and technologies are pervasive and ubiquitous in many modern societies, and are increasingly changing the nature of knowledge and discourse in these societies (whilst being themselves the products of various social and economic forces). This, in turn, alters both the nature of learning

(both formal and informal) and alters the ways that learning can be delivered. Learning that used to be delivered 'just-in-case,' can now be delivered 'just-in-time,' 'just enough,' and 'just-for-me.' Finding information rather than possessing it or knowing it becomes the defining characteristic of learning generally and of mobile learning especially, and this may take learning back into the community.

Mobile technologies also alter the nature of work (the driving force behind much education and most training), especially of knowledge work. Mobile technologies alter the balance between training and performance support, especially for many knowledge workers. This means that 'mobile' is not merely a new adjective qualifying the timeless concept of 'learning'– 'mobile learning' is emerging as an entirely new and distinct concept alongside the 'mobile workforce' and the 'connected society.'

Mobile devices create not only new forms of knowledge and new ways of accessing it, but also create new forms of art and performance, and new ways of accessing them (such as 'pop' videos designed and sold for *iPods*). Mobile devices are creating new forms of commerce and economic activity as well. So mobile learning is not about 'mobile' as previously understood, or about 'learning' as previously understood, but part of a new mobile conception of society. (This may contrast with technology enhanced learning or technology supported, both of which give the impression that technology does something to learning.)

In a different sense, ongoing developments on implementing e-Learning, for example in developing the ontologies of learning objects, makes us examine and question how knowledge is organised and interrelated. Here too our notions of knowledge and learning are evolving. It could be argued that the need to organise and navigate through 'bite-sized' pieces of mobile learning content (whether or not as Learning Objects) will also impact on these notions of knowledge and learning and perhaps individual learners will create their own ontologies on-the-fly as they navigate through a personalised learning journey.

One can also focus on the nature of mobility in order to explore the nature of mobile learning. For each learner, the nature of 'mobility' has a variety of connotations and these will colour conceptualisations of mobile education. It may mean learning whilst traveling, driving, sitting, or walking; it may be hands-free learning or eyes-free learning. These interpretations impact on the implementation and hence the definition of mobile learning.

Having earlier discounted technology as a defining characteristic of mobile learning, it may in fact transpire that different hardware and software platforms support rather different interpretations of mobile learning. At the risk of over-simplification, the philosophy behind the Palm™ based brand of handheld computers (or rather, organisers) initially led to a zero-latency task-oriented interface with only as much functionality as would fit inside the prescribed size of box and this would coax maximum performance out of the processor, the memory, and the battery. *Microsoft*-based mobile devices by comparison inherited a PC-based interface with considerable latency, making much higher demands on memory, battery, and processor. This dichotomy may be less sharp than it once was, but it could be viewed as underpinning two different interpretations of mobile learning; the former a 'bite-sized' 'just-in-time' version near to the one described above, the latter more like a portable but puny version of 'tethered' e-Learning described above. Similarly, if we were to address whether learning delivered or supported on the current generation of laptop and *Tablet* PCs should be termed 'mobile learning' then the answer must be 'no.' Learners, and indeed people in general, will carry and use their phones, their *iPods*,

or their PDAs habitually and unthinkingly; however, they will seldom carry a laptop or *Tablet* PC without a premeditated purpose and a minimum timeframe.

Another technical factor, however, may hinder direct comparison with e-Learning. That is the geometry of mobile devices. For several years, proponents of mobile learning have looked for the eventual convergence of mobile phone technologies and handheld computer technologies, creating a basic generic mobile learning platform to which extra (learning) functionality could be added as desired. This might include camera and other data capture, media player capacity, and location awareness using, for example, global positioning systems (GPS). This now looks unlikely to happen and currently the hardware manufacturers and vendors treat their markets as highly segmented and differentiated. This may be due to the nature of the hardware itself. Unlike desktop PCs, where functionality and connectivity can be easily added or subtracted by adding or subtracting internal chips and cards, mobile technologies are fairly monolithic. In the case of laptops, external slots and ports can provide extra connectivity or memory. Anything smaller, such as a handheld or palmtop computer, has one or at best, two slots. This means that a handheld device has only the functionality with which it was made. Manufacturers cannot position and reposition variations on a basic chassis to suit changing markets. Therefore, it is unlikely that we will be able to build a conceptualisation of mobile learning upon the idea of a generic and expandable mobile hardware platform in the way that 'tethered' e-Learning has implicitly been built upon the PC or personal computer platform.

In any case, hardware devices and technical systems are all without exception designed, manufactured, and marketed for corporate, retail, and recreational users. Any educational uses of the devices and the systems are necessarily parasitic and secondary. Therefore, conceptualisations of mobile learning are also constrained by the distorting nature of the technologies and the devices.

The community of practice cohering around mobile learning nevertheless may feel the need for a theory of mobile learning (although in a postmodern era, the role of theory as an informing construct is under threat). Such a theory may be problematic since mobile learning is inherently a 'noisy' phenomenon where context is everything. e-Learning has certainly gained credibility from the work of many outstanding authors. Finding similar beacons for mobile learning may be more challenging and proponents of mobile learning are still struggling to find a literature and a rhetoric distinct from conventional 'tethered' e-Learning.

The discussion so far has implicitly focused on conceptions of mobile learning based on the culture and affordances of developed countries. If we look at the emerging practice of mobile learning based around phones and PDAs in developing countries, especially the poorest, a different picture emerges based on wholly different affordances. The radically different physical infrastructure and cultural environment – including landline telephony, Internet connectivity, electricity, the rarity of PCs, and the relative inability of societies to support jobs, merchandising, and other initiatives based around these prerequisites – has meant that prescriptions for mobile learning are more cautious than in the developed world (Traxler & Kukulska-Hulme, 2005). It has also meant that mobile phones are now being recognised as the pre-eminent vehicle not only for mobile learning, but also for wider social change (Traxler & Dearden, 2005). It is entirely possible that the emergence of mobile learning in developing countries will take the evolution of e-Learning along a trajectory that is very different from that in developed countries, where it has been predicated on massive, static, and stable resources. Distance learning will form a significant component of this because of its existing status within the development communities.

The Case for Mobile Education

It is possible to make a strong case for mobile education on 'purist' or theoretical pedagogic grounds. This 'purist' case for mobile learning includes the idea that mobile learning will support a wide variety of conceptions of teaching, and furthermore the ideas that mobile learning are uniquely placed to support learning that is personalised, authentic, and situated.

Different teachers and disciplines will have different conceptions of teaching (Kember, 1997) that they will attempt to bring to education. These conceptions of teaching may vary from ones primarily concerned with the delivery of content, to ones primarily concerned with supporting students learning (i.e., by discussion and collaboration). Mobile learning technologies clearly support the transmission and delivery of rich multi-media content. They also support discussion and discourse, real-time, synchronous and asynchronous, using voice, text and multi-media. Different disciplines, say for example sociology or literature as opposed to engineering, may also require broadly different conceptions of teaching. Distance learning versus site-based/ face-to-face education form another alternative axis to the subject axis; distance educators will have their own conceptions of teaching, often influenced by Illich (1971), Freire (1972), and Gramsci (1985).

What are called 'styles of learning' will also exert an influence on how mobile learning is conceptualised. This is currently a contested area (Coffield, Moseley, Hall, & Ecclestone, 2005), but similar arguments could be advanced about the capacity of mobile learning to fit with the various preferred approaches to learning adopted by different (distance) students at different times.

By personalised learning, we mean learning that recognises diversity, difference, and individuality in the ways that learning is developed, delivered, and supported. Personalised learning defined in this way includes learning that recognises different learning styles and approaches (though perhaps this phrase should not be related too literally to the established literature of 'learning styles,' see for example, Coffield, et al., 2005), and recognises social, cognitive, and physical difference and diversity (in the design and delivery of interfaces, devices, and content). We would argue that mobile learning offers a perspective that differs dramatically from personalised conventional e-Learning in that it supports learning that recognises the context and history of each individual learner and delivers learning to the learner when and where they want it.

By situated learning, we mean learning that takes place in the course of activity, in appropriate and meaningful contexts (Lave & Wenger, 1991). The idea evolved by looking at people learning in communities as apprentices by a process of increased participation. It can be, however, extended to learning in the field (in the case of botany students for example), in the hospital ward (in the case of trainee nurses), in the classroom (in the case of trainee teachers), and in the workshop (in the case of engineering students), rather than in remote lecture theatres. Mobile learning is uniquely suited to support context-specific and immediate learning, and this is a major opportunity for distance learning since mobile technologies can situate learners and connect learners.

By authentic learning, we mean learning that involves real-world problems and projects that are relevant and interesting to the learner. Authentic learning implies that learning should be based around authentic tasks, that students should be engaged in exploration and inquiry, that students should have opportunities for social discourse, and that ample resources should be available to

students as they pursue meaningful problems. Mobile learning enables these conditions to be met, allowing learning tasks built around data capture, location-awareness, and collaborative working, even for distance learning students physically remote from each other.

Mobile learning uniquely supports spontaneous reflection and self-evaluation and the current e-Portfolio technologies (see for example, http://www.pebblepad.co.uk/) are expected to migrate to mobile devices in the near future.

It is equally possible, however, to make a strong case for mobile education on practical or 'impurist' grounds. This 'impurist' case recognises that learning takes place in a wider social and economic context, and that students must be recognised to be under a range of pressures, most obviously those of time, resources, and conflicting/ competing roles. This is true of distance learning and part-time students. Mobile learning allows these students to exploit small amounts of time and space for learning, to work with other students on projects and discussions, and to maximise contact and support from tutors.

Evaluating Mobile Education

This section makes the case that the increasing diversity of mobile education and the increasing power, sophistication, and complexity of mobile technologies call into question the adequacy of the conventional repertoire of evaluation techniques based largely around formal, sedentary, and traditional learning. This has always been the case with informal and distance learning anyway. There is a need for a more comprehensive, eclectic, and structured approach to evaluation based on sound and transparent principles. The section briefly elucidates these principles and shows how they can be used to underpin evaluation methodologies appropriate to mobile education.

There are a variety of problems associated with evaluating mobile learning. Perhaps the most fundamental is the problem of defining the characteristics of a 'good' or acceptable evaluation though, of course, the issue of evaluating mobile learning will also take us back to the issue of defining and conceptualising mobile learning. A definition or conceptualisation of mobile learning in terms of learner experience will take evaluation in a different direction from a conceptualisation of mobile learning in terms of hardware platforms. Of course, the categorisation of mobile learning (above) will also influence the practicalities and the priorities of evaluation.

What is not always accepted is that there are no *a priori* attributes of a 'good' evaluation of learning (to say that there were would be to take an implicitly realist or essentialist position that not every stakeholder would agree with, and would also confront a widely held view that in fact evaluation is a contingent activity). In an earlier work, we tried to outline some tentative candidate attributes of a 'good' evaluation (Traxler, 2002), but we also identified the reasons why evaluation of mobile learning is unusually challenging. Briefly some of these attributes were that a ‘good’ evaluation could be:

- Rigorous, meaning roughly that conclusions must be trustworthy and transferable
- Efficient, in terms of cost, effort, time, or some other resource
- Ethical, specifically in relation to the nuances of evolving forms of provision, in terms of standards from
    - legal

  - to normative

- Proportionate, that is, not more ponderous, onerous, or time-consuming than the learning experience or the delivery and implementation of the learning itself (bearing in mind earlier remarks about the learners' experiences of mobile learning)

- Appropriate to the specific learning technologies, to the learners, and to the ethos of the learning – ideally built in, not bolted on

- Consistent with the teaching and learning philosophy and conceptions of teaching and learning of all the participants

- Authentic, in accessing what learners (and perhaps teachers and other stakeholders) really mean, really feel, and sensitive to the learners' personalities within those media

- Aligned to the chosen medium and technology of learning

- Consistent across:
  - different groups or cohorts of learners in order to provide generality
  - time, that is, the evaluation is reliably repeatable
  - whatever varied devices and technologies are used

The last of these attributes is challenging in mobile learning, since the technologies are changing at an exceptional pace and consequently reaching any understanding of underlying issues is difficult. Some of the others are more subtle. Some issues around ethics have been explored elsewhere recently (Traxler & Bridges, 2004): mobile learning continues to evolve however.

A recent review of practice in the evaluation of mobile learning (Traxler & Kukulska-Hulme, 2005) suggests that not many accounts (none were distance learning anyway) articulated an explicit position on pedagogy or epistemology. They seldom cited any works from the literature of evaluation or any works from the literature of the ethics of evaluation. They seldom, if ever, mentioned any ethical issues in relation to their evaluation. Most accounts cited focus groups, interviews, and questionnaires as their elicitation instruments. Some used observation and some used system logs. A few accounts mentioned several techniques and were triangulated, but most accounts used only one or, at most, two techniques. None of these elicitation techniques were particularly consistent with mobile learning technologies. And all accounts of such evaluations assumed that the evaluators were told the truth by subjects (that is, learners and teachers); Hopefully, those involved in mobile distance learning evaluation will learn from this critique.

Clearly, there are problems with the epistemology and ethics of evaluating mobile learning; there are also challenges in developing suitable techniques to gather, analyse, and present evaluation. Nevertheless, the credibility of mobile, including distance, learning as a sustainable and reliable form of educational provision rests of the rigour and effectiveness of its evaluation.

Mobile Education in Universities and Colleges

Mobile education, however innovative, technically feasible, and pedagogically sound, may have no chance of sustained, wide-scale institutional deployment in higher education in the foreseeable future, at a distance or on site. This is because of the strategic factors at work within educational institutions and providers. These strategic factors are different from those of technology and

pedagogy. They are the context and the environment for the technical and the pedagogic aspects. They include resources (that is, finance and money but also human resources, physical estates, institutional reputation, intellectual property, and expertise) and culture (that is, institutions as social organisations, their practices, values and procedures, but also the expectations and standards of their staff, students and their wider communities, including employers and professional bodies).

Implementing wireless and mobile education within higher education must address these social, cultural, and organisational factors. They can be formal and explicit, or informal and tacit, and can vary enormously across and within institutions. Within institutions, different disciplines have their own specific cultures and concerns, often strongly influenced by professional practice in the 'outside world' – especially in the case of part-time provision and distance learning. Because most work in mobile learning is still in the pilot and/ or trial phase, any explorations of wider institutional issues are still tentative (Traxler, 2005; JISC, 2005) but it points to considerable hurdles with infrastructure and support.

Conclusions

This has been a very wide-ranging attempt to explore the nature and possibilities of mobile learning. It draws together much existing work, but this is still a relatively immature field. It has not explored the actual technologies or pedagogies in any detail and has sought to define questions for discussion rather than provide answers for what might in fact be premature or inappropriate questions. It is too early to describe or analyse the specifics of mobile learning for distance learning since the field, as a whole, is new and accounts are relatively sparse. The synergy between mobile learning and distance learning, however, holds enormous potential.

References

Attewell, J., & Savill-Smith, C. (Eds.) (2003). *Learning with Mobile Devices: Research and development. MLEARN '03 Book of Papers.* London: Learning and Skills Development Agency.

Brown, B., & Green, N. (2001). *Wireless World: Social and interactional aspects of the mobile age.* New York: Springer-Verlag.

Chen, Y. S., Kao, T. C., & Sheu, J. P. (2003). A mobile learning system for scaffolding bird watching learning. *Journal of Computer Assisted Learning, 19*(3), 347-359.

Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004). *Should we be using learning styles? What research has to say to practice.* London: Learning and Skills Research Centre.

Freire, P. (1972). *Pedagogy of the oppressed.* London: Penguin.

Gayeski, D. (2002). *Learning Unplugged - Using mobile technologies for organisational and performance improvement.* New York: AMACON - American Management Association.

Gramsci, A. (1985). *Selections from cultural writings.* London: Lawrence & Wishart.

Griswold, W., Boyer, R., Brown, S., Truong, T., Bhasker, E., Jay, G., & Shapiro, B. (2002). *Using mobile technology to create opportunistic interactions on a university campus.* San Diego, CA.: Computer Science and Engineering, University of California, San Diego.

Hackemer, K., & Peterson, D. (2005) Campus-wide handhelds. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A handbook for educators and trainers.* London: Routledge

Hewson, C., Yule, P., Laurent, D., & Vogel, C. (Eds.) (2003). *Internet Research Methods: A practical guide for the social and behavioural sciences* (New Technologies for Social Research series). London: Sage.

Illich, T. (1971). *Deschooling society.* London: Marion Boyars.

Katz, J. E., & Aakhus, M. (Eds.) (2002). *Perpetual Contact - Mobile Communications, Private Talk, Public Performance.* Cambridge, UK.: Cambridge University Press.

Kember, D. (1997). Reconceptualisation of Research into University Academics' Conceptions. *Learning and Instruction, 7*(3), 255-275.

Kneebone, R. (2005). PDAs for PSPs. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A Handbook for Educators and Trainers* (pp. 106-115). London: Routledge

Kukulska-Hulme, A., & Traxler, J. (2005). *Mobile Learning: A Handbook for Educators and Trainers.* London: Routledge

Kukulska-Hulme, A., & Traxler, J. (*in press*). Learning Design with Mobile and Wireless Technologies. In H. Beetham & R. Sharpe (*in press*). Rethinking Pedagogy for the Digital Age London: Routledge

JISC (2005). *Innovative Practice with e-Learning.* Bristol, UK.: Joint Information Services Committee

Lave, J., & Wenger, E. (1990). *Situated Learning: Legitimate peripheral participation.* Cambridge, UK.: Cambridge University Press.

Lundin, J., & Magnusson, M. (2003). Collaborative learning in mobile work. *Journal of Computer Assisted Learning, 19*(3), 273-283.

O'Malley, C., & Stanton, D. (2002). Tangible Technologies for Collaborative Storytelling. *Proceedings of MLEARN 2002, European Workshop on Mobile and Contextual Learning,* June 20-21, 2002 (pp. 63-64). Birmingham, UK.: University of Birmingham,

Pasanen, J. (2003). Corporate Mobile Learning. In H. Kynaslahti & P. Seppala (Eds.) *Mobile Learning* (pp. 115-123). Helsinki: IT Press.

Perry, D. (2003). *Handheld Computers (PDAs) in Schools.* Coventry, UK.: BECTa.

Pinkwart, N., Hoppe, H. U., Milrad, M., & Perez, J. (2003). Educational scenarios for cooperative use of Personal Digital Assistants. *Journal of Computer Assisted Learning, 19*(3), 383-391.

Polishook, M. (2005) Music on PDAs. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A Handbook for Educators and Trainers.* London: Routledge

Sariola, J. (2003). The Boundaries of University Teaching: Mobile Learning as a Strategic Choice for the Virtual University. In H. Kynaslahti & P. Seppala (Eds.), Mobile Learning (pp. 71-78). Helsinki: IT Press.

Seppala, P., & Alamaki, H. (2003). Mobile learning in teacher training. *Journal of Computer Assisted Learning, 19*(3), 330-335.

Smordal, O., & Gregory, J. (2003). Personal Digital Assistants in Medical Education and Practice. *Journal of Computer Assisted Learning, 19*(3), 320-329.

Traxler, J. (2002). Evaluating m-learning. Proceedings of *MLEARN 2002, European Workshop on Mobile and Contextual Learning*, June 20-21 (pp. 63-64). Birmingham, UK.: University of Birmingham,

Traxler, J. (2005) Institutional Issues: Embedding and Supporting. In A. Kukulska-Hulme, & J. Traxler (Eds.) *Mobile Learning: A Handbook for Educators and Trainers* (pp. 173-188). London: Routledge

Traxler, J., & Bridges, N. (2004). Mobile Learning - The Ethical and Legal Challenges. *Proceedings of MLEARN 2004, Bracciano, Italy*, June 2004.

Traxler, J. & Dearden, P. (2005) The Potential for Using SMS to Support Learning and Organisation in Sub-Saharan Africa. Proceedings of Development Studies Association Conference, Milton Keynes, September 2005

Traxler, J., & Kukulska-Hulme, A. (2005). Mobile Learning in Developing Countries. In G. Chin (Ed.) *A report commissioned by the Commonwealth of Learning.* Vancouver, BC.: Commonwealth of Learning.

Traxler, J., & Kukulska-Hulme, A. (2005) Evaluating Mobile Learning: Reflections on Current Practice. *Proceedings of MLEARN 2005*, October 25-28, Cape Town, South Africa.

Vuorinen, R., & Sampson, J. (2003). Using mobile Information Technology to Enhance Counselling and Guidance. In H. Kynaslahti & P. Seppala (Eds.) *Mobile Learning* (pp. 63-70). Helsinki: IT Press.

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Mobile Distance Learning with PDAs: Development and testing of pedagogical and system solutions supporting mobile distance learners

Torstein Rekkedal and **Aleksander Dye**
The Norwegian School of Information Technology and NKI Distance Education
Norway

Abstract

The article discusses basic teaching-learning philosophies and experiences from the development and testing of mobile learning integrated with the online distance education system at NKI (Norwegian Knowledge Institute) Distance Education. The article builds on experiences from three European Union (EU) supported *Leonardo da Vinci* projects on mobile learning: *From e-learning to m-learning* (2000-2003), *Mobile learning – the next generation of learning* (2003-2005), and the ongoing project, *Incorporating mobile learning into mainstream education* (2005-2007).

Keywords: Distance learning; mobile learning; learning management systems; LMS

Introduction

The article discusses NKI basic philosophies of distance learning and their consequences for development of a learning environment supporting mobile distance learners. Most NKI courses are not designed to function as online interactive e-Learning programmes, although some parts of the courses may imply such interaction with multi-media materials, tests, and assignments. NKI courses normally involve intensive study, mainly of text-based materials and includes problem solving, writing essays, submitting assignments, and communicating with fellow students by email or in the Web-based conferences. This means that most of the time the students will be offline when studying. From experience, we know that students often download content for reading offline and print content for reading on paper.

When developing system solutions for mobile learning, it is assumed that the NKI students will have access to a desktop or laptop computer with an Internet connection. This means that when students are mobile and wishing to study, the equipment and technologies they use will be in addition to they equipment use at home or at work. It should also be noted that the solutions

developed were based on the absolute assumption that mobile learners would study within the same group of students who do not have access to mobile technology. Thus, the design of the learning environment must efficiently cater to both situations and both types of students.

During the first project, NKI developed solutions for mobile learning applying mobile phones and Personal Digital Assistants (PDAs) with portable keyboard. Learning materials were developed mainly for downloading to the PDA and off-line study, while online access to forum discussions, responding to forum messages, reading in forums, communication with fellow students and tutors, and submitting assignments, were handled online via mobile equipment when students were on the move.

During the second project, NKI developed and tested solutions for an '*always online multi-media environment*' for distance learners based on the use of PDAs with access to wireless networks. During this project, NKI first developed one specific course for mobile access with PDAs. Cost and efficiency considerations, however, required server-side solutions that made access independent of devices on the user-side. Thus, during the second year of the second mobile learning project, NKI installed software and solutions which, in principle, made all online courses accessible independent of devices on the receiving side – e.g., most types of pocket PCs, PDAs, and mobile phones.

One of the main challenges concerning the use of mobile devices was to find acceptable solutions adapted to the small screen. There is simply not enough space on a small screen for all the information found on a traditional webpage. Another problem encountered was the limited data transfer rate and processing power found in mobile devices. When people use a mobile device with Internet connectivity, the connection speed is traditionally lower than, for instance, that of a traditional mobile phone. Thus, the project tried out solutions designed for a future, as we believe it might be, with online high speed access wherever the student is located.

The aim of the third and present project is to develop mobile learning course content and services that will enter into the mainstream and take mobile learning from a project-based structure and into mainstream education and training.

The article presents and discusses the student experiences from the first two trials of mobile learning and their consequences for further developments within an online distance learning system.

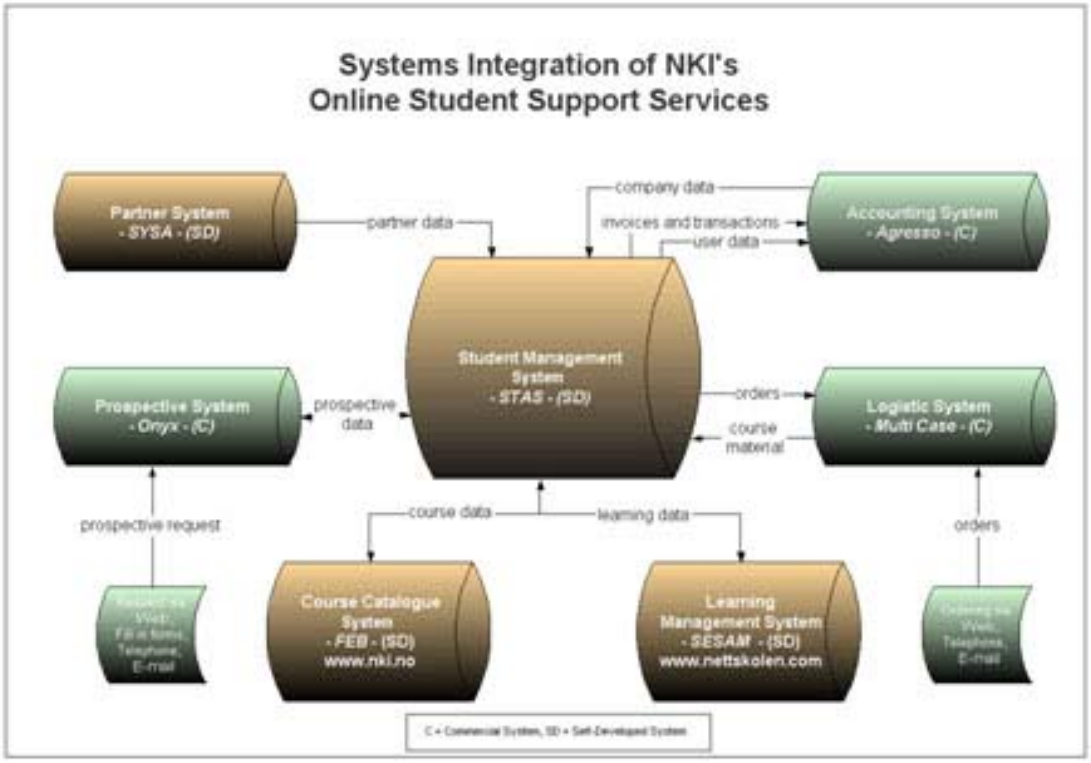
Although it is difficult to foresee what will be the technical solutions for mobile devices in the years to come, there is no doubt that the research on mobile technology in online distance learning at NKI has inspired developments that also increase the quality of our online distance learning in general, helping make us better prepared to serve mobile students now and in the future, independent of which technology students prefer to use when on the move.

Context

NKI Distance Education is the largest distance teaching institution in Norway, recruiting 7,000-10,000 students every year. NKI Distance Education is one unit in the NKI group, a non-governmental educational institution offering full-time and part-time training on secondary and tertiary level.

NKI Distance Education was one of the first institutions worldwide to offer online distance education when, in 1987, we started the first trials on our in-house developed Learning Management System, EKKO (Norwegian acronym for "electronic combined education"). Since then, online education has continuously been offered to increasing numbers of students. At time of writing, NKI has approximately 9,000 active online students, studying one of more than 80 study programmes or over 400 courses offered on the Internet/ Web. Since 1987, NKI online distance education has had 60,000 course enrolments. In 2001, we launched what we consider to be the fourth generation online distance education system at NKI: the internally developed Learning Management System (LMS) called Scalable Educational System for Administration and Management or SESAM, a solution which totally integrates NKI's Web-based LMS with its overall Student Administration System and a number of other applications designed for the efficient operation and administration of the logistics and student support measures in online distance education (see Figure 1). We consider the total integration of distance education information technology systems as one major prerequisite for operating an efficient and effective large-scale distance education system. A description of SESAM and its functionalities has been given by Paulsen, Fagerberg, and Rekkedal (2003).

Figure 1. NKI's integrated systems for online administration and student support.



When engaging in the EU Leonardo da Vinci m-Learning projects, the NKI research and development group was very clear that our aim would be to develop solutions that increase access and flexibility, and refine the total distance learning environment to meet the needs of the 'mobile distance learner.'

NKI's Basic Philosophies Concerning Distance Learning

Increasing the flexibility of distance education

A number of evaluation studies among distance and online learners at NKI have demonstrated that students emphasize flexibility (Rekkedal 1990; 1998; 1999; Rekkedal & Paulsen, 1997).

We have argued that distance education generally seems to develop in two quite different directions. The solution at one end of the flexibility continuum can be described as an individual, flexible solution that allows students the freedom to start at any time and follow their own progression according to their personal needs for combining studies with work, family, and social life: This solution is called '*the individual flexible teaching model*.' This model represents a development of the generic model of distance teaching institutions and normally applies media and technologies independent of time (and place), such as asynchronous computer communication, and pre-produced video, audio, and printed materials. The model on the opposite end of the flexibility continuum, which is called '*the extended classroom model*,' assumes that the students are organised into groups that are required to meet regularly at local study centres and applies technologies such as video conferencing, satellite distribution, radio, and television (Gamlin, 1995).

In this connection, we have chosen the philosophy for the development of Internet-based education at NKI: *flexible and individual distance teaching with the student group as social and academic support for learning.* Each year, NKI recruits nearly 10,000 students to more than 400 courses and over 130 study programmes by correspondence-based and Internet-based distance teaching. In 2006-2007, approximately 70 percent of NKI students choose online study. Students can enrol in any course or programme or combination of courses anytime and progress at their own pace. This flexibility does not exclude group-based solutions in cooperation with one single employer, trade organisation, or local organiser, nor individual students on their own initiative, or by the initiative of their tutor, are collaborating on learning tasks. According to the NKI philosophy on online learning as expressed in the strategic document (NKI, 2005): "NKI Distance Education facilitates individual freedom within a learning community in which online students serve as mutual resources without being dependent on each other" (translated from Norwegian, p. 6).

Faced with the challenge of supporting distance students within a flexible distance learning context wherein they must identify and invite fellow students to become their 'learning partner,' NKI has developed different kinds of social software solutions within the LMS-system. As such, all students are urged to present themselves in ways that invites social interaction for learning purposes. This information may be open to all – e.g., members of the learning society of NKI Distance Education, to fellow students studying the same programme, or to tutors and administration only. Student lists contain information about where individual students live and which module they are studying at any given time. Software solutions for inviting and accepting learning partners and for establishing connections have been developed in parallel to the research on mobile learning (Paulsen, 2004). There is no doubt that mobile technology may increase possibilities for efficient interaction between distance students, making them more independent of time and space. The potential of social software for developing solutions that allow students within 'maximum freedom and flexibility' modes of distance learning to engage in cooperative learning activities has been presented by Anderson (2005).

Views on knowledge and learning

When we started our first discussions on m-learning and planning for the first m-learning solution development, it was very clear that the learning aims, content, and teaching/ learning methods in the NKI online courses and programmes were, for the most part, very different from most e-Learning courses, which are typically designed with self-instructional programmed learning materials (Dichanz, 2001).

To us, learning results in a change in students' perception of reality related to the problem areas under study. Learning also results in students' increased competence in problem-solving, ability to differentiate between focal and more peripheral questions, and increased analytical skills and competence in using various tools within a field, in appropriate ways. This means that learning results in qualitative changes taking place in students' understanding, academic, social, and technical competence. Learning is a result of students' active processing of learning material and solving problems individually and/ or in groups. This view is different from what often we find in many so-called e-Learning programmes, wherein 'knowledge' often is seen as providing students a large amount of information and testing their ability to recall and reproduce facts. In addition to cost considerations, this is why NKI has generally placed little emphasis on developing interactive programmed learning courses or modules based on a tradition more related to behaviouristic pedagogy and knowledge transmission (see Marton, Dahlgren, Svensson, & Säljö, 1987; Marton, Hounsell, & Entwistle, 1997; and Morgan, 1993; on students' conceptions of learning, deep level, and surface level approaches to learning). We also hold the view that learning is an individual process that can be supported by adequate interaction and/ or collaboration in groups (Askeland, 2000), a viewpoint that is stated in the NKI strategic plan (2005).

From the discussion of NKI philosophy of learning, views on knowledge, and aims and objectives in formal studies, we came to the conclusion that we should experiment with mobile learning based on more advanced technology than what was available on mobile phones in 2001, the WAP and Smart phones. Thus, we found that the *Compaq iPAQ* PDA in combination with mobile phone communication was suitable for our purposes. Our experiences, combined with the experiences of other project partners (Fritsch, 2002) during the first project, resulted in continuing the developments of mobile learning with PDAs in further m-learning projects.

Our main objective in the first m-learning project was to extend the distribution of learning materials and communication to lighter equipment, specifically PDAs and mobile phone. During the first project, we understood that for NKI, our long-term challenge would be to develop a system and server-side solution that presented learning materials in ways suitable for PDA and other mobile technologies. We also had to determine acceptable solutions for access to, and interaction with, NKI learning materials and for teacher-to-student, student-to-teacher, and student-to-student communication. We should also add at this juncture, that parallel to the m-learning projects, NKI was also engaged in projects aimed at developing universal accessibility of distance learning (Mortensen, 2003), which, it should be noted, has similar consequences concerning server-side solutions for making content available to anyone independent of physical handicaps or technology on the receiver-side.

Our aim in designing the environment for the mobile learner was to extend, enhance, or arguably even restore, flexibility that should be inherent in distance education. Indeed, to a great extent, the flexibility aspects of distance education took a step backwards when we converted from paper-

based to online learning, making a situation wherein students were oftentimes required to study at a place (and at a time) where a computer with access to the Internet was available. This aim was still in focus during the second and third m-learning projects.

By trying out the didactic and system solutions with different types of students in different settings, we studied the results and effects of the developments of mobile learning solutions in the two first projects. Students' opinions and experiences concerning mobile learning were assessed through our use of structured interviews. As well, because of our need to make comparisons with project partner experiences, formal questionnaires containing the same questions to students studying in different mobile learning environments in other European countries were applied.

Designing and Testing the Environment for Mobile Learners in the Project, *'From e-learning to m-learning'*

Studying online and offline

In line with the above discussions on learning and studying, most NKI courses are not designed to function as online interactive e-Learning programmes, although some parts of the courses may imply such interaction with multi-media materials, tests, and assignments. NKI courses normally involve intensive study mainly of text-based materials that requires students to solve problems, write essays, submit assignments, and communicate with fellow students via email or during Web-based conferences. This means that most of the time NKI students will be offline when studying. From experience, we also know that students often download content for reading offline and print-out content for reading on paper.

Technical solution

It should be emphasized that we assume that NKI distance education students will have access to a desktop or laptop computer with an Internet connection. This means that the equipment and technologies students use when mobile are, in fact, 'additions' to the equipment they normally use when studying at home or at work. It should also be noted that our developments were based on the absolute assumption that NKI's mobile learners would be studying with students who do not have access to mobile technology. Thus, the design of the learning environment had to cater efficiently to both learning contexts.

When planning for the m-learning environment of the first project, the NKI project team engaged in long discussions on whether to develop the learning materials for online or offline study. Given the above experiences, coupled with cost considerations concerning mobile access to online learning materials, we concluded that the learning environment for the first course should include the following aspects (Fagerberg, Rekkedal & Russell, 2002; Rekkedal, 2002a):

Technology

- Pocket PC/ PDA
- Mobile phone
- Portable keyboard

Learning content and communication

Learning content to be downloaded to the mobile device could be studied offline, if the student so desires. Downloaded content included all course materials, such as:

- Content page
- Preface
- Introduction
- All study units
- Resources (articles on the web, references to other resource materials)
- Online access to the discussion forum, with capacity that allows students quick access to readings in the forum, and writing and responding to contributions made in the forum
- Email with capacity that allows students to communicate with tutors and fellow students, and for submitting assignments either as text-based emails or as Word or Text attachments

Students' and tutor's use of technology when mobile

When mobile – and using mobile technologies – we found that it was generally satisfactory for students (and tutors) to have the course content available to study on the *PocketPC*. In addition, when mobile, students must be able to:

- Access the course forum to read archived messages (if necessary). Messages on the forum were also emailed to participants
- Access their course forum to submit their contributions to the course discussions
- Send email to fellow students, their teacher, and to administration (i.e., study advisor)
- Receive email from fellow students, their tutor, or from administration
- Submit their assignments by email, including attachments
- Receive assignments back from their tutor, corrected and commented on, as attachments

To access email and discussion forums, mobile phones with infrared connection to the PDA were used.

Trial of two Project 1 courses

The first project two courses were tested and evaluated with students using mobile phones and PDAs. The two courses were: *The Tutor in Distance Education* (Norwegian version of the introductory course for tutors); *Online Teaching and Learning* (Master level course 5 ECTS credits).

The first course, comprising nine (n = 9) students, was a simulated distance teaching setting. The second course, comprising three (n = 3) students studying with other students not using mobile technology, was trial of a *'real setting'* – a context expected to be the normal situation for mobile learning in NKI's distance education setting. In both cases, technological evaluations were carried out using qualitative methods employed in field research models. The first course was a trial designed to evaluate the use, functionality, and acceptance of the technology. The researcher functioned as tutor and used the course to test and evaluate its mobile learning aspects. Rather than asking subject related questions in connection with assignments and forum discussions however, the researcher instead asked students questions related to the technology itself. The educational background of the nine students taking the first course ranged from two associates degrees to PhD; the age of participants ranged from 24 to 56 years. All participants were competent in the use of information technologies.

The second course was administered in a normal study setting, and the researcher had access to the course forum and carried out the evaluation by asking participants questions on the use of the technology, while another tutor was teaching of the course. This test course had five (n = 5) registered students: four in Norway and one in Canada. Three of the Norwegian students used mobile devices (mobile telephone and PDA with a foldable keyboard). The three "mobile learners" included one man (age 32, with a Bachelor degree in computer science) and two women (the first, age 55, with a PhD in Chemistry and working as webmaster, and the second age 35, with a Bachelor of Education and director of studies at a technical research centre). Both questions and answers on mobile learning were distributed as contributions to the course forum.

In addition to the open qualitative questions given during the study, students in both trials answered a questionnaire consisting mainly of statements to be answered on a 5-point Likert scale. The questionnaire was used as part of the common evaluations in the international project. For our purpose, the qualitative evaluation was found to produce the most relevant and valid data.

Main Conclusions: Project 1 trials

We learned that downloading and synchronizing learning materials to the students' PDAs caused few (if any) problems. The learning content was delivered in two versions: HTML and *Microsoft Reader* e-book format. As students' preference for the e-book format was evident from the results of first trial course, the second course applied e-book materials only. During the first trial course, we found that figures and illustrations were hard to read on the PDA. Taking notes was also a problem. Therefore, for the second trial, we equipped students with keyboards, which resolved these problems and enabled students to write longer texts in connection with assignments. Using mobile phones to submit assignments and respond to the course forums was found to be fairly easy, with few problems encountered. Costs were also acceptable, but only on the condition that students produced their lengthy texts offline before sending them.

Our main aim in designing solutions for mobile learners was to support and maximize students' freedom to study with increased flexibility. This supports findings in previous trials, which shows that the main advantage of m-learning (as designed in these trials) is that it increases flexibility for students studying at a distance (Rekkedal, 2002b; 2002c).

Figure 2. The picture on the left shows a tutor 'on the move,' writing and sending emails to his students from Düsseldorf 'Himmelturm.' The next picture is of a student on holiday communicating from the garden of his hotel in Rome.

Designing and Testing an Always Online Environment for Mobile Learners in the Project *'Mobile Learning: The next generation of learning'*

Based on the results and our experiences gained from the first project, NKI continued its research on m-learning, this time based on the PDA solutions that were available in 2003-2005. After examining the different brands available, we decided to develop solutions for the *HP iPAQ Pocket PC 5500* series with a built-in wireless network card. Again, all developments were undertaken with the main objective of developing generic solutions.

For NKI, a large-scale provider of flexible online distance learning, it is extremely important to deliver cost-effective solutions. For instance, we needed to find system solutions that suited the needs of mobile learners in addition to students who wish to study using more standard technologies, such as desktop PCs. Any solution must be designed in ways to allow both groups to participate in the same course. In other words, we had to find optimal solutions for communication and for distributing course content, independent on whether students and tutors choose to use mobile technologies or standard desktop PCs.

