Chapter 14

MOBILE LEARNING

Small devices, Big issues

Mike Sharples, Inmaculada Arnedillo Sánchez, Marcelo Milrad, Giasemi Vavoula
Affiliations: various

Abstract: Over the past ten years mobile learning has grown from a minor research interest to a set of significant projects in schools, workplaces, museums, cities and rural areas around the world. Each project has shown how mobile technology can offer new opportunities for learning that extend within and beyond the traditional teacher-led classroom. Yet, the very diversity of the projects makes it difficult to capture the essence of mobile learning or to show how it contributes to the theory and practice of education. In this chapter we attempt to address the central issues of what is mobile learning and how can we design and evaluate it. Drawing on a theory of mobile learning as 'the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies' (Sharples et al. 2007) we shall discuss how learning contexts are created through interaction, and how portable and ubiquitous technologies can support effective conversations for learning. We shall draw on the findings from recent major projects to show how people artfully engage with their surroundings, peers and technology to create impromptu sites of learning and to carry their conversations from place to place, from time to time, from topic to topic.

Key words:

1. INTRODUCTION

The foundations for mobile learning were laid over thirty years ago with the far-sighted Xerox Dynabook project that proposed a "self-contained knowledge manipulator in a portable package the size and shape of an ordinary notebook" which would allow children to explore, create and share dynamic games and simulations (Kay, 1972). This project led directly to the

development of personal computing and can be seen as an enduring success of research in technology enhanced learning. However, the early innovations were desktop-based and it is only over the past ten years that mobile learning has developed as a set of significant projects in schools, workplaces, museums, cities and rural areas around the world. These projects range from providing revision questions to children by mobile phone (BBC Bitesize Mobile[1]), through small group learning in classrooms using handheld computers (MCSCL from Pontificia Universidad Católica de Chile (Zurita and Nussbaum 2004)), to context-sensitive learning in museums and workplaces (MOBIlearn European Project (Brugnoli et al. 2007)).

We are in an age of personal and technical mobility, where mobile devices, including PDAs, phones, and MP3 players are carried everywhere. We have the opportunity to design learning differently: linking people in real and virtual worlds, creating learning communities between people on the move, providing expertise on demand, and supporting a lifetime of learning. In order to understand how people learn through a mobile, pervasive and lifelong interaction with technology, we need to understand the implications of learning with mobile technology and build an appropriate theory of education for the mobile age.

The Kaleidoscope Network has made a substantial contribution to exploring the issues arising from learning with mobile technology. In June 2006, a workshop at Nottingham, UK, brought together leading European researchers to explore six major issues of theory, design and evaluation. The workshop, and its subsequent report on Big Issues in Mobile Learning (Sharples, 2007), sparked a discussion that has continued through the Kaleidoscope Mobile Learning SIG.

This chapter explores these issues under three broad themes: "what is mobile learning", "designing mobile learning" and "evaluating mobile learning". A selection of mobile learning projects is discussed within the context of these themes to show the range of European research on mobile learning and the issues they present for education and technology design.

2. WHAT IS MOBILE LEARNING?

There is little to connect delivery of location-based content on mobile phones with group learning through handheld computers in the classroom, apart from a reliance on handheld devices, so early definitions of mobile learning were anchored on the use of mobile technology:

[1] http://www.bbc.co.uk/schools/gcsebitesize/mobile/

> "It's elearning through mobile computational devices: Palms, Windows CE machines, even your digital cell phone." (Quinn 2000)

The focus on the technology does not help in understanding the nature of the learning. It also overlooks the wider context of learning as part of an increasingly mobile lifestyle. While discovering a city during short break vacation a tourist might, for example, learn from: a travel internet site on a home desktop computer, a phone conversation to a friend who has visited the city, a travel magazine and promotional video on the plane flight, a Google map of the city on a mobile phone, an interactive multimedia guide in the tourist information office, printed brochures, and handheld audio guides in the tourist locations. It is the combined experience that constitutes mobile learning. In trying to unpack the 'mobile' in mobile learning one will find:

- Mobility in physical space: people continually on the move trying to cram learning into the gaps of daily life or to use those gaps to reflect on what daily life has taught them. The location may be relevant to the learning, or just a backdrop.
- Mobility of technology: portable tools and resources are available to be carried around, conveniently packed into a single lightweight device. It is also possible to alternate between different devices, moving from the laptop to the mobile phone, to the notepad.
- Mobility in conceptual space: learning topics and themes compete for a person's shifting attention. A typical adult undertakes eight major learning projects a year (Tough 1971) as well as numerous learning episodes every day, so attention moves from one conceptual topic to another driven by personal interest, curiosity or commitment.
- Mobility in social space: learners perform within various social groups, including encounters in a family, office, or classroom context.
- Learning dispersed in time: learning is a cumulative process involving connections and reinforcement among a variety of learning experiences (Dierking et al. 2003), across formal and informal learning contexts.

