Challenges in Evaluating Mobile Learning

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ABSTRACT

We propose six challenges in evaluating mobile learning: capturing and analysing learning in context and across contexts, measuring mobile learning processes and outcomes, respecting learner/participant privacy, assessing mobile technology utility and usability, considering the wider organisational and socio-cultural context of learning, and assessing in/formality. A three-level framework for evaluating mobile learning is presented, comprising a micro level concerned with usability, a meso level concerned with the learning experience, and a macro level concerned with integration within existing educational and organisational contexts. The paper concludes with a discussion of how the framework meets the evaluation challenges and with suggestions for further extensions.

Author Keywords

Mobile learning evaluation; learning context; evaluation framework.

INTRODUCTION

Mobile learning is a relatively new research area, with the first research projects appearing in the second half of the 1990s and the first international research conferences less than a decade ago. It is a field whose practice has not been standardised yet in terms of research frameworks, methods and tools. Thankfully, mobile learning has a lot of common ground with other research areas including technology-enhanced learning and Mobile Human-Computer Interaction (mobileHCI). 'Borrowing' frameworks and techniques from these areas has been common practice for early mobile learning research, and has indeed provided researchers with useful starting points.

As our conceptions and understanding of mobile learning deepen, these 'borrowed' frameworks and tools might no longer be adequate. We now appreciate mobile learning not just as learning that is facilitated by mobile technology, but also as the processes of coming to know through conversations and explorations across multiple contexts amongst people and personal interactive technologies (Sharples et al. 2007b). Such evolving conceptions introduce numerous challenges to all aspects of mobile learning research, including evaluation. As the field matures, our frameworks and tools need to respond to these challenges.

In this paper we summarise six challenges in evaluating mobile learning: capturing and analysing learning in context and across contexts, measuring the processes and outcomes of mobile learning, respecting learner/participant privacy, assessing mobile technology utility and usability, considering the wider organisational and socio-cultural context of learning, and assessing in/formality. The paper proposes an evaluation framework with three levels: a micro level concerned with usability, a meso level concerned with the learning experience, and a macro level concerned with integration within existing educational and organisational contexts. The paper concludes with a discussion of how the framework meets the evaluation challenges and with suggestions for further extensions.

CHALLENGE 1: CAPTURING LEARNING CONTEXT AND LEARNING ACROSS CONTEXTS

A major task for educational evaluation is to capture and analyse learning in context. For mobile learning, the interest is not only in how learning occurs in a variety of settings, but also how people create new contexts for learning through their interactions and how they progress learning across contexts. This poses a significant challenge to evaluators of mobile learning. To appreciate the challenge, let us compare mobile learning contexts with traditional classroom contexts from the researcher's perspective. In order to establish and document the learning context, the researcher needs to know: the location of learning and the layout of the space (where); the social setting (who, with whom, from whom); the learning objectives and outcomes (why and what); the learning method(s) and activities (how); and the learning tools (how).

In a traditional classroom, researchers generally have access to information about these context elements before, during and after the learning experience. For example, they can approach the teacher and learners in advance of a lesson to find out about objectives, methods, or tools; or they can visit the location beforehand. For mobile and informal learning, however, even the learners may not know this information in advance. Learning objectives, for example, may develop

on-the-fly as a response to interactions with the environment. The learners themselves may not be known in advance as is the case, for example, when evaluating general museum visitors' learning. If the evaluation is not confined to a specific learning site (e.g. a museum or work environment), the location, space layout and social settings can be unpredictable. Table 1 below portrays this increased vagueness as we move from the classroom to a school museum visit, to general museum visits, to everyday mobile, informal learning contexts. This increased vagueness has implications on the design of the evaluation in terms of data collection and analysis.

-- _____vagueness_____ ++

	Classroom	**School museum visit**	**…**	**General museum visit**	**Mobile**
Location and space layout	☑ fixed	☑ but not standard		☑ but not standard	☒ unpredictable
Social setting	☑ fixed	☑ but not fixed		☒ unpredictable	☒ unpredictable
Learning objectives and outcomes	☑ pre-set, external	☑ pre-set, external		☒ unknown	☒ unknown
Learning method and activities	☑ pre-determined	☑ pre-determined		☒ unknown – maybe some idea	☒ unknown
Learning tools	☑ fixed	☑ fixed		☒ unpredictable	☒ unpredictable

Table 1. Context elements discernible to the learning researcher: vagueness of context increases as we move away from the classroom into more informal, mobile situations.