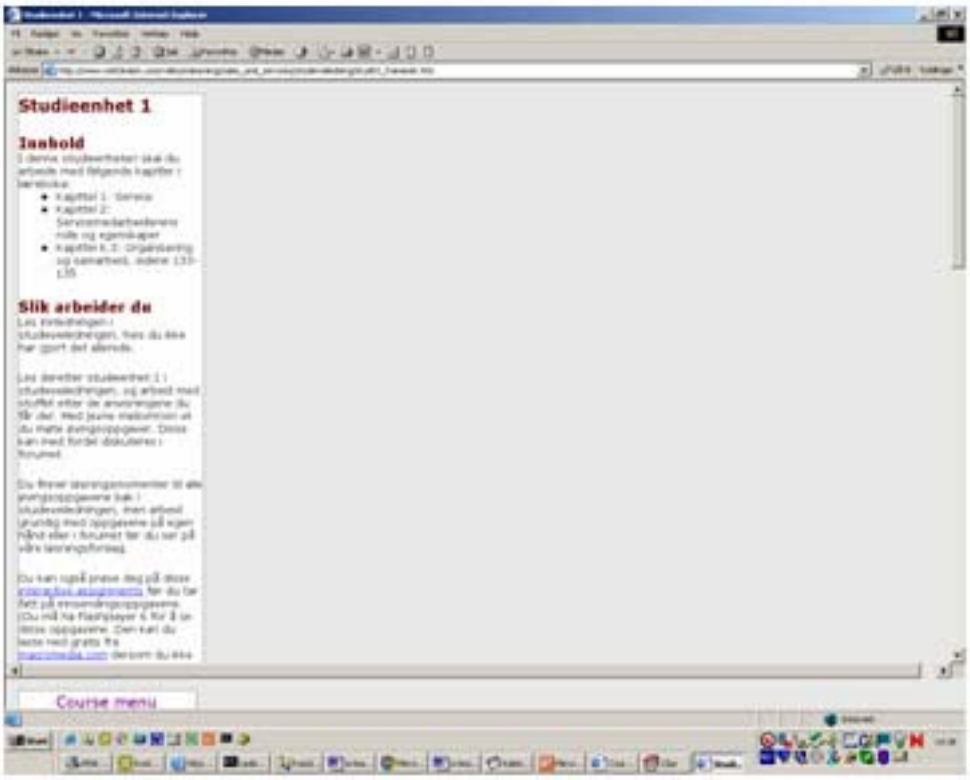
When planning the first m-learning project, we determined online access to course content to be the best solution to meet NKI's needs. However, when we started researching the first m-learning project, it was neither technologically nor economically feasible to provide continuous online access. By 2004, however, technological advancements where such that they allowed us to start developing and experimenting with solutions based on the notion that students had access to an 'always-online mobile learning environment.' Today, the 'always online' mobile learning environment is almost a reality and will likely be the norm in the near future.

Provisional Developments during Year 1 of the Project

The NKI project team committed itself to develop one standard NKI course, *Sales and Services*, to an 'always-online mobile learning environment' during the first year, and a second course, *Administration Systems and Support Services for Online Education*, during the second year.

The first course, *Sales and Services*, was developed with an additional version with specific materials for mobile learners. This version was produced on the server in a format *adapted* to the PDA screens and multi-media materials specifically developed to be accessed by the PDA. These developments have been described by Dye, Faderberg, and Midtsveen (2004).

Figure 3. Screen shot from a PC of the specific version of the course, *Sales and Services.*



We found that the text used was perfectly adapted to the PDA's screen. For ease of navigation, the menu link was fixed at the bottom of the PDA's screen. Multi-media elements were also developed using *Macromedia Flash*. We designed and tried different solutions to ensure that the multi-media elements were readable on the PDA, but we really did not arrive at any good solutions. Our conclusion, both during development and beta testing with students, was that most multi-media elements included details, which were very difficult read on the PDA. We also found that it was more useful focus our efforts on the readability of text versus the background colour combinations. We found that the choice of font was also important. For example, below are two screens shots of assignments on the PDA (in Norwegian).

Figure 4. Screen shots from the PDA of multi-media multiple-choice question and 'drag-and-drop' assignment.

It was clear during internal testing that the solutions functioned according to expectations; they allowed all students in the course, irrespective if they were mobile or tied to a desktop computer, to participate and communicate in the same course. However, because additional materials had to be developed specifically for the mobile learners, we found that these solutions could never be applied cost-effectively on a large scale.

Second Year Functionalities of the 'Always Online Environment' Developed by NKI in the Project *'mLearning: The next generation of learning'*

When planning for this second project, the project team sought to develop m-learning solutions wherein students and tutors using wireless PDA/ PocketPC could benefit an 'always-online' environment. In the first project, although the downloaded course contents could be accessed any time, some significant disadvantages were found, mainly that:

- Participants in the course often lacked incentive to log into the Internet College to take advantage of the larger learning community
- Participants had no access to interactive materials
- Participants encountered low – or no – access to other Internet resources
- Participants were restricted in their communication, likely due to costs but also because of having to connect to mobile networks for email, submitting assignments, and contribute to the forum.

During the planning process, we described the following aspects of an 'always-online' solution, which we determined would be necessary to increase the quality of service for those teaching and learning in a mobile environment:

- Access to high bandwidth networks, which enable faster uploading and downloading of course content and use of streaming audio, video, and advanced graphics
- Mobile technologies that are not tied to and operate independent of students' and tutors' desktop PCs
- Access to the Internet, 24/ 7
- Access to email, 24/ 7
- Access to online assessments, assignments, course activities
- Options that enables group collaboration
- Options that support synchronous communication such as chat and IP telephony
- ADSL or free access to WLAN, needed to make mobile learning affordable

During the first phase of this project, an 'ideal' description of requirements for a mobile learning management system (mLMS) for the NKI context was developed by Dye and Fagerberg (2004). These requirements were based on the assumption that the NKI Learning Management System, SESAM, would be further developed to accommodate the needs of mobile learners using PocketPCs. The specifications proposed by Dye and Fagerberg (2004) are presented below and divided into the following categories:

1. Overall framework needs

The mLMS must be a part of an LMS. It must support both the mobile client as well as traditional clients, and it should automatically provide different types of content on different devices. It must also create a comfortable learning environment for mobile learners.

2. Course content

The mLMS must be able to archive course content, provide easy navigation, and provide a zoom function for display of illustrations and pictures.

3. Access to courseware

The mLMS should provide access to online resources such as libraries, references, glossaries, exams, databases, and to course planning tools and calendars. Students must be allowed to submit assignments, and tutors must be allowed to comment on, and return, students' assignments using mobile devices. Students must have access to a class list with tutor and student information. They should be allowed to answer questions using multiple choices, drag-and-drop test/ exercises, etc. Text-to-speech options (that are available on PCs for all NKI courses) would similarly be very desirable. Further, the mLMS must support graphics, audio and video, moving images, provide access to search engines, and provide capacity for immediate response and feedback.

4. Communication

The system must provide access to online synchronous communication tools such as chat, and to asynchronous communication tools such as email, and Short Messages Service (SMS) to allow for broadly distributed information such as notices on grades and assignments. Multimedia Messaging Service (MMS) should be also supported. Students and tutors must have access to message boards, course forums, and online lists that contain tutor and student information.

5. Other

The mLMS should allow for students to enrol in a course online, and provide export features that allow students to access to their course materials offline. Personal settings should be adjustable (i.e., changing passwords or email addresses). The system should provide access to technical support services, frequently asked questions, contact information, general study information such as exam dates, course syllabi and handbooks, regulations, and so forth. A site map should also be provided for easy navigation. Ideally, users should be able to print from their mobile devices and access an area where they can upload and store personal files.

Conclusions from Testing

During year two of the project, NKI developed SESAM into a functioning mLMS. The mLMS system was beta tested in March, 2005.

The test students were 18 NKI employees registered as regular students in the course, *Sales and Services* (Dye & Rekkedal, 2005), seven (n = 7) males, and eleven (n = 11) females. All had no previous connection to the m-learning project. Ages of the participants ranged from 30 to 60 (10 were between the age of 51 and 60). All had higher education.

The trial was carried out in a sort of laboratory situation, after which the students had the opportunity to study the course for three weeks. The test was administered by two researchers in the project; one researcher functioned as a tutor and the other as an observer. The evaluation was carried out using the same questionnaire with Likert attitude scales, plus some open ended questions used in Project 1. In addition, the researchers observed the participants, made note of students' viewpoints, and asked students questions concerning their use of the technology in connection with their assignments, forum contributions, and use of email with other students and tutors.

User friendliness

User-friendliness of mobile learning in the context examined. Nearly all the students reported that they found the equipment easy to use. Some indicated that the "experience was fun." When asked whether or not they would like to take another m-learning course or recommend a m-learning course to others, some students were more reserved, however. We speculate, however, that students' experiences of the trial situation may have influenced their answers, as they did not provide decisive answers.

Didactic efficiency

In terms of didactic efficiency, taken the assumed context of m-learning as a supplement to NKI's established distance online learning environment, students in this trial project agreed that "m-learning increases quality," that "objectives can be met by m-learning," that "accessing course content and communication with the tutor was easy," and that "m-learning is convenient for communication with other students."

A majority agreed that "evaluation and questioning" was effective. Again, however, some students in this trial were uncertain and in some cases negative. The negative attitudes of some students may be related to the fact that during the trial phase, some of the test and questioning materials were distributed with graphical materials, which was far from perfectly presented on their PDAs. The students were also exposed to graphical materials specifically developed for the PDA (part of Year 1 developments) and to the standard graphical course materials presented on the PDA. Both types had definitely significant weaknesses. The size of the illustrations specifically developed for the PDA had to be reduced to make the number of details readable on the small screen. Moreover, illustrations were generally too detailed to be easy to read on the small screen.

Technical feasibility

Most students found navigation easy. They did not agree, however, whether the graphics and illustrations were necessary. More than half of the students in the trial course were uncertain – or disagreed – with the statement that "graphics and illustrations are necessary for m-learning to be effective." We speculate, however, that this finding may partly be based on students' learning context at NKI, which assumes that students would also be accessing their learning materials on standard desktop PCs equipment and that their course work would consist primarily of text-based learning materials.

Cost efficiency

Most participants agreed that m-learning increases access to learning. Access to technology, however, is still lacking. Mobile phones with more PocketPC-like functionalities may resolve this problem in the near future, however. Previously, we have shown that communication costs, even when communicating by mobile phone, are low. As such, in these trial situations, we assumed that the learning could take place in an 'always-online' environment with free access. For most users today, however, sending emails is still easier to send via their mobile phone than taking the time needed to configure their PDA for sending emails through different network providers.

Students tried synchronous communication both via chat and IP telephony. Based on their experiences in the m-learning test, it generally seemed that they assumed that the chat function would be similar to chatting on an ordinary PC. When questioned, the majority of participants indicated that they believed that the chat function could be useful in m-learning.

Figure 5. Video on the PDA

Functionalities and quality

Video on the PDA using small video clips worked very well using the *Windows Media Player*. No problems were reported in viewing the picture and audio files, and most participants reported them to be high quality. We did, however, encounter problems when we tried to stream video directly from the Web browser. Unlike Internet Explorer (IE) for a PC, the pocket version of IE is not capable of streaming video directly from the browser; nor can it start the *Windows Media Player*. This means that users must copy the URL into the *Media Player* to access and watch the video. While this tactic seemed to work okay, it is clearly a cumbersome way to watch a video. The students' opinions concerning the functionality of the video also differed. It was clear to us, however, that their 'uncertain' and 'negative' responses were related to the difficulties they encountered in playing the video than to the quality of the video itself. In fact, the students in this trial course found the quality of the streamed video to be quite good.

As a result of previous projects working with universal accessibility (Mortensen, 2003), we also tested the use of synthetic speech. We implemented a technology that makes it possible to save the text on a webpage as an MP3 file and have it 'read' afterwards using the PDA. The students reported that they were generally positive concerning the quality of both human and synthetic sound on the PDA – all responding on the positive side of the scale. The quality of both digital human voice and synthetic speech was found to be sufficient.

Generally, participants also indicated that they were generally impressed by the quality of IP telephony on the PDAs. Most agreed with the statement that "IP telephony could be useful in mobile learning." The one participant, however, disagreed with this statement, likely because s/he

held the position that synchronous communication generally is not useful in distance learning, which, in principle, is fully in-line with the NKI philosophy and strategy premised on asynchronous communication.

According to students functions such as sending and receiving emails, making posts to their course forum, submitting assignments as Word attachments, and receiving tutor feedback on projects, functioned well. There were a few negative responses, however.

Students were generally very positive towards reading text on the PDAs, with the majority holding positive opinions to most of the questions asked concerning the m-learning environment. Despite these positive opinions, however, many indicated to us that they did not find the solutions of sufficient quality for mobile access only. This finding falls in line with our assumptions that m-learning in the NKI online system, should only be seen as an addition to increase access and enhance flexibility.

The students agreed that the 'always-online' mobile solutions increase the flexibility of distance learning. To a large extent, they also agreed that the m-learning solutions increase the quality of course arrangements. More than half of the students, however, reported that they were uncertain as to whether the solutions used in the course trial could actually increase the quality of learning outcomes. This, of course, is a very difficult question to answer based on the experiences from this trial situation.

It was clear that students with a technical background and working in IT-positions were less enthusiastic about mobile learning than students with limited technical backgrounds. According to their statements, this group of students were less tolerant of functions that were more complicated or took longer than similar functions found on standard PC equipment. This could be seen as an indication that the technology still needs to be developed further before it will be attractive enough for online learners in general. The research undertaken to date, however, has demonstrated that developing solutions that make courses available in sufficient quality, and independent of devices on the user-side, seems to be a sound strategy.

Incorporating Mobile Learning into the Mainstream of Education and Training

Introduction

The project '*Incorporation of Mobile Learning into Mainstream Education and Training*' was launched in October 2005 and is projected to end in September 2007. This scope of this project is based on what we learned during the two earlier projects reported in this paper. We now feel it is time to take mobile learning from its project trial status and incorporate more formalized m-learning solutions into mainstream education and training in Europe. It is also time to disseminate the results of our research to interested parties in Europe and around the world.

For NKI, this final project builds on the situation that all online distance courses will be available on PDAs (and also on smart phones with Web-browser capacities) without any need for adaptation for individual courses. As such, during this final project we are seeking to develop services using primarily Short Message Service (SMS) technology to support online distance education within the context of a cost-efficient, large-scale distance education institution.

Infrastructure for new and additional services must be developed to be applied in all courses, irrespective if they are tied to ordinary PCs or available on mobile devices.

Specification for the project

The term 'mobile,' as used in the project, includes all types of devices that are connected to the mobile phone system. These devices will include capacity for voice communication, and in many cases, SMS and Multimedia Message Service (MMS) messages. Advanced versions of these devices will include Wireless Application Protocol (WAP), a secure specification that allows users to access online information instantly (i.e., send and receive email and surf the Web) via handheld wireless devices such as mobile phones and smart phones.

Mobile technologies can be divided into two basic categories

Push: MMS and SMS are the two leading push technologies for mobile devices. SMS functionality is available on nearly all mobile phones in use today, thus making it the most robust platform for push technologies for communications where 'guaranteed' delivery is needed. MMS is nipping on the heals of SMS, as it is very, very close to becoming a universal standard as well.

Pull: Key technologies used for pull communication will include WAP, HTML, and email. For optimal use, an analysis of the market penetration of these technologies will be required. As well, a market penetration of JAVA/ *Flashlite* and other relevant technologies will also be ascertained. The more valuable – or critical – a given service is to students, the more important it will be for students to own and make use of the service. Important/ valuable services will therefore probably be delivered using SMS because of its ubiquitous availability and proven track record of reliability.

Hardware

To set up a basic infrastructure, a SMS/ MMS gateway is needed, which should include the ability to send and receive SMS/ MMS messages. Received SMS/ MMS messages should be made available to a computer, so that they can be processed either by NKI staff responsible for handling students requests, errors, and so forth. An in-house SMS service will consist of one or more GSM modem terminals, along with software (housed on a server) that enables different devices to 'talk' to the GSM modem terminals, will be needed as well.

Service requirements

The mobile service development process will start with the smallest and easiest service that will deliver a business function to NKI, which means increasing to quality of NKI's distance education offerings. The next phase will then deal with more complex and advanced services. All services should handle error messages and log them, record costs, and so forth.

As mentioned, NKI will focus its efforts on services that support mobile phones for all online courses and programmes. The first service that will be evaluated is an SMS message, which will include practical information such as 'how-to' log on to the NKI Internet College, how to get a username and password, etc. This SMS message will be sent to new NKI students whom we, for whatever reason, have not been able to reach via email. This SMS message will also include a

link to '*Learning to Learn*,' an introductory course applicable to all online programmes, in that it offers students tips on how to study and what to expect as an NKI student. This will be a lightweight WAP version of the original '*Learning to Learn*' course.

We will also use the system to get in touch with students who have registered using invalid email addresses. Our plan is to develop a solution that automatically sends an SMS message to the student if an invalid email address is detected by the system.

Possible services

There are numerous possibilities for the use of SMS/ MMS services suitable for supporting online distance learners. NKI practices flexible pacing and free start-up times, and has developed advanced support systems to follow-up with students and teachers alike.

The following services might be developed and implemented for mobile technologies during the present project (Russell, 2005):

- Password retrieval for students who have forgotten their password
- Welcome message to students, which includes their user name and password. Included in the 'welcome' could include tips on 'how-to' log on to course webpages. Messages should be stored on mobile phones, and provide links to other services available from mobile devices. The message may also include a question for permission to communicate to the student via mobile phone
- The introductory course *Learning to Learn* will be designed specifically for delivery to mobile devices, preparing news students on what to expect as an NKI student. We hope to include an introduction on study techniques available for mobile via WAP
- Reminders to students who fall behind their studies
- Reminders to students to register and enroll for exams via mobile phones
- Delivery of interactive quizzes
- Delivery of notification to teachers, indicating that a student has submitted an assignment, and possibly automated follow-ups if the teacher is late in responding
- Delivery of notifications related to assignments and grade posted
- Development of a Web interface that allows teachers and administrators to send SMS messages to students, and allows students to send messages to other students
- Allow students to upload pictures and text to their presentation
- Allow students to upload pictures and text to their blog
- As much of the NKI teaching/ learning site as feasible to be made available to mobile Web browsers

Because this third project is in its first stage at the time of writing, it is difficult to describe in detail exactly what services will be developed and tested. It is also premature to determine any costs involved to students or NKI, along with this usefulness and general level of acceptance by users.

Conclusions

NKI's research and development on mobile learning in connection with the three EU *Leonardo da Vinci* projects have led to better, more flexible mobile solutions needed to serve distance learners studying online. Through trial and error, we have learned that cost-efficiency considerations did not permit us to develop parallel versions of courses. Instead, we found that courses must be developed, presented, and distributed in a manner that allow both mobile and non-mobile distance learners to participate in the same course, using the same course materials that can be accessed from standard and mobile technologies. Moreover, we found that course contents available on mobile devices must be of minimum acceptable quality. Interaction with course content and multi-media materials, as well as communication with tutors and fellow students, must function adequately using both standard and mobile technologies.

The question remains on what the 'ideal' device and solution for mobile learning will look like. In all probability, however, the answer will very likely rest with students' individual preferences. That is why NKI has found it extremely important to experiment with different solutions which, in turn, have inspired further developments in finding the right mix of course design and system solutions that serve the needs of all learners, independent of whether they are using a desktop PC or whether they are using mobile devices.

References

Anderson, T. (2005). Distance Learning – Social software's killer ap? Paper to the *Open and Distance Learning Association of Australia Conference, Breaking Down Boundaries*, Adelaide, November 9-11. Retrieved June 26, 2005 from: http://www.unisa.edu.au/odlaaconference/PPDF2s/13%20odlaa%20-%20Anderson.pdf

Askeland, K. (2000). Fjernundervisning i spenningsfeltet mellom pedagogen og teknogen. In G. Grepperud, & J. A. Toska *2000 Mål, myter, marked – Kritiske perspektiv på livslang læring og høgre utdanning. SOFF-rapport 1/2000*. Tromsø: SOFF.

Dichanz, H. (2001). E-learning, a linguistic, psychological and pedagogical analysis of a misleading term. Paper presented at the *20th ICDE World Conference,* April 2001, Düsseldorf, Germany.

Dye, A., Fagerberg, T., & Midtsveen B. (2004). *Technical Working Paper 2004, NKI Distance Education: Exploring online services in a mobile environment.* Retrieved June 26, 2006 from: http://learning.ericsson.net/mlearning2/files/workpackage2/NKI_technical_workingpaper_2004.pdf

Dye, A., & Fagerberg, T. (2004). *Mobile Learning Management System specification.* Retrieved June 27, 2006 from: http://learning.ericsson.net/mlearning2/files/workpackage1/nki.pdf

Dye, A., & Rekkedal, T. (2005). Testing of an "always-online mobile environment." Evaluation paper for the project, *mLearning, the Next Generation of Learning.* Retrieved June 26, 2006 from: http://learning.ericsson.net/mlearning2/files/workpackage6/testing.doc

Fagerberg, T., Rekkedal, T., & Russell, J. (2002). Designing and Trying Out a Learning Environment for Mobile Learners and Teachers. Sub-project of the EU Leonardo project, *From e-Learning to m-Learning.* Retrieved June 27, 2006 from: http://www.nettskolen.com/forskning/55/NKI2001m-learning2.html

Fritsch, H. (2002). mLearning for Smartphones. Conference presentation at mLearning: The Cutting Edge. November 11, Dublin, Ireland. Retrieved June 7, 2006 from: http://learning.ericsson.net/mlearning2/project_one/presentation/helmut1911.ppt

Gamlin, M. (1995). Distance Learning in Tranisition: The Impact of Technology: A New Zealand perspective. Keynote address to *1995 EDEN Conference: The Open Classroom, Distance Learning, and New Technologies in School Level Education and Training*. September 18-20. Oslo, Norway.

Leonardo Da Vinci Project (*n.d.*). *European Commission Leonardo Da Vinci project website.* Retrieved April 17, 2007 from: http://ec.europa.eu/education/programmes/leonardo/leonardo_en.html

Marton, F., Dahlgren, L. O., Svensson, L. & Säljö, R. (1987). Inlärning och omvärldsuppfatning [in Swedish]. Stockholm: Almquist & Wiksell. 6. opplag.

Marton, F., Hounsell, D., & Entwistle, N. (1997). *The Experience of Learning. Implications for Teaching and Studying in Higher Education.* Edinburgh: Scottish Academic Press.

Morgan, A. (1993). *Improving Your Students' Learning: Reflections on the experience of study*. London: KoganPage.

Mortensen, I. (2003). *Universell tilrettelegging av nettbasert studium i 'Ledelse og organisasjon'* [in Norwegian]. Bekkestua: NKI. Retrieved June 27, 2006 from: http://www.nettskolen.com/forskning/soffrapport_universell.pdf

NKI (2005). *Strategisk plan for NKI Fjernundervisning 2005-2007* [in Norwegian]. Internal document. Bekkestua: NKI.

Paulsen, M. F. (2006). COGs, CLIPs and Other Instruments to Support Cooperative Learning in Virtual Environments. Paper presented at the 4th EDEN Research Workshop, Research into online distance education and e-learning, 25-28 October. Barcelona, Spain, 2006. Selected papers (in print) from the workshop.

Paulsen, M. F., Fagerberg, T., & Rekkedal, T. (2003). Student Support Systems for Online Education available in NKI's Integrated Systems for Internet Based E-learning. Oslo: NKI. Retrieved June 27, 2006 from: http://learning.ericsson.net/socrates/doc/norwayp3.doc

Rekkedal, T. (1990). Recruitment and Study Barriers in the Electronic College. In M. F. Paulsen & T. Rekkedal (Eds.) *The Electronic College: Selected Articles from the EKKO project.* Bekkestua: NKI/ SEFU.

Rekkedal, T. (1998). Courses on the WWW: Student Experiences and Attitudes Towards WWW Courses. An evaluation report written for the *Leonardo Online Training Project.* Retrieved June 27, 2006 from: http://www.nki.no/eeileo/research/eei/Rekkeval.htm

Rekkedal, T. (1999). Courses on the WWW: Student Experiences and Attitudes Towards WWW Courses, II. Evaluation report written for the Leonardo On-line Training Project, MMWWWK. Retrieved June 27, 2006 from: http://www.nki.no/eeileo/research/Rekkedalcorrected.html

Rekkedal, T. (2002a). Enhancing the Flexibility of Distance Education – Experiences with a Learning Environment for Mobile Distance Learners. Paper presented at the *mLearning: The Cutting Edge conference.* November 22, Dublin, Ireland. Retrieved June 26, 2006 from: http://learning.ericsson.net/mlearning2/project_one/presentation/torstein1911.ppt

Rekkedal, T. (2002b). Trying Out a Learning Environment for Mobile Learners. Evaluation of the course "The Tutor in Distance Education" – Phase 1 of the NKI sub-project of the EU Leonardo Project 'From e-learning to m-learning.' July 2002. Retrieved June 26, 2006 from: http://learning.ericsson.net/mlearning2/project_one/NKI2001m-learningevaluationFinal.doc

Rekkedal, T. (2002c). Trying Out a Learning Environment for Mobile Learners II Evaluation of the course "Online Teaching and Learning" – *Phase 2 of the NKI sub-project of the EU Leonardo Project 'From e-learning to m-learning.*' Retrieved June 26 2006 from: http://learning.ericsson.net/mlearning2/project_one/student_use_year_2_nki.doc

Rekkedal, T., & Paulsen, M. F. (1997). The Third Generation NKI Electronic College. A Survey of Student Experiences and Attitudes. An evaluation report written for the *Leonardo On-line Training Project, MMWWWK.* Retrieved 27, 2006 from: http://www.nki.no/eeileo/research/nki/evaluati.htm

Russell, J. (2005). *SMS, the in house development experience.* (Unpublished technical working paper) Oslo: NKI Distance Education.

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

The Growth of m-Learning and the Growth of Mobile Computing: Parallel developments

Jason G. Caudill
Grand Canyon University
USA

Abstract

m-Learning is made possible by the existence and application of mobile hardware and networking technology. By exploring the capabilities of these technologies, it is possible to construct a picture of how different components of m-Learning can be implemented. This paper will explore the major technologies currently in use: portable digital assistants (PDAs), Short Message Service (SMS) messaging via mobile phone, and podcasts via MP3 players.

Keywords: m-Learning; mobile technology; portable digital assistants; PDA; Short Message Service; SMS; podcast

Online learning and blended instruction, both utilizing technology to convey educational content, are shifting from a model working only with e-Learning to encompassing mobile learning (m-Learning). This shift in learning locations and learner access to information has been driven both by demand and by advances in technology that make mobile technology access a practical option for the average person. In examining the growth of these technologies it is possible to see the growth to date, and possibly the future direction of, m-Learning.

Introduction

m-Learning is broadly defined as the delivery of learning content to learners utilizing mobile computing devices (Parsons & Ryu, 2006). Kambourakis, Kontoni, and Sapounas (2004) defined it as, "The point at which mobile computing and e-Learning intersect to produce an anytime, anywhere learning experience" (p. 1). The advantages of learning anytime and anywhere have long been near the top of the benefits listed by proponents of online education, but until the advent of m-Learning technologies it was not really an anytime, anyplace environment. The demand for a learner to be physically at a computer and physically connected via some kind of cable to a network meant that learning locations were constrained. With constraints in place on the available learning locations, time constraints existed as well; someone taking classes using their computer at work might not have access to that resource at midnight or on Sunday afternoon (Petrova, 2004). Mobile learning is exactly that; mobile; m-Learning as an educational method is new and more flexible than previous e-Learning applications (Georgiev, Georgieva, & Trajkovski, 2006). Learners can have the opportunity to review course materials or correspond with instructors or colleagues while sitting in a restaurant or waiting for a bus; they are not made immobile by the restrictions of desktop computer technology.

Because m-Learning is such a new field the research is still in a stage where different categories of m-Learning pedagogy are being developed, identified, and researched (Frohberg, 2006). With this developmental stage in mind, the very existence of m-Learning, not to mention its growing application, is directly tied to the growth of mobile technology. This fact is why it is so important for researchers and practitioners to be familiar with mobile technology applicable to m-Learning. It simply is not possible for someone to log onto a learning management system (LMS) wirelessly from a personal digital assistant (PDA) if wireless networks don't exist or if PDAs do not support wireless connectivity.

Hardware advances are one of two key components to the emergence of m-Learning, the other being networking. To be mobile technology, hardware had to advance to a point at which people would carry and access the device on a regular basis. It is generally accepted that devices like mobile phones, PDAs, and MP3 players fit into the category of mobile devices (Mellow, 2005; Andronico, Carbonaro, Casadei, Colazzo, Molinari, & Ronchetti, 2003). Sources disagree on the status of laptop and notebook computers as mobile devices. While they are capable of working without plugging into a power source and can utilize wireless networks, they are not devices that people can carry everywhere and quickly access at any time due to their size, configuration, and the time required to boot up and shut down. For the purposes of this paper, mobile technology will be described as a device that can fit in the average shirt or jacket pocket and be carried on a daily basis.

Wireless networking is the second technological component contributing to m-Learning success. While some m-Learning resources can be utilized in a non-networked, offline environment, many depend on access to the Internet to exchange information and access up-to-date information. To serve this need, mobile devices needed a way to access network resources without plugging into a land line connection. Currently the leading candidate for this technology is the IEEE 802.11 wireless communication standard, commonly called Wi-Fi. Also gaining ground in the market are wireless phone broadband connections and, to a lesser extent, the IEEE 802.15.1 wireless communication standard, commonly called *Bluetooth*. While *Bluetooth* is more frequently used as a device-to-device data transfer technology, its use as a network system is possible. Regardless of which standard is in use, wireless networking provides learners with the opportunity to connect with colleagues and instructors via online resources from a much broader variety of places than are accessible via traditional wired connections. An in-depth review of the technology will be explored in a later section, but it is important to recognize just how important this technology is in facilitating m-Learning environments.

Defining m-Learning

There is much debate as to whether m-Learning is the next progressive step from e-Learning or simply an advanced tool that integrates with e-Learning. In either case, m-Learning is a new and unique component of distance learning. Georgiev and colleagues (2006, p. 1) defines it as, " . . . a new stage of the development of e-learning . . . " To understand the distinctions, it is necessary to look at what e-Learning really is, followed by the emerging definitions of m-Learning:

Laouris and Eteokleous (2005), cite Pinkwert, et. al. (2003) as defining e-Learning as, "learning supported by digital 'electronic' tools and media." Ramshirish and Singh (2006) open by defining e-Learning as " . . . essentially education via electronic network in which content is transferred via the Internet, intranet, extranet, audio/ video tapes, satellite television, and CD-ROMs" (p. 2). It is important to recognize that definitions of e-Learning almost always specify that there is indeed learning taking place in an environment, and that environment happens to utilize

electronic means of communication to convey the learning experience. While it may be difficult to precisely define what is e-Learning and what is not, dependent on the amount of electronic integration into the course, it is probably fair to say that any educational environment which utilizes any electronic media tools as a part of the instruction is utilizing e-Learning, even if it is not a 100 percent e-Learning environment. As an example, a face to face class viewing information on an archeological dig on DVD would be utilizing e-Learning as a component of their experience, while an asynchronous online course where all activities take place in the confines of a CMS would be a dedicated e-Learning class.

Given that e-Learning is learning incorporating electronic media, what defines m-Learning? This paper will define m-Learning as any e-Learning application delivered on-demand via mobile digital device. As a relatively new term, however, there are many other definitions in use. Kambourakis, Kontoni, and Sapounas (2004) define m-Learning as being, "The point at which mobile computing and e-Learning intersect to produce an anytime, anywhere learning experience" (p. 1). Colazzo, Ronchetti, Trifonova, and Molinari (2003) state that, "A mobile learning educational process can be considered as any learning and teaching activity that is possible through mobile tools or in settings where mobile equipment is available." Laouris and Eteokleous (2005, p. 2) cite multiple sources for definitions of m-Learning, including:

- Pinkwert et. al. (2003), who defines m-learning as ". . . e-learning that uses mobile devices and wireless transmission."
- Polsani (2003), who defines m-learning as " . . . a form of education whose site of production, circulation, and consumption is the network."
- Traxler (2005), who defines m-learning as " . . . any educational provision where the sole or dominant technologies are handheld or palmtop devices."
- and Sharples (2005), who defines m-learning " . . . as a process of coming to know, by which learners in cooperation with their peers and teachers, construct transiently stable interpretations of their world."

The common thread of all these above definitions as cited by Laouris and Eteokleous (2005, p. 2) is that they incorporate the use of mobile technology to facilitate the transfer and acquisition of knowledge, the learning process. Again, like e-Learning, m-Learning can be utilized on different scales. One environment may utilize m-Learning as a single component of a single topic, while another environment may be dedicated to using m-Learning as the only means for learning. In either case the technology applied will be mobile.

With both e-Learning and m-Learning defined, it is possible to see many similarities between the two processes. Most obviously, learning is a key component of both; the goal of the application, regardless of the technology utilized, is to engender the acquisition of knowledge by a learner. Also obvious is that electronic technology is used in both systems. Granted, there are differences in the types of devices and the types of media used, but e-Learning and m-Learning are really studies in technology integration into educational environments. Clearly, the theories behind these two different forms of instruction are the same; the integration of technology can improve the learning experience. With such common goals and methods, then, why is it necessary to delineate m-Learning from e-Learning? The answer to that is in the very real differences between the two.

Kambourakis and colleagues' (2004) definition of m-Learning is a good start to identifying the differences from e-Learning. m-Learning is, to an extent, e-Learning, but e-Learning is not necessarily m-Learning. What this means is that while by definition learning through mobile computing devices utilizes electronic media and therefore meets the definition of e-Learning, e-Learning may or may not incorporate mobile devices, and as such may or may not meet the definition of m-Learning. Georgiev and colleagues (2006) states this concept as, "The main difference between e-Learning and m-Learning is in the technologies used for educational content supply" (pp. 2-3). In many ways, m-Learning acts as a partner to e-Learning, providing learners with the opportunity to maintain involvement in their learning environment while not accessible via static technological devices such as desktop computers (Charmonman & Chorpothong, 2005). It is this unique connection that defines the difference between the two. M-Learning is a dedicated, special-purpose component of the e-Learning world that provides expanded opportunities and abilities to learners. As a special component, m-Learning warrants its own definition and dedicated study into its creation and application to provide the best facility to mobile learners.

Given that m-Learning is a discipline unto itself, there are certain advantages provided in a m-Learning environment that are not present in other kinds of e-Learning. The primary advantage of m-Learning is to provide truly anytime, anyplace learning (Kambourakis, et. al., 2004; Ramshirish & Singh, 2006). What this means to the learner is that they are no longer constrained by static resources. A desktop computer, no matter how powerful or user-friendly, will always be limited by size, weight, and the need for power and network connections via cables plugged into sockets and ports that are not mobile.

In addition to being able to access resources from anywhere with a mobile device, this ease of transport has other advantages. Perhaps most notably, mobile devices provide users with an interface to their content that is both personalized and secure (Petrova, 2004). In the computing environments of many educational institutions or corporations, personalization is simply not a viable option for computer systems. Indeed, convenience is one of the identified benefits of m-Learning technology (Parsons & Ryu, 2006). Because there are multiple users for each public machine, individuals are often unable to set up personal profiles for things as simple as *Post Office Protocol* (POP) or *Internet Message Access Protocol* (IMAP) access to email accounts or bookmarks in browsers. While this may seem to be a minor inconvenience it can quickly add up to large quantities of wasted time. The time required logging in and finding specific pages or accessing e-mail through a Web interface may even reduce the frequency of a person's access to the learning environment. Lack of access can adversely influence learners' experience in the environment. With mobile devices these issues are eliminated. By carrying a personalized device, the user has media access tailored to best fit their personal preferences. This being the case, the user can quickly and easily access the resources they need, which may result in a higher frequency of access. Complimenting this advantage is the ability of m-Learning to deliver, via these media sources, a personalized learning experience (Turker, Gorgun, & Conlan, 2006). Taken as a whole, m-Learning delivers to the learner a flexible, easy to access learning resource that can be tailored to their specific needs.

The advantages of m-Learning can be summarized as being advantages of access. Whether it is a question of time, place, or simply convenience, ease of access streamlines the learning process for the learner. From an efficiency perspective, the less time spent managing resource access, the more time is available to capitalize on the value of those resources. These advantages do come at a price, however. There are unique demands for designing and administering m-Learning environments.

Because of the multiple technologies involved in m-Learning, designing instructional content for this medium can be very challenging. The first demand for a successful application of m-Learning is one of scale; without a saturation of the technology in the target audience the system will fail (Viteli, 2000). The need for learners to have equal access to the technology is not significantly different from access issues for other teaching methods. A class website is not helpful if none of the students have Internet access, just as course notes distributed on CD are not helpful if students do not have access to computers to access the CD. While the hardware and networking technologies of m-Learning will be covered in a later section, the best Short Message Service (SMS) system or podcasting platform is useless if learners do not have access to SMS-capable mobile phones or devices to play MP3 files. Thus, in planning m-Learning integration, some difficult decisions have to be made. It is very dangerous to assume that all learners will have access to a certain type of technology, while at the same time mandating the purchase and use of what can be very expensive hardware can be a challenge as well. These issues have to be addressed in every individual environment, and addressed early so that the m-Learning environment can be properly planned and implemented. Closely connected to the issue of access is the issue of capability. While all users may possess a certain type of hardware, different models may have different capacities in terms of processing power, network access, or other features. Thus, when designing a m-Learning environment, it is necessary to consider the content and format of the information being delivered, taking into account the users' locations and the limitations of their devices (Lonsdale, Baber, Sharples, & Arvantis, 2003).

One of the possibly unexpected, but very real, demands of designing m-Learning environments is to maintain the proper focus during the design phase. As the point of m-Learning is to facilitate the acquisition of knowledge, it is critical to focus on the learner, rather than the technology, when working with m-Learning pedagogy (Lonsdale et al., 2003). With such an intense focus on the capabilities of the new technology available to integrate into a learning environment it is far too easy for a designer or instructor to put all of their time into the technical aspects of an environment. Similar to the issue of access to the devices themselves, the best system ever devised is of no use to the students if it is too complicated for them to use. Therefore, the technical acumen of the intended consumers of the information must be considered along with the technology access of the group. More and more the degree to which this consideration matters is changing in relation to the intended audience. Current traditional undergraduate students are coming in as what are referred to as digital natives, who can seamlessly integrate technology into their daily practice, while older students, referred to as digital immigrants, can not (Cobcroft, Towers, Smith, & Axel, 2006). Two good rules of thumb are that users are rarely at the same level as designers, and that just because something can be done does not necessarily mean that it should be done.

m-Learning Technology

With these design requirements in mind, the available m-Learning technologies can be explored. The broad categories include PDAs, mobile phones, and MP3 players. The start of this discussion involves defining what m-Learning devices are. The Hardware section will explore details of each device, but what categorization defines these devices? Generally, mobile devices can be defined as electronic devices that are small enough to fit in a shirt or jacket pocket. Mellow (2005), states that, "This would include such devices as mobile phones, portable digital assistants (PDAs) and *iPods.* It would not include laptops, as while they are portable, they are not mobile . . . Mobile devices should fit in your pocket" (p. 1). In relation to the widespread availability of these devices, Petrova (2004) says that, " . . . in the near future mobile communication devices will exceed the number of personal computers" (p. 1). Finally, Trifonova and Ronchetti (2003) define

mobile devices as, ". . . by mobile device we mean PDAs and digital cell phone, but more generally we might think of any device that is small, autonomous, and unobtrusive enough to accompany us in every moment of our every-day life, and that can be used for some form of learning" (p. 1).