Research into mobile learning is the study of how the mobility of learners augmented by personal and public technology can contribute to the process of gaining new knowledge, skills and experience.

The next section proposes a theory of mobile learning. The work is based on a series of discussions amongst members of the Kaleidoscope Philosophy of Technology Enhanced Learning SIG, and by detailed written responses from the members of the group to a series of published papers (Sharples et al., 2005; Taylor et al., 2006; Sharples et al., 2007).

3. A THEORY OF MOBILE LEARNING

The theory of mobile learning described here summarises and also extends the account published in Sharples et al. (2007). It puts mobility and context as the objects of analysis. Rather than assuming that learning occurs within a fixed location, such as a classroom, over a bounded period of time, it examines how learning flows across locations, timed, topics and technologies. The strategies and opinions we form in childhood influence the way we come to understand in later life. The learning undertaken in one context, such as informal discussion, can become a resource for other contexts, such as a seminar or a workplace. Learning activities and the technologies used to enact them are interleaved, so that we maintain our long-term projects and our familiar personal devices, while also picking up incidental ideas and ready-to-hand tools as we pass through the day.

Context is a central construct of mobile learning, not as a container through which we pass like a train in a tunnel, but as an artifact that is continually created by people in interaction with other people, with their surroundings and with everyday tools. Traditional classroom learning is founded on an illusion of stability of context, by setting up a fixed location with common resources, a single teacher, and an agreed curriculum that allows a semblance of common ground to be maintained from day to day. If all these are removed, then a fundamental challenge is how to form islands of temporarily stable context to enable meaning making from the flow of everyday activity.

Following Dewey (1916) and Pask (1976), we propose that the fundamental processes by which we achieve this meaning making are exploration and conversation. These are the means by which we come to understand the world and our knowledge of it. We make distinctions between elements of experience (hot/cold, friendly/unfriendly, freedom/authority) which we label, explore and discuss, with ourselves as we refine our knowledge and with others as we move towards agreed understandings by shared discovery and discussion.

Exploration is essentially mobile in that it either involves physical movement or movement through conceptual space, linking experiences and concepts into new knowledge. Conversation is the bridge that connects learning across contexts, whether through a discussion that builds on ideas formed in different settings, or from a phone call between people in different locations, or by making a note to oneself that can be read at a different time or place.

The role of technology in these explorations and conversations is to form a distributed system of meaning making. At a first level of analysis we shall make no distinction between people and interactive technology, instead

examining how the human-technology system enables knowledge to be created and shared in a continual process of coming to know through the construction and distribution of shared external representations of knowledge. For example, Wikipedia is a massively distributed system for the construction of shared meaning out of differing perspectives and opinions. The technology of Wikipedia does not stand apart as a medium of inscription, rather it is an active participant in the process, enabling certain forms of activity and constraining others.

Proposing symmetry between people and technology, however, raises tensions concerning the legitimate place of technology in learning and the privileged role of human knowledge and activity. These demand to be explored, not only to claim a central role for the human teacher, but also to determine the ethics of mobile learning, such as who owns the products of conversational learning (such as online discussions, or Wikipedia pages) and what are the rights of children, and adults, to be free from continual engagement with educational technology. Technology can become a constant companion and guide to learning; it can also continually monitor activity so that our every movement and conversation is stored and assessed as part of a lifelong record of achievement. If learning is continually mobile and evolving then it is also continually provisional. How can we distinguish between the intimacy of coming to know and the need to publicly record and register our attainments?

So, we come to a characterization of mobile learning as the processes (both personal and public) of coming to know through exploration and conversation across multiple contexts amongst people and interactive technologies. This analysis is not at odds with learning as knowledge construction or learning as a tool-mediated socio-cultural activity (Engeström, 1996). Indeed it draws on these conceptions to examine how knowledge is constructed through activity in a society that is increasingly mobile. Nor does it negate learning in formal settings. Conversation and context are essential constructs for understanding how mobile learning can be integrated with conventional education. Mobile learning offers new ways to extend education outside the classroom, into the conversations and interactions of everyday life.

4. DESIGNING MOBILE LEARNING

As can be seen from the previous section, a central task in the design of technology for mobile learning is to promote enriching conversations between learners and teachers within and across contexts. This involves

understanding how to design technologies, media and interactions to support a seamless flow of learning across contexts, and how to integrate mobile technologies within education to enable innovative practices.