Recent research efforts have focused on devising tools and methods appropriate for capturing and analysing mobile learning contexts. Some efforts concentrate on implementing technology-based solutions for data collection, such as mobile eye tracking (Wessel et al. 2007) or wearable interaction capture kits (Roto et al. 2004). Although such technical solutions have the advantage of capturing accurate data in context, they have some disadvantages, not least the obtrusiveness of the apparatus used. Other efforts opt for approach-based solutions, such as using learners' accounts of the experience through retrospective interviews, diaries, or attitude surveys (Vavoula 2005; Clough & Jones 2006), although these come with their own shortcomings such as the accuracy of recall, the degree to which post-rationalisation skews data, and the effect of the participants' concern over the image they project. Increasingly, mobile evaluation designs include mixed methods. These are useful not only for validating data, but also for capturing different perspectives of the learning experience. Thus, collected data might include recorded video, audio transcripts, observation notes, artefacts produced by the learners, application screenshots, etc. Interpreting such rich collections of data can be challenging too, in terms of assembling it into a meaningful, accurate and elaborate account of the learning experience. Related research addresses the design of tools and methods to support the sequencing, inter-relation and visualisation of evaluation data (Papadimitriou et al. 2007; Smith et al. 2007).

CHALLENGE 2: HAS ANYONE LEARNED ANYTHING?
A second challenge that faces mobile learning evaluation is the assessment of learning processes and outcomes. In traditional learning settings such as the classroom there are well-established and accepted methods for the assessment of learning activities, such as essay writing, multiple choice tests, open-book exams, and unseen examinations. Distinctions have been made between formative assessment (aiming to provide students with feedback regarding their progress) and summative assessment (aiming to judge and sum up the students' achievements) (Scriven 1967), with formative assessment bearing the greater potential to aid and complement teaching and learning (Black & Wiliam 1998a; b).

Summative assessment is often used as a measure of success of the teaching as well as a measure of effectiveness of the learning (Boud 1995), but with many (often unresolved) issues regarding the reliability and validity of summative assessment methods (see Knight 2001 for a discussion of these issues). Despite these difficulties, summative assessment can be meaningful in formal learning contexts where learning objectives and desired outcomes are well specified in advance. By contrast with formal education, mobile, informal learning can be both personal and elusive. The learning may be personally initiated and structured, such that it is not possible to determine in advance where the learning may occur, nor how it progresses or what outcomes it produces. It may also be difficult to track the progress of learning if it occurs across multiple settings and technologies.

Instead, suggestions have been put forward to examine the experience for evidence which might suggest that productive learning is taking place. For example, in the context of museum learning, Griffin and Symington (1998) suggest to watch for instances where learners show responsibility for and initiate their own learning (e.g. by writing, drawing, or taking photos by choice; deciding where and when to move), are actively involved in learning (e.g. by absorbed, close examination of resources; or persevering with a task), make links and transfer ideas and skills (e.g. by comparing evidence), and share learning with experts and peers (e.g. by talking and gesturing; or asking each other questions). One method to do this is to videotape the activities of learners who wear radio microphones and are observed by a video-camera at a discrete distance. The evaluators then watch the videotapes to identify observable critical incidents that

appear to be breakthroughs (indicating productive new forms of learning or important conceptual change) or breakdowns (where a learner is struggling with the technology, is asking for help, or appears to be labouring under a clear misunderstanding). These incidents can be assembled into a compilation tape and reviewed with the learners. The problem of assessing learning across multiple settings can be addressed in part by evaluating a combination of log files of computer activity or web access to show activity, outcomes such the results of online quizzes and media created by the learners, and personal reflective documents such as blogs and e-portfolios. Further work is needed to integrate these into a revealing and valid assessment of learning.

The challenge of assessing learning is not unique to mobile learning and does not afford an easy fix. Although a learning experience can be a well defined event with a start and a finish, learning is an ongoing, lifelong process of personal transformation and, as such, requires longitudinal, historical assessment.