It is interesting to note that these definitions, by default, eliminate notebook computers from classification as mobile devices. As Mellow (2005) stated, there is a distinct difference between portable and mobile. The prime characteristic of mobile devices is that they are carried on a regular, if not constant basis. The old routine of picking up car keys and wallet every morning has for most people expanded to include at least a cell phone, if not a PDA and MP3 player as well. It is this constant access to the devices that drives m-Learning as a viable delivery system.

In order to be different from other forms of distance learning, and in order to function at all, mobile learning has to be exactly that; mobile. Mellow (2005) quotes Oblinger (2004) as saying that today's learners are " . . . digitally literate, always on, mobile, experimental, and community-oriented" (p. 2). The mobility of m-Learning takes advantage of an entire population that maintains their connectivity through digital devices; they are involved with it all day every day and are comfortable with its use (Charmonman & Chorpothong, 2005). This cultural phenomenon leads to what Woukeu, Millard, Tao, and Davis (2005) identify as the goal of m-Learning, "The ultimate objective being for learning to become an integrated part of our daily life, that is no longer recognized as learning at all" (p. 2). It is mobility that drives m-Learning as a product. Because learners are connected to digital media devices at all times of their day, and are comfortable accessing information through these devices, they no longer require a particular location or environment to review educational material. Learners not only do not need a classroom, they do not even need a table to set up their notebook computer or enough elbow room on a train or bus to get into a comfortable typing position; their thumbs or a stylus have supplanted the need to type on a traditional keyboard.

Working hand-in-hand with the physical mobility of the devices is the virtual mobility of networking. No device, no matter how powerful or portable, can deliver educational material if it does not have access to that material. Thus, mobile networking is a key component of the m-Learning environment. The connectivity allowed by mobile networking gives learners not only access to static instructional materials, but to dynamic discussion environments and updated information from an instructor. Taken to the farthest extreme, anytime, anyplace learning becomes all the time, everywhere learning. With these parameters of mobility defined, it is time to examine the mobile devices themselves in detail.

Mobile Hardware

Probably the first device that comes to mind when mobile hardware is discussed is the PDA. These devices offer many of the features of a full-size laptop computer but in a package that fits in a pocket. As discussed, mobility is a primary component of m-Learning hardware, and few devices offer the combination of mobility and features that the PDA does.

From the start, the PDA experience lends itself to being ideal for the m-Learning environment. Whether a *Palm* or *PocketPC* operating system, a PDA will start up almost instantly, as opposed to the boot process that is required for a larger computer. This advantage by itself is a significant one; if a learner wants to check e-mail or reply to a message board while in between appointments, the time spent booting up and shutting down a traditional computer platform is a very real deterrent, the PDA interface eliminates that wasted time.

Once the PDA is active, it provides a wide variety of applications that in the past were not available on mobile devices. Andronico and colleagues (2003, p 3.) investigate three areas of applications using PDAs in the m-Learning environment:

1. The use of PDA as an enhanced organizer, by uploading/ downloading data with the central system in order to align periodically or on demand the agenda of the user (teacher, student, or other actors of the system) with all the academic appointments. This will imply the integration of the data schema of the agenda software of the portable device with the data coming from the central system.

2. The browsing of newsgroups managed by the central Learning management system (LMS) on the PDA screen, in case the user has no keyboard attached to the portable device, or the full interaction with the newsgroup in the other case.

3. The browsing of the LMS web pages where it is possible to download the educational material and consult it with specific viewers (at the moment those related with the Office suite and with Acrobat PDF format).

The first area, use as an enhanced organizer, speaks to the origins of PDAs as electronic date books and rolodexes. Prior to networking technology, the PDA was primarily a mobile data storage system, maintaining calendars, phone numbers, and other personal and business information for the user. With networking capability and shared calendars the PDA can apply this use to the m-Learning environment by facilitating the schedules of multiple people with the goal of achieving a learning objective. As anyone who has been through a post-secondary degree, and particularly a graduate degree, knows, scheduling time to meet with a busy professor or to assemble a project team to work on a class assignment can be difficult at best, and at times it borders on the impossible. By providing a live-update, shared calendar environment, the networked PDA can facilitate arranging these meetings that are so critical to learning. Like many of the things seen in m-Learning, and with technology in general, meetings are not a new or unique tool, but the technology improves the efficiency of arranging the meeting therefore saving time for the individuals and sparing that time for some other purpose.

Andronico and colleagues' (2003) second case, the engagement of an LMS, connects directly to not only m-Learning, but e-Learning. As a digitally delivered instructional media, the LMS is well established as a component of distance or blended instruction. What takes the LMS from e-Learning to m-Learning is the application of mobile technology, in this case, the PDA. With a mobile network connection, the user can access the LMS in live time and view updates, assignments, or discussions. While it is true that the lack of an attached keyboard may inhibit full participation, devices are improving to a level where even when using the stylus as an input tool it is possible to compose messages with practice. For a more user-friendly data entry environment, many manufacturers are also offering thumbpads, small keyboards designed to be used by a user's two thumbs while the device is held in the hands, that will dock with PDAs that do not have such an entry device included in their construction. In either case, a learner has the ability to participate in discussions from virtually any location, at any time, and the educational environment is maintained as a dynamic, active exchange of ideas.

The final of Andronico and colleagues' (2003) three points relates to the downloading and accessing of course materials. Again, this type of function was not long ago limited to only computers, but the PDA platform has become much more capable. Once linked into wireless networks, PDAs can now read and even edit traditional office and PDF files (Savill-Smith, 2005).

With this level of functionality a user can truly access all of the resources that would be available to their computer-bound colleagues. It will likely not be long before the mobile device is simply another computing platform, without a clear distinction between the desktop or laptop and the palmtop (Qingyang, 2003).

The only potential drawback to the use of PDAs is their lack of processing power relative to a laptop or desktop computer. Baek, Cho, and Kim (2004) say that, "Mobile devices have the shortcomings of small screens, low processing speed, and limited storage while they can provide very specific learning materials for an individual learner with mobility at any time" (p. 2). While this is true, the technology is changing at a rapid rate. To put the current state of PDA power in perspective, the author completed the first year of business school in the year 2000 with a laptop computer that had a 166Mhz processor. The author's current PDA, not the most powerful on the market, has a 312Mhz processor. While laptops will almost always hold the advantage in processing power, it is important to remember just how little power is really required to use common applications like word processors and document viewers. Also, memory capacity is changing rapidly as most PDAs accept Secure Digital (SD) or other memory cards and the capacity of these cards is constantly improving. Where the power and capacities of mobile devices are really being seen as issues is at the design stage of m-Learning media. Because there are so many differences among different mobile devices, it is critical for m-Learning media designers to know what kind of hardware platforms their intended audiences are working on (Georgiev et al., 2006).

Outside of the PDA realm, another mobile technology finding success in m-Learning is the use of SMS messaging on mobile phones. SMS allows learners to access text information, and exchange messages and information, via their mobile phones. This provides the learner with access to the learning environment anywhere they can receive a mobile phone signal and utilizes a device that they will likely be carrying every day even in the absence of a m-Learning requirement to do so. Mellow (2005), cited the advantages to SMS as being, ". . . true flexibility to control the time, place, and pace of their learning, specificity of content, tutor constructed study aides designed for those areas that are 'challenge to learn' concepts, using technology that is engaging and totally comfortable for the student, non-threatening, private availability of on-demand study support" (p. 5).

There are three possible models of information exchange via SMS, one that involves the educational institution sending out information on their schedule, one in which the student requests information as they need it, and a third where the student is involved interactively with the environment (Mellow, 2005). The most immediate difference that is apparent between the SMS model and that of an LMS is that there is not a set of available information resident on a server for students to access on-demand; a process must be initiated to transmit the information to a recipient. While this may not be the ideal model for some applications, for others it is a very good fit. Messages regarding class changes, reminders of upcoming deadlines, or questions and responses involving specific course material could all be excellent uses of SMS. Because of the constant presence of a mobile phone, all individuals involved in the system are likely to receive and respond to SMS messages more quickly and possibly more reliably than they are to e-mail. Again, the application of technology to the m-Learning environment is facilitating all the time, everywhere learning.

The third and final unique hardware category to consider is the MP3 player. These devices store and play digital audio files that, in the case of m-Learning applications, are commonly referred to as podcasts. The podcast term comes from the popular Apple MP3 player, the *iPod.* The term

itself is somewhat of a misnomer, however. Any device that can play MP3 files can be used to listen to podcasts, not just the *iPod* device.

Most podcasts consist of an audio file that conveys information on a given topic. In many ways, this is simply a recorded lecture that is made available on-demand to learners, and in some cases, it actually is a recording of a lecture that was originally delivered live. Recently, however, podcasts have begun to evolve in response to improved MP3 players. Many of these devices now offer the option of displaying a slide show of static digital image files, or even playing digital video. Using this technology, podcasts can include traditional slides to accompany a lecture or even a video file of the lecture where sample problems or other information can be viewed as it is written out to accompany the audio of the lecture. In a dramatically short time podcasts have advanced from simply theory to a fully-developed instructional tool, utilizing not only audio, but also image and video files. For users, podcasts have become much more popular as a tool to download audio files of lectures and tutorials (Oloruntoba, 2006).

Having examined the individual devices that are prevalent in m-Learning it is important to note that single-use devices are not necessarily a reality anymore. While dedicated PDAs, mobile phones, and MP3 players can certainly be purchased, there is increasing cross-over of functionality between them.

More common than anything else is the inclusion of an MP3 player in another device. Very few new PDAs lack a headphone jack and MP3 playing capability and an increasing number of mobile phones are embedding this functionality in their devices as well. In application, this indicates that incorporating m-Learning technologies in the form of podcasts, particularly audio-only podcasts, may capitalize on the greatest saturation of available technology in the population. Also, if an organization plans to utilize m-Learning technologies that require a PDA it is helpful to recognize that with virtually any current PDA having the capability to play podcasts the use of any PDA-based m-Learning technology can be coupled with podcasting, thereby delivering multiple media streams via a single piece of hardware.

The other increasingly common combination of mobile devices is that of the PDA phone. Several mobile phones currently integrate a PDA platform into the handset, thus providing the user with not only a mobile phone but also a mobile computing platform. With these devices, it is possible to combine not only PDA and MP3 functions, but SMS messaging applications as well. In an environment where users can be required to purchase a given device, a PDA phone can incorporate all the aspects of m-Learning into a single hardware package. Pedagogy of each organization will determine if it is reasonable to require such capacity, but the technological capability does exist if it appears useful in the proper situation.

Mobile Networking

For mobile hardware to engage in the mobile learning environment it is necessary for these devices to have access to m-Learning content, often located on a network resource. If the mobile device was limited to working at a location where a network cable could be plugged in then its use would no longer be mobile, regardless of how small the device itself is. The second half of technology mobility has been the rise in mobile networks. The combination of mobile hardware with mobile technology is what allows this phenomenon to progress.

Perhaps the most prevalent and most widely recognized mobile networking technology is the IEEE 802.11 specification, commonly called Wi-Fi. Wi-Fi works by using a series of access

points, which are transmitter/ receiver stations that wireless devices can connect to via their own Wi-Fi networking card. Initially seen as external cards that were used in a Personal Computer Memory Card International Association (PCMCIA) slot on laptops, Wi-Fi networking devices are now being integrated into standard-size PDAs and even smaller platforms such as mobile gaming devices. If a mobile device does not have a built-in Wi-Fi card there are a wide variety of add-on cards available, some small enough to fit into the SD slots on handheld devices. Thus, many devices not originally configured to access wireless networks can be converted to do so.

There are two widely used standards, 802.11b (b), which transmits at 11 Megabits per second (Mbps), and 802.11g (g), which transmits at 54 Mbps. Both of these common standards are interoperable, meaning that a g device can operate at a slower speed on a b network, and a b device can access a g network. Most devices today that include built-in Wi-Fi connectivity are using either the g or b standard, as are most publicly accessible Wi-Fi access points, which are referred to as hotspots.

The hotspot phenomenon has rapidly expanded to provide coverage to many public places (Balachandran, Voelker, & Bahl, 2003). This gives m-Learning students and instructors the freedom to not only work at a wide variety of locations, but also to deliberately choose comfortable locations, such as a favorite coffee shop, from which to work. Thus, m-Learning participants can not only work on the move, but they can also work from a good environment that may not be available to someone tied to a desktop or landline networked laptop.

The other side of the Wi-Fi connectivity issue is the possibility for groups to meet and connect to each other via what is referred to as an ad-hoc wireless network. This does not require an access point as it does not necessarily connect users to the Internet, it just allows users to connect to each other via Wi-Fi. In the event that participants in a m-Learning course meet in a physical location to work on a group project or just to discuss the course content they can avoid the need to print notes on paper or e-mail documents ahead of the meeting even if they are at a location that does not have an accessible hotspot. Once together, they can create an ad-hoc network and exchange electronic documents wirelessly even without a service provider.

The question of device to device networking brings up a second wireless networking standard, this one being IEEE 802.11.1, commonly called *Bluetooth*. Commonly seen as a networking technology, *Bluetooth* connects hardware devices to each other. Perhaps the most commonly witnessed application of the technology today is the *Bluetooth* headset, which wirelessly connects a headphone and microphone to a mobile phone. While in wide use for this purpose, *Bluetooth* can also be used to transfer data between devices, synch PDAs and mobile phones with other devices for data backup, and even access *Bluetooth* network portals to the Internet. *Bluetooth* is a much shorter-ranged technology than Wi-Fi, and because of that is rarely used for hotspots, but it is very useful for device-to-device communication. In the m-Learning environment, this would be useful for sharing data between devices. As an example, a m-Learning system utilizing SMS messaging would transmit messages to a learner's mobile phone. With a *Bluetooth*-enabled phone and PDA, the learner could transfer that message from their phone to their PDA wirelessly and store and access the information from that device at a later time. Because of its relatively new presence in the market of mobile technology, *Bluetooth* probably does not have a fully-developed application set at the time of this writing, and it bears watching to see what new uses may be beneficial to the m-Learning environment.

The final two mobile networking technologies are connected to mobile phones, SMS and cellular broadband. SMS is a data transmission option that allows the sending and receiving of short

messages via mobile phone. This does require a mobile phone to use, but has the advantage of not being tied to hotspots like Wi-Fi technology, the messaging is accessible anywhere the user has a mobile phone signal. Also seen most often on mobile phones but far more fully featured is the cellular broadband network. Cellular broadband provides full Internet access to a mobile device, most frequently a mobile phone, via wireless cellular network. Coverage at the time of this writing is still more limited than cellular phone coverage, but it is growing daily and encompasses most urban areas in the United States. First seen on mobile phones, it is now possible to access a cellular broadband network via a variety of devices through the appropriate expansion cards. Basically, this technology provides the user with Wi-Fi capabilities without the need to access a hotspot. Its applications in m-Learning are much the same: it provides Internet access on mobile devices. In the future, it will be interesting to see if cellular broadband builds a customer base to rival Wi-Fi for mobile networking applications.

Conclusions

Mobile technology, both hardware and networking applications, is a necessary component for the existence of m-Learning. As instructors and designers, practitioners of m-Learning need to be fluent in the use of these technologies and cognizant of what technologies their learner population has access to. Application of specific pedagogical theories is directly connected to the technologies in use in a m-Learning system and as such, design of m-Learning environments demands a systems approach, where development accounts for all aspects of the environment. As technology continues to improve and innovate the options open to m-Learning will expand; the key is to focus on the fact that the goal of m-Learning is to facilitate learning, no matter what form the delivery may take.

References

Andronico, A., Carbonaro, A., Casadei, G., Colazzo, L., Molinari, A., & Ronchetti, M. (2003). Integrating a multi-agent recommendation system into a Mobile Learning Management System. *Artificial Intelligence in Mobile System 2003 Conference.* October 12. Seattle, WA. Retrieved April 23, 2007 from: http://w5.cs.uni-sb.de/~krueger/aims2003/camera-ready/carbonaro-4.pdf

Baek, Y. K., Cho, H. J., and Kim, B. K. (2004). Uses of learning objects in a wireless Internet based learning system. Proceedings of the *International Conference on Computers in Education.* November 30 - December 3. Melbourne, Australia. Retrieved April 24, 2007 from: http://ieeexplore.ieee.org/iel5/8445/26602/01186107.pdf?arnumber=1186107

Balachandran, A., Voelker, G., & Bahl, P. (2003). Wireless Hotspots: Current challenges and future directions. Proceedings for *WMASH'03*. September 19, San Diego, USA. Retrieved April 24, 2007 from: http://research.microsoft.com/~bahl/Papers/Pdf/monet05.pdf

Cobcroft, R., Towers, S., Smith, J., & Axel, B. (2006). Mobile Learning in Review: Opportunities and challenges for learners, teachers, and institutions. Proceedings of the *Online Learning and Teaching Conference 2006*. September 26. Brisbane, Australia. Retrieved April 24, 2007 from: https://olt.qut.edu.au/udf/OLT2006/gen/static/papers/Cobcroft_OLT2006_paper.pdf

Charmonman, S., & Chorpothong, N. (2005). Digital Lifestyle and the Road Ahead. Proceedings of the *Fourth International Conference on eBusiness*. December 5-9. Beijing, China. Retrieved April 24, 2007 from: http://www.charm.ksc.au.edu/SCPaper/Digital%20Lifestyle%20and%20the%20Road%20Ahead.pdf

Colazzo, L., Molinari, A., Ronchetti, M., & Trifonova, A. (2003). Towards a Multi-Vendor Mobile Learning Management System. Proceedings for the *World Conference on E-learning.* Phoenix, USA. Retrieved April 24, 2007 from: http://www.science.unitn.it/~foxy/docs/Towards%20a%20multi-vendor%20Mobile%20LMS%20(long).pdf

Frohberg, D. (2006). Mobile Learning is Coming of Age: What we have and what we still miss. Proceedings for *DeLFI 2006*. September 11-14. Darmstadt, Germany. Retrieved April 24, 2007 from: http://www.ifi.unizh.ch/im/fileadmin/user_upload/personen_downloads/2006_DELFI_Darmstadt_MLearn_Framework.pdf

Georgiev, T., Georgieva, E., & Trajovski, G. (2006): Transitioning from e-Learning to m-Learning: Present issues and future challenges. Proceedings of the *Seventh ACIS International Conference on Software Engineering, Artifical Intelligence, Networking, and Parallel/ Distributed Computing (SNPD '06*). Retrieved April 24, 2007 from: http://ieeexplore.ieee.org/iel5/10923/34372/01640716.pdf?tp=&isnumber=34372&arnumber=1640716

Jobmann, K., Kyamakya, K., Garcia, J. E., & Kruger, M. (2003). mLearning with the Notebook-Seminar. Proceedings for the *International Conference on Engineering Education.* July 23-28, San Juan, Puerto Rico. Retrieved April 24, 2007 from: http://projekte.l3s.uni-hannover.de/pub/bscw.cgi/d25783/mLearning%20with%20the%20Notebook-Seminar

Kambourakis, G., Kontoni, D. P. N., & Sapounas, I. (2004). Introducing Attribute Certificates to Secure Distributed E-Learning or M-Learning Services. Proceedings of the *IASTED International Conference.* Innsbruck, Australia. pp 436-440. Retrieved April 24, 2007 from: http://www.ice.upc.edu/butlleti/innsbruck/416-174.pdf

Laouris, Y. & Eteokleous, N. (2005). We need an Educationally Relevant Definition of Mobile Learning. Proceedings of the *4th World Conference on mLearning.* October 25-28, Cape Town, South Africa. Retrieved April 24, 2007 from: http://www.mlearn.org.za/CD/papers/Laouris%20&%20Eteokleous.pdf

Lonsdale, P., Baber, C., Sharples, M., & Arvanitis, T. (2003). A context awareness architecture for facilitating mobile learning. Proceedings of *MLEARN 2003.* May 19-20, London, UK. Retrieved April 24, 2007 from: http://www.eee.bham.ac.uk/sharplem/Papers/Lonsdale%20mlearn%202003%20abstract%20SUBMITTED.pdf

Mellow, P. (2005). The Media Generation: Maximize learning by getting mobile. Proceedings for *ASCILITE 2005 Conference: Balance, Fidelity, Mobility: maintaining the momentum?* December 4-7, Brisbane, Australia. Retrieved April 24, 2007 from: http://www.ascilite.org.au/conferences/brisbane05/blogs/proceedings/53_Mellow.pdf

Oloruntoba, R. (2006). Mobile Learning Environments: A conceptual overview. Proceedings for the *OLT 2006 Conference.* September 26, Brisbane, Australia. Retrieved April 24, 2007 from: https://olt.qut.edu.au/udf/OLTCONFERENCEPAPERS/gen/static/papers/Oloruntoba_OLT2006_paper.pdf

Parsons, D., & Ryu, H. (2006). A framework for assessing the quality of mobile learning. *Massey University website.* Retrieved February 20, 2007 from: http://www.massey.ac.nz/~hryu/M-learning.pdf

Petrova, K. (2005). Mobile Learning Using SMS: A mobile business application. Proceedings for the *18th Annual Conference of the National Advisory Committee on Computing Qualifications.* July 10-13. Tauranga, Australia, pp. 412-417.

Qingyang, G. (2003). Mlearning: A new development towards more flexible and learner-centered learning. *Teaching English with Technology, 3*(2). Retrieved April 24, 2007 from: http://www.iatefl.org.pl/call/j_nt13.htm

Ramshirish, M., & Singh, P. (2006). e-Learning: tools and technology. Proceedings for the *DRTC Conference on ICT for the Digital Learning Environment.* January 11-13, Bangalore, India. Retrieved April 24, 2007 from: https://drtc.isibang.ac.in/bitstream/1849/226/1/paperS_prachi_ram.pdf

Savill-Smith, C. (2005). The Use of Palmtop Computers for Learning: A review of the literature. *British Journal of Educational Technology, 36*(3), 567-568.

Trifonova, A., & Ronchetti, M. (2003). Where is mobile learning going? *E-Learn 2003 Conference.* November 7-11. Phoenix, AZ. Retrieved April 24, 2007 from: http://www.science.unitn.it/~foxy/docs/Where%20is%20Mobile%20Learning%20Going%20(E-Learn2003).pdf

Turker, A., Gorgun, I., & Conlan, O. (2006). The challenge of content creation to facilitate personalized e-learning experiences. *International Journal on E-Learning, 5*(1), 1-17.

Viteli, J. (2000). Finnish Future: From e-Learning to mLearning? Proceedings for the *ASCILITE Conference*. December 5-8. Perth, Australia. Retrieved April 24, 2007 from: http://www.ascilite.org.au/conferences/coffs00/papers/jarmo_viteli.pdf

Woukeu, A., Millard, D., Tao, F., & Davis, H. (2005). Challenges for semantic grid-based mobile learning. Proceedings for the *IEEE SITIS Conference.* November 27 - December 1. Yaounde, Cameroon. Retrieved April 24, 2007 from: http://www.u-bourgogne.fr/SITIS/05/download/Proceedings/Files/f135.pdf

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Instant Messaging for Creating Interactive and Collaborative m-Learning Environments

James Kadirire
Anglia Ruskin University, England

Abstract

'Instant Messaging' (IM) and 'Presence,' which is essentially the ability of being able to detect if other users are logged in on the network and send them messages in real time, has become one of the most popular applications of the Internet, causing people to want to stay connected to the Internet for inordinate amounts of time, a phenomena that also fosters a sense of "online community," that perhaps no other application has done previously (Alvestrand, 2002). This research looks at the use of mobile devices to send instant messages that can carry much more information than the short message service (SMS) messages, but would be free to use, notwithstanding the price of getting online. We present a prototype IM system that can be used as a viable means of communicating and learning in higher education establishments. There is some evidence to show that learning using mobile devices reduces the formality of the learning experience, and helps engage reluctant learners and raise their self-confidence. In order for the learning process to be successful in online distance learning, unlike in the traditional face-to-face learning, attention must be paid to developing the participants' sense of community within their particular group. Instant messaging – or IM – is a natural medium for online community building and asynchronous/ synchronous peer discussions.

Keywords: Instant messaging; mobile device; wireless; presence; chat; authentication; database; microportal

Introduction

The introduction of the General Packet Radio Service (GPRS), Enhanced Data GSM Environment (EDGE), and Universal Mobile Telecommunications System (UMTS) /3G networks, has made it possible for users to browse the Web or hold videoconferences from mobile phones or portable digital assistants (PDAs). The potential offered by these developments is huge, particularly in education where not only the short message service (SMS), but also instant messaging (IM) can be used. Mobile devices have truly become ubiquitous and pervasive, with over two billion mobile users worldwide, sending 235 billion SMS messages in the first quarter of 2006 (Cellular Statistics, 2006). In the United Kingdom alone, there were 41.8 billion text or SMS messages in 2006, giving a daily SMS average for the year of 114 million (Text.IT, 2006). There is also evidence from a story published in Cellular Online (2003), which claims that there is a boom in the number of British citizens that are using GSM text or SMS messaging. Although SMS is quick and easy to use, it comes at a cost, not only in monetary terms, but also in the maximum number of characters that can be used for a message.

'Instant Messaging' (IM) and 'Presence,' which is essentially the ability of being able to detect if other users are logged-in on the network and send them messages in real time, has become one of the most popular applications of the Internet. Instant messaging is making people want to stay connected to the Internet for an inordinate period of time, a phenomenon that is also helping to foster a greater sense of "online community" that no other application has done previously (Alvestrand, 2002). Instant messaging is becoming widespread in universities and is now being used for online discussions, chatting, file transfer, library access and usage, and so forth. Some of the most common IM applications are *AOL Instant Messenger*, *MSN Messenger*, *Yahoo Messenger*, *Google Talk*, and *Skype*. All IM systems support avatars (a movable icon representing a person in cyberspace or virtual reality graphics), in addition to user icons. Instant messaging has also become the latest employee productivity tool (Hinds & Kiesler, 2002). For example, a customer-service representative can use it as a quick-and-easy way to answer an enquiry, whereas a salesperson can inform a busy vice president about a new account. Gartner (as cited in Korzeniowski, 2004) estimates that 70 per cent of corporate employees rely on IM while at work. According to the research conducted by Lenhart and Shiu (2004), 42 per cent of Internet users in the United States (about 53 million people) use instant messaging, and its appeal is apparent amongst young adults and technology enthusiasts. Research carried out at *Wake Forest University* (Walker, 2005) has shown that student mobile phone usage patterns are moving away from more traditional messaging, like email for instance, to newer technologies such as instant messaging and SMS. This trend should encourage students to become more engaged with course material outside the classroom, and help them communicate better among themselves. Often students want to communicate or locate other people while in indoor environments, for instance, in a meeting room, lecture theatre, or inside a large building; mobile phones and laptops are ideal devices for this.

Our research is also supported by the article published in NESTA FutureLab (2005), which claims that a mobile phone also increases the possibilities for informal learning that is not tied to a particular physical location. Students can stay in touch with their tutors and with each other while they are away from the classroom. It argues that mobile devices are being used quite comfortably for discussions and so a discussion that can be enriched with other media makes the phone an 'important collaborative learning tool.' Perhaps the most revolutionary aspect of mobile technology is that it addresses the problem of social inclusion. Many young people who would not go near a university or who do not own a computer, typically do own a mobile phone. A three year pan-European research project carried out at Anglia Ruskin University and its European partners into mobile learning (m-Learning) found that learning with mobile devices was good at reducing the formality of the learning experience, engaging reluctant learners, and raising self-confidence (Attewell, 2004). The e-Viva research project at Anglia Ruskin Univeristy, funded by the Qualifications and Curriculum Authority, enabled its Key Stage 3 students (Key Stage 3 covers children aged 11-14 in years seven, eight, and nine at schools in England) to take part in assessments by answering pre-recorded questions over their mobile phones. This research showed that teachers believed that mobile phone usage made their pupils much more aware of what they were doing and why they were doing it. Knowing that their work was going to be seen by others also had a positive effect, in that it increased their motivation and built their self confidence (Walton, 2005). Research in mobile learning in classrooms by Roibas and Sanchez (2002) also showed that the way forward in mobile learning in formal educational settings, will be the introduction of handheld devices. Research carried out in the *Numina project* at the University of North Carolina at Wilmington (Vetter, Heath, Herman, et al., 2005) found that students enjoyed the technology and became more active in their learning when handheld pocket computers were used in the classroom. It also suggests that there is every indication that in the near future, wireless data devices will be as widespread as wireless voice devices are now. Experience with Anglia Ruskin University's fully online degree has shown that when students were asked to

evaluate the effectiveness of their online learning experience, it was their ability to engage in asynchronous discussions with their peers that they valued the most (Ultralab, 2006). Unlike in face-to-face classroom settings, in order for the learning process to be successful in online distance education, attention must be paid to developing a sense of community amongst participants. Indeed, instant messaging is a natural medium for online community building and asynchronous peer discussions (Nardi, Whittaker, & Bradner, 2000; Rheingold, 2000; Quan-Haase, Cothrel, & Wellmann, 2005).

This paper first looks at the design of an IM system used for the creation of interactive and collaborative m-Learning environments. It also looks at the use of mobile devices (mobile phones and PDAs) used to send instant messages that can carry more information than text or SMS messages, and are offered free of cost, except for the price of connecting online and downloading content. For instance, mobile telephone operators in the United Kingdom, charge GPRS/ 3G users based on the amount of the data downloaded in kilobytes. If the instant message arrives while the user is not online, it can be stored in a database; when the user logs on, he or she can retrieve their messages off the database, rather like email. With technologies such as Web-enabled and IEEE 802.11x enabled mobile phones and PDAs, connected to IEEE 802.11x networks (IEEE 802.11x is technical speak for Wireless Fidelity/ Wi-Fi hotspots) mobile wireless communications are well on their way to becoming pervasive. So, for those users whose mobile phones are Wi-Fi enabled, like the *Nokia N80, Nokia N95* and the *Sony Ericsson P990i* that have fully working Web browsers for example, their usage costs will become less of an issue. These mobile devices allow users to connect to their campus networks, surf the Web, and take part in instant messaging sessions, typically for free. If they have subscribed to a broadband Internet connection, users can also logon to the Internet via their wireless hotspots at home, also free. Not only do these advancements arguably make online distance learning much more attractive, irrespective of where users are physically located, they also foster a greater sense of connectedness and community amongst users.

The next section on "System Design" looks at the instant message environment and what components an IM system must have. It also examines 'content adaptations,' specifically how one must adapt content that is normally designed for regular sized computer display screens, to fit onto small mobile, handheld devices (typically with a 200 x 300 pixel screen resolution). This section is followed by sections on the "System Architecture," "Mobile Devices Used," "Results," "Discussion and Conclusion" and suggested avenues to "Future Research."

System Design: The instant message environment

The system is essentially based on the idea of a community of students within some educational establishment. The instant message environment is composed of multiple features or components, some of which are:

- **User identity –** This identifies the valid user of the system and in our system, it is made up of the user name and password for authentication.

- **User Profile/ Microportal –** In all instant messaging systems, it is important for users within a particular online community to be able to find out basic information about the other users without having to ask anyone. It is important for registered and authenticated users to be able to look up any other registered users on the system and get details about them (i.e., their age, picture, interests, etc.). Such functionality is provided via a user profile or microportal, which is created dynamically when each user logs on. A

microportal is a small version of a portal and has essentially the same meaning as a portal. A portal is a Web-based application that commonly provides personalization, single entry point log-in, content aggregation from different sources, and hosts the presentation layer of information systems. Aggregation is the process of integrating content from different sources within one webpage (Kadirire, 2005a). For the purpose of our research, we define a microportal as a Web-based application that is essentially a simpler and smaller version of a portal, but specifically targeted at mobile devices. Also, from within their microportal, users can access learning content from a learning management system (see Figure 1).

- **User Database or Directory –** This is the main database that stores all the system users and has a list of those that are also currently logged in. In this research, we used an *Oracle 9i* database running on *Windows 2000*.

- **Presence Awareness –** This is the ability to determine if a user is logged on. We implement this by setting a flag in the database tables which was activated when a user logged-on and reset it when they log-off. So, it is only a matter of querying the database to display a list of the users currently logged-on. When users are logged-on to the system, they will appear on a contacts list of online users. From this list, it should be possible to invite selected users for a private synchronous chat or a one-on-one instant messaging session.

- **Instant Messages** – These have been implemented very much like email. Messages are stored in the database and if a user is logged-on, they will receive a notification by an unopened mail-message icon to alert them of the new instant message. They can reply to their instant message straight away or choose not to, if they wish.

- **Asynchronous Chat –** If a user is not online and another user knows their user identification/ name, they can send them an instant message, which will be stored on the database. The next time they login, they will be notified of an instant message they have waiting for them. This means that messages need never be missed; they can be received and handled both synchronously and asynchronously.

- **Message Size** – The size of the messages will be determined by the database used. This research uses *Oracle 9i* for storing the messages and attributes associated with each user. Up to 4000 characters or bytes can be stored as text in each field, which means an instant message can be up to 4000 characters long, and which is 25 times longer than an SMS message.

- **Ease of Use** – The user interface must be graphical, user friendly, and easy to use.

- **Multi-user Chat** – In addition to providing one-to-one synchronous chat, IM systems should allow users in the community to chat in groups (which can be selected based on the names of the 'chat room' created by the administrator). We implemented a Web-based chat service, which students also used as part of their messaging to interact as a group if they so desired.

- **Security** – There is an authentication system which provides security for the users of the system. If the IM system is made an open system (i.e., anonymous users are able to join in) this poses serious security risks to online resources. This also opens the door to computer viruses being 'injected' into the IM system by potentially malicious users.

Clearly, no online system can be 100 per cent secure. As such, one must assume that 'registered users' of the university who have gone through the the normal university selection, vetting, and registration processes, will have no malicious intent. The credentials used for authentication to the IM system will be the user name and password (after the user has had their student status verified).

System Design: Content adaptation

To be able to use instant messaging for m-Learning on mobile devices, the software must be intelligent and adaptable, and render well on different devices with widely varying capabilities. However, designing software for different mobile devices is often a resource allocation problem wherein the utility-value of the content presented is maximised, subject to constraints (Chua, Scott, & Blanchfield, 2005; Kadirire, 2005a). The main constraints used by existing Web-content adaptation engines are display resolutions, for instance, display size, colour-depth, and ability to display certain types of Web objects such as Flash files, animated gifs, and MP3 files. Some considerations that must be taken into account when calculating the utility of the contents are:

- **Informational Content –** When items are being converted to less resource-intensive forms, often the information content of the items is reduced and therefore needs to be accounted for (Mohan, Smith, & Li, 1999). A good example of this is that images can only be shrunk so far before they become useless (Scott, 2003).

- **Cost –** Mobile telephone operators in the United Kingdom charge GPRS/ 3G users on the amount of the data downloaded in kilobytes. Therefore, when adapting content to be displayed on mobile devices, costs need to be taken into account in terms of the number of embedded images and size.

- **Design Metrics –** These are measures relating to composition (i.e., word count, link count), formatting (i.e., emphasized text, positioning), and other general webpage characteristics (i.e., total bytes) (Ivory, Sinha, & Hearst, 2000). The presentation of Web-content, such as the amount of text emphasis and the number of colours used, must be considered in calculating the utility of the adapted content. Research carried out by Scott and Koh (2003) shows that mobile device (i.e., PDA) webpages have different design metrics as compared to personal computer (PC) webpages.

- **Relevance –** Determining if an item really needs to be included in a webpage is clearly subjective. Much depends on who is viewing it, and its 'relevance' is difficult to factor into the design. Some research done in this area using "click stream analysis" (Anderson, Domingos, & Weld, 2001) to determine an items purpose. An item can be categorised as being used for navigation, advertisement, as content, or even decorative purposes (Paek & Smith, 1998).

To make this IM system user friendly, intelligent, and adaptable, we based the design on the following criteria:

- **Web Browser Type –** Each Web-browser has a user agent vis-à-vis a Web browser type. When the user accesses the website, the first thing the software does is that it detects the user agent to determine what type of device it is.

- **Device Characteristics –** Each device has its characteristics stored in a database for use by the software to adapt the content when a device logs onto the system. The main characteristics stored are: screen resolution, colour depth, Web browser type, whether or not the device uses a stylus for navigation, whether or not it has a keyboard or joy stick, if it supports dynamic content like flash movies, animated gifs, MP3 files, and so forth, and the amount of memory it has.

- **Generic HTML Template –** Each page on an IM system has a generic HTML/ XML template used to create that page dynamically. The page is not stored in a static form; when the user logs-on, their device type is detected and the relevant instant message page is then created on-the-fly using the stored device characteristics in the database.

This design methodology, coupled with the use of object oriented design techniques in *Java*, makes the IM system design extremely robust, intelligent, and extensible. Only one set of software is required to adapt the content for all devices. When a new device is introduced, the only things that need to be done are to add the new devices characteristics to the database and also add a few lines of code to detect the user agent.

System Architecture

Figure 1. An example of IM system architecture

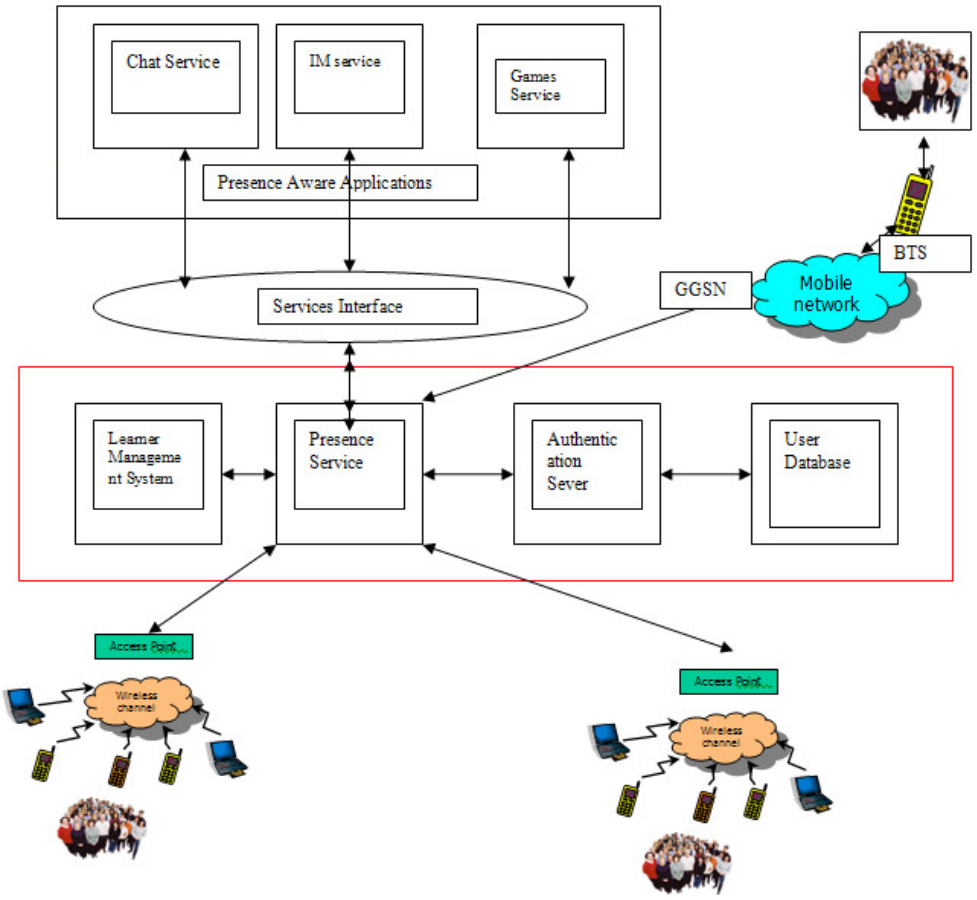


Figure 1 illustrates an example of system architecture. This system is made up of groups of students that may be connected to the Internet via mobile phones using the GSM/ GPRS/ UMTS network, or via Wi-Fi/ IEEE802.11x enabled mobile phones, such as the *Nokia N80* for instance, or normal notebooks and laptops. The remainder of the system is comprised of a learning management system, an authentication server, user database, presence service, a services interface, and presence aware applications like the IM service, Chat service, and Games service. To deliver 'presence,' the system needs a network that can identify users independent of their location; this is done via the normal mobile telephone network (GSM/ GPRS/ UMTS) as well as the Wi-Fi wireless network users can access from their college campus, their home, or anywhere in the world where wireless access points, typically called 'hotspots,' are located. The database has all the registered user details for students who will be taking part in the online community via instant messaging.

