Chapter 8
Mobile Learning

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The Evolution of Research in Mobile Learning

Mobile learning has emerged as a field of research and development over the past decade. What differentiates it from other forms of technology-enhanced learning is a focus on mobility of the learner supported by a variety of personal and handheld technologies. By putting mobility as an object of analysis we may come to understand how interactions between people equipped with personal handheld devices such as smartphones and tablets can support flexible learning.

People move among locations, times, objects and social interactions. Even within a fixed setting such as a school, children move between classrooms, teachers, equipment, topics, and from individual to group working. Research into mobile learning can inform the design of software for smartphones and tablets, to help learners connect knowledge across settings such as school and home, and support a lifetime of learning in an increasingly mobile world.

The four selected papers illustrate the diversity and evolution of the field, from a focus on software for mobile devices, to embedding learning into everyday locations and the continuity of learning across locations. Early research into *wirelessly connected classrooms* with one device per child (Roschelle & Pea, 2002) led to exploration of new forms of classroom learning, with mobility between individual, group and whole class activity, supported by a combination of teacher and personal devices such as netbooks and tablet computers. A separate strand of research on

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mobile learning outside the classroom—in museums, galleries, workplaces and campuses—has examined how learning can be maintained across settings, such as between workplace and home, and how contexts for learning are continually created through interactions between learners, technologies, locations and social environments (Sharples, Taylor, & Vavoula, 2007). The technical challenges of providing 'anytime anywhere' access to learning materials have evolved into a consideration of *ubiquitous learning*, where learning comes from engagement with interactive and information-giving objects embedded in the environment (Ogata & Yano, 2004). These perspectives of mobility of activity in the classroom, mobility across locations, and ubiquitous learning, can be compatible. Recent work has explored how the notions of the mobility and ubiquity can be combined through the concept of *seamless learning*, where portable technologies support a continuity of learning across formal and informal settings including classrooms, non-formal learning environments such as museums, homes, and outdoors (Wong & Looi, 2011).

Handheld Devices in Classrooms

The first selected paper by Roschelle and Pea (2002) identifies an opportunity for wirelessly connected handheld computers (which they describe as Wireless Internet Learning Devices, or WILD) to enable new forms of learning through collaboration in the classroom. In their vision of the future classroom, students work towards shared understanding in groups, building joint representations of their knowledge through interacting with computer simulations, manipulable models of mathematics and science, and interactive diagrams. By connecting their devices to form a shared learning space, students can move easily from working individually on a problem to contributing towards a group solution, or they can explore their understanding by running a group simulation or collaborative learning game.

An example of this collaborative classroom in action is the Virus simulation game by Colella and colleagues at MIT Media Laboratory (Colella, 2000). They developed "participatory simulations" in classrooms using small custom wearable computers called "Thinking Tags". The aim was to give each child a personal experience of being a participant in a simulation of a dynamic system. Their best-known example was the Virus Game, where each child wore an electronic tag that that engaged them in the simulation of an epidemic. Though every tag appears the same, one of them starts the spread of a disease by simulating a virus. This spreads electronically from person to person as the children move closer to each other within the class. The tags then start to indicate symptoms, until over time the tags show that all the children are infected. The initiation, rate of spread and time till the symptoms appear can all be controlled so that the game can be repeated to explore aspects of viral behaviour. According to Colella (2000), the combination of people and tags form a digital ecology, where the devices run the simulation and the children can move around, interacting freely with each other, sending automatic messages between tags, exploring the consequences as the system unfolds.

This notion of a classroom ecology of learners and handheld technologies has been investigated by Nussbaum and colleagues in a series of studies of Mobile Computer Supported Collaborative Learning (Roschelle, Rafanan, Estrella, Nussbaum, & Claro, 2010; Zurita & Nussbaum, 2004). The approach is to explore how two networks can be combined to enable productive learning: the social network of children working together around a classroom table, and the technological network of their interconnected handheld computers which coordinates and supports the collaborative learning activity. Their studies have shown that students equipped with communicating handheld devices, running software to coordinate their learning activities, can learn effectively by solving a problem individually, then coming to agreement in a group, and then presenting their result to the teacher or class. The teacher also has software running on a handheld device that shows a "dashboard" of how each child and group is performing.

Learning Within and Across Contexts

A broad contribution of mobile learning research has been to probe some tacit assumptions of traditional education. One of these assumptions is that the physical context of learning is fixed and unproblematic, i.e. that children learn at desks in school classrooms or labs, supported by a teacher. We have come to understand that learning could occur anywhere, with or without the assistance of a teacher. Much of this everyday learning is not new: a discussion in the corridor, a chat at a party, a chance meeting in the street. But increasingly, these informal encounters are mediated by technology that offers both a source of information and an extension of the physical discussions into virtual spaces through social media and remote conferencing. For these to support learning, the opportunity of the moment needs to be captured, related to previous knowledge, and made available for recall at a later time and place. Mobile devices can assist by recording these encounters through sound and image, and also by preserving the context of learning, for example using the sensors on mobile phones to capture the time, location and possibly other data such as weather or movement.