CHALLENGE 3: AN ETHICAL QUESTION
Mobile learning can involve the use of mobile technology, which may also be personal technology. Tapping into a person's mobile phone to find out how they have been using it to learn might mean invading that person's privacy. Although research ethics frameworks are implemented by most research institutions and organisations, mobile learning research raises profound ethical issues.

The extent to which learners are willing to be monitored and the extent to which they will be ready to let the evaluators into their private lives is one particular concern. Obtaining informed consent can be problematic: the previous sections described the vagueness of mobile learning context and the elusiveness of mobile learning outcomes. When evaluators are uncertain of what will constitute the mobile learning experience, how accurately can they inform the participants of what data is sought and why? Assuming that a vague description of the requirements for participations is acceptable, how can learners consent to disclosing information about events they currently do not know when, where and under what circumstances will take place?

Even if the essence of the evaluation is successfully conveyed to the participants, and they consent to it, there are still important issues to consider relating to the degree to which they will co-operate in practice – either in terms of disclosing *all* that might be relevant, or in terms of carrying out related practical tasks such as synchronising their mobile devices as and when requested (Trinder et al. 2007).

 A major challenge then for mobile learning evaluation is to accurately inform participants and to ease their participation in practice. In the process it will be worth for the evaluator to ask themselves how much they really need to know, and to investigate best practices in safeguarding and disseminating sensitive personal data.

CHALLENGE 4: LET'S NOT FORGET THE TECHNOLOGY
Evaluations of mobile learning often reference inherent limitations of mobile devices, such as their small screens, short battery lives, intermittent connectivity, and associated human factors, all of which affect their usability. As the focus of research shifts from the mobility of the technology to the mobility of the learner, additional issues arise as learners move across multiple devices, possibly over short time periods in multiple locations. Assessing the usability of the mobile technology and the effectiveness of its integration with the mobile learning practice remains a high priority for evaluation.

Thus, mobile HCI challenges stemming from the complexity introduced by physical movement and changing variables (Kjeldskov & Stage 2004) and the small scale and ubiquitous nature of mobile devices (Hagen et al. 2005), add to the challenges already facing mobile learning evaluation.

CHALLENGE 5: SEEING THE BIGGER PICTURE
Oliver and Harvey (2002) suggest four different kinds of impact of educational technologies in Higher Education (HE): impact on students' learning, impact on individual academics' practice, impact on institution, and national impact. In the same context of HE Price and Oliver (2007) identify three types of impact studies: anticipatory, ongoing and achieved. Anticipatory studies relate to pre-intervention intentions, opinions and attitudes; ongoing studies focus on analysing processes of integration; and achieved studies are summative studies of technology no longer 'novel'. Riley (2007) extends this impact framework by distinguishing between minor modifications and culturally significant changes in practice, and suggesting that different kinds of change will emerge over different timescales.

Although not exclusively linked with HE contexts, mobile learning evaluation has similar questions to answer regarding impact. It needs to consider the relation between personal and institutional learning. It needs to look at the immediate learner experience, the processes of integrating emerging with existing practices, and the implications that manifest after full deployment. These requirements necessitate an extended view of learning context to include not only the learner's personal context but also the changing socio-cultural and organisational contexts of the mobile learning experience; and also an extended view of the role of evaluation as a continual process of adjustment and fine-tuning.

CHALLENGE 6: FORMAL OR INFORMAL?
Mobile learning is often defined in terms of the technology that mediates the learning experience: if the technology is mobile, so is the learning. Mobility, however, is not an exclusive property of the technology, it also resides in the lifestyle

of the learner, who in the course of everyday life moves from one context to another, switching locations, social groups, technologies and topics; and learning often takes place inconspicuously or is crammed in the short gaps between these transitions. Although this view of learning is inclusive of formal education contexts, it is particularly pertinent to everyday, informal learning.

Nevertheless, characterising a learning experience as formal or informal can be complicated. For example, is the learning of pupils visiting a museum (largely considered an informal learning setting) with their school (an irrefutably formal learning setting) a case of formal or informal learning? There is a large literature related to definitions of informal learning and related terminology, a review of which is beyond the scope of this paper; however, a general tendency seems to be to define informal learning in contrast to formal learning, and formal learning in turn to be confined to learning that takes place in educational settings. Colley and colleagues (2003) argue that "seeing informal and formal learning as fundamentally separate results in stereotyping and a tendency for the advocates of one to see only the weaknesses of the other … It is more sensible to see attributes of informality and formality as present in all learning situations". They advocate four groups of attributes: those related to the learning process, to the location/setting, to the learning purposes and to the learning content; and propose that attributes of in/formality are interrelated in different ways in different learning situations, and that those attributes and their interrelationships influence the nature and effectiveness of learning in any situation.