Mobile Devices Used

The software was designed to detect and adapt the content for the devices listed below, which were in widespread use and were likely to continue being in widespread use. Because users in the UK have access to and use many types of mobile devices, we examined devices with different operating systems, functional capabilities, screen sizes and resolution, to make them more generic:

- ***Nokia Communicator 9210***, running EPOC32 with an STNC-WTL/6.0 Web Browser. User-Agent: EPOC32-WTL/2.2 Crystal/6.0 STNC-WTL/6.0(611). Screen Resolution: 600x200 pixels

- ***Handspring TREO 270***, running Palm OS 3.x with Blazer 1.o Web browser. User-Agent: UPG1 UP/4.0 (compatible; Blazer 1.0). Screen Resolution: 160x160 pixels

- ***SPV Orange Smart Phone***, running windows CE with *Internet Explorer* 3.02. User-Agent: *Mozilla/2.0* (compatible; MSIE 3.02; Windows CE; Smartphone; 176x220). Screen Resolution: 176x220

- ***O2 XDA PDA***, running *Microsoft Pocket PC* 2002. User-Agent: *Mozilla/2.0* (compatible; MSIE 3.02; Windows CE; PPC; 240x320). Screen Resolution: 240x320 pixels

- ***Sony Ericsson P800***, running Symbian OS. User-Agent: Mozilla/4.1 (compatible; MSIE 5.0; Symbian OS) Opera 6.02 [en]. Screen Resolution: 175x320 pixels.

Results

Several user accounts were created at Ultralab, Anglia Ruskin University, to test access to the site. Results were positive. The criteria used to evaluate the IM system included: the speed of loading a webpage; the ease of navigating within the microportal; and the ease with which text could be typed into the chat or instant messenger windows. The user accounts were stored in the *Oracle 9i* database to test the IM system using the various mobile devices outlined above. A mobile device was detected during authentication by the authentication server, in conjunction with the user database, and stored in a session object. Figure 2a below shows the login interface when a user with a mobile phone like the *Sony Ericsson P800* attempted to access the system. After they were authenticated, they were taken to their microportal or user profile as is shown in

Figure 2b, where the user was authenticated and gained access using an *O2 XDA PDA*/ mobile phone. The microportal was created dynamically by reading their data from the database and filling in some generic template using a servlet.

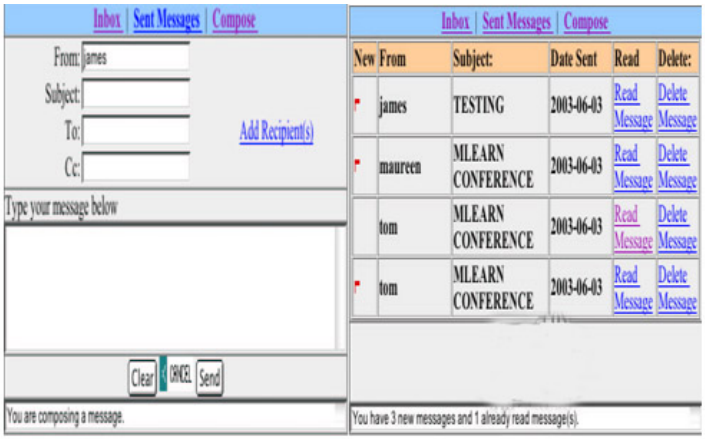
Figure 2a, a snapshot of the user login screen on the P800. **Figure 2b,** an example of what the user sees when they first login.

User login interface on a Sony Ericsson P800 mobile phone

User microportal when they first login into the IM system using an O2 XDA

The software was designed in an adaptable and intelligent way, which allowed it to detect various types of mobile devices accessing the IM server and to format or adapt the content to fit the particular device capabilities. Mobile devices have different screen resolutions. Some have browsers and some do not. Some are in colour and some not. Some offer a stylus, while others do not offer that capability. We confined our research to mobile devices that had Web browsers only, as this made content adaptation more consistent and easier to implement. When a user logged in, they were automatically added to a list of users that could be sent an instant message. From within the users microportal, by clicking a link for the users that were online, a list of all the logged-in users could be displayed. By selecting a user from the list, a message could be composed and sent to that user. Figure 3a below shows how the instant message was composed. Figure 3b shows what the user inbox looked like when they had messages waiting. There were essentially two ways of sending instant messages. The first method is as shown in Figure 3a, where the message was composed in a similar way to ordinary email. The second method was where a chat window was displayed and the users could type in messages in real time to each other.

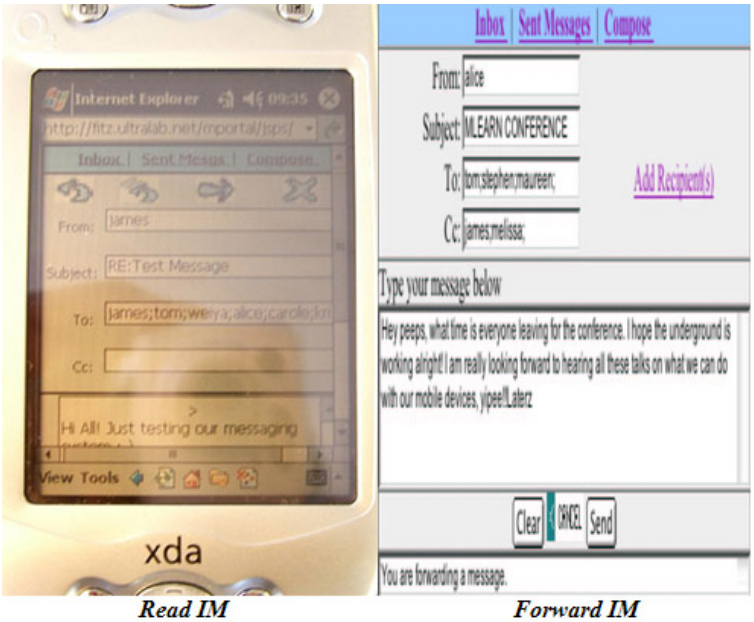
Figure 3a, a snapshot of an empty instant message screen. **Figure 3b,** a snapshot of a user's inbox showing instant messages received



Compose IM *Inbox showing IMs*

When a user first logged in, they were taken to their microportal, which among other things, has a message notifying them that they had messages waiting in their inbox. This could be either a text notification or a graphical notification such as icons representing unopened messages on the bottom part of the users microportal. Figure 3b shows the users inbox containing four messages, three of which had not been read (as denoted by the small red flags). To read an instant message, users click on the "Read Message" link for the particular instant message and which was then displayed, as shown in Figure 4a which shows an *O2 XDA* mobile phone was being used to read an instant message. In addition to reading instant messages, they could also be forwarded, as shown in Figure 4b. 'User identifiers' or names can also be called-up by pressing the "Add Recipient(s)" link, also shown in Figure 4b.

Figure 4a, a snapshot of an instant message displayed on the screen. **Figure 4b,** a snapshot of an instant message being forwarded to another user.



Read IM *Forward IM*

In addition to the instant messaging service, users also had access to learning material provided via the learning management system, accessed via the services interface on the microportal.

Discussion and Conclusions

Device characteristics like the resolution, Web browser type, et cetera, were stored in a database to allow rapid creation of the microportal from the same code and not have different software for each device. So, if a new device was introduced, there would be minimal changes to the code. This is one of the advantages of using *Java* as it is an object oriented language and is extensible and easy to modify.

No empirical data was collected in assessing the performance of the different mobile devices. Clearly, this is an area where things might have been done better. We instead relied on feedback from a group of about 10 users we specifically selected to help us evaluate the performance of the IM system. These 10 users were from within the Faculty and had an interest in using mobile device features like chatting and instant messaging. In terms of the speed with which the webpages were loaded, there did not seem to be any appreciable difference after logging into the IM system. However, the Windows-based devices, such as the *O2 XDA* and the *SPV Orange Smart* phones, did take longer in establishing a connection to the IM server. In terms of 'navigating content' and 'text entry' in the instant message chat window, two mobile devices with styluses, the *Sony Ericsson P800* and the O2 XDA, in that order, were easier to use. Although the *Handspring Treo 270* also has a stylus, it was awkward to use due to its inability to render images properly and its low resolution. The *Nokia Communicator 9210* was the next best device in terms of 'content navigation' and 'text entry,' followed by the *SPV Orange Smartphone,* neither of which have a stylus. The best overall device for 'accessing content' and instant message text entry usage was the *Sony Ericsson P800,* followed by the O2 XDA. The *Nokia Communicator* also performed well, but its weight and size made it more like a laptop rather than a mobile device (although it is a mobile phone). The most awkward device to use was the *SPV Smart* phone, primarily because it lacked a stylus and its small keypad was found to be awkward for navigation and text entry. While there are many IM systems like *MSN Messenger* and *Yahoo Messenger* widely used already, we have shown how an IM system can be further designed for use in m-Learning environments that require enhanced interaction and collaboration.

Research carried out at *Wake Forest University* (Walker, 2005) shows that student mobile phone usage patterns are moving away from more traditional messaging like the use of email towards newer technologies such as IM and SMS. We feel this trend should encourage students to be more engaged with course material outside the classroom as well as communicate better among themselves. Limited research carried out by Sotillo (2006), for example, shows evidence of successful learner uptake in a synchronous instant messaging environment. The IM system presented in this research, which was part of a pan-European mobile learning research project (Attewell, 2004), shows that learners were typically enthusiastic about mobile learning, with 62 per cent reporting that they were keen to take part in future learning after trying mobile learning (which included instant messaging, as well as accessing online learning material via their mobile devices). Research by McGuire and colleagues with mobile devices (as cited in Walton, 2005) also showed that learning with mobile devices helped reduce the formality of the learning experience by engaging reluctant learners by raising self-confidence. In order for the learning process to be successful, attention must be paid to developing a strong sense of community in online distance education settings (Quan-Haase, et al., 2005). Not only does the quality of instant messages create a sense of connectedness and help bring people together, it is a natural medium for online community building and asynchronous peer discussions (Nardi, et al., 2000; Rheingold,

2000). With technologies such as Web-enabled and IEEE 802.11x enabled mobile phones and personal digital assistants, IEEE 802.11x networks, mobile wireless communication is well on its way to becoming wholly pervasive. For mobile phone users with Wi-Fi enabled devices like the *Nokia N80, Nokia N95* and the *Sony Ericsson P990i*, connection and usage costs are low simply because users can connect to their campus networks, surf the Web, and take part in instant message sessions, all for free. Mobile phone users with access to broadband connections can also access the Internet with their mobile devices via their wireless connections, which will not cost anything except for the basic cost of broadband access. Arguably, such trends will likely make online distance learning much more attractive, as they will bridge 'distance' between students and instructors. Users will only be aware of their particular online community, irrespective of where they are physically located. And while no single technology is going to create a complete collaborative learning environment, based on our own limited research, and research carried out by others (Sotillo, 2006), we believe that IM systems can play an important role in creating interactive and collaborative m-Learning environments. For instance, the research carried out by Sotillo (2006) shows that when corrective feedback was embedded in learning activities conducted via instant messaging tools (like the ones described in our research), learners were able to expand their linguistic competence outside the traditional face-to-face environment.

Future Research

Collaborative filtering

The growth of Internet commerce has stimulated the use of collaborative filtering (CF) algorithms as recommender systems. Collaborative filtering combines the informed opinions of humans to make personalized and accurate predictions, and recommend items of interest to other users. CF methods have been harnessed to make recommendations to users about such items as which webpages to browse, movies that might be of interest, relevant books to read, and toys to use, etc. Content-based filtering uses the speed of computers to make complete, fast predictions. Very little research, however, has been done on CF in education. As a follow-up from our instant messaging research, we propose to use CF in mobile settings. For example, if a student is, say, conducting research on a given subject, that student can be presented with a list of books or other relevant online resource materials (i.e., presentations, portals and communities of practice, online libraries, etc.). If a user queries information about, say, a particular sport at their university or school, they would also receive a list of recommendations on other collateral activities such as 'the best nearby restaurants to eat at' and information that other users found useful in this 'sporting' context. If a user queries information on where to find good material on, say, writing an essay on a particular subject, they can see what other resources students also found useful. The scope of CF is enormous, and we feel CF will influence how students/ pupils get information online using mobile devices. More significantly, CF will also allow the lecturer to focus on students' learning processes and progress, instead of on relaying facts or information such as administrative details.

Acknowledgment

This research was partly funded by the European Commission, under the *Education Area of the Information Society (IST) Programme* and co-ordinated by the *Learning and Skills Development Agency*.

References

Alvestrand, H. (2002). Instant Messaging and Presence on the Internet. Brief published on the *Internet Society.org website.* Retrieved July 14, 2006 from: http://www.isoc.org/briefings/009/briefing09.pdf

Anderson, C. R., Domingos, P., & Weld, D. S. (2001). Personalizing web sites for mobile users. Proceedings of *ACM 2001: 10th International WWW Conference*. November 5-10. Atlanta Georgia, pp. 565-575.

Attewell, J. (2004). Mobile Technologies and Learning. Paper published on the *Learning and Skills Development Agency* website. Retrieved June 27, 2006 from: http://www.lsda.org.uk/files/pdf/041923RS.pdf

Cellular Online (2003, December 20). *UK GSM text messaging numbers boom.* Retrieved June 27, 2006 from: http://www.mobileoffice.co.za/news_2003/121903-uk_gsm_text_messaging_numbers_bo.htm

Cellular Statistics (2006). *Latest Mobile, GSM, Global, Handset, Base Station, & Regional Cellular Statistics for April 2006.* Retrieved June 27, 2006 from: http://www.cellular.co.za/stats/stats-main.htm

Chua, N. H., Scott, S. D., & Blanchfield, P. (2005). Web-Page Adaptation Framework for PC & Mobile Device Collaboration. *AINA '05: 19th International Conference on Advanced Information Networking and Applications*. March 28 - 30. Taipei, Taiwan. Retrieved April 24, 2007 from: http://csdl2.computer.org/persagen/DLAbsToc.jsp?resourcePath=/dl/proceedings/&toc=comp/proceedings/aina/2005/2249/02/2249toc.xml

Ivory, M. Y., Sinha, R. R., & Hearst, M. A. (2000). Preliminary findings on using quantitative measures to compare favourably ranked and unranked information-centric web pages. Paper presented at the *6th Conference on Human Factors and the Web.* June 19, Austin, TX.

Hinds, P., & Kiesler, S. (2002). *Distributed work.* Cambridge, MA.: The MIT Press.

Kadirire, J. (2005a). Learning with Mobile Devices - A Microportal Design Experience, Recent Research Developments in Learning Technologies. Paper presented at the *Third International Conference on Multi-media and Technologies in Education.* June 7-10, Cceres Spain. Retrieved June 27, 2006 from: http://www.formatex.org/micte2005/7.pdf

Kadirire, J. (2005b). The Short Message Service (SMS) for Schools/ Conferences: Recent research developments in learning technologies. Paper presented at the *Third International Conference on Multi-media and Technologies in Education.* June 7-10, Cceres Spain. Retrieved June 27, 2006 from: http://www.formatex.org/micte2005/4.pdf

Korzeniowski, P. (2004, March 31). Instant Messaging Opens New Security Holes. Published in *TechNewsWorld.com.* Retrieved June 27, 2006 from: http://www.technewsworld.com/story/33271.html

Lenhart, A., & Shiu, L. (2004). How Americans use instant messaging. *Taylor University, archived Blog posting.* Retrieved June 27, 2006 from: http://www.taylor.edu/Weblogs/zblog/archives/2004/09/new_report_on_h.html

Mohan, R., Smith, J. R., & Li, C. S. (1999). Adapting multimedia Internet content for universal access. *IEEE Transactions on Multimedia 1*(1), 104-114. Retrieved July 14, 2006 from: http://ieeexplore.ieee.org/iel4/6046/16151/00748175.pdf?arnumber=748175

Nardi, B. A., Whittaker, S., & Bradner, E. (2000). Interaction and Outeraction: Instant messaging in action. Proceedings of *2000 Conference on Computer Supported Cooperative Work* (CSCW) December 2-6. (pp. 79-88). Philadelphia, PA.: ACM, Inc.

NESTA FutureLab (2005, June) *The Future of Mobile Technology: Learning on the run?* Retrieved June 27, 2006 from: http://www.nestafuturelab.org/viewpoint/vision/vision_01_04.htm

Paek, S., & Smith, J. R. (1998). Detecting image purpose in World-Wide Web documents. From the proceedings of the *IS&T/ SPIE Symposium on Electronic Imaging: Science and Technology Document Recognition*. January 21-26, San Jose, CA.

Quan-Haase, A., Cothrel, J., & Wellmann, B. (2005). Instant Messaging for Collaboration: A case study of a high-tech firm. *Journal of Computer-Mediated Communication, 10*(4), 120-121

Sotillo, S. M. (2006). Using Instant Messaging for Collaborative Learning: A Case Study. *Innovate, 2*(3). Retrieved December 12, 2006 from: http://www.innovateonline.info/index.php?view=article&id=170

Rheingold, H. (2000). *The Virtual Community: Homesteading on the Electronic Frontier.* Cambridge, MA.: MIT Press.

Roibas, A. C., & Sanchez, I. A. (2002). Pathway to m-learning, Mlearn 2002. Proceedings of the *European Workshop on Mobile and Contextual Learning*. June, 20-21. Birmingham, UK.

Scott, S. D., & Koh, Y. H. (2003). Design metrics and the adaptation of Web-page content chunks for PDAs. Proceedings of the *3rd International Conference on Information Technology in Asia*, July 10-12, Kuching, Sarawak, Malaysia.

Scott, S. D. (2003). Edge-based algorithms for determining how far an image can be shrunk. Proceedings of *ROSVISP 2003, The IEEE International Conference on Robotics, Vision, Information and Signal Processing*, January 22-24. Penang, Malaysia.

Text.IT (2006, June 27). *UK text messaging love affair surges ahead.* Retrieved June 27, 2006, from http://www.text.it/home.cfm

Ultralab (2006). *BA (Hons) Learning, Technology and Research program, part of the Ultraversity scheme run by Ultralab at Anglia Ruskin University.* Retrieved June 27, 2006 from: http://www.ultraversity.net

Vetter, R., Heath, B., Herman, R., Lugo, G., Reeves, J., & Ward, C. R. (2005). Developing a mobile learning environment to Support Virtual Education Communities. PowerPoint presentation published on *Dr. Ron Vetter's homepage at the University of University of North Carolina, Willimington.* Retrieved June 27, 2006 from: http://people.uncw.edu/vetterr/ncsu-mle-2005.ppt

Walker, C. (2005). WFU first with campus pilot of pocket PC phones. *Wakeforest University News.* Retrieved June 27, 2006 from: http://www.wfu.edu/wfunews/2005/082405m.html

Walton, S. (2005). The eVIVA project: Using e-portfolios in the classroom. *Qualifications and Curriculum Authority website.* Retrieved June 27, 2006, from http://www.qca.org.uk/10359.html

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

m-Learning: Positioning educators for a mobile, connected future

Kristine Peters
Flinders University
Australia

Abstract

Mobile learning is variously viewed as a fad, a threat, and an answer to the learning needs of time-poor mobile workers, so does it have a place in delivering mainstream learning? Based on a 2005 comparative research project, commissioned by the Australian Flexible Learning Framework, the paper reports on research into Web-based information about the use of mobile technologies for commerce and learning, which was then tested through 29 interviews with manufacturers of mobile devices, businesses and education providers. The research found that mobile technologies were in common use in some commercial sectors, but their use purely for learning was rare. m-Learning lends itself to new methods of delivery, however, that are highly suited to the 'just enough, just in time, and just for me' demands of 21st Century learners.

Keywords: Communications; demand; flexible learning; m-Learning; m-technology; online learning; SMS; teaching; training delivery; trends

Introduction

The distinguishing feature of our society at the beginning of the 21st Century is the rapid rate of technological and social change. Technological advancements that allow fast communications and information processing are supporting new social patterns. As a result, communities are no longer only based on geographical proximity, and new 'tribes' (Rheingold, 2002) are developing and disbanding according to interest, work patterns, and opportunity.

Mobile information and communication technologies are important enablers of the new social structure. We are experiencing the first generation of truly portable information and communications technology (ICT) with the relatively recent advent of small, portable mobile devices that provide telephone, Internet, and data storage and management in products such as: *i-Mate*, *O2*, *Palm*, *HP*, and *Bluetooth* (all registered trademarks) that combine mobile telephony, removable memory chips, diaries, email, Web, basic word processing and spreadsheets, and data input, storage, and transfer.

The communication and data transfer possibilities created by mobile technologies (m-technologies) can significantly reduce dependence on fixed locations for work and study, and thus have the potential to revolutionise the way we work and learn. A mobile, connected society, however, creates new training delivery challenges. Individuals expect training that is 'just in time,

just enough and just for me' (Rosenberg, 2001), and that can be delivered and supported outside of traditional classroom settings (Peters & Lloyd, 2003).

In order to support a strategic response to the opportunities and demands of mobile learners, the education and training sector needs to be informed about the actual use of mobile devices at work and in workplace learning, and about potential future trends in mobile learning. This paper is based on research commissioned in 2005 by the Australian Flexible Learning Framework, which aimed to provide a better understanding of the separation between real opportunities for mobile learning using small electronic communication devices (m-Learning) and the hype surrounding the introduction of new technologies. The research provided an overview of popular media coverage of the use of m-technologies and m-Learning, and compared this with the findings from a small number of qualitative interviews. A short review of the academic literature was conducted, but the need for a contemporary perspective meant that there were very few research articles on m-Learning available and, therefore, limited reference has been made to peer-reviewed academic publications. As the key aim of the research was to separate the 'hype' from the 'reality,' the focus was on providing a snapshot of mobile technologies and their use in 2005. Indeed, a completely new generation of mobile communication devices (3G cell or mobile telephones) became available during the six months of research for this project, thus illustrating the challenge of maintaining publishing currency in a fast-moving field.

An Introduction to m-Learning

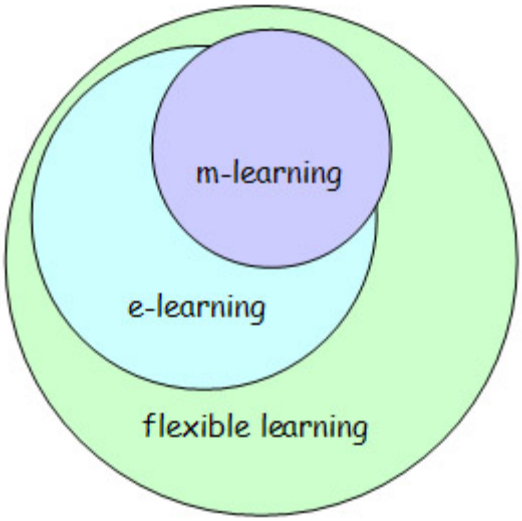
The availability of mobile and wireless devices is enabling different ways of communicating. Mobile communications are no longer restricted to companies that can afford large investment in hardware or specialised software. Individuals now have easy and inexpensive access to mobile telephony, and the cost of mobile access to the Internet is steadily reducing. Mobile technologies have enabled a new way of communicating, typified by young people, for whom mobile communications are part of normal daily interaction, who are 'always on' and connected to geographically-dispersed friendship groups in 'tribal' communities of interest.

This research aimed to test the validity of news and information media comment on mobile communications, which indicated that the 'always on' generation is, to a large degree, driving development of consumer communication technologies – as can be seen from the rapid adoption of Short Message Service (SMS). SMS is texting via mobile phones – also known in some countries as 'cell phones' – which was unexpectedly adopted by the 'text' generation, and became a pervasive communication tool in its own right. The popular and business press also reported that mobile and professional employees are driving the convergence of Personal Data Assistants (PDAs) and telephony, and of 'smart' phones (that provide both telephone and Internet services) through their demand for greater integration of online information, data management, and voice, image, and text communications. The same source shows that industries with specialist needs (such as mobile barcode readers in supermarkets and electronic courier delivery confirmations) are another significant driver of mobile product development.

The three drivers described above – consumers (particularly young consumers), mobile professionals, and specialist industries – have created strong demand, which is reflected in the increasing rapidity of development of new mobile communication and data management technologies. The trend toward convergence of applications, the ubiquitousness of mobile phones, and the continuing demand for smaller, more powerful devices indicates that mobile technologies are, indeed, mainstream. Is their use for learning, however, following the same trend?

The advent of mobile technologies has created opportunities for delivery of learning via devices such as PDAs, mobile phones, laptops, and PC tablets (which are laptops designed for a handwriting rather than a keyboard interface). Collectively, this type of delivery is called m-Learning. While m-Learning can be thought of as a sub-set of e-Learning (which is Web-based delivery of content and learning management), the emerging potential of mobile technologies tends to indicate that m-Learning, while mostly situated within the e-Learning framework, also has links directly to the 'just enough, just in time, just for me' model of flexible learning (see Figure 1), and is therefore just one of a suite of options that can be adapted to suit individual learning needs.

Figure 1. The 'just enough, just in time, just for me' model of flexible learning



Literature Review

Much of the documented evidence of m-Learning in this paper has been sourced from www.flexiblelearning.net.au, the Australian website that supports the flexible delivery of, and practice improvements in, vocational education and training. While peer-reviewed academic journals are a preferred source of material, the constraints of this research project (primarily the requirement to find out what was actually happening at the time the research was undertaken in 2005), and the funding body perspective (that m-Learning projects undertaken under the Australian Flexible Learning Framework should inform the research) determined that the outcome would be a report that provided guidance to future scholarly investigation, rather than one that contributed to the formal literature. The following discussion, therefore, is largely based on the informal literature.

m-Learning as a Practical Training Solution in Mobile Workplaces

Klopfer, Squire, Holland and Jenkins (2002) propose that mobile devices (handheld computers) 'produce unique educational affordances', which are:

a) Portability

b) Social interactivity

c) Context sensitivity, the ability to 'gather data unique to the current location, environment, and time, including both real and simulated data'

d) Connectivity, to data collection devices, other handhelds, and to networks

e) Individuality, a 'unique scaffolding' that can be 'customized to the individual's path of investigation'

The 2005 Web search found that organisations of all sizes were using mobile devices for learning because technological advances meant that there was no longer the need for large infrastructure and support costs, and even small enterprises could deliver mobile learning simply by structuring learning around Web-based content that could be accessed from Web-enabled mobile devices.

Work by Marcus Ragus (2004a) for an Australian Flexible Learning Framework New Practices in Flexible Learning Project, tested the use of PDAs in four different work environments: botanical gardens, nursing home, food and hospitality, and workplace assessor. The Royal Tasmanian Botanical Gardens trial found that simultaneous personal development for staff in separate organisations was possible, and that such strategies can be designed and targeted for a mixed audience comprising managers, teachers, ground staff, and apprentices. The nursing home trial used integration of PDAs into the general on-site training of the nursing staff through the use of simple resources created with *Microsoft PowerPoint* (Ragus, 2004a). The food and hospitality sector trials grew from a need to develop interesting, interactive resources for use by trainee bar and beverage staff, and demonstrated the application of an existing PDA image program to create a learning resource (the importance of this project was that special software was not required). Workplace assessment practice trials were undertaken within the horticulture sector, the aim of which was to use PDAs and a peripheral plug-in camera to capture evidence of assessment at remote workplaces where it is imperative that both assessors and learners are able to operate with a high degree of flexibility for delivery of learning, and for the materials and equipment required for the work (Ragus, 2004a).

Many other m-Learning applications were identified, perhaps best exemplified by Deviney and von Koschembahr (2004) who describe the situation in a major electronics retailer, which used a mobile learning program to train new sales associates. In this organisation, new employees had previously spent several hours off the job reading materials or accessing a learning portal to study products; because learning was abstracted, the quality and usefulness of this type of learning was limited. Using m-technologies, the retailer was able to equip staff with a hand-held PDA and bar-code scanner, and employees were able to learn about products on the sales floor where the learning was situated within the context of their job.

Lundin and Magnusson (2003, p. 19) saw mobile technologies as a solution to the fragmentation of a mobile workforce: "within a distributed and mobile workforce opportunistic meetings with colleagues are naturally less likely to occur than if workers are co-located" (citing Bellotti and Bly, 1996), where mobile technologies provided synchronous communications that enabled connectivity between workers in real time and thus overcame many of the barriers created by mobility.

m-Learning and the Teacher-Student Relationship

The digital age has created a new relationship between teachers and learners. Research conducted by the London School of Economics found that children are typically the Internet experts in the family, and described this situation as a "lasting reversal of the generation gap" (Smithers, 2003, ¶ 1). This reflects the challenges facing education and training providers who are steeped in traditional delivery styles when confronted with digitally literate students, where, rather than simply receiving and memorising the wisdom of their elders, which has been the tradition for millennia, students are now demanding training that meets their specific information needs. Dale Spender, renowned feminist scholar, writer, and consultant, whose work includes exploration of the social effects of new technologies, observed that there is a divide between traditional teaching techniques and the attitudes of contemporary youth. Spender's (*personal communication*, Sept., 30 2005) observation reinforces the divide between traditional teaching and the attitudes of contemporary youth:

Eight year olds think there's something wrong with their teachers. Don't teachers know that heads are unreliable places? That's what the save key is for. Even if you do store things in your head, you can't ever find them again.

m-Learning also creates learning opportunities that are significantly different to those provided by e-learning (at a desktop) or paper-based distance learning. Chen and colleagues (as cited in Bridgland & Blanchard, 2005) describe the principal considerations to be taken into account when designing m-learning delivery:

- The urgency of the learning need
- The need for knowledge acquisition
- The mobility of the learning setting
- The interactivity of the learning process
- The situatedness of the instructional activities
- The integration of instructional content

Young people do not experience geographical place and time as barriers (Fannon, 2004). Fannon's research found that although some older learners used their mobile phones to arrange face-to-face meetings to work on assignments or discuss learning issues, younger learners were more comfortable with the thought of using mobile phones for learning, and almost half (45%) of the research group were prepared to use Internet-enabled telephones as their only tool for learning. The challenges of creating learning to be delivered via mobile phones are not easily solved by teachers, however, many of whom are recent 'migrants' to the digital world (Prensky, 2001).

Dale Spender (personal communication, 2005) expressed concern about the ability of teachers to understand and respond to digital learning opportunities, citing the aging teacher population and their lack of comfort with digital ICTs, the focus on 'teaching and memorising' as opposed to 'learning and seeking information,' and reliance on 'doing it by the book.' This approach is fundamentally different to the approach of 'digital natives,' Prensky's (2001) term for those born in the digital age for whom ICT is second nature, for whom 'not knowing is an impetus to find out,' and who believe that 'if you need to use the manual, the product is no good'. Spender's position is reinforced by Aquino's (*n.d.*) observation:

Teaching has a long established culture of individualism and secretiveness and many teachers are very challenged by the need to work collaboratively with technicians, Web developers, instructional designers and programmers to deliver successful Web-based education (p. 9).

Many teachers are interested and able, however, to provide m-Learning content, learning management and support. The following examples illustrate how m-Learning is being used and supported:

- '*Environmental Detectives*' is an example of an increasing suite of games designed for mobile devices. Students played the role of environmental engineers presented with a scenario in which the spread of a toxin was simulated on a location-aware *Pocket PC* equipped with a Global Positioning System (GPS). The *Pocket PC* allowed students to investigate a toxic spill by sampling chemicals in the groundwater and responding to different variables programmed by the teacher (Klopfer et al., 2002). The use of virtual characters within the program allowed students to gain an experience that is close to real life, provided context, significantly reduced abstaction, and resulted in a blurring between the game and real life. For instance, in an unanticipated event, one group stopped in the middle of the game and used *Google* to search for clues. The strategy of accessing other outside resources was not only acceptable within the rules, it was perhaps advisable, given the time constraints and use of authentic chemicals and historical data. Students were able to locate information quickly and easily on *Google*, suggesting the role that a tool such as *Google* can play in transforming an educational experience.

- In designing Melbourne Law School's new building (built in 2002), a key feature was the provision of wireless networking that allowed students with mobile computing devices to access course material and conduct searches of legal databases during class, thus expanding the depth of the discussion and the learning experience for the student (Hartnell-Young & Jones, 2004).

- The medical field has applied mobile technology to remote learning in rural health education. Hartnell-Young and Jones (2004) described the use of Tablet PCs that helped students to capture and store confidential patient information, and deliver just-in-time information on clinical problems. Students kept a reflective journal using their mobile device, which was later used as a reference for discussion with their instructors.

- Zurita and Nussbaum (2004) demonstrated the effectiveness of handheld devices in teaching first-grade children to construct words from syllables. In a month-long controlled experiment, children who were supported with technology had significantly higher word construction test score improvements than children who were using paper-based activities.

These examples of good practice, and of m-Learning 'in the field' are by no means isolated. The generic uptake of m-Learning, however, is still some way off, and the application of m-Learning requires a new paradigm. Indeed, as Aquino (*n.d.*, p. 5) reflects, learning is ". . . emotionally based and consistently and powerfully influenced by the learner's culture and experience" and traditional teaching methodologies that are "essentially passive, theoretical, text-based and linear" will fail to engage young learners and fail to deliver the skills needed for future social and work environments.

m-Learning and Learning Cultures in Workplaces

Is the promise of mobile technologies as a trigger to generate learning cultures realistic? And is m-Learning any more likely to increase interest in learning than any other form of delivery? Articles about the link between mobile technologies and learning organisations appear to fall into three categories:

1. A database focus that captures organisational knowledge

2. A human systems focus that allows synchronous communication and information sharing at the worksite

3. A learning development focus that suggests that learning about new technologies generates a more general drive for learning

The database focus has, to a large degree, become the accepted wisdom in organisations that use structured processes to collect, codify, and manage knowledge. Mobile technologies have the potential to collect a greater range and percentage of data, through recording of activity on the device (and subsequent analysis of the patterns of access to specific information or information sources) and through the reduction of paper-based records as electronic systems replace paper in the field.

The capacity of mobile technology to deliver synchronous communication and knowledge-sharing can provide benefits to human (or soft) systems. Evidence of these benefits has been reported by Ragus (2004a), who found that m-Learning encouraged simultaneous personal development, such as networking and socialisation, outside of normal working groups – an unexpected, and positive result of the m-Learning trials.

The ‘learning tools leads to learning culture’ concept is more tenuous and has received limited attention in the m-Learning literature. However, the industry participants in Ragus’ (2004b) New Practices Project found that m-Learning had generated new ideas for the incorporation of technology in the workplace, which indicates an enthusiasm for further learning introduced through the m-Learning experience.

Brodsky (2003) looks at drivers in learning organisations and concludes that the trend toward customer self service (such as automated options for telephone enquiries, or online payment or registration of service needs) will result in changes to the nature of customer service training. Brodsky suggests that the automation of routine transactions means that the role of customer service or sales staff changes, there is greater need to manage complex transactions, with a higher level of knowledge and interaction skills and that, as a result, training technologies will become so intuitive that the technology will no longer be the focus, instead the focus will be on how the application serves the needs of the business.

The literature described a range of uses of m-technologies for learning, some of which were in the trial stages, and others where mobile devices are in common or daily use, and are accepted as a normal part of learning. To what degree did the experience of Australian businesses and education and training providers reflect the findings from the literature? This question will be answered in the next section that describes the research results.

Research

The purpose of the research was to provide an indication of whether Australian businesses are actually using m-technologies and m-Learning in the ways portrayed by the popular media. Originally intended to form the basis of a discussion paper for vocational education practitioners, the research brief did not require rigorous investigation or statistically valid samples. This paper reports on the findings of that (limited) research, framed by the literature, using interviews to establish the status of m-technology use and m-Learning uptake. Interviews were conducted with 29 respondents, representing: Australian businesses that use mobile technologies; manufacturers of mobile devices and software developers for mobile applications; and educational and training institutions.

The following criteria were used to determine whether devices were within the scope of the research: 1). capable of providing electronic communication and/ or information functions; 2). small enough to be easily carried; 3). can be used (at least part of the time) without a physical connection to fixed power or telecommunications services.

The following section of the paper describes the method and findings.

Method

Based on the findings from the literature search, three survey instruments were developed: manufacturer/ software developer, business and educational provider. Four manufacturers/ software developers were interviewed: two large international corporations (*Nokia* and *Palm*Australasia), and two developers of software for mobile devices. Six businesses were interviewed, including large national corporations, medium sized firms, and small companies. Nineteen educational providers (n = 19) were interviewed, representing universities, high schools, private training providers, TAFE (the largest public provider of vocational education and training in Australia), and industry skills councils (the organisations that determine the content of national vocational curriculum).

The manufacturer survey instrument contained questions about: the use of mobile technologies for business and personal purposes; product uses that were not an expected part of the product design; drivers of new product development (specifically whether designs responded to requests by particular customer demographic groups); future trends for mobile technologies; and whether mobile devices were being produced specifically for educational use. Interviews were carried out by the author's company, KPPM Organisational Strategists, during the period May to July 2005.

The business survey instrument investigated: mobile technologies used as part of ‘normal business processes’; whether mobile technologies contributed to business efficiencies and greater productivity; the value of mobile technologies to the business; and the use of m-technologies for learning.

Education providers were asked: whether m-technologies were discussed by students and teachers; what (if any) mobile technologies were in use as learning aids; whether m-technologies presented opportunities for new types of delivery or management of learning; and the type of student most likely to use m-technologies for a variety of learning purposes (such as communicating with peers or teachers, doing research, or timeshifting lectures).

Results

Business interviews

A search of the print media and Internet revealed a steady stream of new mobile technologies aimed at a wide range of markets. Small mobile communications and storage devices were advertised for applications as wide-ranging as: risk assessment, triage, fire inspection, bylaw enforcement, building inspection, city engineering, security, surveillance and military purposes. These findings were tested through the interviews with businesses, which revealed that (despite the low number of respondents), a range of technologies were used, with the most common being laptops, mobile phones, PDAs and portable media players.

An example of how m-technologies were being used in business was provided by South Australia's Department of Transport, Energy and Infrastructure, which was implementing mobile communications for traffic signal maintenance workers. This is what they had to say:

Field staff had previously been using laptops, but had to wait until they were back at the office to update data. The introduction of communications cards enabled real-time communication through automatic redirection of fault logs straight from signal switchboards to field worker laptops. This process also allowed the capture of fault and repair data, which needed to be recorded for legal reasons. Mobile phones were considered for this task, but did not have the bandwidth to deliver sufficient data at the required speed.

Has the use of mobile technologies increased business efficiency? Businesses saw significant benefits from mobile technologies. The following list shows common business efficiencies from the use of m-technologies:

- Flexibility, speed, and more efficient networking, which allows access to large numbers of staff throughout the world
- Provision of efficient customer service
- A more efficient working environment, with less manual paperwork – work can be done faster, more flexibly, and with greater levels of accessibility
- More efficient training, saving time to inform staff about new products and processes
- Improved storage and backup of data, with much of the risk removed
- Saving of time and money
- Creating greater responsiveness to change.

Respondents reported that these outcomes were based on carefully thought-through business cases that considered markets, productivity, professional development, staff morale, risk management, knowledge management, cost, and responsiveness to a dynamic operating environment:

If we moved offices again we would commit to 100 percent wireless network. It makes more sense as we have a lot of core infrastructure already in place. This would also allow flexibility to

increase PDA use which would result in increased access to email from outside the office, and automatic synchronising of remote data with the server.

Laptops were the most commonly mentioned device for mobile learning.

The value of mobile technologies was further tested by asking scaled questions about business benefits in four categories: finance, staff satisfaction, competitive edge and business culture. The highest ratings were for financial and business culture, but all categories rated at least 4 out of 5 as can be seen in Table 1.