The design of mobile technology for learning has much to learn from interaction design research (e.g. Jones & Marsden, 2006), which offers general principles for human-computer interaction on mobile devices. These have been supplemented by more specific findings from mobile learning projects (Naismith and Corlett, 2006):

- create quick and simple interactions;
- prepare flexible materials that can be accessed across contexts;
- consider special affordances of mobile devices that might add to the learner experience (for example, the use of audio; or employing anonymity of the user);
- use mobile technology not only to 'deliver' learning but to facilitate it, making use of the facilities in current mobile devices for voice communication, note-taking, photography, and time management.

The design of mobile learning activities should be, like the design of any learning activity, driven by specific learning objectives. The use of (mobile) technology is not the target; rather, it is a means to enable activities that were otherwise not possible, or to increase the benefits for the learner(s). It is possible that the use of mobile technologies is suitable for only a part of the learning activity, whereas other parts are better supported by other technologies or even by no technology at all, as will be shown in the case studies.

One design challenge is to enrich the learning conversations and enhance the learner experience without interfering with it (Beale, 2007). A key issue is attention. Having to change the focus of attention from the surrounding world to a handheld device can at best be distracting and at worse dangerous (such as the hazard of walking while gazing at the screen). To counter this, a number of projects have reported the benefits of short audio presentations to enhance or interpret the surroundings, for example by telling the story behind a museum exhibit or tourist site (see e.g. Naismith, Sharples & Ting, 2005; Bradley, Haynes and Boyle, 2005).

Technology is not always used for the activities it was intended. Young people are appropriating technology originally designed for adult work (such as SMS text messaging and media file sharing) into their social world. This is already having deep implications for learning. For example, why would people need to memorise facts when they can look them up on Google? And what are the implications for copyright, authorship and plagiarism when young people can so easily capture, share and publish their experiences (and

those of other people) as they go about their daily lives? Until recently, the activities of instant messaging, file sharing and social networking have been mainly restricted to home computers and internet cafes, but some countries such as South Korea (ConsumerEase Publishing, 2006) have already adopted mobile networking and the next generation of personal devices will support collaboration and context awareness. An issue for schools is how to accommodate children bringing into the classroom not only powerful personal technologies, but also new and disruptive skills of informal collaboration and networked learning.

Reigeluth (1999) describes an instructional design theory as one that offers explicit guidance on how to help people learn and develop. An instructional design theory for mobile learning has not yet been fully articulated, however, the theory of mobile learning discussed above suggests mobile learning instructional design should:

- support learners to reach an understanding through conversations,
- use technology to enrich learners' conversations with other learners and teachers, and
- support learners' transitions across learning contexts.

Naismith and Corlett (2006) identified five critical success factors for mobile learning which offer further detail to the principles above, drawn from projects described in the proceedings of the mLearn conferences from 2002-2005. These are:

- *Access to technology*: The successful projects make mobile technology available where and when it is needed, either by developing for users' own devices such as phones and media players, or by providing learners with devices that they can use at home and on the move.
- *Ownership*: It is important that learners are able to either own the technology, or to treat it *as if* they own it. Using the technology for entertainment and socializing does not appear to reduce its value as a tool for learning, but rather helps to bridge the gap between institutional and personal learning.
- *Connectivity*: Many successful mobile learning projects have been based on wireless or mobile phone connectivity, to provide access to learning resources, to link people across contexts, and to allow students to capture material that can be sent to a personal media space and then shared or presented.
- *Integration*: Successful mobile learning projects are integrated into the curriculum, the student experience, or to daily life, or a combination of all of these. One way to achieve this integration is to extend a successful form of learning onto mobile devices, such as Frequently Asked

Questions, or audio/Powerpoint recordings of lectures. Another approach is to provide mobile technology that augments the student experience, for example by mobile tools such as 'moblogs' (mobile weblogs) to maintain an electronic portfolio or record of learning.

- *Institutional support*: Although a major benefit of mobile technology is "the ability to put control in the hands of the learner" (Naismith and Corlett, *op. cit.*) successful projects also need strong institutional support, including the design of relevant resources in mobile format, staff training and technical support.

These success factors were identified largely from observations of critical incidents in pilot projects. In the next section we indicate some issues and possible solutions to moving beyond an inventory of successes and failures towards a systemic evaluation of mobile learning.

5. EVALUATING MOBILE LEARNING

Evaluation is a central activity in the lifecycle of interactive systems design. When performed in the course of design and implementation, formative evaluation serves as a means to inform design. When performed after system deployment, summative evaluation offers a systematic way to assess the effectiveness of the system and the learning it enables. These are already big goals that evaluation has to achieve. Mobile learning poses additional challenges for evaluation of both the technology and the learning.