Understanding such attributes of in/formality and their interrelationships in mobile learning is important for evaluation, as it is not only a case of analysing pre-existing practices in terms of processes, settings, purposes and content, but also a case of capturing how the introduction of, or new way of supporting, mobile learning practices changes the in/formality of the learning experience.

REQUIREMENTS FOR MOBILE LEARNING EVALUATION

The challenges discussed in the previous sections indicate that mobile learning evaluation needs to:

- Capture and analyse learning in context with consideration of learner privacy

- Assess the usability of the technology and how it affects the learning experience

- Look beyond measurable cognitive gains into changes in the learning process and practice

- Consider organisational issues in the adoption of mobile learning practice and its integration with existing practices and understand how this integration affects attributes of in/formality

- Span the lifecycle of the mobile learning innovation that is evaluated, from conception to full deployment and beyond

A THREE-LEVEL FRAMEWORK FOR EVALUATING MOBILE LEARNING

To illustrate how the above requirements might guide evaluation in practice, this section will summarise an evaluation framework for mobile learning and its application in the context of supporting students' mobile learning when they visit a museum with their school.

The framework was developed in the context of the Myartspace project, which was an attempt to support structured inquiry learning through the design of an integrated technology that connects learning in the classroom with learning in museums and galleries. Detailed descriptions of the project and the evaluation process and outcomes have been presented elsewhere (Vavoula et al. 2006a; Vavoula et al. 2006b; Sharples et al. 2007a; Vavoula et al. 2007). In summary, Myartspace addresses the problem of how to connect activities on a museum trip to planning and further study in the classroom. It enables users to create their own interpretations of museum objects through descriptions, images and sounds they collect at the museum and then further research, reflect upon and share outside the museum. Before the visit, the teacher will typically set an open-ended question that the students can answer by gathering and selecting evidence from the museum visit. On arrival at the museum, students are given multimedia mobile phones which they can use to 'collect' exhibits, take photos, record sounds, or write text comments. This content is transmitted by the phone to their personal online collection which, back at school, the students can organize into personal galleries to present their findings in the classroom and share with their friends and family. Evaluations showed that the service was effective in enabling students to create multimedia evidence from enquiry-led learning in the museum, which provided resources for effective construction and reflection in the classroom. Minor usability problems did not detract from the learning, however there are significant issues concerning how to structure the museum visit and on the viability of Myartspace as a regular museum service.

The evaluation framework of Myartspace consisted of three levels:

1. Micro level: the micro level examines the individual activities of the technology users and assesses usability and utility. In the case of Myartspace the activities included collecting objects through exhibit codes, making notes, contacting people who have collected a particular item, recording audio, and taking pictures.

2. Meso level: the meso level examines the learning experience as a whole, to identify learning breakthroughs and breakdowns; it also examines how well the learning experience integrates with other related learning experiences. In the case of Myartspace, evaluation at this level involved exploring whether there was a

successful connection between learning in the museum and in the classroom as well as identifying critical incidents that reveal new patterns and forms of learning or where learning activity is impeded.

3. Macro level: the macro level examines the longer term impact of the new technology on established educational and learning practice. For Myartspace this related to the organisation of school museum visits. The evaluation at this level looked, for example, at the appropriation of the new technology by teachers, the emergence of new museum practices in supporting school visits, and how they related to the original project visions.

For Myartspace, the development comprised four phases: (1) Requirements analysis, to establish the requirements for the socio-technical system (people and their interactions with technology) and specify how it would work, through consultation with the different stakeholder groups; (2) Design of the user experience and interface; (3) Implementation of the service; and (4) Deployment of the service.

In the requirements phase, evaluation established the criteria against which individual requirements would be tested. In the design and implementation phases, formative evaluation activities fed into the design-implement-redesign cycle to aid and inform design. In the deployment phase, summative evaluation activities assessed the extent to which the technology satisfied the requirements.