Table 1. Business benefits of m-technology use

Category	Mean rating
The value of mobile technologies in creating a business culture that values new knowledge	4.6
The financial value of mobile technologies to the organisation	4.6
The value of mobile technologies to staff satisfaction	4.1
The value of mobile technology in establishing a competitive edge	4.0

[Scale 1= not important to 5= essential]

Businesses saw the next evolution of mobile technology applications for their businesses to be:

- Greater choice in hardware, resulting in a better fit between commercially available devices and the needs of individual businesses
- More customers using phones, PDAs, Internet, and email to order and make bookings
- Blended training with an increased proportion of learning delivered on mobile devices
- Faster, more efficient technology as part of a normal work environment
- Simulated and interactive training using games to teach problem solving and resolve issues
- Convergence of technologies and increased use of devices that can do more than one thing
- Increase in wireless hotspots to provide improved access to the Internet from outside the standard work environment, so that workers are not restricted when travelling
- 100 percent mobile

As one responded noted:

> It's a great benefit to be totally mobile – efficient and faster – however at this stage it is not a core part of our business. It is important in terms of safety that we get the information out there quickly and efficiently. Moving towards more mobile technologies would be a really good influence in changing the whole culture of this business.

Education and training interviews

Interviews with the education and training providers showed that less than half engaged in discussions with students about the use of mobile technologies for learning, despite the high level student use of mobile phones. A public training provider commented:

The topic that is becoming more frequent is how to get access to learning without coming into the classroom, and what mobile technology could be used to receive and store information.

Approximately half of the educational providers said that the use of mobile technologies for learning was a frequent topic of discussion with teaching staff. Some of their comments were:

- M-technology is being discussed more because the organisation is forcing it to become an issue
- Change is happening, but the first task is to learn about and understand how to use the technologies
- The most common discussion is about the development of mobile technologies within industry

Providers were asked about student readiness for mobile technologies. The most common mobile technology is the mobile telephone, so it was interesting to see what the following seven providers thought about student readiness for using mobile phones for learning.

- Mobile phones are mainly used to SMS parents regarding attendance and other communications
- Students already have mobile phones and it would be good if they were used more for learning
- Students have mobile phones although PDAs are not as popular. Providers are less concerned with the device that students use, than with what they do with it
- Some colleges already use mobile phones for communicating with students using text reminders
- SMS is already in place but the opportunities to use it for learning have not been considered in great depth – implementation will largely depend on practicalities and cost
- Resourceful teachers are incorporating SMS because young people are using it anyway, it's a great motivational tool

- m-Learning is ideally suited to adult education if it is used to extend the reach of programs. It allows students to get a response quickly, at all hours, they like the interactivity and the ability to receive a quicker response than they would via email

A number of educators mentioned that cost is a barrier; the following four quotes are good examples:

- Laptops enable students to dock into the student network, however these are not widely accepted because of cost

- More students would like laptops and wireless technology, but there is a cost constraint in providing the equipment

- If all students already owned laptops, PDAs, or mobile phones, it would be easier to use them for learning; but providers cannot ask students to buy them because the cost would exclude some people

- Teachers would like to use PDAs and laptops, but the problem is resources to develop materials and provide support, the infrastructure is lacking

How ready are students for m-technologies other than mobile phones? The five quotes below provide some telling clues:

- Students are already using laptops, but are looking for more wireless options

- Students are ready for SMS and PDA to access learning objects and assessment pieces

- PDAs are provided to students to do tests

- Students are ready for greater use of 3G mobile phones and pocket PCs/ organisers, which are already being used for communication because of their flexibility and portability

- Students use laptops for general learning, mobile phones for downloads from the Internet and general learning, and a few who travel long distances use MP3 players to download lectures

One regional provider found that students were not ready for mobile technologies, but felt that workplaces were ready.

Teacher readiness for mobile learning is seen as a barrier by a number of providers. The following three quotes are examples of this:

- It all depends on the teachers and some have not yet mastered desktop technologies! The teachers are a critical part of this, and some are not ready. Only a small percentage of classroom teachers use PDAs and they are mainly for personal use, although some have used them as a teaching tool

- A recent survey of our teachers found that 2 percent had never turned on a PC, 5 percent could not burn to CDROM and there is no use of ICT for general teaching, although some ICT-based communications are done on an individual, personal basis

- Not a lot of teachers use mobile technologies. PDAs are an executive tool, although mobile phones are ubiquitous

On the other hand, others found mobile technologies to be beneficial. The following three quotes illustrate this:

- Mobile technologies are being developed for field work, primarily to communicate with the office

- We use mobile phones to edit our newsletter

- The availability of m-technologies presented opportunities for new types of delivery and management of learning.

Seven education and training providers reported that m-technologies:

- Make teachers think — the thought process is often hard to change and using new technologies seems to help

- Overcome geographic barriers, m-Learning removes the problem of locality and the requirement that students travel to access learning

- Offer greater flexibility for staff and students

- Allow learners to learn in the field, where and when they want. However, mobile phones are not a huge teaching tool, as the students use them mainly for social contact and do not want to use them as a learning tool

- Force providers to rethink the way that they teach: We need to break down the elements of the course into small packages based on mobile technology so that students can access portable learning, learning activities, and multiple choice games from their mobile units

- Provide a faster way of informing students (using SMS) and flexible delivery that is not bound to computer so we can engage across physical space

- Enable situated learning or learning in context, using phones with cameras/ video capabilities to enable students to capture their own material and instantaneously transfer to other students and lecturers. Mobile phones are also used as tools for group learning

Education and training providers were asked about learning outcomes. Their responses show that they understand the pedagogical opportunities provided by m-Learning, which is seen to:

- Help to break down the financial and mobility constraints of learning

- Improve literacy through collection and provision of evidence for assessment portfolios
- Enable the use of digital story-telling to demonstrate competence
- Provide faster, more exciting ways of teaching, more flexibility, more mobility
- Allow for full qualifications to be delivered via mobile devices

In many organisations, m-Learning is yet to be structured into the curriculum; the following six quotes illustrate this:

- The uptake of m-Learning depends on the teacher and the curriculum coordinator
- It is experimental at moment, providers are looking at all ways to deliver subjects, so that students can choose how they would like to learn
- The education of school teachers about m-Learning needs to come first. Teachers need to understand the benefits of letting students use mobile devices for learning. At this stage, teachers are still very negative about students using mobile phones in the classroom other than for contacting parents at home time
- m-Learning needs to fit within a whole matrix of curriculum and assessment, the positioning of this mode of delivery needs to be thought through before it is implemented
- We are just starting to look at mobile technologies, which are regarded as a new area within e-Learning
- The uptake of the technology at the workplace is the prime driver of m-Learning

Only two respondents said that m-Learning was already in place in their organisations, and both were delivering learning to remote communities:

- m-Learning is not formally included in courses, but students would experience it in most subjects
- m-Learning is structured into remote teaching so that all students have access to learning without having to come into the campus. m-Learning provides financial savings because we don't have to provide physical space for all students. However, issues such as whether m-Learning allows higher quotas for courses and how to structure lecturers' pay are still to be resolved

Manufacturers and software developers

Because of the limited number of interviews with manufacturers and software developers, the findings have been grouped into the following:

- First, producers of hardware and operating systems often minimise costs and maximise effect through product development partnerships

- Second, demand from consumers and businesses is the influence on the type of product being developed, with the common requests being: easier to use, smaller, faster, smarter, and greater security. This has resulted in advancements such as multiple security layers, *Bluetooth*, car and business kits, hands free and infrared/ data cables. When asked about the future applications or capabilities that are planned for existing products, the response was: 'smaller, faster, better, cheaper, and more wireless technology to send bigger files faster.'

What percentage of mobile technologies are purchased for business purposes and what percentage is purchased for consumer use? The following quote tells the situation:

- There is such a cross-over between personal and business use we're unable to tell them apart. Higher end products (i.e., *Bluetooth* or wireless, products with extra security, or products containing enterprise solutions) are marketed only to business clients, but the simplest phone can be used for business as well as personal purposes

Much is made of the potential of m-Learning, but what is actually happening from a developer perspective? The two following quotes illustrate the developers' insights:

- A flash-based mobile interface is now being produced for m-Learning, so that animated material can be used on mobile phones; the technology is now moving quickly to respond to the increasing speed of m-Learning uptake

- As an add-on to other modes of deliver, m-Learning will increase. But it won't replace other forms of e-education because screens are too small and hard to read, and if you make them bigger, the device isn't as mobile. m-Learning is most useful when it's in a mobile, field environment

Conclusion

The key features of mobile learning identified in this report are: its ability to provide learning that is 'just in time, just enough and just for me;' learning that is situated (typically in the field or at the workplace); and learning that is contextualised through mediation with peers and teachers. While mobile devices are making some types of learning easier to access, they have the potential to deliver the kind of learning that in past times could only be done with a knowledgeable tutor working on-site, alongside the student. Clearly tutors are too expensive to provide *en masse*, but mobile technologies provide the capability for training that can be tailored to the needs of the individual learner and diverse worksites.

Is this hype, or is it actually happening? Informal learning using mobile technologies is already embedded in our daily lives. Millions of Web-enabled phones are being used by learners (who may not be enrolled in formal courses) to seek information. Use of mobile phones, PDAs, and laptops in organisations is well-established, and interviews with employers indicate that m-Learning, indeed, is occurring at the workplace, although the focus tends to be on business needs, rather than the technology used for delivery.

Many education and training providers recognise the benefits of mobile learning, but there appears to be limited adoption for educational use, which was attributed to: the age and ability of teachers and trainers; the cost of providing m-Learning devices and infrastructure; the slow rate

of change in large educational institutions; and that mobile devices are not designed with the education market in mind.

With consumers driving the global uptake of mobile telephony, and the growing functionality of these devices, it appears that m-Learning does indeed have a place in mainstream education and training. Managing m-Learning as a part of a suite of services that offers greater choice to learners will have benefits for providers, because it can allow teachers to move from delivery to the management of learning, and will help learners to gain specific skills of immediate value in the knowledge-based economy.

Acknowledgement

Based on research undertaken by Kristine Peters entitled Learning on the Move: Mobile technologies in business and education, for the 2005 Australian Flexible Learning Framework. To read the full paper: http://www.flexiblelearning.net.au/projects/resources/2005/Research.htm

References

Aquino, M. (*n.d.*). *Something to do, not something to learn: Experiential learning via online role play*. Australian Flexible Learning Framework. Retrieved March 17, 2007 from: http://www.flexiblelearning.net.au/leaders/fl_leaders/fll04/papers/reviewessay_aquino.pdf

Bridgland, A., & Blanchard, P. (2005). *Powerful, portable, personal computing: Is m-learning an opportunity in e-learning?* University of Melbourne. Retrieved March 17, 2007 from: http://eprints.infodiv.unimelb.edu.au/archive/00000889/01/bridgland.blanchard.pdf

Brodsky, M. (2003, May 7) E-learning Trends Today and Beyond. *LTi Newsline*. Retrieved March 17, 2007 from: http://www.ltimagazine.com/ltimagazine/article/articleDetail.jsp?id=56219

Deviney, N., & von Koschembahr, C. (2004, March 21). Learning goes mobile. *Human Resource Executive*. Retrieved July, 22 2005 from: http://www.workindex.com/editorial/train/trn0402-02.asp Editor's Note: This link no longer available, but it is cited in Keegan, D. (2005). *Mobile Learning: The Next Generation of Learning, Distance Education International.* Retrieved March, 17 2007 from: http://learning.ericsson.net/mlearning2/files/workpackage5/book.doc

Fannon, K. (2004). Connectedness: Learner perspectives on learning futures. *Australian Flexibile Learning Network: Flex e-News Newsletter*. Retrieved September, 27 2005 from: http://www.flexiblelearning.net.au/newsandevents/Flexenews/ 41/Kate_Res.pdf

Hartnell-Young, E., & Jones, P. (2004, October 6). Mobile Law and e-Portfolios. *The Knowledge Tree*. Retrieved March 17, 2007 from http://knowledgetree.flexiblelearning.net.au/edition06/html/cr_elizabeth_hartnell-young.html

Klopfer, E., & Squire, K., Jenkin, H. (*n.d.*). *Environmental Detectives – The development of an Augmented Reality Platform for Environmental Simulations. Educational Research Technology and Development.* Los Alamitos, CA.: IEEE Computer Society Publications.

Lundin, J., & Magnusson, M. (2003). Collaborative Learning in Mobile Work. *Journal of Computer Assisted Learning, 19*(3), 273-283.

Peters, K., & Lloyd, C. (2003). Differentiating Needs: Customer demand for online learning. *The National Centre for Vocational Education Research (NCVER), Australian National Training Authority website.* Retrieved March 17, 2007 from: http://www.ncver.edu.au/research/proj/nr2f02.pdf

Prensky, M. (2001, October). Digital Natives, Digital Immigrants. *On The Horizon. NCB University Press, 9*(5), October 2001. Retrieved March 17, 2007 from: http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf

Ragus, M. (2004a). Mobile Learning: handheld innovations in flexible learning – Case Studies. *New Practices in Flexible Learning, Australian Flexible Learning Framework.* Retrieved March 17, 2007 from: http://pre2005.flexiblelearning.net.au/projects/mobilelearning.htm

Ragus, M. (2004b). Mobile Learning: Handheld innovations in flexible learning. Project Report. *New Practices in Flexible Learning, Australian Flexible Learning Framework.* Retrieved March 17, 2007 from: http://pre2005.flexiblelearning.net.au/projects/mobilelearning.htm

Rheingold, H. (2002). *Smart Mobs: The next social revolution.* New York: Basic Books.

Rosenberg, M. J. (2001). E-learning: Strategies for delivering knowledge in the digital age. New York: MacGraw-Hill.

Smithers, R. (2003, October 16). Children Are Internet Experts. *The Guardian online.* Retrieved March 16 2007 from: http://education.guardian.co.uk/elearning/story/0,,1064034,00.html

Spender, D. (2006, September 30). *Personal communication with Dr. Dale Spender via telephone.*

Zurita, G., & Nussbaum, M. (2004). A constructivist mobile learning environment supported by a wireless handheld network. *Journal of Computer Assisted Learning, 20,* 235-243. Retrieved May 24, 2007 from: http://www.blackwell-synergy.com/doi/pdf/10.1111/j.1365-2729.2004.00089.x?cookieSet=1

SOME RIGHTS RESERVED

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Integrating Mobile Learning into Nomadic Education Programmes in Nigeria: Issues and perspectives

R. A. Aderinoye, **K. O. Ojokheta**, & **A. A. Olojede**
University of Ibadan, Nigeria

Abstract

The establishment of the Nigerian National Commission for Nomadic Education in 1989 created wider opportunities for an estimated 9.3 million nomads living in Nigeria to acquire literacy skills. This commission was struck to address low literacy rates among pastoral nomads and migrant fishermen, which put literacy rates at 0.28 percent and 20 percent respectively (FME, 2005). To improve the literacy rate among Nigeria's nomadic populations, the National Commission for Nomadic Education employed various approaches such as onsite schools, 'shift system' schools with alternative intake, and Islamiyya (Islamic) schools, to provide literacy education to its nomads. A critical appraisal of these approaches by the commission, however, shows that very few of the schools were actually viable. This paper explores why these approaches have not notably helped to improve the literacy rate among Nigeria's nomadic people. Thus, there remains a need for alternative approaches to educational delivery. In face of the revolutionary trends taking place in information and communication technologies (ICTs) in Nigeria, there is now opportunity to embrace mobile learning using low cost mobile technologies (i.e., mobile phones) to enhance the literacy rates among Nigeria's nomadic people, some of whom are enrolled in Nigeria's current Nomadic Education Programme. Indeed, mobile telephones with simple text messaging features, for example, are prevalent in many parts of Nigeria. This paper explores the needs and advantages of integrating mobile learning into Nomadic Education programmes in Nigeria to ensure a successful implementation and achievement of the goals of the programme.

Keywords: Mobile learning; nomadic education; information and communication technologies; ICT; radio literacy; distance education

Introduction

Article 13 of the International Covenant on Economic, Social, and Cultural Rights (UNESCO, 2003) articulates:

> Education is both a human right in itself and indispensable means of realising other human rights. As an empowerment right, education is the primary vehicle by which economically and socially marginalized adults and children can lift themselves out of poverty and obtain the means to participate fully in their

> communities. Education has a vital role in empowering women, street working children from exploitative and hazardous labour and sexual exploitation, promoting human rights and democracy, protecting the environment, and controlling population growth (UNESCO, 2003, p. 7).

Clearly, achieving the right to education for all is one of the biggest challenges of our times. The second 'International Development Goal' addresses this challenge through the provision of universal primary education in all countries by 2015.

The centrality and importance of education as a fundamental 'human right' has been well documented in the literature. According to Ezeomah (1983; 1982) and Aleyidieno (1985) making education a fundamental 'human right' provides a viable springboard for transforming social and economic policy (as cited in Iro, 2006). For example, Wennergreen, Antholt, and Whitaker (1984) suggest:

> All who have mediated on the art of governing mankind have been convinced that the fate of empire depends on the education of youth (p. 34).

From the foregoing, it is clear that any nation looking for a lasting economic success must raise the literacy level of its citizens. The educational provision in Nigeria, as written in its National Policy on Education (FME, 2004) first published in 1977, has articulated five main national goals:

1. a free and democratic society
2. a just and equalitarian society
3. a united, strong, and self-reliant nation
4. a great and dynamic economy
5. a land full of bright opportunities for all citizens

Therefore, Nigeria's philosophies of education are based on:

- The development of the individual into a sound and effective citizen
- The full integration of the individual into the community
- The provision of equal access to educational opportunities for all citizens of the country at the primary, secondary, and tertiary levels, both inside and outside the formal school system.

To this effect, the establishment of various institutions like the National Mass Education Commission in 1999, State Agencies of Adult Education, and most especially, the National Commission for Nomadic Education in 1989, created a wider opportunities for the estimated population of 9.3 million Nigerian nomads. The nomadic population of Nigeria currently makes up approximately 6.8 percent of its total estimated population of 140 million people (NPC, 2006).

While proportionally small, Nigeria's nomadic people represent a sizable population that needs access to basic educational provisions to acquire literacy skills. Education is widely considered as

an authentic and necessary tool for national development. Every segment of Nigerian society must therefore have access to education, including Nigeria's relatively small nomadic population.

Nigeria's nomadic people are typically described in terms of what they do not have. They do not have access to adequate food, clean water, health care, clothes, or shelter. They do not possess basic literacy skills. Their children do not have access to basic education. Young female nomads do not have the cultural freedom to marry who they want to marry. Nigeria's nomads, therefore, arguably need a better understanding of their socio-cultural predicament, which many consider as less developed.

Educating Nigeria's nomadic populations via distance education (and using mobile-learning methods), can be viewed as a positive step towards effective implementation of the provision of Nigeria's National Policy on Education (NPE) on equal access and brighter opportunities for all its citizens regardless of where they live. The establishment of nomadic schools in Nigeria's various nomadic States, however, has failed to produce desired results because of the non integration of mobile learning technologies.

The literature has identified mobile learning as any service that supplies a learner with general electronic information and educational content that aids in acquisition of knowledge regardless of location and time (Lehner & Nosekabel, 2002).

In recent years, there has been a steady growth in Nigeria's mobile telephone infrastructure and a concomitant acquisition and hence, use of mobile telephones amongst Nigerians. Increasing rates of accessibility throughout Nigeria is encouraging more and more people to have access to, or purchase, a mobile phone. Service providers in Nigeria are also on the increase to meet this growing demand, and over time, interconnectivity is projected to be both easier and more affordable, especially for Nigeria's nomadic population.

Current Education Provision Aimed at Nigeria's Nomadic Peoples

'Literacy by Radio' is an educational programme that has been implemented throughout the country. Indeed, radio currently provides instructions and relays messages to Nigeria's nomads, who are typically on the move while grazing their cattles. The provision of tele-centres that provide Nigeria's rural and nomadic peoples with practical skills acquisition are currently being used to teach topics such as health and socio-economic issues that affect their daily lives. Further, from a pedagogical perspective, Kinshuk (2003) believes mobile learning will serve a whole new highly mobile segment of society, a reality that could very well enhance the flexibility of the educational process. Chen, Kao, Sheu, and Chiang (as cited in Milrad, Hoppe & Kinshuk, 2003) say that characteristics of mobile learning must include:

- Urgency of learning need
- Initiative of knowledge acquisition
- Mobility of learning setting
- Interactivity of the learning process
- 'Situatedness' (*sic*) of instructional activities
- Integration of instructional content

According to Kinshuk (2003), mobile learning facilitates provision of educational opportunities. In the Nigerian context, Kinshuk's (2003) work can be expanded to include the integration mobile learning into nomadic educational contexts and programmes. The principle of this paper is based on this contextual and pedagogical viewpoint.

The Concept of Mobile Learning

Mobile learning is the use of any mobile or wireless device for learning on the move. It is any service or facility that supplies a learner with general electronic information and educational content that aids their acquisition of knowledge, regardless of location and time (Lehner & Nosekabel, 2002). Kinshuk (2003) in quoting Vavoula and Sharples (2002) suggested that there are three ways in which learning can be considered mobile: (1) learning is mobile in terms of space; (2) in different areas of life; and (3) with respect to time. These definitions, according to Kinshuk (2003), suggest that mobile learning systems should be capable of delivering educational content to learners anytime and anywhere they need it.

Mobile learning, as a novel educational approach, encourages flexibility; students do not need to be a specific age, gender, or member of a specific group or geography, to participate in learning opportunities. Restrictions of time, space and place have been lifted.

Mobile technologies enable students to become more adaptable to flexible and contextual lifelong learning, a situation defined by Sharples (2000) as the "knowledge and skills" people need to prosper throughout their lifetime. Clearly, these activities are not confined to specified times and places; however, they are very difficult to achieve through traditional education channels. Put simply, mobile technologies fulfill the basic requirements needed to support contextual, life-long learning by virtue of its being highly portable, unobtrusive, and adaptable to the context of learning and the learners' evolving skills and knowledge (Sharples, 2000).

Nomadic Education in Nigeria

According to Akinpelu (1993), the contemporary definition of 'nomadism' refers to any type of existence characterized by the absence of a fixed domicile. He identifies three categories of nomadic groups as: hunter/ food gatherers, itinerant fishermen, and pastoralists (a.k.a., herdsmen).

In Nigeria, there are six nomadic groups:

1. The Fulani (with population of 5.3 million)
2. The Shuwa (with population of 1.0 million)
3. The Buduman (with population of 35,001)
4. The Kwayam (with population of 20,000)
5. The Badawi (with population yet to be established)
6. The Fishermen (with population of 2.8 million)

The last group, The Fishermen, is concentrated in Rivers, Ondo, Edo, Delta, Cross River, and Akwa-Ibom States (FME, Education Sector Analysis, 2000). The first five nomadic groups listed are considered pastoralist nomads.

Delivery of educational services to the children of all nomadic groups has tended to follow the lines of the formal school system. Special attention was paid to these groups by the Nigerian Government when it set-up the National Commission for Nomadic Education by Decree 41 of 12 December 1989 (Federal Government of Nigeria, 1989).

Of the estimated 9.3 million people that currently comprise Nigeria's nomadic groups, approximately one third, that is 3.1 million are of school and pre-school age. The pastoral nomads are more highly disadvantaged than the migrant fishermen, in terms of access to education primarily because they are more itinerant. As a result, the literacy rate of pastoral nomads is only 0.28 percent, while that of the migrant fishermen is about 20 percent (FME, 2000). The basic responsibility of the Commission for Nomadic Education, among others, is to provide primary education to the children of pastoralist nomads – a responsibility shared with the States and Local Governments. To provide education to its nomads,a multifaceted strategy has been adopted by the Commission, that includes on-site schools, the 'shift system,' schools with alternative intake, and Islamiyya (Islamic) schools. The current mobile school system in the strictest sense remains sparingly used, primarily due to the enormity of problems associated with this model. Some mobile schools, however, are in operation in the River Benue area of Taraba, Benue, Adamawa, Nassarawa, Borno, and Yobe Sates.

By the beginning of the 1995/ 1996 school session, there were 890 nomadic schools in 296 Local Government Areas of 25 States of the Federation catering for the education needs of the children of pastoral nomads alone. Of these, 608 schools are owned and controlled by States, 130 by Local Government, and 152 by Local Communities. Together they serve 88,871 pupils of the estimated population of the 3.1 million nomadic school-age children. Of this number, 55,177 (62%) were boys and 33,694 (38%) were girls. There were 2,561 teachers, a majority of whom 1,326 or 51 percent were teacher-aides, who are unqualified and in need of upgrading. This has been the usual practice because of the nature and characteristics of the nomadic populace.

As of 1993, 661 schools had been built for pastoral nomads, out of which 24 percent (n = 165) had permanent classrooms and 46 percent (n = 293) had temporary classrooms built of grass, mats, canvas tarpaulins, et cetera. Subsequently, mobile, collapsible classrooms were procured. Altogether, the schools had an enrolment of 46,982 children taught by 1,896 teachers. This number, however, only scratches the surface of the problem, as it only serves an estimated 3.1 million primary school age nomadic children. The Comprehensive Education Analysis Project, (Federal Government of Nigeria, 2000) provides the enrolment figures during the 1990s in Table 1.

Table 1. Enrolment of Pastoral Nomads in the 1990s

Pastoral Nomads	
1993	46,982
1994	49,617
1995	64,459
1997	118,776
1998	116,944
1999	122,517

Source: ESA (2000)

Note that between 1993 (*n* = 46,982 students were enrolled) and 1999 (*n* = 122,517 students were enrolled), there has been an increase of 260.8 percent. Considering that there are an estimated 3.1 million pastoral nomads in Nigeria, however, there is still a long way to go.

Table 2. Enrolment of Migrant Fishermen, 1998-99

Migrant Fishermen		
1998	38,842	With 860 Teachers
1999	40,826	With 847 Teachers

Source: ESA (2000)

In spite of these efforts, access to education is still a major problem affecting Nigeria's pastoral nomadic people and migrant fishermen (see Tables 1 and 2).

Approaches to Nomadic Education in Nigeria

To improve the literacy rate of Nigeria's nomads, the National Commission for Nomadic Education employed various approaches such as on-site schools, the 'shift system,' schools with alternative intake, and Islamiyya (Islamic) schools to provide literacy education to the nomads. The nomadic education programme has a multifaceted schooling arrangement designed to meet the diverse habits of the Fulani people, with the largest population of 5.3 million. In Nigeria, the government set up different agencies to implement education for the nomads; these agencies include the Federal Ministry of Education; Schools Management Board; National Commission for Nomadic Education; Agency for Mass Literacy, and the Scholarship Board. Together, they offer a mobile school system wherein the schools and the teachers move with the Fulani children.

Mobile Schools

Mobile schools use collapsible classrooms that can be assembled or disassembled within 30 minutes and carried conveniently by pack animals. While a whole classroom and its furniture can be hauled by only four pack animals, motor caravans are replacing pack animals to move the classrooms. A typical mobile unit consists of three classrooms, each with spaces to serve 15 to 20 children. Some classrooms are equipped with audio-visual teaching aids.

Radio and Television Education

In a study jointly carried out by the Federal Government of Nigeria and UNESCO in 2004, "Improving Community Education and Literacy, Using Radio and Television in Nigeria," it was established that 37.0 percent of Nigerians owned only radio, while 1.3 percent owned only TV sets. Nearly forty-eight percent (47.8%) owned both radio and TV sets, while 13.9 percent had neither. Findings from the study revealed that radios are easily affordable, accessible, and often more handy to use than TV. Those without TV and radio, however, still have access to the media through socialization in their local communities.

The pastoral Fulani as a captive audience for radio and television programmes have radios, which they carry along during herding. The literate world can, thus, reach itinerants Fulani without disrupting their nomadic life or livelihood. To improve literacy, especially in the rural areas, the Nigerian Government has introduced radio and television educational programmes. The government supplies hardware such as radio, television, and electric generators, and builds viewing rooms for public use.

Although the Nigerian Government has spent millions of naira (the currency of Nigeria) to support its nomadic education programme, educational attainment among the Fulani remains low, and the quality of education among them is mediocre at best. The current form of nomadic education, therefore, has truly yet to lift the literacy and living standards of the Fulani people as children of farmers rather than fulanis constitute up to 80 percent of the pupils in nomadic schools. In Plateau State, for example, only six of 100 children in the Mozat Ropp nomadic school are Fulani (Iro, 2006).

Time and audience

Time of tuning to radio or TV varies according to programmes of interest and the time of the day, when the audience's attention is most available. Table 3 indicates the time when most Nigerians tune to radio and television.

Table 3. Time and Audience in Nigeria

Time	Radio %	TV%
Morning	97.5%	61.7%
Afternoon	88.5%	51.4%
Evening	97.0%	88.1%
Night	91.2%	93.0%

Source: NMEC/UNESCO, 2004

Table 3 shows that Nigerians tuned to radio all day long. Of those surveyed, 97.5 percent indicated that they listened to radio in the morning, 88.5 percent in the afternoon, while 97 percent and 91.2 percent listen in the evening and night, respectively. Of those surveyed, 61.7 percent view television in the morning, 51.4 percent in the afternoon, 88.1 percent in the evening, and 93 percent in the night. These findings indicate that higher percentages of Nigerians tune into radio and television during the evening and at night.

These findings suggest that scheduling of education programmes for community education purposes (i.e., nomadic educational programmes) will be more effective if broadcasts are transmitted when audiences are most available and, arguably, attentive.

Ownership of radio sets

Ownership of radios naturally leads to radio listening habits. It is expected that all members of a household will have access to radio (if available). Table 4 analyses the pattern of ownership of radios in Nigeria.

Table 4. Distribution of radios by heads and members of households in Nigeria

Do you own a radio?	Frequency	Percentage
Yes	1,017	81.4%
No	233	18.6%
Total	1,250	100.0%

Source: NMEC/UNESCO, 2004

Table 4 above shows that 81.4 percent of Nigerians own a radio, while 18.6 percent had none. This shows that radios are readily available. The implication is that four out of every five members in any community own a radio. Broad access to radio arguably facilitates the flow of information to both urban and rural areas, and can assist in the development of community education, especially at the grassroots.

Listening habits

Audience listening habits develop based on overall availability of radio in the community. Table 4 shows that radios are readily available, primarily because they are affordable and easy to operate in both rural and urban centres. Table 5 below examines the listening habits of Nigerians, which supports the findings in Nigeria's Federal Ministry of Education (2005), ESA Study.

Table 5. Frequency distribution of listening habits

Do you listen to radio?	Frequency	Percentage
Yes	1,126	90.1%
No	124	9.9%
Total	1,250	100.0%

Source: NMEC/UNESCO, 2004

Table 5 shows that 9 out of every 10 Nigerian adults listen to radio. Analysis by State, also shows the same pattern with more State recording higher percentage of between 90 percent and 100 percent. As noted earlier, the accessibility to radios accounts for the high listening habits. Table 6 below examines how Nigerian's listen.

Table 6. Mode of radio listening in Nigeria

How you listen to radio?	Frequency	Percentage
Alone	321	25.7%
Alone & Group	595	25.6%
In a Group	323	25.8%
I do not listen	11	0.9%
Total	1,250	100.0%

Source: NMEC/UNESCO, 2004

The mode of listening in Table 6 indicates that the pattern of radio listening habits are uniformly distributed among those listening alone (25.7%), listening in-group (25.8%), and alone or in-group (47.6%). It is observed that across the States, listening habit 'alone or in-group' is higher than others. In fact, the 'alone or in-group' mode of listening is nearly the same as Nigerian's TV viewing habits, with the exception of radio sets, which are more easily transportable. Group listening provides opportunity to discuss various programmes of interest and is arguably a good forum to develop education programmes.

Television viewing habits

The ESA (2000) study also examined Nigerians' television viewing habits. The purpose of this study was to determine possible prerequisites to watching educational programmes in various communities. The survey was administered to 60 percent rural people and 40 percent for urban people. This distribution is indicative in itself, as the target of this study centred on Nigeria's nomadic populations based in its rural areas; it was also based on fact that demographically more than half of Nigeria's population live in rural areas.

Ownership of television sets

Ownership of television sets can be viewed as a yardstick upon which to predict and, arguably, cultivate television-watching habits, especially for the use of tele-centres as a distance learning method. In Nigeria, households that have a television not only attract viewers from within the immediate family, it can attract extended family members in the neighbourhood, and even neighbours who may also be interested in the programme aired. With the introduction of Rural Electrification Projects in many communities throughout Nigeria, more areas and regions are now being opened-up to modern technologies. Put simply, televisions are no longer a foreign sight in rural areas. Moreover, some televisions can be operated on batteries, which overcomes problems of electrical shortages and blackouts. Table 7 below shows the home ownership of television sets as a prerequisite to developing television viewing habits.

Table 7. Distribution of household ownership of televisions in Nigeria

Do you own a television set?	Frequency	Percentage
Yes	395	31.6%
No	855	68.4%
Total	1,250	100.0%

Source: NMEC/UNESCO, 2004

Table 7 above indicates that only 31.6 percent of Nigerians own television sets. The percentage of those without television sets is higher due to poverty and low incomes of many Nigerians. This study also reveals that radios are more affordable, and hence attainable, than television sets. Indeed, many Nigerians face difficult times as many families have been affected by retrenchment, under-employment, and unemployment in recent times. This creates and perpetuates a situation whereby many adult Nigerians – who are often struggling to support and feed their families – cannot afford luxury goods like televisions.

Due to the exchange rate of the naira, the exchange currency of Nigeria, problems of inflation also abound. For example, the exchange rate of the naira in 1986 was N .7550 to US $1.00; in 2006 it was N 137.00 to US $1.00. This means many consumer goods, including television sets, are financially out-of-reach of most Nigerians who lack discretionary cash and hence, buying power. To further exacerbate problems brought about by pressures of high inflation, electrical failures are common throughout Nigeria, a reality that further discourages many Nigerians from buying power-hungry appliances and durable goods like television sets. The major source of electricity is government owned. In Nigeria's cities, where electricity does exist, power interruptions are very common, while most rural areas altogether lack the electrical infrastructure to power televisions.

The social structure of Nigerians encourages communal living, which encourages people within the same household or community to share things. This is especially true for the nomadic families. Nomadic people tend to share whatever they have without grudge; thus, their 'culture of sharing' encourages communal television viewing and as such, should advance the use of tele-centres to accommodate literacy programmes aimed at teaching nomadic populations.

Critique of the Approaches and Adoption of Innovation Approach

The role of the National Commission for Nomadic Education (which does not have a school of its own) is to provide instructional and infrastructural support to schools catering for nomads, and conduct training courses for teachers working in nomadic schools. The reality is, however, Nigeria's States and Local Governments tend not to coordinate their activities to support this programme; they also make little effort to discover what is happening in the schools. Infrastructure and facilities that were provided during the mobilization period – 1988 to 1990 – have either been destroyed or dismantled, and replacement and renovation have not taken place. The demise in 1991 of the National Primary Education Commission, which by law allocated 2.5 percent of the National Fund to support Nomadic Education, affected the funding of the Nomadic Education Commission until a new Primary Education Commission (NPEC) was re-established in 1993. The re-injection of funding has improved the situation.

In sum, nomadic education in Nigeria is affected by defective policy, inadequate finance, faulty school placement, continual migration of pupils, unreliable and obsolete data, and cultural and religious taboos (UBE, 2006). While some of these problems can be solved by policy and infrastructure interventions, the fact remains that most problems are complex and difficult to solve. The persistence of these problems is causing the roaming Fulani to remain educationally deficient.

The current top-down planning process, wherein the Fulani are the passive recipients rather than proactive planners of their education, dominates the nomadic education policies. For instance, during the first national workshop on nomadic education, only a few Fulani were invited to attend. Ironically, it was at this particular workshop that far-reaching decisions that affected the lives of the Fulani were made (Iro, 2006). Writing about education among the East African pastoralists, Iro stated further "Pastoralist, in our education system, get knocked on the head, being told they don't know anything . . . although they, in fact, come in with knowledge that even if we studied half our lives, we wouldn't achieve" (p. 194). This is exactly what is happening to the pastoralist Fulani in Nigeria. The Fulani are concerned that their children who go to school will graduate with ideas that will be at odds with their traditional pastoral practices. In quoting a Fulani leader, Iro (2006) wrote ". . . we are not opposed to the idea of getting our children to schools, but we fear that at the end of their schooling they will only be good at eating up cattle instead of tending and caring for them" (p. 51).

New Learning Technologies

Beyond the use of technology in formal education programmes for adults, wherein computer skills and other components of 'digital literacy' often define a given programme's learning objectives, distance learning supported by ICTs, can provide significant learning opportunities for informal and non-formal continuing literacy in adults and in basic youth education programmes. Indeed, four high-population countries – Cuba, China, Mexico and Nigeria – have each shown that the combination of distance education and ICT can and does work.

Distance learning and ICTs enable interaction and practice, use leaner-generated materials, stimulates learner awareness and learner motivation, supports and trains literacy workers, facilitates the distribution of materials and information to resource centres, and gathers feedback from centres and individual learners regarding available materials and programmes (Iro, 2006). It is rare, however, for adult literacy programmes to be conducted solely through these media, which primarily are used in support of conventional educational programmes in Nigeria. Interestingly, Cuba has used the combination of the above mentioned media to successfully promote literacy. Cuba's track record of success, in essence, shows that Nigeria can borrow a leaf from Cuba's experience.

Some scholars recognize that access to technology does not guarantee that its use will be meaningful or empowering. Instead, the real challenge facing educators is to shift students from acquisition of technical skills to that of proactively determining how digital technologies can enable them and others to engage in social and academic pursuits (Hayes, 2003). Indeed, emphasizing individual instruction and individual ownership of technology at the expense of sound pedagogy could, in fact, widen rather than bridge the 'digital divide.' Given such pedagogical and resource constraints, ICTs and distance learning have more immediate potential for the professional development of literacy educators than for literacy programmes themselves *per se*.

Nigeria's telecommunications infrastructure and its use are rapidly expanding. The popularity and relative affordability of text messaging, for instance, suggest that it could be used for mass distribution of messages to learners and to facilitate communication among learners, and between learners and their distance trainers.

Radio continues to be the most potent tool for use in literacy development. Locally produced interactive radio instruction, along with community radio for locally specific programme support, can allow two-way engagement among learners and programme providers, especially where potential learners are widely scattered or mobile, such as is the case with the newly introduced literacy by radio for all. One good thing about the radio literacy is its relevance on local languages: Hausa, Yoruba, Igbo, Kolokuma, Fulfide, and Ijaw. Radio is also used for awareness generation and community mobilization (Aderinoye, 2005). Use of cassettes offer still more potential for genuine multimedia pedagogy to enrich functional teaching in literacy courses. In some cases, they could even be the primary tool used to teach basic literacy skills. Support in the form of cassettes relies on fairly simple technology; albeit one that includes a system of making and distributing recordings. It also requires extra visits by local coordinators/ supervisors to distribute cassettes. Still cassettes can be reused – for instance, for in-service support purposes.

Relevance of Mobile Learning in the Context of Distance Learning in Nomadic Education Programmes in Nigeria

The terms "distance education" or "distance learning" have been used interchangeably by many different researchers in a variety of programs, providers, audiences, and media. Its hallmarks are the separation of teacher and learner in time and/ or space (Perraton, 1988), and noncontiguous communication between student and teacher, mediated by print or some form of technology (Keegan, 1986; Garrison & Shale, 1987). It does not imply the physical presence of the teacher appointed to dispense learning in the place where it is received, or in which the teacher is present only on occasion (Kaye, 1989).

Distance education is an important component of non-formal education that caters to those that lack access to traditional, bricks and mortar and four walled institutions to learn. This form of education through mass media and correspondence makes access to health education, civic education, literacy, and vocational training possible (Abiona, 2003). Through distance education modalities, relevance is also attached to the improvement of personal improvement, especially for Nigeria's nomadic populations whose lifestyles do not permit them to participate in Nigeria's conventional school system. There is, of course, the need for further, more in-depth research (i.e., curriculum design, media used, personnel work release, equipment, initiatives, etc.