5.1 Unpredictable context of use

Evaluation methods for static technologies are based on the assumption that the context of use is fixed and well defined. In the case of mobile learning, however, the context of use can vary significantly, for example, the ergonomics (user posture, lighting, and background noise), social context, and demands on the user's attention. Moreover, mobile contexts of use are often impromptu and are thus difficult to observe, predict or simulate. Taylor (2006) sums up this challenge:

> "the mobile environment is eminently suited to supporting learning outside the context of curricula, institutions and timetables. Our potential subjects of study may be wandering around studying things that interest them, at times that suit themselves, with little or no concern for consistency."

New methods of assessing the usability and usefulness of mobile technology include automatically generated datalogs that can be 'data mined' to reveal patterns of activity, such as the time and location where events occurred (Romero & Ventura, 2007). Another approach is to take advantage of the technology and for the evaluator to regularly phone or text users to enquire about their current activity [Reference needed].

5.2 Unpredictable learning process

Another complication is that mobile learning blurs the distinction between formal and non-formal learning. Children have always been able to bring homework into the classroom for assessment or bring in a personal or found object, such as a leaf or a stone, to illustrate a lesson, but now they can systematically capture their experience of learning outside the classroom, through images, notes and audio recordings. Traditional assessment methods are not appropriate for accrediting learning not directly related to the curriculum or done through informal collaboration.

New methods of assessment are being developed around e-portfolios where learners compile multimedia records of their learning activities outside the classroom (Hartnell-Young & Vetere, 2007). While this is an attempt to recognize and assess the value of non-curriculum learning it also raises profound issues of the legitimate scope of formal education. Where does school end? When can a child just delight in learning for its own sake without having to present the results for school assessment?

5.3 Unpredictable mode of use

Technology for mobile learning is designed to aid the practice of learning, however this same technology may also change and affect practice. The way a technology is used cannot be determined until it is actually used by real people in real settings. Often the way people adopt a piece of learning technology is not the same as was intended by the designers. Tools that enable users to do new activities may change the way users perceive and practise old activities; and may give rise to additional, unpredicted patterns of learning. An essential task of evaluation thus is to look at how new tools and services are appropriated by people in their everyday learning practice (Waycott, 2004).

5.4 Looking beyond the 'wow' effect

Evaluations of mobile learning systems and applications often show that learners, children and adults alike, enjoy using mobile devices for learning and report increased motivation as a result of this use. Jones et al. (2006) have initiated a discussion through the Kaleidoscope SIG on the role of affect in mobile learning. They propose an initial set of factors that contribute to the high affective value of mobile learning: control over goals, ownership, fun, communication, learning-in-context, and continuity between contexts. Specifying the attributes that make mobile devices 'cool' for learning and understanding how best to exploit these attributes is also an issue worthy of further investigation. Thus, in the context of mobile learning evaluation, the effort should also be to see beyond the initial 'wow' factor associated with the technology, into how effective this is in engaging the learner over the longer term.

5.5 Seeing the bigger picture

We argued earlier that supporting mobile learning is about supporting people to continue their learning conversations across contexts. It is important, therefore, that evaluation explores how well these conversations and transitions are supported and their consequences for learning. At the same time, it is important to assess the impact of the new technology on previously established learning contexts and practices.

6. MOBILE LEARNING EXEMPLARS

In this section we describe three exemplars of mobile learning that show how children can be helped to explore the physical environment, how learning can be supported across contexts, how handheld technology can enable conversations for learning, and how new methods of evaluation can reveal the practices and outcomes of learning outside traditional settings.

6.1 MyArtSpace: Learning with phone technology on museum visits

MyArtSpace project was a year-long project funded by the UK Department of Culture Media and Sport to develop and evaluate mobile technology for school students on field trips to museums and art galleries. It has been deployed in three museums for a year-long trial during which over 3000 school students used the service, on organised visits from local schools. The

aim of the project was to address a well-recognised problem (Guisasola, Morentin and Zuza, 2005) of the lack of connection between the school visit and any preparation and follow-up in the classroom.

MyArtSpace enabled students to produce their own interpretation of a visit through pictures, voice recordings and notes that they can examine back in the classroom. The activity typically started with a 'key topic' in a pre-visit classroom lesson to guide and motivate the students in a process of inquiry-led learning during the trip, as they collect and interpret evidence to address the question..

On arriving at the museum, the students are loaned multimedia phones running a Java application that allows them to capture photos, notes and audio recordings. These are sent automatically via the GPRS phone network to a personal website that provides a multimedia 'weblog' of the visit. The students can also view short presentations on museum exhibits by typing in a two-letter code shown beside the exhibit which are also recorded in the weblog. Back in the classroom, they can view the material they collected and produced during the visit, as well as the other students' collections and further material provided by the museum. They then use a basic presentation tool to add captions to the images and to form the material into individual or shared presentations that form their responses to the key topic.