Central to this theory of informal mobile learning is an examination of the continuity of learning within and across contexts. Within a classroom, the context is familiar and largely under the control of the school and teacher, providing standardized resources and facilities. Beyond the classroom the familiar context is removed, so learners (and where appropriate a teacher or mentor) may have to establish "micro sites" for learning (Vavoula & Sharples, 2009) in the form of ad hoc learning spaces, such as a patch of grass on a field trip, instrumented with appropriate technologies and resources. Learning not only occurs in a context, it also creates context through the continual interaction between learners, their technologies, resources (e.g. teachers, learning materials, experts), and locations, to achieve mutual understanding and shared goals (Boyle & Ravenscroft, 2012). For example, a group of people are standing in front of a painting in a gallery, discussing the artwork. They are creating a micro-site for learning through their situated discussion, bringing to the conversation their differing knowledge of art and their journeys to reach the painting. Thus, the common ground of learning is continually shifting as we move from one location to another, gain new resources, or enter new conversations. A challenge for mobile learning is to design mobile assistants that will enhance these context-dependent encounters without dominating or replacing the conversation as happens with the current generation of museum audio guides.

Architectures for Mobile Learning

From 2002, the European Commission funded a series of major research projects to explore mobile learning beyond the classroom. These projects, that included MOBIlearn[1] and M-Learning,[2] developed and evaluated technologies for learning in settings that included museums, university campuses, workplaces and the home. MOBIlearn was an ambitious project, involving 24 partners from academia and industry, to develop, implement, and evaluate a computer systems architecture for mobile learning, based on theories of informal and context-dependent learning (Da Bormida, Bo, Lefrere, & Taylor, 2003). The Open Mobile Access Abstract Framework (OMAF) was a general architecture for mobile learning services such as user registration and messaging, management of content, and specific tools for mobile interaction and context awareness. The services could be distributed across the web and were accessed through a portal that adapted to mobile devices including mobile phones, PDAs and tablet computers. The MOBIlearn system was implemented and tested with three scenarios in a museum, workplace and campus setting.

For the museum setting, the MOBIlearn project developed a context-based museum and gallery guide (Lonsdale, Baber & Sharples, 2004), using ultrasonic location sensing accurate to within 10 cm indoors. The information it offered depended on the user's location, path, interests and time at the location. As the visitor walked past a painting, the guide mentioned its title and artist. If the user stopped for a few seconds at a painting, the guide offered a short description. After a longer wait, the guide indicated interesting features of the painting—a feature intended to prompt discussion among groups of visitors.

Other European projects developed support for vocational education and training using mobile phones to deliver learning content. From all these projects came an extended conception of mobile learning as "Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies" (O'Malley et al., 2003).

[1] http://cordis.europa.eu/pub/ist/docs/ka3/mobilearn.pdf.

[2] http://cordis.europa.eu/project/rcn/58411_en.html.

Learning in a Mobile World

The second selected paper, by Sharples et al. (2007), is the culmination of a study within the MOBIlearn project to understand learning in a world of technology-enhanced mobility. It draws on theories of learning as conversation (Pask, 1976), learning through context (Westera, 2011), and learning as a cultural historical practice (Engeström, 1996), to propose a framework for understanding mobile learning as a tool-mediated process of coming to know across continually changing contexts.

The paper distinguishes what is special about mobile learning compared to other types of learning activity, suggesting that a theory of mobile learning must be tested against the following criteria:

- Is it significantly different from current theories of classroom, workplace or lifelong learning?
- Does it account for the mobility of learners?
- Does it cover both formal and informal learning?
- Does it theorise learning as a constructive and social process?
- Does it analyse learning as a personal and situated activity mediated by technology?

From these general criteria, the paper proposes a definition of mobile learning as: "the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies". This emphasised the processes of learning in a mobile world, as opposed to gaining knowledge from handheld devices. As the paper indicated: "The focus of our investigation is not the learner, nor their technology, but the communicative interaction between these to advance knowing" (Sharples et al., 2007, p. 225). The paper describes a dynamic process of learning through conversation that overlays the technological mediation of communication channels, devices and human-computer interactions, with the semiotic mediation of social rules, communities and conversations. This conception of mobile learning as conversations across contexts undermines the solid ground of education as the transmission of a fixed curriculum within known constraints. Learning in a mobile world involves continual communication with and through technologies, merging real and virtual spaces, extending education outside classrooms to the conversations and interactions of everyday life.