According to Slavin (1990) two theoretical models support the relevance of using distance education in the context of nomadic education. The first model, 'motivational theory,' suggests that the motivation of each learner working with other students in cooperative learning contexts is high. That is, the combination of well-planned learning environment wherein the learner knows the goals will increase his or her motivation to learn. The other explanation, 'cognitive learning theory,' relates to learners' cognitive processes occurring during cooperative learning. Because cooperative learning involves dialogue and interaction between learners, students are more likely to grasp the conceptual material under study.

How Mobile Learning can be Used as a Distance Learning Approach in Nomadic Education?

In a recent Mobile Telecommunication Nigeria (MTN) advertisement, a Fulani pastoralist is depicted making a call and telling other Fulani friends that MTN network was now available, even in the remotest regions. This advertisement portrays the fact that pastoralists – like other Nigerians – can also use mobile telephones wherever and for whatever reason. In terms of using mobile technologies to teach basic literacy skills to Nigeria's nomadic pastoralists, one of the most practical mobile technologies currently available are mobile telephones. The processes of using mobile phones for educational purposes can be illustrated as:

1. Mobile schools that can be dismantled and quickly moved have proven their worth and appear to fit with Nigeria's nomadic peoples' peripatetic culture, lifestyle and livelihood.

2. The National Commission for Nomadic Education can enter into contractual agreement with the network providers to procure relatively inexpensive mobile phones, which can then distribute to the nomads in their schools.

3. Designated learning centres can be established at strategic locations along the nomads traveling routes, providing a place where a facilitator can attend to the needs of the nomads. Other materials, such as learning manuals and programme syllabi, can also be distributed from these strategic locations.

4. Facilitators, via a simple call using their mobile telephones, can call the nomads to track their students' progress in their studies, and to determine and address any problems that any learner – whether they are stationary or mobile – typically face in mastering the course materials and learning objectives. Similarly, the nomadic learners can also be regularly encouraged to call the course facilitator on their mobile phones, should they encounter any problems or require clarification or help. Facilitators are also encouraged to call and network with their fellow facilitators. Use of mobile phone in one's native language, helps to establish a cordial and hence, sustainable learning atmosphere based on trust and collegiality.

The Perceived Benefits of Mobile Learning to the Nomads

Mobile learning systems, to a great extent, are capable of delivering educational content anytime and anywhere learners need it. In this regard, there are many benefits that Nigeria's nomadic populations can draw upon if mobile learning is integrated into Nigeria's current nomadic education programme. Some projected benefits are:

- Mobile learning will afford Nigeria's nomadic people the opportunity to acquire literacy skills with little disruption to their nomadic lifestyles and livelihoods.

- The establishment of nomadic schools, in fixed locations, appears to be a misguided educational policy. Indeed, the inherent nature of Nigeria's nomads as groups of wandering people was not taken into consideration during the formulation of this policy. Therefore, one viable option available for these wandering people is to learn through a mobile learning system.

- One major problems usually faced by Nigeria's nomads in their wandering activities, is that they lack 'interactional' and 'transactional' skills with the people they come across during their travels. The acquisition of literacy skills through the mobile learning system will, to a large extent, equip them with valuable interactional and transactional skills needed to enhance their relationships with the people they meet.

- Lastly, the modern world is knocking on their door; nomads need to develop a sense of belonging to the larger, modern world wherein learning is a key commodity for survival.

Adopting Mobile Learning in Nomadic Programmes in Nigeria: The challenges

Of course, other, perhaps hidden, challenges still must be faced in the integration of mobile learning into nomadic education programmes in Nigeria. Some apparent challenges are:

1. Nigeria's nomads may not wish or be willing to embrace mobile learning. Such reluctance to adopt a new technology or innovation, however, can be mitigated through a well designed public awareness campaign and project mobilisation strategies specifically targeting Nigeria's nomadic populations. Indeed, it is a well known fact that innovations like mobile phones and mobile learning, typically take time to take root and take hold, to eventually become more widely accepted (Rogers, 1995). The use of targeted awareness campaigns and project mobilisation strategies, however, can help address issues of low and non-adoption of mobile learning technologies among Nigeria's nomadic populations.

2. The sheer cost of procuring enough mobile phones for distribution among Nigeria's nomads and literacy facilitators may be seen by some as too costly an endeavor to undertake. On the other hand, if the Nigerian Government is truly committed to its own philosophy of widening access to education to its less-privileged citizens, it should start committing at least part of its funds realised through the Education-Tax-Fund towards achieving effective nomadic education in Nigeria.

3. Effective monitoring and evaluation of mobile learning in the nomadic education programme in Nigeria, as in most developing and underdeveloped countries, remains a big challenge. Without effective monitoring and evaluation, effective implementation of this new learning mode might not be realized. It may not be possible for governmental parastatals to ensure effective monitoring and evaluation of mobile learning approaches in nomadic education. This is where non-governmental and community-based organisations must be involved. Nigeria's Federal and State governments can enter into working agreement with these parastatal organisations to ensure regular, prompt, and up-to-date feedback on the monitoring and evaluation of the nomadic mobile learning programme.

Conclusion

The processes described certainly look novel. Most innovative ideas usually start as something – a project or a technology – that looks funny or virtually impossible, before they are implemented and subsequently widely accepted (Rogers, 1995). However, because current approaches to addressing problems of nomad literacy have been found to be inadequate, trials of innovative ideas, such as mobile phones for mobile learning, is worth the expense and effort. Mobile technologies have been found to be very relevant in certain educational contexts. Nigeria's

pastoralists and nomads are equally aware of the importance of these technologies as portrayed in the Mobile Telecommunication Nigeria advertisement. Procuring mobile phones for these nomadic groups of learners will not only motivate them and instill positive attitudes towards learning, it will also help to sustain their interest in gaining literacy skills, especially through the distance learning approach. It is high time Nigeria joined the League of Nations in promoting mobile learning as a pedagogical approach to increase both relevancy of education and access to education.

References

Abiona, K. (2003). The Use of Media in Adult Education. *A paper presented at a one day workshop organised for Local Adult Literacy Officers of Agency for Adult and Non-Formal Education.* Oyo State, Nigeria.

Aderinoye, R. A. (2005). Innovation in Mass Literacy Promotion in Nigeria: the intervention of the Cuban Radio Literacy Model. *2005 ICDE International Conference,* November 19-23. New Delhi, India.

Akinpelu, J. A. (1993). Education for special groups. In O. O. Akinkugbe (Ed.) *Nigeria and Education: The challenges ahead* (p. 23). Second Obafemi Awolowo Foundation Dialogue. Ibadan: Spectrum Books.

Aleyidieno, S. (1985). Education and Occupational Diversification Among Young Learners: The problem of harmonising tradition practices with the lessons of our colonial heritage. In *Issues on Development: Proceedings of a Seminar held in Zaria*. January 12-13. Zaria, Nigeria: Ahmadu Bello University Press.

Chen, Y. S., Kao, T. C., Sheu, P. P., & Chiang, C. Y. (2002). A Mobile Scaffolding: Aid-based bird-watching learning system. In M. Milrad, H. U. Hoppe, & Kinshuk (Eds.) *IEEE International, Workshop on Wireless and Mobile Technologies in Education* (pp. 15-22). Los Alamitos, CA.: IEEE Computer Society.

Ezeomah, C. (1982). Movements and Demography of Fulani Nomads and their implications for Education Development. Published in the proceedings of the *1st Annual Conference on the Education of Nomads in Nigeria*, Jos, Nigeria

Ezeomah, C. (1983). The Education of Nomadic People: The Fulani of Northern Nigeria. In Ver Eecke, C. (1989) *Nigeria's Experiment with a National Programme for Nomadic Education*. Ohio Centre for African Studies: The Ohio State University.

Federal Republic of Nigeria (2004). *National Policy on Education (NPE) 4th Edition.* Abuja: NERC Press, Yaba.

Federal Ministry of Education (2005). *Education Sector Analysis (ESA).* Abuja: FME Publication.

Federal Ministry of Education (2004). *National Policy on Education 4th Edition*. Abuja: FME Publication.

Federal Ministry of Education (2000). *Comprehensive Education Analysis Project (Secondary Data Report)* Lagos: FGN/UNICEF/UNDP.

Federal Government of Nigeria (1989). *Federal Government of Nigeria, NCNE Decree 41 of 2.* December 1989. Lagos.

Garrison, R., & Shale, D. (1987). Mapping the Boundaries of Distance Education: Problems in defining the field. *The American Journal of Distance education, 1*(1), 7-13.

Iro, I. (2006). *Nomadic Education and Education for Nomadic Fulani.* Retrieved May 18, 2007 from: http://www.gamji.com/fulani7.htm

Kaye, A. R. (1989). Distance Education. In Titmus, J. T. (Ed.) *Lifelong Education for Adults: An international handbook.* Oxford: Paragon Press.

Keegan, D. (1986). *The foundations of distance education.* London: Croom Helm.

Kinshuk (2003). *Adaptive mobile learning technologies.* Department of Information Systems: Massey University, New Zealand. Retrieved May 19, 2007 from: http://www.whirligig.com.au/globaleducator/articles/Kinshuk2003.pdf

Lehner, F., & Nosekabel, H. (2002). The Role of Mobile Devices in E-learning – First experience with a e-Learning environment. In M. Milrad, H. U. Hoppe & Kinshuk (Eds.) *IEEE International Workshop on Wireless and Mobile Technologies in Education* (pp. 103-106). Los Alamitos, CA.: IEEE Computer Society.

NMEC/ UNESCO (2004). *National Commission for Mass Literacy, Adult & Non-Formal Education National Report on Improving Community Education and Literacy Using Radio and Television in Nigeria.* Abuja: NMEC/ UNESCO.

NPC (2006). *National Population Census.* Abuja, Nigeria.

NMEC (1999). *National Mass Education Commission Annual Report.* Abuja, Nigeria.

Perraton, H. (1988). A theory for distance education. In D. Sewart, D. Keegan, & B. Holmberg (Eds.) *Distance Education: International perspectives* (pp. 34-45). New York: Routledge.

Rogers, E. M. (1995). *Diffusion of Innovations, 4th Ed.* New York: Free Press.

Slavin, R. E. (1990). *Cooperative Learning: Theory, research and practice*. Englewood Cliffs, NJ.: Prentice-Hall.

Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers & Education, 34*(3), 177-193.

UBE (2006). *Universal Basic Education Commission Study on the state of Non-Formal Education in Nigeria*. Abuja. Retrieved June 12, 2007 from: http://www.ubec.gov.ng/about/index.html

UNESCO (2003). Right to Education: Scope and Implementation. General comment 13 on the right to education. *UNESCO Economic & Social Council.* Retrieved May 18, 2007 from: http://portal.unesco.org/education/en/file_download.php/c144c1a8d6a75ae8dc55ac385f58102erighteduc.pdf

Vavoula, G. N., & Sharples, M (2002) Kleos: A personal, mobile, knowledge and Learning Organisation System. In M. Milrad, H.U. Hoppe and Kinshuk (Eds.) *IEEE International workshop on wireless and mobile technologies on Education* (pp. 152-156) Los Alamitos, CA.: IEEE Computer Society.

Wennergreen, E., C. Antholt, & M. Whitaker, (1984). *Agricultural Development in Bangladesh.* Boulder, CO.: Westview Press.

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Setting the New Standard with Mobile Computing in Online Learning

Yuhsun Edward Shih and **Dennis Mills**
Capella University, USA

Abstract

Mobile learning represents exciting new frontiers in education and pedagogy. With the features of 'wearable' computing and multimedia content delivery via mobile technologies, mobile learning becomes feasible and offers new benefits to instructors and learners. How do mobile technologies influence our teaching and learning in traditional education? What are the possibilities for m-Learning in the various disciplines, such as history or English studies? To illustrate these possibilities, this paper presents an application that combines an innovative learning model for mobile learning with an established literature class. This ongoing study focuses on student learning outcomes relative to the benefits and challenges of using mobile technologies in a traditional classroom and online learning settings.

Keywords: Mobile learning; learning model; instructional design; hybrid course; motivation

Introduction

Mobile communication technologies are rapidly evolving to include local area wireless connections using Wi-Fi, Third Generation (3G) mobile communications, and Worldwide Interoperability for Microwave Access (WiMAX), and related mobile computing devices such as smart phones, pocket PCs, tablet PCs, and various Personal Data Assistants (PDAs) handheld devices. As such, applying mobile technologies in learning represents an exciting new frontier in education and pedagogy. With the capabilities of 'wearable' computing and multimedia content delivery via mobile technologies, learning with mobile technologies becomes feasible because it offers many new benefits, such as ubiquitous learning that connect instructors and learners in both traditional classroom and online settings. As Alexander (2004) suggests, “the combination of wireless technology and mobile computing is resulting in an escalating transformation of the educational world” (p. 1).

There are many different learning theories that address how people learn, such as behaviorism, cognitivism, constructivism, control theory, learning styles, and social learning. While implementing mobile learning, it is necessary to consider – at minimum – the following aspects of new mobile technologies: a) new learning opportunities; b) potential influence on changing individuals’ learning styles; c) potential influence on social interaction; and d) how the mobile technology itself will be changed or enhanced. How individuals learn and how learning takes place are essential considerations for instructional designers, especially in designing learning

activities in the mobile learning environment. Unfortunately, at the present time many individuals enter this field with no pedagogical guidelines, and based on existing research findings this has become a major issue. How can we better utilize mobile technologies to improve teaching and learning in education? How can we effectively motivate and engage online learners? This paper proposes a new mobile learning model identified as the *Shih's Mobile Learning Model*. The goal of Shih's model is to facilitate mobile learning design and to achieve better mobile learning outcomes. From a pedagogical point of view, this paper supports understanding of mobile learning and facilitates the instructional design for applying mobile technologies to a traditional learning context.

Mobile Technologies in Education

Internationally, mobile technologies are on the cutting edge of business applications. Widespread use of mobile phones, PDAs, MP3 players, handhelds, tablet PCs, and laptops for learning, working, meeting, and conferencing is evident. The academic environment has been introduced to mobile learning through the use of laptops, PDAs, and smart phones. Research outcomes reported in Attewell's (2005) summary of the 2001 MLearn project, suggest that the use of mobile learning may have positive contributions to make in the following areas:

1. Mobile learning helps learners to improve their literacy and numeracy skills and to recognise their existing abilities

2. Mobile learning can be used to encourage both independent and collaborative learning experiences

3. Mobile learning helps learners to identify areas where they need assistance and support

4. Mobile learning helps to combat resistance to the use of ICT and can help bridge the gap between mobile phone literacy and ICT literacy

5. Mobile learning helps to remove some of the formality from the learning experience and engages reluctant learners

6. Mobile learning helps learners to remain more focused for longer periods

7. Mobile learning helps to raise self-esteem

8. Mobile learning helps to raise self-confidence (Attewell, 2005, p. 13)

Mobile technologies are the next step in the evolution of technology-mediated teaching and learning. It not only connects people in information-driven societies effectively, it offers the opportunity for a spontaneous, personal, informal, and situated learning. Mobile technologies have sparked the need for the strategies, applications, and resources necessary to support anywhere-anytime connections to formal and situational learning, as well as personal interest explorations (Wagner, 2005). On the other hand, is mobile learning viewed as a technological consideration in delivery systems? Or does it represent a new pedagogy in education? Thomas (2005, p. 9) posed the question: "How can this m-Learning environment change teaching and learning?" Thomas further suggested that wireless connections provide attractive learning environments in a number of ways:

1. ***Ubiquity:*** Faculty and students have access to course information 24 hours a day, 365 days a year, wherever they are on campus

2. ***Project sophistication:*** Student projects created with laptops tend to be more sophisticated

3. ***Compatibility:*** Students have access to the same hardware and software as faculty

4. ***Emphasis on learning and teaching:*** Overcoming equipment problems allows greater time and resources to be devoted to pedagogy

5. ***Savings:*** Replacing desktop computers with laptops, and replacing hard-wired networks with wireless ones translates into cost savings

6. ***Standardization:*** A standard platform maximizes access and minimizes need for technical support (Thomas, 2005, p. 9)

Mobile computing and wireless connections are accelerating transformations in the educational world, such as seen in the rapid development of new delivery platforms for teaching and learning. The impact of mobile learning in higher education is that ". . . the physical vs. the digital, the sedentary vs. the nomadic – the wireless, mobile, student-owned learning impulse cuts across our institutional sectors, silos, and expertise-propagation structures" (Alexander, 2004, p. 34). The culture of education is changing as new avenues are redefining the old. Information literacy enhanced by technology has the capacity to deepen the roots of education while expanding knowledge and information literacy. It may change the structure of how students experience learning. Therefore, it is important to continue to grow the roots of education while exploring new approaches to learning through technology (Alexander, 2004).

The following characteristics define how mobile technologies are currently improving online learning environments. The capabilities for learning anytime and anywhere, just in time, just for me, and multimedia (text, voice, image, or video) messaging are essential characteristics. The use of various types of communication (i.e., phone call, voice/ text messaging, multimedia messaging, email, Web access), that provide real-time online interaction in a series of short burst learning activities, with features such as voice/ video recording for story telling or even a 'mobblogging' journal, complete the roster of characteristics that define effective use of mobile technologies in teaching and learning.

As technology continues to improve, it will be possible to integrate even more features into smart phones, and with the likelihood of several different types of small handheld devices, such as Ultra Mobile Personal Computers (see Figure 1 below). Consumers can expect mobile computing with handheld devices to offer an affordable solution to their learning needs in the classroom, in the lab, at home, or for outdoor activities. Mobile technologies positively influence today’s teaching and learning, in both formal and informal settings.

Figure 1. Ultra Mobile Personal Computer (Source: Fourier Systems http://www.fourier-sys.com)

Toward a New Learning Model

In contrast to the traditional classroom, mobile technologies effectively offer students added convenience and flexibility, and allows them to learn wherever and whenever they choose. In situations where mobile technologies are integrated into a classroom environment, there are opportunities to soften the rigidity of the standard classroom arrangement because each learner is "connected" wherever they choose to be in that learning space. Outside the classroom, learners will be able to continue their studies in spaces that meet their individual needs. Mobile technologies empower learners to conveniently participate in learning environments.

How individuals learn and how learning takes place are essential considerations for instructional design, especially in teaching and learning with mobile technologies. Several different learning theories address how people learn, such as behaviorism, cognitivism, constructivism, and so forth (Smith, 1999). Behaviorism, for example, applies drill-and-practice strategies to achieve learning that results in a change in the learner's behavior. Behaviorists focus on the output of the learning process by frequently reinforcing concepts with examples, interactions, and practices. Meanwhile, cognitivism focuses on how the mind works. Cognitivists believe that the working process of the mind should be exploited to enhance the learning process. Control theory is the theory of motivation which states that behavior is inspired by what a person desires most at any given time, such as love, freedom, power, survival, or other basic human needs. Constructivism, on the other hand, suggests that people construct their knowledge by experiencing things and reflecting on those experiences. Constructivists encourage students to use experiments and problem solving skills to create more knowledge and to reflect on how their understanding is changing. The objective of using reflection is to encourage students to reflect upon and learn from their experiences and conclusions.

The learning styles theory emphasizes that individuals perceive and process information in very different ways, and that individuals learn more when the educational experience is geared toward their particular learning styles. Instructors can introduce a wide variety of experiential elements into the learning environment, such as sound, music, visuals, movement, and even gaming. Instruction should be designed to connect with multiple learning styles (i.e., visual, auditory,

kinesthetic), using various combinations of experience, reflection, conceptualization, and experimentation. Vygotsky's learning theory emphasizes that learning is social and includes arguing, reflecting, and articulating to others (Vygotsky, 1978). Learning occurs through interaction between learners and learning tasks. Social cognition provides learning from a dialectical process, whereby students can learn through problem-solving experiences shared with their learning peers (Riddle & Dabbagh, 1999).

Among these learning theories, learning styles and Vygotsky's are more relevant to supporting mobile learning activities. Most mobile devices are capable of taking pictures, capturing video, and playing music. Mobile technologies can effectively fit into different learning styles by providing picture-video messaging, audio-video conferencing, and 3-D simulation gaming to enhance learners' experiences. It also provides users with effective ways for communicating and accessing learning contents at anytime and anyplace, via phone calls, instant messaging, email, and Web access. These features can facilitate group interactions for collaborative learning by helping students share their information and experiences. Similar to control theory, mobile technologies motivate learners through the use of automatic instant messaging or content forwarding, the so-called "push technologies." In a mobile learning environment, learners can repeatedly practice learning content anytime and anywhere. This feature of learning has similarities to the behaviorism learning theory. Considering how people learn with all these features, the next step is to put it all together.

The New Standard for Mobile Learning

According to Keller's ARCS Model of motivational design, the learning cycle includes: Attention, Relevance, Confidence, and Satisfaction (ARCS). Keller also determined that motivation was the most appropriate and useful construct that might be applied to the problem of variation in learning performance difference, and that motivation was dependent at least, in part, on human interactions (Keller, 1987). In the ARCS model of motivation, the initial phase is to attract learners by stimulating their interest and curiosity. This can involve the use of interesting facts or statistics, conflict, humor, audience participation, variability, and questions. The second phase is designed to show learners the relevance of their learning, so that their motivation to learn increases. This can be accomplished by providing examples, previous experiences, concepts, and presenting goal-orienting statements. The third phase allows learners to develop their confidence. This can be achieved by setting realistic expectations, providing opportunities for practice, and elevating the contents' difficulty to increase learner independence for completion. The final phase provides opportunities for learners to use their newly acquired skills and/ or knowledge in a real or simulated setting. Reinforcement sustains the desired learning behavior, which can produce true satisfaction.

Based on ARCS learning model and mobile technologies' characteristics in promoting and enhancing human interactions, a variation to the ARCS model, the *Shih's Mobile Learning Model* (see Figure 2), was created to support instructional design for mobile learning. The learning cycle in the Shih's model includes:

1. Sending a multimedia message to mobile phones to trigger and motivate learners

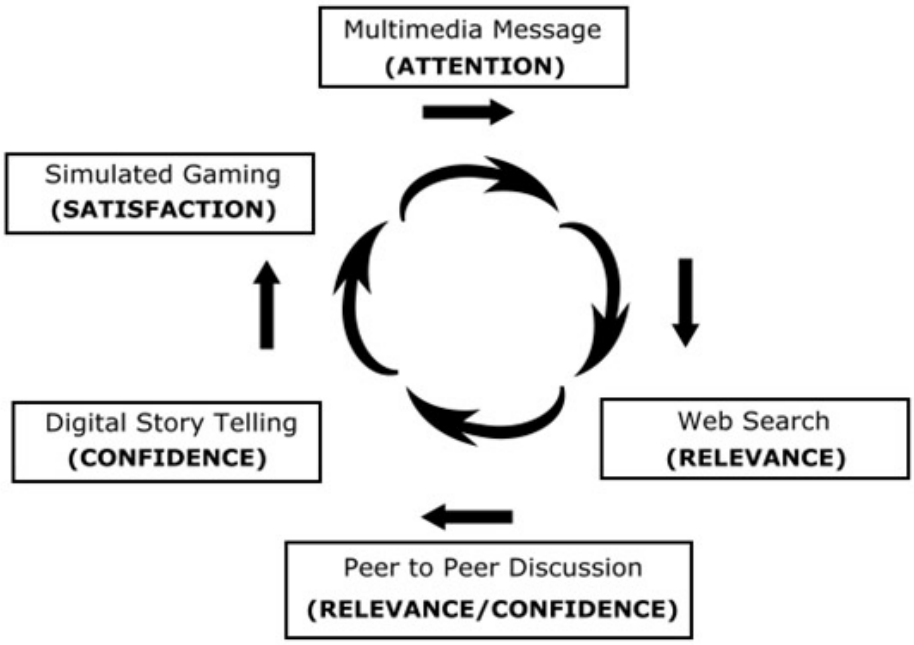
2. Searching the Web for relating information by using embedded hyperlinks (URLs) in the message received in the phone

3. Discussing with learning peers by text, voice, picture, or video messaging

4. Producing a digital story telling of what they learn by audio or video diary (mobblogging journal)

5. Applying what they learn in the simulated environment, such as online educational gaming

Figure 2. Learning Cycle in Shih's Mobile Learning Model



Shih's mobile learning model draws on the philosophy of social constructivism through use of collaborative discussion and a learning styles theory based on digital story telling. Elements of the Vygotsky learning theory are incorporated in Shih's model through peer learner interactions via mobile communication. This learning model mainly relies on the mobile computing infrastructure, and would be most suitable for applications in blended learning and/ or pure mobile learning environments (Shih, 2005).

Research Experiment

An experiment of applying Shih's mobile learning model was conducted in a Children's Literature hybrid course in California State University, San Bernardino during the 2006 winter semester. Forty-six (n = 46) students participated in this experiment. The course provided students flexibility to use their smart phones to access mobile learning contents located on a mobile website (http://mclass.m-learning.us), receive learning activity notifications via text messages, join online discussions with fellow students via the regular online learning site (http://www.m-learning.us), and produce digital stories for their course learning activities.

The hypothesis and intention of this project was to apply mobile technologies to offer participants added convenience and flexibility, arguably two very valuable assets for most commuter student

populations. The study focused on students' learning outcomes, as well as the benefits and challenges students face when using mobile learning in a traditional classroom setting. We anticipated that mobile learning would provide an additional and useful method of information retrieval and reception needed to further facilitate collaborative learning. With an appropriate instructional design used to adapt mobile learning methods in the course, we expected that students would be able to better utilize their time for learning, and be more motivated and active in their learning.

To illustrate these possibilities, we presented an application in an enhanced *Moodle* Course Management System that provided mobile learning capability with an established literature class. We also demonstrated Shih's model, which was used to apply new mobile technologies to a traditional learning context. The learning units were designed to be completed within a fairly small period of time. For instance, students could take a quiz or interpret an illustration while standing in line at the bank, while they are stuck in traffic, or any other situation where a standard computer would be impractical. Short messages (SMS) were sent to students to engage them in – or in many cases, push them forward – in their group projects. Students were encouraged to use their smart phones for creating the digital story telling course projects. In addition, an assessment was built into the study that allowed students to gauge their own readiness for mobile learning.

We began with the following questions:

1. First, and perhaps most importantly, how would our students initially receive the idea of completing part of their coursework on a PDA/ smart phone?

2. Would they find the m-Learning techniques helpful and manageable, or would they view learning in a new medium as an additional burden?

3. What instructional design techniques are needed in mobile learning courses to allow for the limitations of a particular mobile technology?

The survey of the experiments generated some interesting findings. For instance, one of the greatest difficulties was the availability of appropriate mobile phones. For representative statistical charts created from this experiment, see Figures 3-11 in the Appendix.

When compared to purely online learning courses, this preliminary study also found the following:

1. Students were more highly motivated (they said they appreciated the flexibility and convenience)

2. Interaction between the instructor and students was more enhanced

3. Students appeared to be more encouraged to collaborate

4. The instruction was more attractive to students

5. Quality of learning was found to be 'as good' or 'better'

Within this model, the instructor had a better chance to observe and assist students who need extra support; this was accomplished by applying adaptive learning instructions. This model

substantially improved students' overall online learning experiences and helped them to achieve better learning outcomes. This study also revealed additional challenges the instructor faced when receiving student responses and feedback on his or her mobile learning device. The study also revealed the need for support of mobile learning within the wider university culture.

Future Work

Future mobile teaching and learning strategies will need to explore how mobile learning can continue the improvement of overall learning outcomes. Further study is also needed to involve a 'control group' to compare the learning results and to determine whether or not the above findings are supported or rejected.

In addition, following areas are of special concern:

1. Mobile technologies come with limitations for use in educational settings, such as different form factors in mobile devices, communication coverage, and potential security issues. For instance, what instructional design strategies are needed in m-Learning courses that better address limitations of mobile technologies?

2. Mobile learning provides "just in time" help and "just for me" features that supports various learning styles. How can instructional design be individualized to support students with special needs?

3. Messaging capabilities are, such as SMS and multimedia messages, are some of the most powerful "push" features of mobile technologies. However, while it is evident that such push communication can effectively facilitate and motivate learners in collaborative learning activities, it may also intrude upon students' personal space. Therefore the question must be asked: What new 'netiquette' and instructional design strategies are needed?

4. Social implications in the progress and development of mass communications, plus related cost factors may lead to (in)accessibility issues in mobile learning. How can we maximize the potential of mobile technology in educational contexts, without creating another digital divide?

Conclusion

Advancements in technologies have changed the process of learning, not just in formal educational settings, but continuing education settings as well. With the use of mobile technologies in education, online learning communities can incorporate students from different backgrounds with vastly diverse learning styles into a education setting. Motivating online students, as well as learning how to effectively facilitate learning in this format, is essential for developing successful online learning communities. The use of mobile technologies also incorporates a new concept for teaching and learning in this environment.

Today, we live in an information era, a world where technology, economics, society, politics, and theories of learning are all in a state of transition. This competitive environment suggests that theories, definitions, and the practice of distance learning will continue to be contested. In this competitive environment, it is evident that mobile learning has a range of attributes that cannot be ignored because it is highly portable, personal, and contextual. Learning using mobile devices is

informal, spontaneous, situated, and ubiquitous. When comparing mobile learning to online learning using desktop computers, it becomes evident that mobile learning comes with many advantages and some drawbacks. Varied and changing locations, the ability for more immediate interaction with teachers and fellow students, and the portability and affordability of smaller, handheld wireless devices, coupled with their capacity to accomodate learners from different backgrounds, make mobile devices a logical choice for educators. Therefore, as mobile learning moves into the educational mainstream, the need for appropriate pedagogical instructional design models, teaching strategies, learning styles, and effective learning activities, will remain crucial to ubiquitous mobile learning environments.

Shih's Mobile Learning Model is a new instructional design model; it helps instructional designers motivate and engage online learners and instructors, which in turn enhances their online teaching and learning experiences. By focusing on the use of mobile technologies in educational contexts, Shih's model provides an innovation in instructional design that guides the use of enhancements for effective teaching and learning in today's virtual m-Learning environments.

References

Alexander, B. (2004). Going Nomadic: Mobile learning in higher education. *EDUCAUSE Review 39*(5), 28-35. Retrieved September 14, 2005 from: http://www.educause.edu/ir/library/pdf/erm0451.pdf

Attewell, J. (2005). *Mobile Technologies and Learning: A technology update and m-learning project summary*. London: Learning and Skills Development Agency.

Keller, J. M. (1987). Development and use of the ARCS model of motivational design. *Journal of Instructional Development, 10*(3), 2-10.

Riddle, E., & Dabbagh, N. (1999). *Lev Vygotsky's Social Development Theory.* Retrieved June 6, 2005 from: http://chd.gse.gmu.edu/immersion/knowledgebase/theorists/constructivism/vygotsky.htm.

Shih, Y. E. (2005). Seize Teachable and Learnable Moments: SMSE instructional design model for mobile learning. Paper presented at the *International Association for Development of the Information Society International Conference Mobile Learning* June 28-30, Malta.

Smith, M. K. (1999). Learning theory, *the encyclopedia of informal education*. Retrieved June 6, 2005 from: www.infed.org/biblio/b-learn.htm

Thomas, M. (2005, May 23). E-learning on the move. *Education Guardian online.* Retrieved June 10, 2005 from: http://education.guardian.co.uk/elearning/comment/0,10577,1490476,00.html

Vygotsky, L. S. (1978). *Mind in Society: The development of higher psychological process.* Cambridge, MA.: Harvard University Press.

Wagner, E. D. (2005). Enabling mobile learning. *EDUCAUSE Review*, *40*(3), 40–53. Retrieved June 4, 2005 from: http://www.educause.edu/ir/library/pdf/erm0532.pdf