The evaluation methods included: one-to-one interviews with the teachers; focus group interviews with students; video observations of the pre-visit lesson, museum visit and post visit lesson; attitude surveys; and telephone or email interviews with other stakeholders. Three MyArtSpace visits were observed, of a first prototype and in months one and eleven of the year-long deployment. In general, the system worked well, with the phones offering a familiar platform, the two letter code providing an easy way to activate multimedia in context, and the transmission of data taking place unobtrusively after each use of the photo, audio or note tool. The teachers indicated that their students engaged more with the exhibits than in previous visits and had the chance to do meaningful follow-up work.

A significant educational issue was that some students found difficulty in identifying, back in the classroom, pictures and sounds they had recorded. The time-ordered list of activities and objects they had collected provided some cues, but there is a difficult trade-off between structuring the material during the visit to make it easier to manage (for example by limiting the number of items that can be collected) and stifling creativity and engagement.

Although the system was a success at the technical and educational levels, there is a significant impediment to wider deployment of a system like MyArtSpace. Understandably, museum staff need to spend their time curating exhibits and guiding visitors rather than maintaining technology.

There is also the issue of who pays for the GPRS charges: schools, museums, or students and their parents? MyArtSpace may be an indicator of the next generation of mobile technology, when people carry converged phone/camera/media player devices that can capture everyday sights and sounds to a personal weblog. Then, the opportunity for schools will be to exploit these personal devices for learning between the classroom and settings outside school including field trips and museum visits.

6.2 The AMULETS Project: Bridging Outdoors and Indoors Classroom Activities Using SmartPhones, PDAs and GPS Devices

The AMULETS (Advanced Mobile and Ubiquitous Learning Environments for Teachers and Students) project explored how to design, implement and evaluate innovative educational scenarios combining outdoors and indoors activities supported by mobile and ubiquitous computing. We argue that the design of innovative mobile learning activities should be guided by collaborative learning scenarios in context supported by mobile and ubiquitous technologies in authentic settings. To illustrate these ideas, we present the results of two trials we have conducted with Swedish children since the spring 2006.

The first trial took place in June of 2006 in an elementary school while the second trial occurred the following December, in the town square with the same school. For these two trials, fifty-five elementary school children performed remote and co-located activities equipped with Smartphones, PDAs, GPS devices, and stationary computers in the subjects of natural sciences, history and geography. The educational scenarios consisted of different stages with game-like features. At the end of the learning sessions, all these activities were reconstructed in the classroom using several visualization tools such as digital maps. These types of activity provide new opportunities for children and teachers to review and to continue the learning experience in the classroom, thus supporting different aspects of learning such as exploration, discussion, negotiation, collaboration and reflection.

In the first trial the theme of the scenario was learning about “the forest” and in the second trial “the history of the city square through centuries”. In the forest scenario conducted in the spring 2006, twenty-six 4th grade students (10-11 years old) took part, working in 7 groups. The activities were conducted over a two-day period with only one group performing at a time. The active challenges for the children were based on exploring the physical environment, identifying different types of trees and measuring the height and age of trees. Part of the children’s tasks was to record still images

and video clips using the smartphones detailing how they solved the problems. This co-created content was automatically encoded with metadata, containing attributes such as GPS coordinates, time stamp, and the phone ID which provided rich contextual information for later use in the classroom. Pedagogical coaches provided the children with practical support in using techniques to measure the height of trees. Additionally, animated characters delivered location-specific content.

In the city square trial, conducted in the fall of 2006, twenty-nine 5th grade students (11-12 years old) participated. They worked in three groups, with each group divided into two subgroups of five students. One subgroup worked in the local museum and the second group operated in the field, the square. For this second trial we introduced collaborative missions in order to provide the children with challenging problems. In order to solve them, children at the museum and in the field were required to collaborate using a number of mobile tools including an instant text messaging system that allowed communication between the smartphones in the field and the stationary computers at the museum. A narrative journey backwards in time related to the square's history was supported by animated characters and video clips delivered to the smartphones, thus providing the contextual information that was needed in order to accomplish the challenges in the different missions.

In order to assess the result of our efforts, we used several techniques for data collection including questionnaires and interviews with the children, students, and teachers, as well as observation protocols and data stored files. The questionnaires were used mostly to evaluate usability aspects, while the interviews with children, students and teachers where used to evaluate the educational aspects of the trial. The digital content generated during the trials was saved on a digital repository and we have used those data in different ways in our activities and analysis. In the first trial the stored data have been used for reconstruction of the field activity in the classroom settings. In the second trial the server log files have been used to trace the messages exchanged between the indoor and outdoor subgroups to investigate the collaboration that occurred between these subgroups. Kurti et al., (2007) provide an elaboration of these results.