In general, it may not be possible to evaluate the three levels – micro, meso and macro – during all the development phases. For example, the meso level requires that the technology is in place and is robust enough to allow assessment of the learning and teaching experience and its educational value; so evaluation activities at the meso level could not be introduced until well into the implementation phase. Similarly, the macro level requires that the technology is in place and used for long enough to establish its effects on school museum visiting practice; so evaluation activities at the macro level could not be introduced until well into the deployment phase. Thus, the introduction of evaluation activities at the three levels of the framework may be gradual, starting with evaluation activities at the micro level at the initial phases of development, later introducing evaluation activities at the meso level, and finally introducing evaluation activities at the macro level in the final phase. Figure 1 illustrates this gradual introduction of evaluation activities (see shaded areas) at the three framework levels over the different project phases.
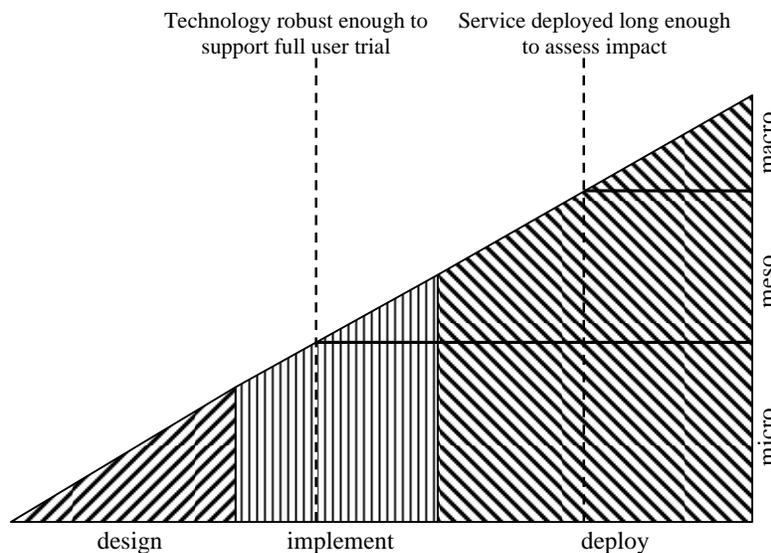

Figure 1: Evaluation activities at the three levels are introduced gradually over the project phases.

To establish the value of the service at the three levels, the evaluation framework explores the gap between expectations and reality and also unforeseen processes and outcomes. This happened in three stages:

1. Stage 1: explores what is supposed to happen at a level. User expectations at each level can be captured through interviews with users (e.g. teachers, students, museum staff) and by analysing user documentation, training sessions and materials.

2. Stage 2: observes what actually happened at a level. The user experience is documented to establish the reality of technology use for the different users.

3. Stage 3: examines the gaps between user expectations and reality through a combination of reflective interviews with users and critical analysis of the findings from stages 1 and 2 by the evaluators.

The framework supported a Lifecycle approach to evaluation (Meek 2006), in which evaluation is the centre of the technology development process, from the early stages of design to the final assessment of the technology in a learning context. Evaluation activities are undertaken at key points in the lifecycle of the system design process, with the outcomes of each evaluation informing the next stage of the system development or feeding into an iteration of an earlier

stage. Different aspects of implementation of the innovation can be considered in context, and differing kinds of impact can be captured at appropriate stages.

Evaluation activities	Framework level	Project phase
• Scoping study of previous projects and related recommendations • Consultation workshop on 'User Experience' to establish requirements • Workshop to finalise educational and user requirements	All	Requirements
Heuristic Evaluations (examining how system designs compare to expectations re established design heuristics)	Micro	All
Technical testing prior to trials	Micro	Implement
Full scale user trial	All	Implement/Deploy
Stage 1		
• Examine system documentation (Teacher's Pack and Lesson Plans, online help) for descriptions of functionality • Interview teacher prior to lesson to assess level of knowledge and expectations for functionality • Observe training sessions at museum and school to document how functionality is described to teachers/students.	Micro	Implement/Deploy
• Analyse description of educational experience based on Teacher's Pack and Lesson Plans • Interview teachers and museum educators prior to lessons about what they have planned for the students' learning experience • Observe teachers and museum educators while presenting learning experience to students in the classroom/museum	Meso	Implement/Deploy
• Analyse descriptions in service promotion materials, original proposal, minutes of early project meetings • Interviews with stakeholders to elicit initial expectations for impact of service	Macro	Deploy
Stage 2		
• Observe lesson to establish actual teacher and student experience of functionality • Interview teacher after the lesson to clarify experience of functionality • Questionnaire and focus groups with students to capture experience of functionality	Micro	Implement/Deploy