Appendix

Figure 3. Mobile PDA Phone availability survey

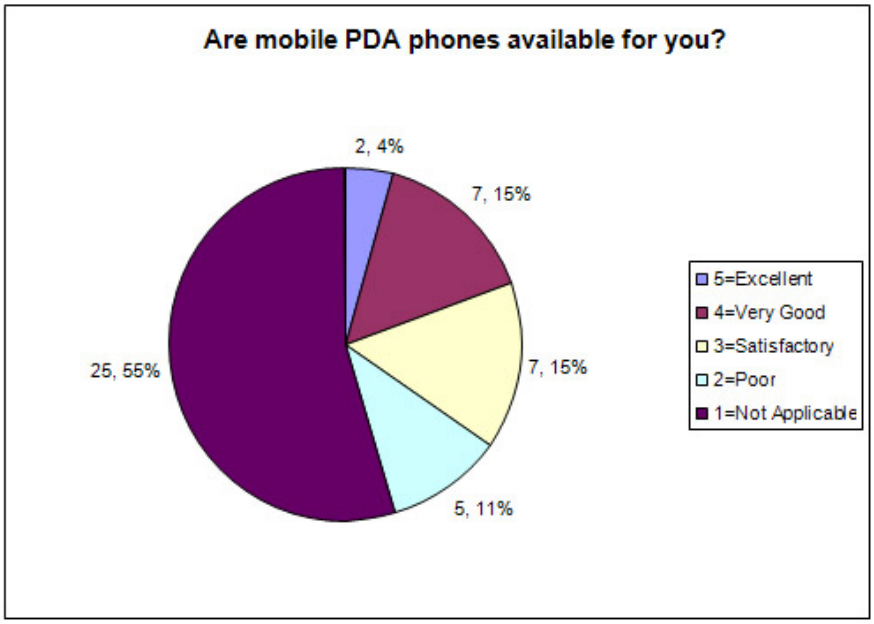


Figure 4. Mobile learning outcomes survey

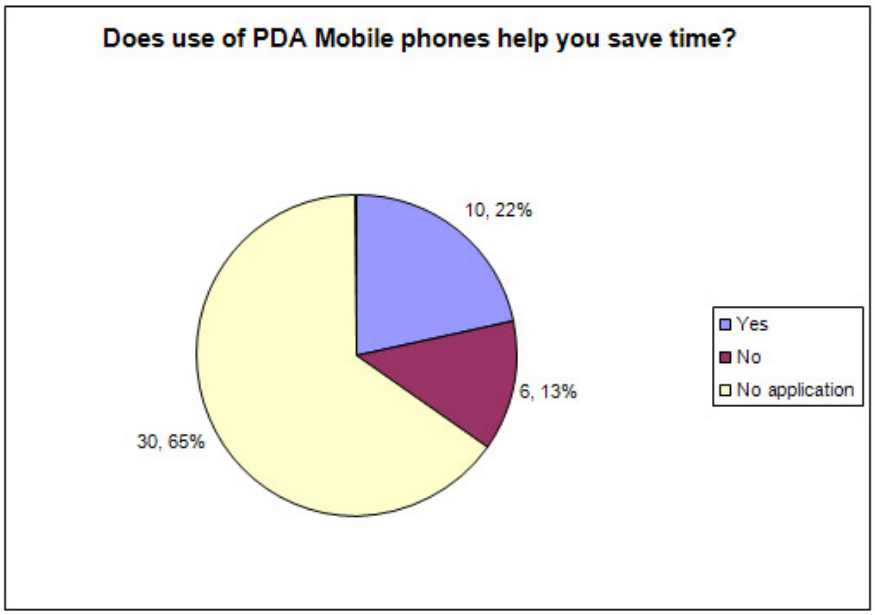


Figure 5. Mobile learning outcomes survey

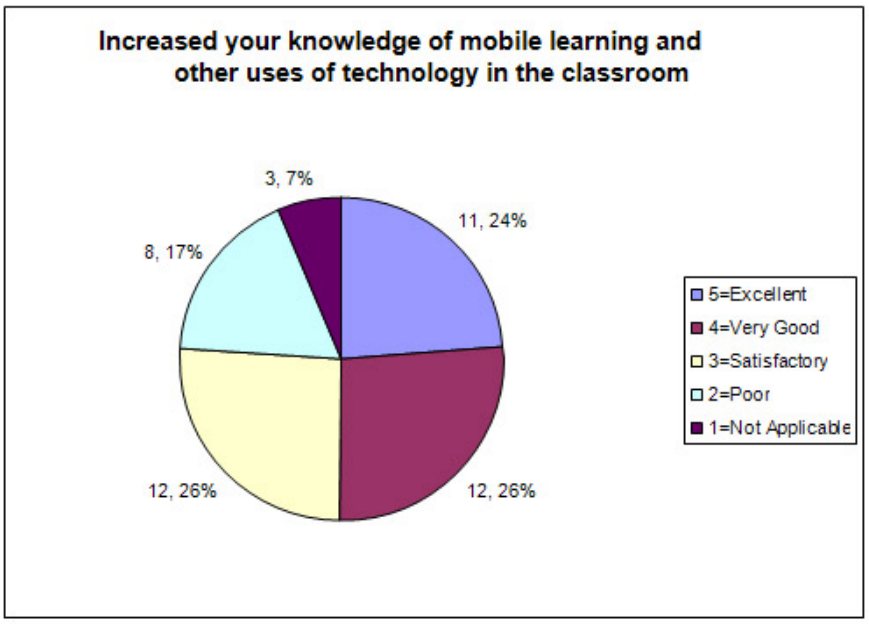


Figure 6. Mobile learning outcomes survey

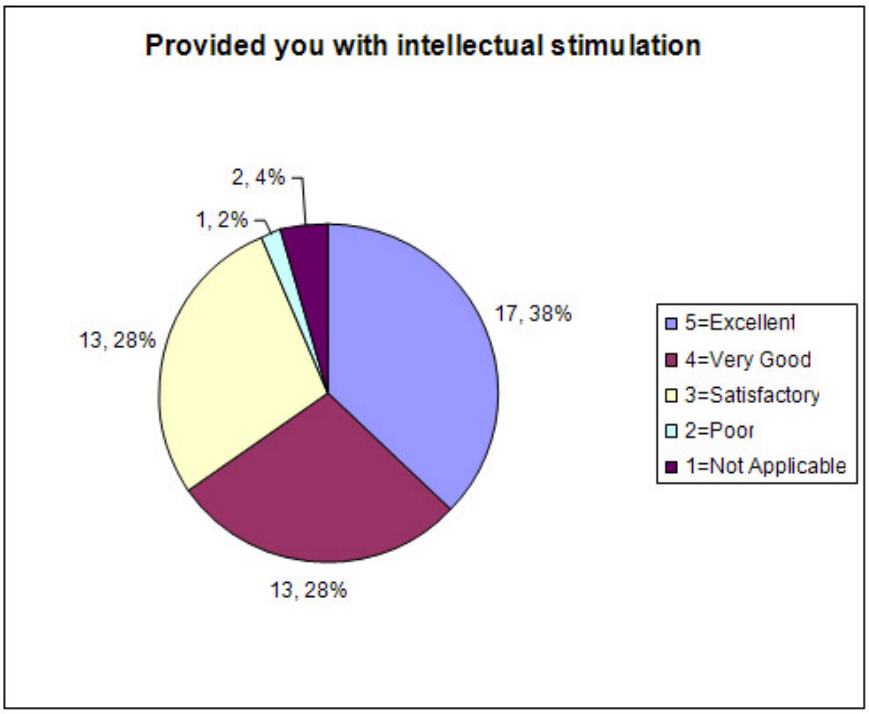


Figure 7. Mobile learning outcomes survey

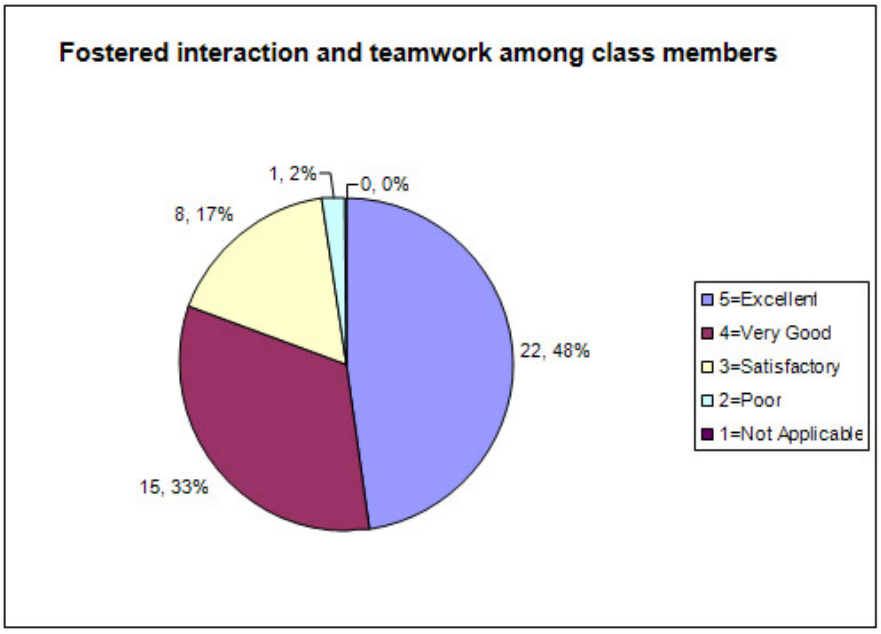


Figure 8. Mobile learning outcomes survey

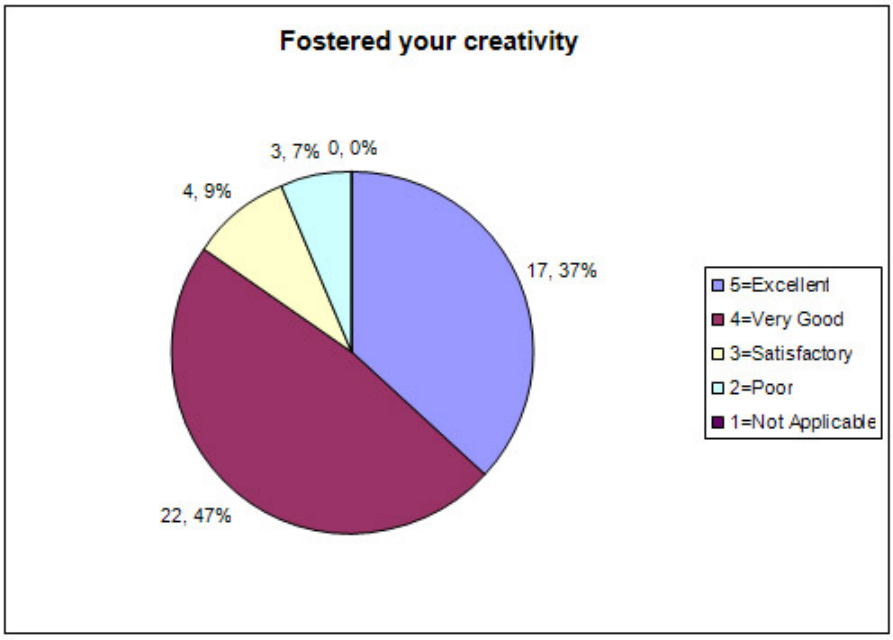


Figure 9. Mobile learning outcomes survey

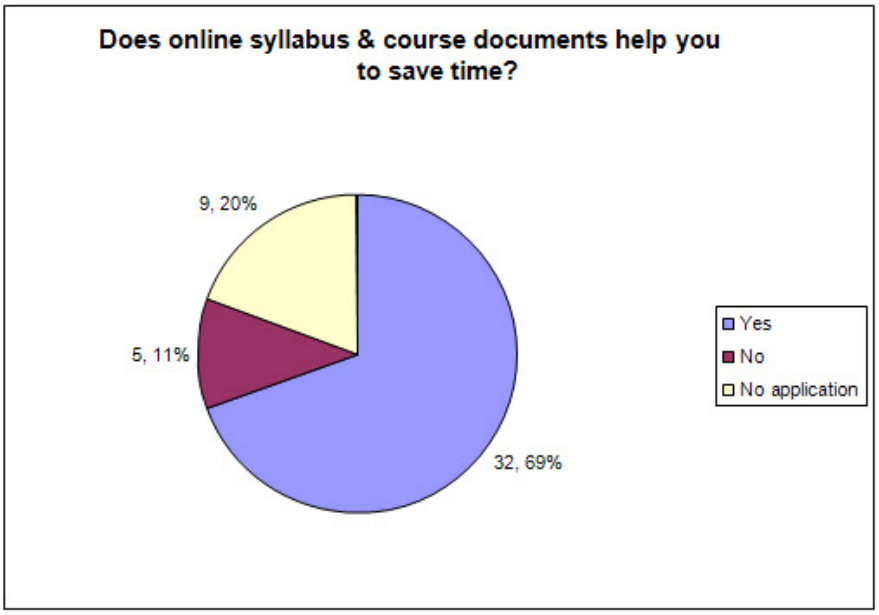


Figure 10. Mobile learning outcomes survey

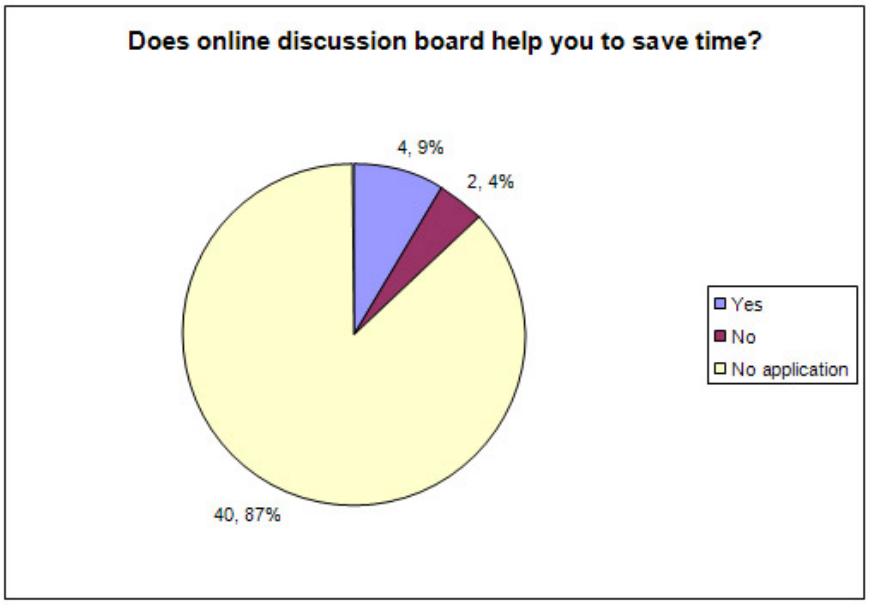


Figure 11. Mobile learning outcomes survey

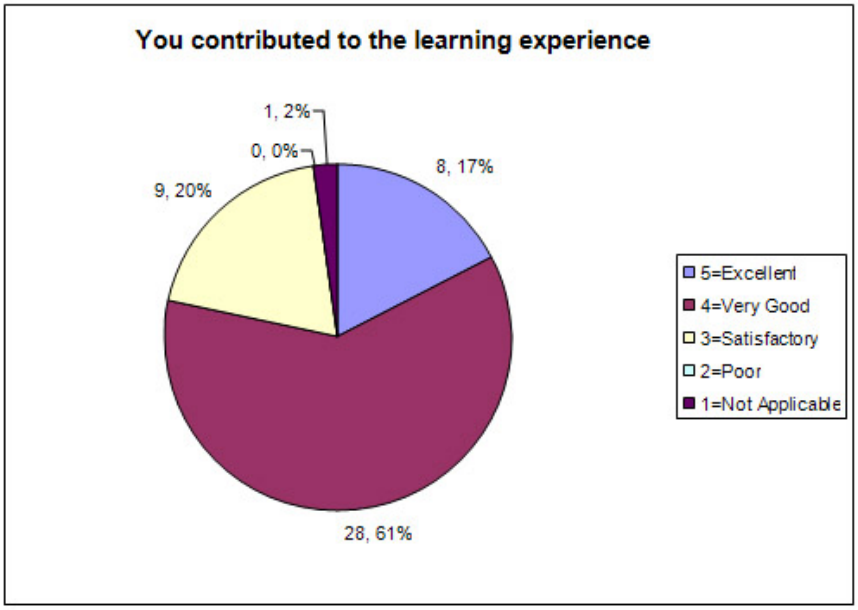
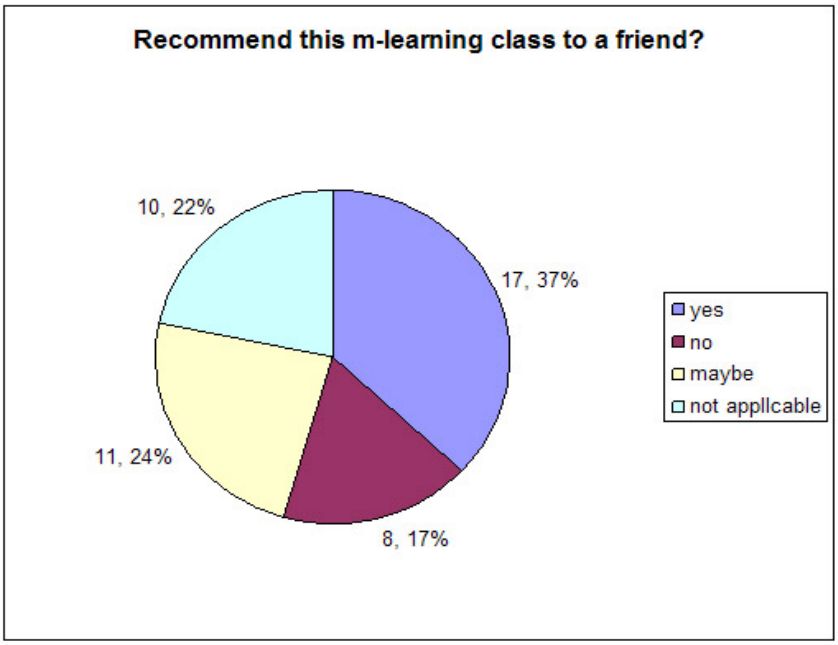


Figure 12. Mobile learning outcomes survey (See short answers below)



Short Answer Qualitative Survey

Would you recommend this m-learning class to a friend? Why or why not?

Responses from participants to this open ended question:

1) Yes, it was a lot of fun I really enjoyed the class.

2) Yes, because it ends up saving stress by being able to access materials anytime,

3) It's in the beginning phases and has wrinkles that need to be ironed out, but I see it as a very positive future method.

4) Only if the m-learning was more organized.

5) If my friend had the capability to use m-learning then I would recommend it because it does save time for the users.

6) Yes, helpful

7) I couldn't say. If they are good at phones, yes.

8) Yes, because you learn.

9) No, to much hassle & Stress I trying to figure out new things online is easier.

10) Yes, It helped me save time, and assisted me in my learning.

11) Yes and No. I personally did not use the mobile learning very much I was a mobile learner but did not use it as planned.

12) Good teacher, m-learning I didn't really like.

13) No, makes the class more difficult.

14) Yes.

15) Not the m-learning, but the class yes. M-learning really just takes more time when you could just use the phone or email.

16) Yes, if it were a bit more organized.

17) I'm not sure! The class content was great but I couldn't follow the organization. It was hard for me to keep up.

18) Yes, Very interesting.

19) Yes, because if you have a busy life m-learning actually works around your schedule and you have 24/7 access to it.

20) Sure, if wasn't hard and it helped get things done faster.

21) No, not easily accessible.

22) Yes, I was not affected by the m-learning portion.

23) No, too difficult, need to have phone's provided.

24) Yes and No. It may be confusing if you do not know how to work technology.

25) Yes, only if everything goes as planned.

26) Nope, because I didn't use it.

27) Sure, it was an interesting experience, and the flexibility made it very every to work with.

28) Yes, I thought that I learned new things I did not know of before.

29) If they liked children's literature and didn't mind the disorganization.

30) Yes, It everything worked out correctly.

31) If you are good with technology go for it other than that you may struggle and spent more time than same time. You don't have to remember where you left your papers you have them in email or something end to always have your phone.

32) No, because it was too much all over the board. May be if it had worked, I would be more positive. However for me it was too much of a hassle.

33) I felt very confused in this class and would probably not recommend it. I am very technological but did not care for the class.

34) The concept sounds really useful, but since we couldn't use the phones fully I couldn't tell. Overall, the concept sounds great.

35) Not really b/c it seemed easier just to talk in class and share ideas with everyone.

SOME RIGHTS RESERVED

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Book Review – Mobile Learning: A handbook for educators and trainers

Editors: Agnes Kukulska-Hulme and John Traxler (2005). *Mobile Learning: A handbook for educators and trainers.* London and New York: Routledge. ISBN: 0-415-35740-3, paper back.

Reviewed by: Sanjaya Mishra, Indira Gandhi National Open University, India

Most conventional educational activities are time and space dependent. With the emergence of the correspondence education, a new era of education started that was not entirely dependent on time and space requirements. Education in the form of printed materials reached the learners wherever they are, rather than learners coming to the classrooms. These learners were mobile (changed places due to job mobility and other situations), and used the learning materials anytime, anywhere. But, it was never called mobile learning! However, with the increased use of mobile phones and Personal Digital Assistants (PDAs), and the demands for just-in-time education, a new genre of teaching-learning emerged in the form of 'Mobile Learning.' With the rapid growth in the number of users of mobile devices around the world, it is touted as the new found panacea for education in the less developed world. The book under review is a testimony to the current interests in the use of mobile technologies in education. Agnes Kukulska-Hulme and John Traxler bring together a group of researchers to report their indulgence with mobile technologies and education. The book includes 12 case studies and eight general chapters on mobile learning, besides an exhaustive glossary on the topic at the end.

In Chapter 1, Agnes Kukulska-Hulme provides an overview of mobile learning and explains the 'ubiquitous,' 'pervasive,' and 'ambient' nature of mobile devices. John Tinder in Chapter 2 describes the mobile technologies, especially their types, technical characteristics, and performance, and provides advice on how to choose a PDA. In Chapter 3, the editors discuss the pedagogy of mobile learning that can be broadly categorized into: didactic content, discursive interactions, generic academic support, subject-specific support, and guidance and support. They concluded that "Mobile learning can be spontaneous, portable, personal, situated; it can be informal, unobtrusive, ubiquitous and disruptive" (p. 42). In Chapter 4, Kukulska-Hulme analyses the usability of the mobile devices from human computer interaction perspective and reviews the twelve case studies presented in the book from Chapters 7 to 18. The ergonomic and pedagogic challenges of using mobile devices such as PDAs are highlighted in this chapter. Chapter 5 deals with an important issue – accessibility of mobile learning. Though primarily focused on the legal provisions of the UK for learners with disabilities, it discusses the principles of universal design for mobile devices. Many mobile devices include these features, and interestingly these are also useful to other users without any disabilities. This chapter also emphasizes the importance of creating accessible materials for mobile learning. In Chapter 6, John Traxler gives an overview of the 12 case studies, of which eleven used PDAs for delivery of teaching and learning.

The use of mobile phone, particularly the use of short messaging services (SMS), has been described in Chapter 7 by Mike Levy and Claire Kennedy to demonstrate how they were engaged with students over a seven-week period to teach 'Italian Literature and Society' in Italian language. The SMS technology proved to be suitable for vocabulary learning in this study. In Chapter 8, Andy Ramsden describes the delivery of a HTML and ASP based learning materials to Palm Pilot PDAs through wireless network. Ramsden highlights two important issues – (a) Design and authoring of materials for PDAs by maximizing the accessibility and minimizing the need for re-purposing existing materials like the *Blackboard*-based course materials; and (b) Need for appropriate pedagogical designs to harness the unique potential benefits of mobile technology. Chapter 9 describes a mini-project on portable learning and assessment at the University of Glasgow that used PDAs to teach a course on semiconductor design and technology. Chapters 10, 11 and 17 describe the use of mobile devices in medical education, though these experiments covered only a small population of learners. Chapter 12 describes the Sussex Mobile Interactive Learning Environment (SMILE) project and emphasizes whether it is m-learning or e-learning; what students want is 'personalization.' In Chapter 13, Agnes Kukulska-Hulme discusses the experiences of the project on e-book reading using PDAs by Open University students; and Mark Polishook in Chapter 14 describes the use of PDAs to compose music at the Central Washington University. Mike Sharples et al in Chapter 15 describe the experiment related to design of a student learning organizer for use in PDAs. Though the experiment was never expected to explore learning gains, the survey showed that it had not enhanced their learning; and though the PDA entered the activity space of communication and entertainment of the students, it never replaced other gadgets such as laptops, mobile phones, and MP3 players. Chapter 16 describes one of the most sophisticated uses of mobile devices in education at the Nayang Technological University, Singapore. The system includes the use of wireless network, PDAs, mobile phone with Wireless Application Protocol (WAP), Mobile Ad hoc NETwork (MANET), and General Packet Radio Services (PGRS). The system enables learners to be connected to the university's e-learning system anywhere, anytime, and not just within the hot spots of the university campus. The University of South Dakota's Plam initiative is described in Chapter 17, while in Chapter 18 use of PDAs in IBM has been discussed.

John Traxler in Chapter 19 analyses the institutional issues in embedding and supporting m-learning. It analyses m-learning from the viewpoint of finance, quality and change management in the institution. While the discussions in this chapter are highly relevant to any organization, the author admits that "it is probably the chapter with the greatest UK focus" (p. 173). The last chapter by Agnes Kukulska-Hulme is a brief review of reasons for using mobile technologies, their benefits and pitfalls as described by various authors in this book.

Though a number of reasons and benefits have been identified, it would be suffice to say that the most important reason to use mobile learning is to provide just-in-time support to learning. The support could be content related, administrative related or personal guidance related. The current available mobile devices may have certain impediments in terms of battery life, size and cost. But, the rapid advancement in technology and constant reduction in price have made it one of the most diffused technology available to us with over "77 percent of the world's population" (p. xiv) within the reach of a mobile network. In order to teach through mobile technologies, it is important to develop appropriate pedagogical designs compatible to specific technologies. Through this book, the editors have successfully demonstrated some of the innovative use of mobile devices. However, not all experiments reported were a success, and it would be difficult to generalize the findings as most of the experiments covered a very small population. Technology use of the time is yet another factor to look into. Today, m-learning can use a collection of tools

that tutors and instructional designers can combine to deliver their teaching resources. Some of these are:

- SMS (text messaging) for skills test and for collecting feedback
- Learning from audio (iPods, MP3 player, Podcasting)
- Java-based quizzes
- Learning modules use on PDAs
- Collection of pictures and video using camera-phone
- Online publishing, including blogging, email, etc.
- Field trips using GPS and positional tools (Stead, 2006).

M-Learning will be more and more pervasive and ubiquitous in the coming years, and for all those who would like to use these cutting edge technologies, this book is a definitive starting point.

Reference

Stead, G. (2006). Mobile Technologies: Transforming the future of learning. In *BECTA: Emerging Technologies for Learning*. Conventry, UK: BECTA. Retrieved June 26, 2006 from: http://www.becta.org.uk/corporate/publications/documents/Emerging_Technologies.pdf

SOME RIGHTS RESERVED

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Book Review – Knowledge Education and Learning: e-Learning in the Knowledge Society

Author: Lars Qvortrup (2006). *Knowledge Education and Learning – e-Learning in the Knowledge Society*. Frederiksberg Denmark: Forlaget Samfundsliteratur Roskilde Universitets Forlag (www.forlagetsl.dk). Price: 158.00 Dk. Kroners. ISBN 87-593-1248-1. Paperback, 139 pages.

Reviewed by: Gary Boyd, Concordia University, Canada

The Author

Lars Qvortrup is a professor of media research at the University of Southern Demark and the Director of the Knowledge Lab there. He is an important continuing contributor to the journal, *Cybernetics and Human Knowing*, on many aspects of knowledge media and society.

What Qvortrup provides

In the field of open and distance learning, despite the dictum that 'there is nothing more practical than a good theory,' there actually are very few practical theories of any depth. There is an overwhelming predominance of practical persons who get things done with despatch, but who have little understanding of what their ventures are really doing to people, and, indeed, "don't want to know" because that would make decisions slower and more painful. Our tools and media are now becoming really potent for changing people – and for doing so all over the world. This should give us pause.

Qvortrup is particularly interesting because he does make a good attempt at developing deep understanding of how knowledging (*sic*) proceeds and carries that understanding over into practical advice for e-Learning developers. He offers a distinctive and valuable European perspective to enable us to understand just how we live in a 'knowledge society' and how the development of a knowledge society implies the need for life-long learning with particular kinds of e-Learning support. He offers it in clear and, for the most part, quite readable English.

The main question Qvortrup sets out to answer in this book is: *How does and can information and communication technology mediated life-long learning help us in making the 'knowledge society' vision a reality?* To answer this question, new systemic categorizations of knowledge, learning, and teaching are advanced. These then are carefully related to existing theories of e-Learning. The whole undertaking is done within the large societal systems framework of Niklas Luhmann. There is, however, a worrisome aspect about making epistemology primary, as post-

modernists and neo-pragmatists have pointed out, in that using second and third order epistemic structures is detrimental to meaning when we let them do our interpreting for us (Taylor, 2007).

There are aspects of the so called 'knowledge society,' which Qvortrup seems to accept, and which I believe ought to be seriously questioned. There are important cases where much greater knowledge is not a good thing. For instance, knowledge without power is frustrating and depressing; b) knowledge with power and without compassion and commitment to its socially responsible use is evil. (I define *evil* as whatever gratuitously destroys persons' plausible hopes).

What knowledge is and what it is for?

Qvortrup following Luhmann defines knowledge as "condensed observations." In my opinion, that is an inadequate definition because what is involved is much more complex and creative and collaborative than mere condensation. In any case, the noun 'knowledge' is a questionable reification; it is better to consider us as collaboratively doing `knowledging'. As Qvortrup himself asserts: "knowledge is not just a fixed ability but a dynamic ability."Qvortrup then goes on to assert that "its function is to manage complexity, based on the principle that complexity can manage complexity." I agree! Actually, this is an example of the application of the Ashby-Shannon central cybernetic "law of requisite variety" – the control variety available must equal or exceed the disturbance variety for any system to be controllable (Ashby, 1956; Klir & Weierman,1999).

Managing complexity, or at least coping with and steering complex dynamic processes, is indeed a most important challenge for all of us. However, surely that is not the be all and end all of a person's life? Qvortrup's approach is a very pragmatic and to me, a somewhat depressingly utilitarian view of knowledge. Humanist educators would argue that the elaboration validation and sharing of wonderful knowledge is an essential deeply satisfying part of being human, and as such is an end in itself (Nunan, 1983).

Categories Arising from "Applying Knowledge to Itself Recursively"

Qvortrup argues for four emergent categories of knowledge as being paramount:

1. Simple factual knowledge
2. Recursive, knowledge of how to use one's knowledge = competence
3. Reflective, knowledge of the conditions on which knowledge is based
4. Total knowledge – all that we can know in distinction from what we cannot know

He then explains at length what it takes for educators to enable learners to develop knowledge at those of these levels relevant to agreed goals. Instructors and students, who hope to manage complexity, must be helped to learn how to construct all four kinds of knowledge in turn – at least insofar as they are capable of such learning.

Theoretical structure

Qvortrup supports his analysis, syntheses, and recommendations on three basic perspectives that I believe are of genuinely foundational importance:

1. Contextualisation of learning as embedded in, and constrained by, multiple large societal institution systems – particularly instrumental autopoietic systems as understood by Niklas Luhmann (2005).

2. Models of learners as complexly-coupled non-trivial universe-observer-describer systems – particularly as understood by Heinz von Foerster (1984).

3. A carefully differentiated and stratified understanding of 'knowledge'– in this case as understood by Lundvall (2000) who wrote: "Knowledge is a representation of something according to interpretation standards, which may change from person to person and from teacher to pupil. My knowledge is not equal to your knowledge and it cannot be transported from me to you" (Qvortrup, 2006a, p. 18).

And a new categorization of such knowledge into four very basic successively emergent types: 1) Factual knowledge (know-what and know-why); 2) Recursive knowledge (know-how competencies); 3) Reflective knowledge (creativity capabilities); 4) Meta-reflective knowledge (culture). Each of these basic kinds of knowledge requires specific kinds of learning and evaluation activities according to Qvortrup's prescriptions. Qvortrup's categories can usefully be compared with the recent versions of taxonomy based on the Bloom and Madaus work (Krathwohl, 2002) and with my own system of emergent cybersystemic levels of learning (Boyd, 2000).

Relevance and Value

To assess the relevance and value of Qvortrup's work for e-Learning institutions and developers, let us consider the big challenges now faced by them. What are the main on-going challenges now in open and distance e-Learning venture development? There are two really basic challenges: first, to survive institutionally in a turbulent competitive world; and second to provide enough of their stakeholders, especially students and employers, with good value for time and money spent. Unfortunately, too often it has been possible, at least for awhile, to impress and to please funders and other stakeholders without providing proportionate real value – partly because the beneficiary accountability feedback loops have such long delays built into them. In fact, these delays are getting shorter, so the accountability challenge is increasing. For a current example, look at The Phoenix Online University situation, as reported in the *New York Times* (Dillon, 1997). What of value now, has Qvortrup's book to offer with respect to these two main challenges? A great deal, I believe.

Relevance of Luhmann's theory of society for educational (e-Learning) organisation and venture viability

Qvortrup tackles the viability problem mainly in terms of how e-Learning can meet the needs of the new global knowledge society and how the institutional system imperatives identified by Luhmann must be dealt with by using his ideas. Here a digression about "autopoiesis" is perhaps necessary:

The concept Maturana and Varella (1992) developed in the 1970s to characterize living things "autopoiesis," and which Luhmann applied assiduously to social systems as he conceived them, needs some demystification. Autopoiesis literally means self-production. In order for primitive

living organisms to produce themselves, that is to survive and to reproduce, they must have 'good closing' against chemical and mechanical threats in their environment, which could wreck their metabolism or their DNA. They also have to have 'good opening' to take in food and get rid of waste products. In Maturana's terms, they have to be structurally closed against 'information' which would alter DNA, and so forth. When we come to consider social animals they/we have to communicate to survive and reproduce, but we also have to have good closings against anything that would alter our genetic identity. Thus far 'autopoiesis' holds. However, we also have evolved to feel that we must try to close ourselves off against anything which threatens our personal-cultural identity. So for us, the 'goodness' of openings and closings is not automatically structurally determined, but rather presents formidable choice and action problems (Klapp, 1978). Hence Qvortrup (2006b) refers to structural closure as a problematical construct.

Luhmann, according to Qvortrup's (2006a, p. 99ff.) ". . . distinguished two basic sorts of systems: psychic systems and social Systems." He also asserted that psychic systems do not comprise a society's essence and building blocks, but rather its surrounding world (*Umwelt*). Contra Margaret Thatcher's dictum that "There is no such thing as society!" (Archer, 2002), in Luhmann's view, society is very real and is definitely not considered to be just a sum total of human individuals. A number of highly complex polycentric conglomerates of mutually loosely coupled systems create social order (i.e., constitute meaning based distinctions between themselves and their social environment or *'Umwelt'*). These are our major social systems: Law, Politics, Art, Education, medicine and Religion.

Social order is established when the diversity of communicative systems creates an extremely complex dynamic stability. Society does not exist on the strength of the purity of social order, but rather on the complex impurity of social structures. In other words, a large number of fairly autonomous functional systems such as the legal system, the economic system, the art system, the health-care system, and the educational system, spontaneously emerge from all the complex intercommunication of myriads of groups. These big societal systems are both pre-conditions for each other's existence and competitors. They constantly collide and seek to achieve dominance over each other. Our institutions, our ventures, and our psychic selves, are embedded in them all. In general, the viability of particular e-Learning ventures depends on how the embeddedness is imposed and how it is negotiated. This negotiation occurs through a medium and a symbolic code unique to each big functional system (e.g., the medium of the economic system is money and the code is payment/ non-payment).

Luhmann asserted that the general function of the education system is to change people and therefore that the working medium of the educational system is learner-lifetime (*Lebenslauf*). The 'life-long learner' is a social construction that allows the educator plausible hope that it is possible to change people in ways that are deeply desired. The code which Luhmann asserts is used by the education system is "transmittable/ non-transmittable." This is a bit tricky to grasp, and moreover goes against our current constructivist understanding that education is NOT about transmission, but rather is about co-construction of knowledge and skills, attitudes, and commitments.

As far as I can make out, Luhmann's conception of the education system connects with the understanding that many citizens and most educators wish to either clone the best parts of themselves or transmit something even better along the same lines they have loved and struggled to pursue. Any particular educational organisation has to lay claim to a population of compatible learners and suitable educators, and to claim as legitimate a range of ways (i.e., technologies) by which it can try to transmit changes that most stakeholders agree are for the better. If it can do

that, then the economic system of money can be brought into alignment with the educational system of learners. According to Qvortrup that is the big picture of societal system understanding to which we should continually refer back in setting our strategic and tactical priorities if we wish to carry on viable e-Learning ventures (but cf. Archer, 1979).

Improving the actual learning of our students

Meeting the second Open and distance Learning challenge – to provide enough of our stakeholders, especially students and employers, with good value for time and money spent – requires better learning activity development and better learning environment design and deployment.

Qvortrup's interesting contribution is based on his synthesis of Activity theory and Constructivist theory carried out in terms of his four categories of knowledge. He goes beyond instructivist and the currently fashionable body phenomenological paradigms to what I take to be a revival of Piaget's and George Kelly's uses of the parallel between individuals' learning and the development of knowledge in scientific communities. For him, theoretical epistemology is central to the construction of curriculum and to the design of learning support activities. When seen from my pragmatic point of view, this knowledge-centred approach suffers a certain unreality, because Qvortrup ignores the actual centrality of both intrinsic and extrinsic motivation (Ryan & Deci, 2000) to the generation of knowledging capabilities and, indeed, to all of education.

A great deal more could be said about Qvortrup's understanding of Didactics (off-line) and of Pedagogy – real-time engagement which seems to depend on synchronous communication (i.e., his pedagogy would best apply to interactive online small group teaching).

Qvortrup helpfully exhibits how some actual examples represent realisations of his theory of how higher orders of knowledge can be developed in those e-learning situations where it makes especially good sense (e.g., in social simulations and portfolios supported by teacher-learner discussion).

In Summary:
Why various types of reflective IRRODL readers might wish to read Qvortrup

Lars Qvortrup's book offers a delightful controversial opportunity to reflect insightfully on topics, which I believe are central to any and all legitimately worthwhile e-Learning. Especially now when we are facing many extraordinary new challenges (see Kurzweil, 2005) Qvortrup's work should, I believe, be of appreciable value to all those who are thoughtfully developing open and distance learning ventures today.

In particular, curriculum developers should read Qvortrup on the categories and forms of most-needed knowledge and how they can be evaluated. Instructional designers should read Qvortrup on "didactics," which he defines as immediate first-order reflection on teaching versus "pedagogy" defined as protracted second order reflection on teaching and media and learning. Open and distance learning administrators, innovators, and developers should read Qvortrup on Niklas Luhmann's exposition of how the systemic imperatives of public education systems as

societal systems in competition with the other major societal institutional systems – Business, Politics, Religion, Art, Law – both constrain us and provide us with new opportunities.

References

Archer, M. (1979). *Social Origins of Educational Systems.* London: Sage.

Archer, M. (2002). Realism and the Problem of Agency. *Journal of Critical Realism, 5*(11). Retrieved March 25, 2007 from: http://www.journalofcriticalrealism.org/archive/JCR(A)v5n1_archer11.pdf

Ashby, R. (1956). *An Introduction to Cybernetics.* New York:Wiley.

Boyd, G. (2000). The Identification of Levels of Action through the Use of Stratified Computer-communications Media; Towards the THOUGHTACTORIUM. *SYSTEMICA, 12*(1), 29 - 41.

Dillon, S. (1997, February 11). Troubles Grow For a University Built on Profits. *New York Times*, Sec. 1., p. 1. Retrieved April 16, 2007 from: http://select.nytimes.com/gst/abstract.html?res=F40B15F6355B0C728DDDAB0894DF404482

Klapp, O. E. (1978). *Opening and Closing: Strategies of information adaptation in society.* Cambridge: Cambridge University Press.

Klir, G. J., Weierman, M. J. (1999). *Uncertainty Based Information.* New York: Physica Verlag/ Springer Verlag.

Krathwohl, D. R. (2002). A Revision of Bloom's Taxonomy: An overview. *Theory into Practice, 41*(4), 212-218.

Kurzweil, R. (2005). *The Singularity is Near.* New York: Penguin.

Luhmann, N. (1995). *Social Systems.* Stanford: Stanford University Press.

Maturana, H. R., & Varella F. G. (1992). *The Tree of Knowledge.* Boston: Shambala.

Nunan, T. (1983). *Countering Educational Design.* London: Croom Helm.

Qvortrup, L. (2006a). Knowledge Education and Learning. Frederiksberg, Denmark: Vorlagetsl.

Qvortrup, L. (2006b). Structural Coupling: A problematic concept. Cybernetics & Human Knowing, 13(2), 56-58.

Ryan, R. M., & Deci, E. L. (2000). Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. American Psychologist, 55(1), 68-78.

Taylor, R. G. (2007). *Learning After the End of Knowledge: Instructional technology in the age of interpretive meaning.* Concordia University: Unpublished MA Thesis.

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 8, Number 2. *ISSN: 1492-3831*

June – 2007

Book Review – Control and Constraint in E-Learning: Choosing when to choose

Author: Jon Dron (2007). *Control and Contraint in E-Learning: Choosing when to choose.* Information Science Publishing: Hershey PA. 365 pages, Hardcover and e-Book. ISBN: 978-1-59904-390-6.

Reviewed by: Terry Anderson, Canada Research Chair in Distance Education and Editor, www.irrodl.org

I have been waiting for a couple of years now for a work that successfully ties together the emerging social software/ Web 2.0 scene with established theory and practice of distance education. Unfortunately, I did not write it myself. Jon Dron, however, has created the first in what I assume will be a series of writing, research, and experimentation (his and the work of many others) that helps us harness the affordances of social software for formal and informal learning. Social software makes use of the emerging Semantic Web and Web 2.0 technologies to enhance learning provided through a ubiquitously connected lifelong learning population, an abundance of learning content, and judicious use of agents to make it easy.

In a nutshell, *Control and Constraint in E-Learning: Choosing when to choose* explores how to move beyond distance education's roots as independent study, through the tight cohorts of students moving lockstep through teacher orchestrated activities, to a context in which "many learners, loosely joined" can have the freedom and choice to co-create their own learning. This is a tall order, but one that is very much coming to a computer near you!

Dron begins the book with a look backwards at the theoretical balances between structure, control, power, and 'transactional distance' (note that Moore, Saba, Garrison, Boyer, Pask, Gorsky, Candy, and numerous others have talked abut 'transactional distance'). He concludes (like other scholars) that many of these concepts are fuzzy, hard to validate empirically, and often misunderstood by both readers and authors. He then moves onto something most of us like, and understand – namely having control over choices that affect us – reverberating with the near universal desire for freedom and democracy. Though acknowledging that sometimes students cannot handle, or desire, too much choice, lifelong learning demands that students participate in the experience of learning, if they are to recreate that experience on their own in subsequent experiences. He concludes that control and constraints induced by context, content, and scale shape both formal and informal learning. Since education is about change, Dron then uses these notions of transactional control to map a series of learning trajectories that are changed by active control of the learner, the instructor, or changes in their context of their learning environment.

Having set the theory, Dron then maps "transactional control" onto Net activities, including searching for the 'good stuff,' asynchronous threaded discussion, Learning Management System (LMS) use, and text chat. I liked the application chapters, but the detail of analysis of

asynchronous and text chat became a bit tedious for my tastes; the point made was that the conversation or activity is constantly changing in response to the exercise of control by learners or teachers. I also would have preferred analysis of voice chat as opposed to text, since I rarely use text chat and never in formal classes – but perhaps that is just because I am too old! Dron then plays with the idea of transactional control to resolve some thorny e-learning issues, such as distinguishing the optimal granularity of a learning object. He argues that, "the smallest learning object should be the one that embodies an atomic transactional choice" (p. 135).

Personally, the book got most interesting when Dron began expanding the six forms of interaction (learner-teacher; learner-content; learner-learner; teacher-content; teacher-teacher; and content-content). I had assumed that I had covered all possible combinations of the three main actors when I discussed these in 2003. But alas, Dron complicates the context, by noting that the network or group itself is a learning resource and potentially powerful learning aide as exemplified in blogs, Wikis, referral services, collaborative help systems, and the myriad other forms of Web 2.0 and social software applications. These actors are much less formal, transient, and in many cases, subject to happenstance, yet as the Net matures the possibilities and rewards of interacting with human and content resources outside of the formal learning context increases.

The book ends with a series of design principals for social software. These principles draw from a rather disparate group of theories and principles. Three are extracted directly from general evolutionary theory (Richard Dawkins is no doubt delighted!) the ***Principle of Adaptability*** and the ***Principle of Evolvability***, then more specifically deals with behaviours and techniques of successful species or emergent organizations, such as insects' ability to organize effectively with relatively low brainpower using the ***Principle of Stigmergy***, to allow attainment of objectives impossible by individual or class-sized cooperation. The ***Principle of Trust*** relates directly to the human relationship, community, and sense of common cause that arise through use of high quality learning networks. These activities flourish if emergent networks can form appropriate sized social structures using the ***Principle of Parcellation*** to create the small within the large. To make sense of the ecological complexity of emergent educational social context, education design architects help us construct patterns ***Principle of Constraint*** (think Christopher Alexander's *Pattern Language*). Of course, acknowledgement of the underlying ***Principle of Context*** dictates that learning must be customizable by the large disbursed groups spread across space and time, but that they will also be highly connected – ***Principle of Connectivity*** through today's communications backbone of the Net.

To my knowledge, these are the first attempts at extracting underlying design principles or patterns for educational social software. Dron next applies the principles to a few existing and emerging case studies and speculates about the future of e-learning noting the plight of teachers who cannot 'get with' this new learning agenda.

In the tradition of the critical reviewer, I offer four minor complaints. In the first chapter, I was flattered to see a nice long quote that I had published in 2003. Unfortunately, the bibliography referenced another group of scholars led by another Anderson. I do not usually quibble about minor typos and citation errors – unless they concern me personally! Second, I wish Dron had picked-up on Morten Paulsen's work of 1993 where he defined his Theory of Cooperative Freedom, in which he foresaw many of the affordances of social software in allowing transactional choice over time, pace, place, access, curriculum, media, and 'relationship,' which I later added to the list. Transactional choice is a very broad category, and noting all its dimensions helps us plan and not default to particular familiar defaults. Third, I find the title quite confusing – at quick browse in a bookstore (online or F2F) I might confuse it with Luddite harangue in the

style of David Noble or a guide to retaining teacher control with unruly cyber-kids, but I would not likely think it was a book about social software. Finally, I wish *Control and Constraint in E-learning* was more accessible. Open access publishing would be an appropriate goal for a book like this, as it would result in tens or even hundreds of thousands more readers. At least publication in soft cover has reduce its price from a lofty $110.66 Canadian (OK, so the postage is free!), or e-Book at $70.87, does make it a bit more affordable.

In summary, Jon Dron has made a major contribution to our understanding of learning in the networked era. This book will likely do what writing by Alex Romiszowski in the 1980s, and Tony Bates did for scholars and distance education practitioners in the 90s. I doubt if it will be the final work exploring "many learners loosely joined" but it makes a first and major contribution.

Reference

Dron, J. (2007). *Control and Constraint in E-Learning: Choosing When to Choose.* Hershey, PA.: Information Science Pub.

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 6, Number 2. *ISSN: 1492-3831*

June – 2007

Technical Evaluation Report

60. The World-Wide Inaccessible Web, Part 1: Browsing

Jon Baggaley, Athabasca University – Canada's Open University

Batchuluun Batpurev, Infocon Ltd., Mongolia

Abstract

Two studies are reported, comparing the browser loading times of webpages created using common Web development techniques. The loading speeds were estimated in 12 Asian countries by members of the *PANdora* network, funded by the International Development Research Centre (IDRC) to conduct collaborative research in the development of effective distance education (DE) practices. An online survey tool with stopwatch-type counter was used. Responses were obtained from Bhutan, Cambodia, India, Indonesia, Laos, Mongolia, the Philippines, Sri Lanka, Pakistan, Singapore, Thailand, and Vietnam. In most of the survey conditions, browser loading times were noted up to four times slower than commonly prescribed as acceptable. Failure of pages to load at all was frequent. The speediest loading times were observed when the online material was hosted locally, and was created either in the *Docebo* learning management system (LMS), or in the HTML option provided by the *Moodle* LMS. It is recommended that formative evaluation of this type should become standard practice in the selection and use of online programming techniques, in order to preserve the accessibility of the World-Wide-Web across large geographical distances, as for DE in the developing world.