As mentioned earlier in this chapter, mobile and ubiquitous technologies offer the potential for a new phase in the evolution of technology-enhanced learning, marked by a continuity of the learning experience across different learning contexts. Chan and colleagues (2006) use the term "seamless learning" to describe these new situations. In this section we have presented two examples in which we have implemented seamless learning spaces by augmenting physical spaces with information exchanges as well as using

geospatial mappings between the mobile device and the real-world that facilitate navigation and context-aware applications.

6.3 Digital Narrative: Collaborative 'Film' Making with Mobile Phone Technology

The Digital Narrative (DN) Project (Arnedillo Sánchez & Tangney, 2006) embodies an approach to support creative collaboration with mobile technologies. It involves participants creating a movie entirely shot on mobile phones. The aim is to complete a one-to-three minute movie, from idea generation to final production, in four hours.

The project builds on work in Digital Film Making (DFM) (Burden & Kuechel, 2004) in schools and a Functional Framework for mobile learning arguing for collaborative, constructionist and contextual applications (Patten et al., 2006). DFM facilitates communication, negotiation, decision making skills (Burn et al., 2001), encourages creativity (Reid et al., 2002) and draws on students' out-of-school interest (Parker, 2002). However, access to technology and the need to invest substantial time hinder its adoption in schools. Additionally, technology dependent activities such as filming and editing, though offering the greatest learning benefits (Becta, 2003), are impractical as group activities. The DN project utilises mobile technologies to retain the learning benefits of DFM whilst addressing its reported shortcomings.

The DN process was developed iteratively by running pilot workshops in settings that included teenagers from Dublin and shantytowns in Cape Town. The technology for the project comprises camera phones, notebook computers, a concept-mapping tool to scaffold the story creation, editing software, and portable projectors to project the collaborative editing process and the final movies. These make up a 'knapsack lab' that provides flexibility in terms of where the workshop takes place.

After collaborative face-to-face generation of the storyline (facilitated by a concept-map template), participants are divided into three groups: image (in charge of 'shooting'), sound (in charge of recording dialogues and sound effects) and editing (in charge of assembling the 'film'). With the 'script' (concept-map) in hand, the image and sound group separately go on location, while the editing group stays in the editing-station. As the media is captured it is transferred via MMS to the editors who start editing shortly after the crews arrive on location. When crew and cast are back in the editing-station, the first version of the Digital Narrative is ready for viewing. This is followed by 'targeted' shooting and recording as needed. Final editing and production take place face-to-face as a whole group activity.

Over two years 36 DN workshops with over 200 participants, including young children, teachers, teenagers, postgraduate students and researchers, have been conducted. Findings confirm the approach tackles the issues of access to technology and time investment. All the groups completed a DN in approximately four hours. The work-flow structure and labour division, together with the affordances of mobile technologies, enable parallel activities of shooting and editing, resulting in synchronous collaboration. Participants experience the benefits of lengthier DFM processes and teachers reported it as being practical, hands-on learning. The activities produced rich conversations across contexts as the participants negotiated how the images and sounds could be captured on location then formed into a coherent movie.

Technical problems included delays in MMS transfer and cumbersome use of multiple applications. We are addressing these by developing a DN application (Arnedillo Sánchez & Byrne, 2007) (mobile and PC versions) that seamlessly supports the process and automates media management and transfer. Cost issues are being addressed by providing alternative data transfer mechanisms and we see the Digital Narrative project as a viable alternative to DFM in schools. This project, like others that use readily available and affordable mobile technology, presents cost effective solutions that can help to democratize learning experiences.

7. CONCLUSIONS

Ten years of research into mobile learning has revealed no single 'killer application' for mobile technology in learning, but instead has offered a set of promising scenarios such as those described in the examplars. Others include the use of graphing calculators and handheld response systems in classrooms, the use of PDAs to structure small group working, handheld tools for basic learning including foreign language and numeracy skills, and handheld tourist guides.

A more general consequence of the research into mobile learning has been to open a debate about the nature of learning within and outside the classroom. Focusing on the mobility of learners and learning reveals assumptions and tensions in technology-enhanced learning. Until now, almost all research into TEL has assumed that learning occurs in the classroom, mediated by a trained teacher. Even iconoclasts such as Papert saw technology as a means to reform and extend school education (Papert, 1980). Yet, that has implicitly excluded the design of technology for informal and serendipitous learning.