Ubiquitous Learning

Ogata and Yano (2004) further developed the concept of context-based learning to propose a ubiquitous technology-enabled environment where support for learning is embedded into sensor-augmented "smart objects" such as furniture and utensils. The new technology extends traditional location-based learning, for example on field trips or in museums, by enabling personalised interaction with "semantic objects" such as household items that describe themselves in a foreign language, or buildings that can explain their energy usage. The third selected paper, by Ogata and Yano (2004) describes a context-aware language-learning support system called JAPELAS (Japanese Polite Expressions Learning Assisting System) which enables students of Japanese to understand appropriate polite expressions in context, based on the context of the word and the level of formality of the setting. Another prototype system, named TANGO, uses RFID tags attached to objects in a room to enable the learning of vocabulary in context.

Seamless Learning

Building on previous research into classroom, contextual and ubiquitous mobile learning, a global research collaboration produced a jointly-authored paper (Chan et al., 2006) that sets out a manifesto for research into learning for a world where every person has a networked personal computing device. Predicting that over the next 10 years personal, portable, wirelessly-networked technologies would become ubiquitous and pervasive in the lives of learners, the paper asks "how will classroom life and everyday life be connected?". It proposes a new phase in the evolution of technology-enhanced learning, marked by a continuity of the learning experience across different environments which it terms "seamless learning." Seamless learning implies that students can learn whenever they are curious in a variety of scenarios and that they can switch from one scenario to another easily and quickly, using personal devices and embedded learning technology to store, share and recall contextualised knowledge. The research aims to lessen limitations of human learning, such as the difficulties of transferring learned knowledge from one setting to another and recalling a previous learning episode at a different time and place. A personal seamless learning device can provide knowledge augmentation, for example by capturing direct information and peripheral context on a field trip or visit then allowing the learner to re-visit that learning context at a later time, to reflect on the experience, extract new understanding, compare knowledge with other visitors, and abstract shared memories. Or it can support inquiry learning where the student develops an inquiry science question in class, supported by a teacher, then continues the inquiry at home or outdoors with the personal computer acting as a scientific toolkit and guide, then concludes back in the classroom by sharing and presenting findings (Anastopoulou et al., 2012).

Wong and Looi (2011), in the fourth selected paper, offer a survey of research into Mobile Seamless Learning (MSL), identifying ten salient features that emphasise technology (access and multiple device types), pedagogy (multiple learning tasks and models) and the learner (spanning formal/informal, personalised/social, physical/digital learning across time and space):

(MSL 1): Encompassing formal and informal learning.
(MSL 2): Encompassing personalized and social learning.
(MSL 3): Across time.
(MSL 4): Across locations.

(MSL 5): Ubiquitous access to learning resources.
(MSL 6): Encompassing physical and digital worlds.
(MSL 7): Combined use of multiple technology device types.
(MSL 8): Seamless switching between multiple learning tasks.
(MSL 9): Knowledge synthesis (prior knowledge, new knowledge, multidisciplinary learning).
(MSL 10): Encompassing multiple pedagogical or learning activity models (facilitated by teachers).

From an analysis of 54 relevant research papers they conclude that investigations into the continuity of learning across time, location, and setting have been well-addressed, as have ubiquitous access to knowledge, bridging formal and informal learning, and connecting physical and digital worlds. Studies of short-term learning on field trips emphasise continuity of learning across locations and the seamless switching between learning tasks, whereas research into longer-term learning emphasises ubiquitous access to knowledge and synthesis of prior and new knowledge, and support for multiple levels of thinking skills.

A consequence of seamless learning is that people can be empowered and supported to learn wherever and whenever the need arises, not just by delivering content on demand, but by equipping a learner to make sense of context and learn according to need. This raises deep ethical issues such as the limits of schools, universities and employers to intrude into everyday life by providing continuous teaching and training on personal mobile devices, or to monitor students' everyday activities such as web browsing and social networking for evidence of informal learning (Traxler & Bridges, 2004). Therefore, areas for future research include understanding how learning can be appropriately supported outside the classroom, maintained across major life transitions (such as the transition from school to college, or college to workplace) and continued over long periods of time. A vision for the future is to support people in a lifetime of learning: to capture and recall personally meaningful events, explore the natural world, engage with others in inquiry-led projects, and learn by creating and sharing works of art, literature and science. Some of these activities will be part of formal education, in which case they may need to be supported with curriculum materials and presented for assessment. Others will belong to personal learning projects or be a part of everyday informal learning, so they may need to be organised and blended into family and social life. The challenge for research is to bring our understandings of experiential and lifelong learning, human memory and recall, learning through inquiry and conversation, and physical and social contexts, to the design of a new generation of technologies that promote long-term seamless learning.

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