Introduction

In creating numerous educational websites since 1996, in Canada and Mongolia, the authors have noted the increasing time taken by standard Web browsers in loading webpages. The early Web programming techniques (basic HTML code, frames, etc.) generated displays that were relatively swift to access, for with each new display the material in unchanged frames did not need to be reloaded. The disadvantage of the frames technique, however, was that, if poorly used, it could make browser navigation difficult. It also made the overall display inaccessible to users whose poor sight obliged them to use text-based browsers, and leading analysts of Web design such as Nielsen (1996) deemed the frames technique user-unfriendly for this reason. By 1999, Nielsen had relaxed his negative attitude to frames owing to improvements made in the *Internet Explorer 5* and *Netscape Navigator 4* browsers. The stigma associated with frames stuck, however, and new programming methods (PHP, etc.) have since taken their place. These have overcome many of the early usability problems, though often with a related increase in the speed with which the browser loads the page.

On the question of browser page loading speed, Nielsen's (1994: 1997) advice has been consistent from the mid-1990s to the present day:

"10 seconds is about the limit for keeping the user's attention focused on the dialogue. For longer delays, users will want to perform other tasks while waiting for the computer to finish, so they should be given feedback indicating when the computer expects to be done. Feedback during the delay is especially important if the response time is likely to be highly variable, since users will then not know what to expect" (Nielsen, 1994, ¶ 4).

Since 2006, the authors have collaborated in the development and maintenance of a website designed as an information and communication portal for a distance education (DE) research network across Asia. At the time of testing, the *PANdora* network (www.pandora-asia.org) comprised of 20 educational and government institutions in 12 countries, collaborating on nine research projects funded by the International Development Research Centre (IDRC). The network's website features details of the projects and the teams conducting them, announcements about publications, conference presentations, etc., and a private members' section containing downloadable papers and research materials, and streamlined access to text- and audio-conference software. As many of the *PANdora* projects concern the development of online course material, a series of leading learning management systems (LMS) is available on the site for researchers to evaluate; and one project, conducted in Mongolia by the second author, has formally tested eight of these packages with students, teachers, and administrators. The results of that study have led several of the project teams to adopt (as at the first author's university) *Moodle*, an LMS based on open-source software (OSS).

In using *Moodle* and other LMS systems among the Asian network's 12 countries, however, their slow loading speed in the standard Web browsers has commonly been noted. Several *PANdora* project teams have mentioned this as a serious deterrent to Web use in Asian education (Amarsaikhan, Lkhagvasuren, Oyun, & Batpurev, 2007; Jamtsho & Bullen, 2007; Ramos, Nangit, Ranga, & Triñona, 2007), and have attributed it to factors including congestion on the networks of the users' educational institutions, and the slow domestic dial-up connections of some users. Increasing demands of software upon Internet bandwidth of this type have been dubbed "bandwidth creep", predicted by Maney (2001) to become a significant and source of frustration for Internet users. Since the *PANdora* researchers are expected, at the end of the project's 2005-2008 duration, to present practical recommendations for the use of DE technologies across Asia, slow access to Web materials has been judged sufficiently serious for a formal examination of the browser speeds associated with different Web programming techniques. The current report presents the early findings of this study.

Study A: Browser loading speed (Pakistan server)

The *PANdora* website is hosted on a fast server at the network's administrative centre, the Virtual University of Pakistan (VUP). The network researchers are required to access the site in their international collaboration, and to obtain up-to-date information on network developments. The first study took advantage of the members' wide-ranging geographical dispersal across Asia to compare the lengths of time it took their browsers to load a series of Web displays. The homepage and announcements page of the network's website at www.pandora-asia.org were used as the test displays, coded in five alternative ways:

1. The home page's regular version, a combination of HTML and PHP code

2. The announcement page's regular version, also coded in HTML and PHP

3. The homepage presented in the *Moodle* LMS (www.moodle.org)
4. The announcements page presented in the *Moodle* LMS
5. A *Google Video* menu page hosted at video.google.com

Procedure

An online survey was created in HTML and javascript, containing 15 questions about the user's location and technical facilities, and 10 items designed to test browser loading speed. The survey and the test pages were all hosted on the VUP server in Lahore. The server's technical specifications were as follows:

- Product name and manufacturer: *Headon/ Intel*
- Processor: *Intel* P4 3.0Ghz
- Chipset: *Intel* D845 GERG2
- Memory (size, speed and type): 512MB; 266MHz; DDR
- Operating system: *Fedora Core 4*
- Storage (size, type and RPM): 80GB; IDE interface; 7200RPM
- Communications (LAN card): 100Mbps

The server's software platform was:

- Web server: *Apache* 2.0.52
- Database server: *MySQL* 11.18; Distribution 3.23.58 for *Redhat Linux*-gnu (i386)
- PHP 4.3.9

The participants were instructed to respond to the survey in their *Internet Explorer* browser. On an average Internet connection, the survey took 20-30 minutes to complete. Respondents for whom webpages failed to load typically took up to 10 minutes longer.

The browser loading speeds were measured using a stopwatch-style counter programmed in javascript, and embedded in the survey instrument. The test was preceded by instructions to configure the browser to load each page from the server every time it was requested, and to clear the browser's cache memory before accessing the page. Instructions on how to complete these browser configurations were provided, and thumbnail images of the five displays were presented as they would appear when fully loaded. In each test item, a link was provided to the page to be tested, which opened in a separate window. The respondents were asked to enter into the response box the amount of time (in milliseconds) that each page took to load. The test of the five displays was conducted twice in order to measure possible improvements due to the pages' retention in memory on the Internet provider's Web server. Before the second set of five test items, the respondents were asked to repeat the two browser configurations. If a page did not load within three minutes (180 seconds) on a given test, the respondents were instructed to enter "time out" as

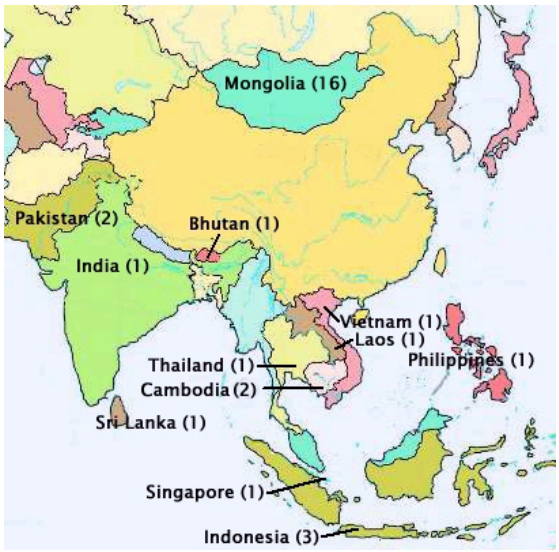
the response. When the task was complete, the respondents pressed a 'Submit' button to send them to a server at Infocon Ltd. in Ulaanbaatar, Mongolia.

A pilot test was conducted (October - November 2006) in order to refine this procedure and clarify its instructions. Fourteen (n = 14) network members in eight countries assisted in the pilot, and provided the researchers with suggestions for optimising the procedure.

Results

The formal test was completed in January/ February 2007 by 31 network members in 12 Asian countries (Figure 1). Their responses showed that 81 percent of them used a Pentium-4 computer in their regular work, with *Windows XP* (94%), *Internet Explorer v5* or *v6* (77%), a RAM size of 512 mb or greater (45%), and a display size of at least 1024 x 768 (74%). The majority (77%) used broadband Internet connections > 64 kps, as opposed to dial-up. They reported using a wide range of anti-virus software including *Avast*, *AVG*, *Bit Defender*, *McAfee*, and *Norton*; only 16 percent stated that they did not have anti-virus software or did not know if they had it. The sample was less informed about the privacy protection software on their computers: 71 percent either did not answer this question, or stated that they did not have such software, or that they did not know if they had it. The other 29 percent mentioned using a wide range of firewall and spyware software. The sample's most common e-mail software was *Microsoft Outlook* or *Outlook Express* (77%). Twenty-two (n = 22) persons reported using *Yahoo* instant messenger (71%). The most common problem reported with the *PANdora* website was its loading speed (45%).

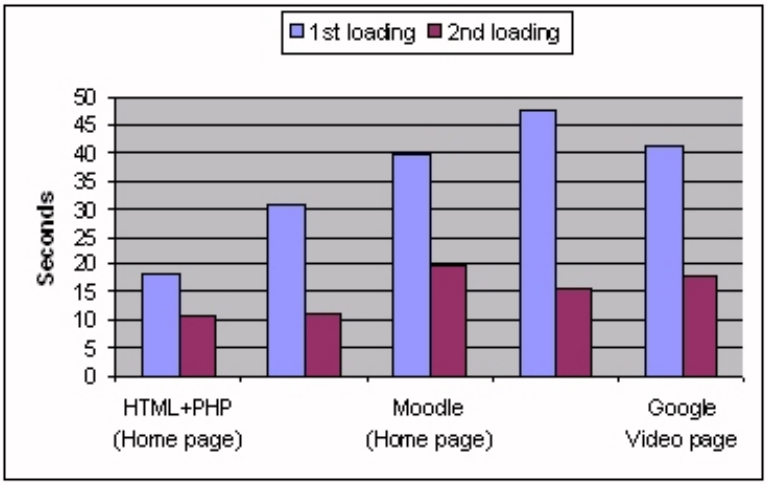
Figure 1. Number of respondents in each country (Study A)



The amount of time (seconds) it took the respondents' *Internet Explorer* browser to load each of the five displays is indicated in Figure 2. The number of "time out" responses for each page (i.e., not loaded within three minutes) was divided approximately equally between 5 of the 31 respondents: the 5 individuals failed to load all five of the pages. As these loading failures appeared to arise at the level of the individual respondent rather than in relation to the specific pages, they were discounted in the analysis to avoid giving a falsely negative impression of the pages' intrinsic loadability. The two pages coded in HTML and PHP were the fastest to load in the first check (19 and 16 seconds respectively, reducing to 11 seconds each in the second check).

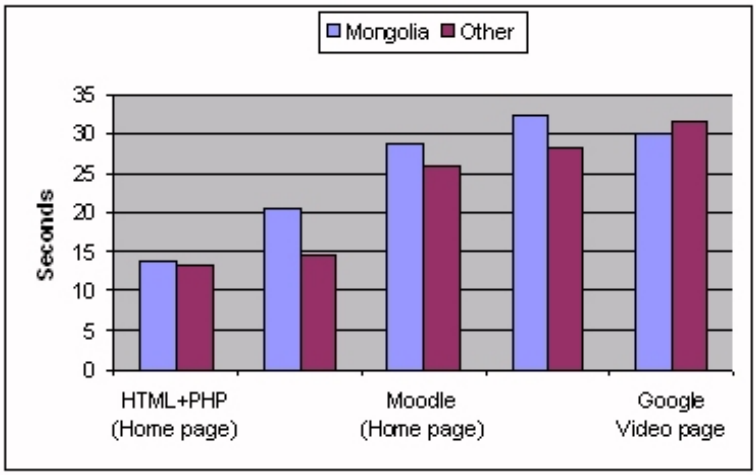
The *Moodle* pages took longer to load the first time (39 seconds each), but took only 16-20 seconds on the second loading. The *Google Video* page initially took 24 seconds, reducing to 18 seconds the second time. The nature of the timing task may have caused participants to over-estimate loading times by a few seconds while they manipulated the on-screen timer's stop button. Psychophysical error of this type may be assumed constant across the five display categories, however.

Figure 2. Browser loading speeds (Study A)



In view of the large number of respondents situated in Mongolia (16/ 31), a comparison was made between their loading speeds and those of the 15 respondents situated elsewhere in Asia (Figure 3). The average of the first and second loading checks on each page was taken for each sub-sample. On four out of five pages, the average loading times in Mongolia were faster (by 4 to 17 seconds) than those reported elsewhere. Failures to load the pages, however, were common among the rural respondents.

Figure 3. Browser loading speeds (Study A): Mongolia versus elsewhere



Study B: Browser loading speed (Mongolia server)

The large number of Mongolian participants in the study also provided the opportunity to see if they would yield similar results in response to web materials hosted on a Mongolian server. The home page of a web site (www.elearning.mn) hosted by the *PANdora* partner in Mongolia, was selected for testing. The page was coded in four alternative ways:

1. As a combination of HTML and PHP code
2. As a *Moodle* display
3. As a display in the *Docebo* LMS (www.docebo.org)
4. In the HTML format provided as an option by *Moodle*

Procedure

The same procedure was used as in Study A. The survey and the test pages were all hosted at Infocon Ltd. in Ulaanbaatar. The server's technical specifications were as follows:

- Product name and manufacturer: *Dell PowerEdge* SC1425
- Processors: 2 x *Intel Xeon*, CPU 3.00GHz, 64 bit, 800MHz FSB, 2MB Cache
- Chipset: *Intel* E7520
- Memory (size, speed and type): 4 x 512MB; 400MHZ
- Operating system: *Fedora Core 5*, kernel 2.6.19
- Storage (size, type and RPM): U320 SCSI *Fujitsu* MAT3073NP, 73GB, 10000 RPM; and U320 SCSI *Fujitsu* MAT3147NP, 147GB, 10000 RPM
- Communications (LAN card): 2 x *Intel PRO*/1000, 82541GI/PI GB

The server's software platform was:

- Web server: *Apache* 2.2.2
- Database server: Mysql 5.0.27
- PHP 5.1.6

Results

Ninety-two (n = 92) people submitted responses to the online survey (February 2007), including 31 who did not answer the demographic and technical questions, and 20 who did not state their country or who cited countries other than Mongolia. The latter two categories of respondents were eliminated from the sample. The responses of the remaining 41 persons were analysed as in Study A.

The respondents were primarily situated in urban Ulaanbaatar (93%). Otherwise their most common responses were as in Study A. The majority (85%) used a Pentium-4 computer in their regular work, with *Windows XP* (88%), *Internet Explorer* (46%), a RAM size of 512 mb or greater (56%), and a display size of at least 1024 x 768 (80%). The majority (71%) used broadband Internet connections > 64 kps, as opposed to dial-up. They reported using a wide range of anti-virus software including *AVG*, *Bit Defender*, *Kaspersky*, *McAfee*, and *Norton*; only 12 percent stated that they did not have anti-virus software or did not know if they had it. The sample was less informed about the privacy protection software on their computers: 66 percent either did not answer this question, or stated that they did not have such software, or that they did not know if they had it. The other 34 percent stated that they use firewall and spyware software, though cited few product names. The sample's most common email software was *Microsoft Outlook* or *Outlook Express* (61%). Thirty-one (n = 31) persons reported using Yahoo instant messenger (76%). The most common problem reported by the sample with the www.elearning.mn portal website was its loading speed (17%).

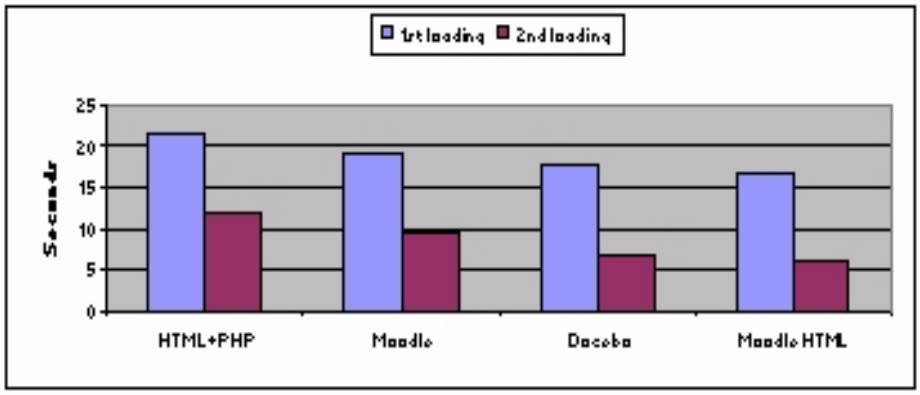
The hardware and software facilities of the two studies are compared in Table 1. The Mongolian sample uses facilities similar to those most commonly reported by the other respondents, though reports a lower usage of *Internet Explorer* (46%) owing to a higher usage of *Firefox* (44%). Both samples show a need for greater use of firewall and spyware software.

Table 1. Computer facilities of the two samples (Studies 1 and 2)

Most common computer facilities	% responses of the two samples	
	Study A (n = 31)	Study B (n = 41): Mongolia
Pentium-IV	81	85
Windows XP	94	88
Internet Explorer	77	46
RAM size, 512 mb or greater	45	56
Display size 1024 x 768 or higher	74	80
Broadband Internet > kps	77	71
Anti-virus protection	84	88
Privacy protection software	29	34
Outlook/ Outlook Express e-mail	77	61
Yahoo Messenger	71	76

The amount of time (seconds) it took the respondents' *Internet Explorer* browser to load each of the four displays is indicated in Figure 4. Ten respondents (24%) gave "time out" responses (i.e. not loaded within 3 minutes) for all four displays. For the remaining respondents, the page coded in HTML and PHP was slower to load (12-14 seconds) than the other pages, though a slight average increase was noted for all pages when they were loaded the second time. The *Moodle* page was faster, at 9-11 seconds. *Moodle* HTML and *Docebo* pages were the fastest to load (9 and 10 seconds respectively, reducing to 6 and 7 seconds on the second check).

Figure 4. Browser loading speeds (Study B): Mongolia



Conclusions and Recommendations

The two studies showed marked differences between the browser loading times associated with different Web development techniques. In both studies, pages created using the common mixture of HTML and PHP coding took, on the first check, 10-19 seconds to load in an *Internet Explorer* browser. Pages delivered by the widely used *Moodle* LMS took up to 39 secs to load. These sluggish speeds are as much as four times slower than the 10-second benchmark adopted in Web design since the mid-1990s (Neilsen, 2007). On the second check, most of the test pages loaded more speedily than the first time, and satisfied this common benchmark. It should be noted, however, that if a page fails to load speedily the first time it is accessed, the user may not try a second time.

The most rapid loading times were those observed in Study B for the pages created in *Docebo* (7-10 seconds) and for the HTML option provided by *Moodle* (6-9 seconds). Each of these options, therefore, has advantages for Web delivery over large international distances. The particular popularity of *Moodle*, however, makes the *Moodle*/ HTML option the more promising of the two.

The slow loading times may have various explanations. The use of low-level computers or poor dial-up Internet connections can be ruled out as reasons because of the up-to-date facilities reported in both studies. Traffic congestion on the institutional networks used by many of the respondents may certainly have been a factor. The long and varying client-server distances between the Asian countries involved in the studies may also account for the slow loading times. This hypothesis explains the fast loading speeds reported by Mongolian respondents in the second study, who received the online materials from a local server in Ulaanbaatar. In addition, while some users may have received the Web displays via straightforward Internet routes using minimal junction points, others may have received them via complex, tortuous international routes. (The current data will be re-examined in light of this hypothesis in Part 2 of this report.) In hosting educational Web materials for Asian DE, the use of alternative mirror sites is therefore likely to be valuable, reducing the distances and complexity of the Internet routes over which the material is conveyed.

It is worth noting that the second study's respondents, downloading the materials rapidly from a local Web server, wherein the same privileged situation as those Web designers who download their draft materials rapidly from a server at their workplace. Unless developers test the reception of their materials on the computers that the students use, or ask the students for feedback, they may never experience the lesser convenience of the remote locations. Regrettably, such checks on

the usability of Web materials do not appear to be a common procedure in DE, either on the part of the Web developers, the teachers, or the institutions themselves. Consequently, students can suffer extreme delays while their learning materials take up to a minute to load, or fail to load at all. In scanning the many displays in a course website, the busy student can find the constant delays disruptive and intolerable. Assuming the problem to be somehow of their own making, students may fail to report it to the teachers or to the institution's service staff. As a result, the inaccessibility of Web materials goes unheeded by their producers, and programming techniques become increasingly complex with little or no heed to the fact that their efficiency has decreased in the process. It is ironic that the move away from the old, faster-loading frames method of Web design has benefited some users while creating a new accessibility problem for many others. This is the type of barrier that the open and distance learning movement is mandated to avoid.

Failure to take account of the efficiency of educational materials has been commonplace in educational media production, and formative evaluation methods are a necessary means of quality assurance (Baggaley, 1980). If such pilot-testing procedures are not adopted as standard practice in online education, and the benchmarks offered by analysts such as Nielsen (1994; 1996; 1999; 2007) are not heeded, the World-Wide Web is likely to become increasingly inaccessible and to decline as a viable educational medium, especially across the large distances of the developing world. With each successive upgrade of online software applications, it is vital for their accessibility on standard connections to be checked so that problems of "bandwidth creep" can be avoided.

Acknowledgements

For assistance in this study, the authors are grateful to their colleagues in the 12 countries of the PANdora research network, to Mr. Ehsen Puri, Network Executive at the Virtual University of Pakistan, and to Steve Song, Manager of the IDRC's ICT4D Africa Programs. The project was conducted with financial support from the Pan Asia Networking (PAN) Program Initiative of the International Development Research Centre (IDRC), under a grant to the Virtual University of Pakistan (VUP) for the project 'PANdora: Distance and Open Resource Access.'

References

Amarsaikhan, D. Lkhagvasuren, T., Oyun, S., & Batpurev, B. (*in press*). Online medical diagnosis and training in rural Mongolia. *Distance Education 28*(2).

Baggaley, J. P. (1980). *Dynamics of Television.* New York: Praeger.

Jamtsho, S., & Bullen, M. (in press). Distance Education in Bhutan: Improving access and quality through ICT use. *Distance Education 28*(2).

Maney, K. (2001, November 8) Broadband takes off at a snail's pace. *USA Today.* Retrieved April 22, 2007 from: www.usatoday.com/tech/bonus/1101/cover.htm

Nielsen, J. (1994). *Response Times: The three important limits. Usability Engineering.* San Francisco: Morgan Kaufmann Retrieved March 17, 2007 from: www.useit.com/papers/responsetime.html

Nielsen, J. (1996, December). Why Frames Suck (Most of the Time). Article published on *useit.com: Jakob Nielsen's Website*. Retrieved March 17, 2007 from: http://www.useit.com/alertbox/9612.html

Nielsen, J. (1999, May 2). "Top ten mistakes" revisited three years later. Article published on *useit.com: Jakob Nielsen's Website.* Retrieved 17 March, 2007 from: http://www.useit.com/alertbox/990502.html

Nielsen, J. (2007, March 1). The need for speed. Article published on *useit.com: Jakob Nielsen's Website.* Retrieved 17 March, 2007 from: http://www.useit.com/alertbox/9703a.html

Ramos, A.J., Nangit, G., Ranga, A., & Triñona, J. (*in press*). ICT-enabled community education in the Philippines. *Distance Education 28*(2).

The next report in this series discusses Internet routes.

N.B. Owing to the speed with which Web addresses are changed, the online references cited in this report may be outdated. They can be checked at the Athabasca University software evaluation site: http://cde.athabascau.ca/softeval/. Italicised product names in this report can be assumed to be registered trademarks.

JPB. Series Editor, Technical Evaluation Report

SOME RIGHTS RESERVED

Athabasca University

International Review of Research in Open and Distance Learning
Volume 6, Number 2. *ISSN: 1492-3831*

June – 2007

Technical Evaluation Report

61. The World-Wide Inaccessible Web, Part 2: Internet routes

Jon Baggaley, Athabasca University – Canada's Open University

Batchuluun Batpurev, Infocon Ltd.
Mongolia

Jim Klaas, DevEd International
Canada

Abstract

In the previous report in this series, Web browser loading times were measured in 12 Asian countries, and were found to be up to four times slower than commonly prescribed as acceptable. Failure of webpages to load at all was frequent. The current follow-up study compares these loading times with the complexity of the Internet routes linking the Web users and the Web servers hosting them. The study was conducted in the same 12 Asian countries, with the assistance of members of the International Development Research Centre's PANdora distance education research network. The data were generated by network members in Bhutan, Cambodia, India, Indonesia, Laos, Mongolia, the Philippines, Sri Lanka, Pakistan, Singapore, Thailand, and Vietnam. Additional data for the follow-up study were collected in China. Using a 'traceroute' routine, the study indicates that webpage loading time is linked to the complexity of the Internet routes between Web users and the host server. It is indicated that distance educators can apply such information in the design of improved online delivery and mirror sites, notably in areas of the developing world which currently lack an effective infrastructure for online education.

Introduction

The previous paper in this series reported two studies examining the amount of time taken to load different types of webpages in the *Internet Explorer* Web browser. The first study involved 31 members of the PANdora distance education (DE) research network in 12 Asian countries. The second study compared the loading times reported by 41 educators in Mongolia. Both studies found that webpages created using the common programming method of combined HTML and PHP coding took, on the first check, 10-19 seconds to load in the browser. Pages delivered by the widely used *Moodle* LMS took up to 39 seconds to load. Such speeds are four times slower than the 10-second benchmark recommended in Web design since the mid-1990s (Nielsen, 2007). It was concluded that if such benchmarks are not heeded in the development of online materials, the World-Wide Web is likely to become increasingly inaccessible as a viable educational medium, particularly in the developing world.

Numerous factors can be responsible for slow browser loading times. In the preceding studies, the use of low-level computers or poor dial-up internet connections was discounted owing to the up-to-date facilities of the studies' respondents. Traffic congestion on the institutional networks used by many of the respondents, and the long client-server distances between the Asian countries involved in the study, may have been contributing factors. In addition, while some users may have received the Web displays via straightforward Internet routes using minimal junction points, others may have received them via complex, tortuous international routes. The current study re-examines the data reported in the previous article, in light of this hypothesis.

The complexity of routes taken by a signal on the Internet can be identified by the 'traceroute' procedure included in most computer operating systems (Moss, 1997). The analyst submits the domain name or Internet Protocol (IP) address of a remote computer/ Web server to the traceroute routine. At any given time, each computer on the Internet has an unique IP address, shared by no other computer. The address consists of four numbers ranging from 0 to 255, each separated by a dot (e.g., 146.23.12.200). The traceroute procedure analyses the signal's route from the originating computer to the remote one, in terms of the number of 'hops' the signal takes through separate servers, the time in milliseconds taken at each hop. The IPs and/ or domain names, and the geographical locations of each computer in the route, are also identified.

Study C: Browser loading times vs. Internet traceroutes

Procedure

In order to determine whether the browser loading speeds observed in the previous study may have been affected by the routing complexity from the user's computers to the PANdora Web server in Pakistan, the IP addresses of each participant in Study A were collected. These were available in the log files of the server in Mongolia on which the responses had been collected. Traceroutes were then conducted from the webpages' host server at the Virtual University of Pakistan to each of the 31 participants' computers. For each traceroute result, the number of hops from the Pakistan server to each computer was recorded. As the standard traceroute procedure sends three successive signals to each server en route to the target computer, the average length of time (milliseconds) taken at each hop was recorded. It was also noted whether or not the traceroute succeeded in locating the target computer or was abandoned after the pre-configured 'time-out' interval (three minutes). Since IP addresses may change between Internet sessions, with a resulting change in the last of the four sections in the address, a trace of the target computer was identified as successful when the IP recorded at the end of the traceroute sequence included the first three sections of the target IP. The geographical locations of each computer in the route was identified by the reverse lookup procedure.

In addition to the 31 'traces' conducted from the Pakistan server to the users' computers, the Web addresses of the users' 14 institutions were also submitted to the traceroute routine (i.e., 45 commands in all). As an individual traceroute command can take several minutes, a program was written to conduct all 45 traceroutes via a single command. The standard traceroute default values were used for the maximum number of hops at each stage of the route, and for the three-minute maximum for measuring individual hops. The program was made available for download and use in the *Windows* operating system by researchers across the PANdora Asian network. To this point, the 45 traceroutes have been run from Lahore (Pakistan), Phnom Penh (Cambodia), Ulaanbaatar (Mongolia), and from sites in Canada. Data collection from all these sources took place during a weekday morning (local time in each city) from May 10-14, 2007.

Results

The analysis indicates that the Internet routes taken by Web materials to the users' computers range from the simple to the exceedingly complex. Figure 1 illustrates three of the most simple routes noted in the traceroute analysis between the PANdora Web server and its users across Asia.

1. ***A traceroute within Pakistan.*** The route observed between materials hosted on the PANdora Web server in Lahore and users in Islamabad is a direct one involving seven 'hops' from source to target.

2. ***The traceroute within Phnom Penh, Cambodia.*** When a Web user in Phnom Penh loads a page from a server in the same city, the route typically goes through Hanoi (Vietnam) via approx. 10 hops.

3. ***The traceroute from Beijing in China to Ulaanbaatar, Mongolia.*** The traceroute from Beijing in China to Ulaanbaatar, the capital of neighbouring Mongolia, typically involves 15 hops through Hernden, USA, and Tomsk, Russia.

In countries such as Mongolia, which lack a comprehensive internet infrastructure, the traceroutes can be more complex. Figure 2 illustrates the routes taken between the Lahore, Pakistan server and Ulaanbaatar, Mongolia, as an 11-hop process through Islamabad and Singapore. The traceroutes conducted from Ulaanbaatar to Lahore reveal an even more complex return route (16 hops) though Tomsk (Russia), Stockholm (Sweden), Rome (Italy), and Islamabad (Pakistan).

Another country with a relatively undeveloped Internet infrastructure is Cambodia. Figure 3 illustrates the return routes between the PANdora Web server in Pakistan and the Cambodian capital, Phnom Penh. It is a route almost too tortuous to display in a single figure. The outward route from Lahore to Phnom Penh (13 hops) goes through Islamabad, Chieti (Italy), Bochum (Germany), Hernden (USA), and Hanoi (Vietnam). The traceroute data collected in Phnom Penh reveal an even more complex 19-hop return route from Phnom Penh to Lahore via Hanoi, Beijing, the US states of Oklahoma, Washington, New York, and Islamabad.

Figure 1. Three direct routes: 1) Lahore to Islamabad; 2) Phnom Penh to Phnom Penh (via Hanoi); 3) Beijing to Ulaanbaatar (via Virginia, USA)

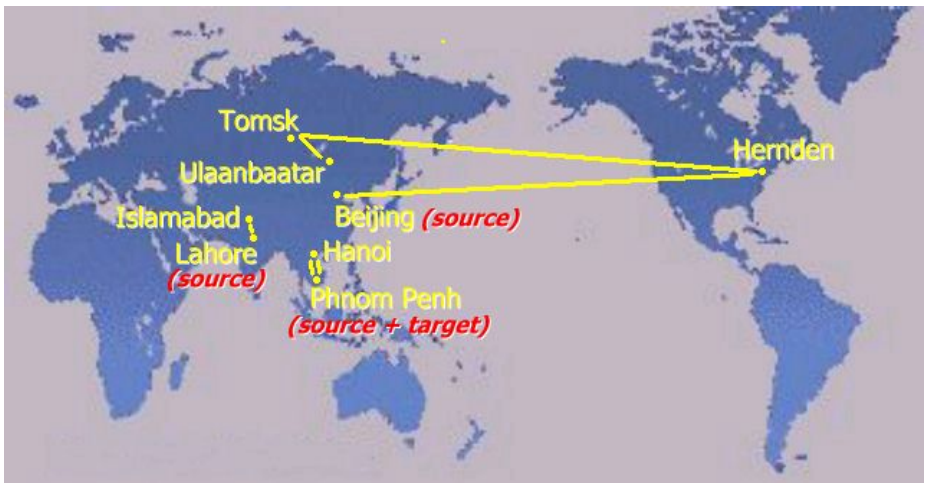


Figure 2. The routes between Lahore and Ulaanbaatar (outward via Islamabad and Singapore; return via Tomsk, Stockholm, Rome, and Islamabad)

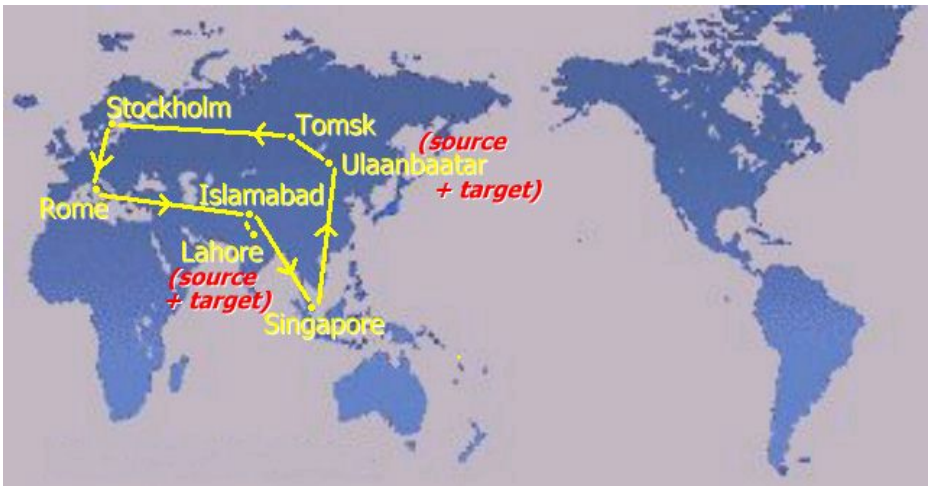
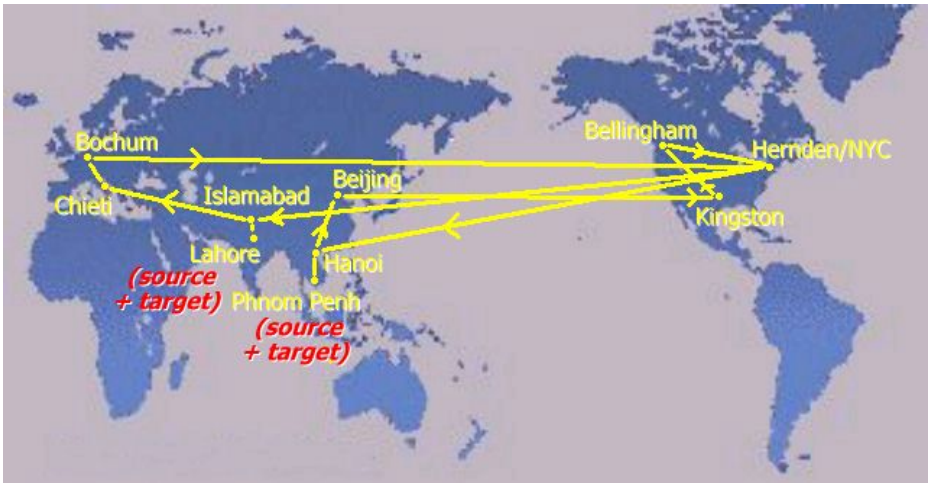
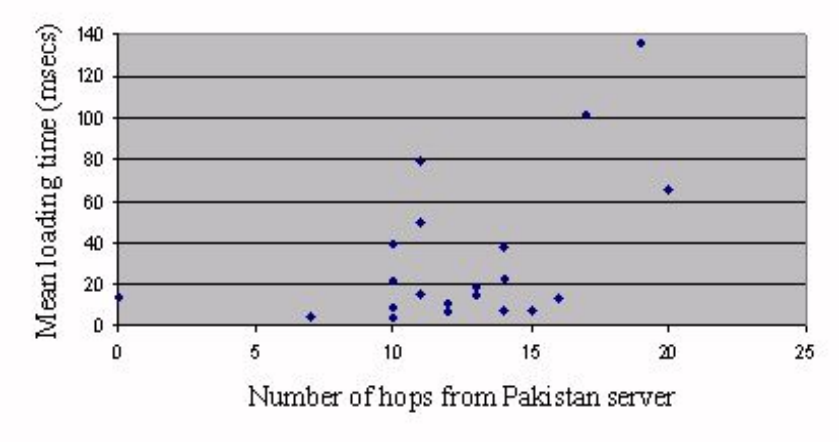


Figure 3. The routes between Lahore and Phnom Penh (outward via Islamabad, Chieti, Bochum, Virginia and Hanoi; return via Hanoi, Beijing, the US states of Oklahoma, Washington, and New York, and Islamabad)



The final analysis examined whether the traceroute complexity between the Pakistan Web server and its users is related to the browser loading times reported in Study A. The respondents' mean loading times across the five Web displays were calculated and compared with the number of hops from the Pakistan server to the respondents' computers. With only one outlying score, two clusters of scores are noted (see Figure 4). The first cluster involves relatively few hops (1-16) and is related to fast loading times (50 milliseconds or less). The second involves the maximum number of hops (19-20 in the current study) and slow loading times of 60-136 milliseconds.

Figure 4. Browser loading speed versus server hops



Despite the above relationship between mean loading time and number of hops, no systematic relationship was observed between the loading times and the actual times taken by the traceroute routine at successive hops. Numerous traceroutes in the study failed to locate their targets at all, probably because of blocks placed upon incoming traceroute requests by the target networks. No reliable generalizations can be made on this in the absence of tests between every institution in the network. Other factors affecting the results may have included packet loss, latency, and the use of the default traceroute setting for the maximal time allowed for measuring each hop. Further studies should be conducted to determine more reliable criteria for hop measurement in specific situations.

Conclusions and Recommendations

Despite the shortcomings of the traceroute measurement method, the follow-up study has yielded promising evidence linking the complexity of Internet routes to the slow webpage loading times observed in the previous two studies. Geographical distance bears no relation to traceroute complexity, for signals between cities relatively close to one another (e.g., Lahore and Islamabad, Beijing and Ulaanbaatar) can traverse several continents before finally reaching their targets. Even signals between computers in the same city (e.g., Phnom Penh in Cambodia) are routed through Vietnam. The reasons for a complex Internet routing have more to do with the availability of adequate routes in the region. Traceroute analyses reveal the need for new Internet routes and Internet Exchange Points (IXPs) in specific geographical areas, and also demonstrate the locations (e.g., Singapore and Hanoi) currently acting as major hubs for Asian Internet traffic. Educational institutions wishing to improve the efficiency of their online communications can use this information in establishing mirror Web servers.

Although well known to computer specialists, such network analysis methods are relatively unfamiliar to educators. In order to overcome the current inaccessibility of Web materials in developing countries (i.e., slow loading times of browser-based courseware, unreliable email delivery, etc.), distance educators should study such data in order to identify constantly evolving solutions. The next report in this series will analyse the relative efficiency of online communications among the 12 Asian countries in the PANdora network, and between the network's major open learning institutions.

Acknowledgements

For advice and assistance in this study, the authors are grateful to their colleagues across the PANdora research network, to Jon Hamel for programming input, Ehsen Puri, Network Executive at the Virtual University of Pakistan, and Steve Song, Manager of the IDRC's ICT4D Africa Programs. Map template used with permission, courtesy of http://www.theodora.com/maps/. The project was conducted with financial support from the Pan Asia Networking (PAN) Program Initiative of the International Development Research Centre (IDRC), under a grant to the Virtual University of Pakistan (VUP) for the project 'PANdora: Distance and Open Resource Access.'

References

Moss, J. (1997). Understanding TCP/IP, Part 1. Article published on the *PC Support Advisor* website. Retrieved May 22, 2007 from: http://www.pcsupportadvisor.com/c04100.htm

Nielsen, J. (2007, March 1). The need for speed. Article published on *useit.com: Jakob Nielsen's Website.* Retrieved April, 22, 2007 from: http://www.useit.com/alertbox/9703a.html

---

N.B. Owing to the speed with which Web addresses are changed, the online references cited in this report may be outdated. They can be checked at the Athabasca University software evaluation site: http://cde.athabascau.ca/softeval/. Italicised product names in this report can be assumed to be registered trademarks.

JPB. Series Editor, Technical Evaluation Report

SOME RIGHTS RESERVED

Athabasca University