One major opportunity is to support a person through a lifetime of learning, providing young children with tools to capture and organise their

everyday experiences, to create and share images of their world, and to probe and explore their surroundings. As they mature, these 'life blogs' can be extended with tools to support personal projects, such as learning languages, sports and hobbies. In old age they become storehouses of memories and aids to remembering people and events. Such technology is not only a technical challenge (for example, maintaining and organizing a useful database of experience over a lifetime) but it also raises deep philosophical, social and ethical issues. Will the technology become a seamless extension of human cognition and memory? What experiences will people want to capture, and how will they erase them? What is the legitimate sphere of parents, formal education and the state in managing and assessing children's mobile learning?

Tensions are already arising between the two spheres of traditional context-bound education and non-formal mobile learning. One future scenario is of schools being unable, or unwilling, to adapt to the new patterns of learning and social interaction outside the classroom, with young people seeing school learning as irrelevant to their skills and interests. The technology will be a focus for that conflict, with schools banning powerful tools for personal learning and social networking while struggling to provide computers that deliver an outdated form of didactic teaching. A very different future scenario is of formal education adapting to the new technologies and opportunities. Children will learn how to adapt their social networking practices to the school environment, supported by tools for teamworking and collaborative learning. Schools will save costs from students bringing their own technologies and will gain from building on students' skills of networked learning. As converged computer/phones become standard consumer products, they will bridge the 'digital divide' and schools can afford to loan additional devices to children who do not own them.

These futures are not at the whim of commercial or social forces; the mobile learning research community has already had a major role in defining the scope of the field, and providing exemplars of successful, and unsuccessful, applications of learning with mobile technology. The Kaleidoscope Network has set an agenda for research into the co-evolution of learning and technology that is not merely a response to the pressures of society, governments and the technology industry, but an attempt to shape a more expansive and inclusive landscape of learning.

REFERENCES

Arnedillo Sánchez, I., & Byrne, P. (2007). A Software Tool to Support Digital Video Production. *Paper presented at the CAL'07 Developement, Disruption & Debate*, Dublin.

Arnedillo Sánchez, I., & Tangney, B. (2006). Mobile Technology Towards Overcoming Technology & Time Constrains in Digital Video Production. In P. Isaias, P. Kommers & I. Arnedillo-Sánchez (Eds.), *Mobile Learning 2006* (pp. 256- 259). Dublin: International Association for Development of the Information Society Press.

Beale, R. (2007) How to enhance the experience without interfering with it? In M. Sharples (ed.) *Big Issues in Mobile Learning: Report of a Workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative*. Nottingham: Learning Sciences Research Institute.

Becta. (2003). *What the research says about digital video in teaching and learning*. Conventry: Becta.

Bradley, C., Haynes, R. & Boyle, T. (2005). Adult Multimedia Learning with PDAs - The User Experience. In H. van der Merwe & T. Brown, *Mobile Technology: The Future of Learning in Your Hands*, mLearn 2005 Book of Abstracts, 4th World Conference on mLearning, Cape Town, 25-28 October 2005. Cape Town: mLearn 2005, pp. 23-27.

Brugnoli, M.C., Morabito, F., Bo, G. and Murelli, E. (2007). "Augmented Itineraries": Mobile services differentiating what museum has to offer. *PsychNologoy Journal,* 4(3): 311-335.

Burden, K., & Kuechel, T. (2004). *Evaluation report of the Teaching and Learning with Digital Video Assets Pilot 2003-2004*. Coventry: Becta.

Burn, A., Brindley, S., Durran, J., Kelsall, C., Sweetlove, J., & Tuohey, C. (2001). The rush of images: a research report into digital editing and the moving image. *English in Education*, 35, 34-47.

Chan, T-W., Roschelle, J., Hsi, S., and 17 others (2006). One-to-One Technology-Enhanced Learning: An Opportunity for Global Research Collaboration. *Research and Practice in Technology Enhanced Learning Journal*. Volume 1(1) (2006): 3-29, World Scientific Publishing Company & Asia-Pacific Society for Computers in Education.

ConsumerEase Publishing (2006). *South Korean Mobile Data White Paper*. http://5myths.com/Publishing/Whitepapers/SKorea/All.aspx. Accessed 28th August, 2007.

Dewey, J. (1916). *Democracy and Education*. New York: Free Press.

Dierking, L.D., Falk, J.H., Rennie, L., Anderson, D. and Ellenbogen, K. (2003). Policy statement of the "informal science education" ad hoc committee. *Journal of Research In Science Teaching* 40(2): 108-111.

Engeström, Y. (1996). *Perspectives on activity theory*. Cambridge: Cambridge University Press.