• Observe educational experience in museum/classroom
  o Note critical incidents that show new forms of learning or educational interaction
  o Note breakdowns
• Interviews/focus groups with teachers, museum educators, students on educational experience in museum/classroom
	Meso	Implement/Deploy

• Review of press coverage and interviews with stakeholders to document impact/transformations effected by the service	Macro	Deploy
Stage 3		
• Capture expectations-reality gaps in terms of user experience of functionality through reflective interpretation of documentation analysis in the light of observations; and also through interviews and focus groups with teachers/students.	Micro	Implement/Deploy
• Capture expectations-reality gaps in terms of educational experience through reflective interpretation of documentation analysis and observations; and also through interviews/focus groups with teachers, students, museum educators.	Meso	Implement/Deploy
• Reflective analysis of expectations-reality gaps in terms of service impact	Macro	Deploy

Table 2: Evaluation activities and methods used at each level, for each project phase

Table 2 summarises evaluation activities and methods in the Myartspace project at each framework level, for all project stages. The three-level evaluation framework provided an efficient way to structure both the data collection and analysis for the evaluation of Myartspace, allowing the documentation of the potential of such a service.

Successes and failures of the service at all levels, micro, meso and macro were identified, along with inter-level influences. For example, in the museum, we noted that collection of museum objects, photographs and audio clips were functions that were easy to use and popular with the students (good usability at the micro level), and students had no

problems in assessing/collecting items (good student performance at meso level), a combination that resulted in the collection of dozens of items during the visit. At the same time we found at the micro level that students were not able to annotate their photographs and recorded audio clips with notes describing what they were about or why they recorded these. Although they could create text notes, such notes could not be directly associated with photos or audio clips.

Back in the classroom, the web-based application that allowed students to create their personal galleries was less intuitive to use: users needed more time to technically put an item in their personal gallery that they had needed in the museum to collect that item through their phone. So at the micro level, the web application afforded slower interaction than the phone application for manipulation of the same item. In addition, students needed more time to interpret a collected item in the classroom than they had needed to assess and decide to collect that item in the museum, a difference related to student performance at the meso level. For photographs and audio recordings this was partly because the students had lost contextual information relating to what the item was about or why they had collected it – thus micro-level issues in the museum gave rise to or amplified meso-level issues in the classroom.

The three-level framework provides a structured format to assess usability, educational and organisational impact, and their inter-relationships. In relation to the requirements for mobile learning evaluation presented earlier: it can illuminate learning activities and contexts at different levels of detail; it relates the intended learning processes and outcomes to observed activities and examines the gaps between expectation and reality; it involves learners and teachers as informed participants in the evaluation process; the focus on interaction puts equal emphasis on the learners and the technology; it can analyse individual interactions, educational processes and organisational change; and it can be applied to formal or informal settings.

CONCLUSIONS

The six challenges in mobile learning evaluation identified in this paper are a direct consequence of the complex nature of mobile learning as we have come to understand it, as a social rather than technical phenomenon of people on the move constructing spontaneous learning contexts and advancing through everyday life by negotiating knowledge and meanings through interactions with settings, people and technology. Although in this paper we discussed these challenges in relation to evaluation, other stages in the development of mobile learning (such as design and deployment) are facing similar challenges, which mobile learning research needs to address.

The mobile learning evaluation framework presented here was one attempt to meet these challenges. Its application in the context of Myartspace was successful and offered valuable insights to the project. Although we believe the framework is transferable to other mobile learning contexts, it needs further development to address, for example, contexts with higher ethical concerns. The outcomes of an evaluation based on this framework can feed directly into system design, as has happened in the case of Myartspace. Perhaps with suitable extensions the framework could serve the design process more directly, guiding mobile learning designers to interpret and implement requirements for learning across self-constructed contexts.

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