Guisasola, J., Morentin, M., and Zuza, K. (2005) School visits to science museums and learning sciences: a complex relationship. *Physics Education*, 40, 6, pp. 544-549.

Hartnell-Young, E., & Vetere, F. (2007). ePortfolios capturing learning on the move. In Kankaanranta, M., Grant, A. & Linnakylä, P. (Eds.). *e-Portfolio: Adding Value to Lifelong Learning*. University of Jyväskylä, Finland. Institute for Educational Research and Agora Center. pp 155-174.

Jones, A., Isroff, K., and Scanlon, E. (2006). Affective factors in learning with mobile devices. In Sharples (2006) (ed). *Big Issues in Mobile Learning: Report of a workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative*, University of Nottingham, pp 14-19.

Jones, M. & Marsden, G. (2006) *Mobile Interaction Design*. Chichester: John Wiley and Sons Ltd.

Kay, A. C. (1972). A personal computer for children of all ages. *Proceedings of ACM National Conference*. Boston, Association of Computing Machinery.

Kurti, A., Spikol, D., & Milrad, M. (2007). (Forthcoming). Bridging Outdoors and Indoors Educational Activities in Schools with the Support of Mobile and Positioning Technologies. Accepted for publication at the *International Journal of Mobile Learning and Organization.*

Naismith, L., Sharples, M., & Ting, J. (2005) Evaluation of CAERUS: a context aware mobile guide. In H. van der Merwe & T. Brown, *Mobile Technology: The Future of Learning in Your Hands*, mLearn 2005 Book of Abstracts, 4th World Conference on mLearning, Cape Town, 25-28 October 2005. Cape Town: mLearn 2005, p.50.

Naismith, L. and Corlett, D. (2006) Reflections on Success: A Retrospective of the mLearn Conference Series 2002-2005. *Proceedings of MLEARN 2006 Conference*, 22-25 October 2006, Banff, Canada.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. Brighton, Harvester Press.

Parker, D. (2002). Show us a story: an overview of recent research and resource development work at the British Film Institute. *English in Education*, 36(1), 38-44.

Pask, G. (1976). *Conversation Theory: Applications in Education and Epistemology*.Amsterdam and New York: Elsevier.

Patten, B., Arnedillo Sánchez, I., & Tangney, B. (2006). Designing collaborative, constructionist and contextual applications for handheld devices. *Computers & Education*, 46(3), 294-308.

Formatted: English (U.K.)

Quinn, C. (2000) mLearning: Mobile, Wireless, in your Pocket Learning. *LineZine*, Fall 2000. http://www.linezine.com/2.1/features/cqmmwiyp.htm. Accessed 28th August, 2007.

Reid, M., Burn, A., & Parker, D. (2002). *Evaluation Report of the Becta Digital Video Pilot Project*. Coventry: Becta.

Reigleluth, C. M. (Ed.) (1999). *Instructional-design theories and models: A new paradign of instructional theory (Volume II)*. Mahwah, NJ: Lawrence Erlbaum Associates.

Romero, A.C. & Ventura, A.S. (2007) Educational data mining: A survey from 1995 to 2005. *Journal of Expert Systems Applications*, 33, 1,135-146.

Sharples, M., Taylor, J., & Vavoula, G. (2005) Towards a Theory of Mobile Learning. In H. van der Merwe & T. Brown, *Mobile Technology: The Future of Learning in Your Hands*, mLearn 2005 Book of Abstracts, 4th World Conference on mLearning, Cape Town, 25-28 October 2005. Cape Town: mLearn 2005, p. 58.

Sharples, M. (ed.) (2006) *Big Issues in Mobile Learning: Report of a Workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative*. Nottingham: Learning Sciences Research Institute.

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*. London: Sage, pp. 221-47.

Taylor, J.,Sharples, M., O'Malley, C., Vavoula, G., & Waycott, J. (2006) Towards a Task Model for Mobile Learning: a Dialectical Approach. *International Journal of Learning Technology*, 2, 2/3, 138 - 158.

Taylor (2006). Evaluating Mobile Learning: What are appropriate methods for evaluating learning in mobile environments? In Sharples (2006) (ed). *Big Issues in Mobile Learning: Report of a workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative*, University of Nottingham, pp 24-26.

Tough, A. (1971) *The Adult's Learning Projects: A Fresh Approach to Theory and Practice in Adult Learning*. Toronto, Ontario Institute for Studies in Education.

Waycott, J. (2004) *The appropriation of PDAs as learning and workplace tools: an activity theory perspective*. Ph D thesis, The Open University.

Zurita, G and Nussbaum, M (2004). Computer supported collaborative learning using wirelessly interconnected hand-held computers. *Computers & Education*, 42(3): 289-314