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Research Methods in Informal and Mobile Learning

Book of Abstracts

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MIL-RM 2007

Proceedings of the Workshop: Research Methods in Mobile and Informal Learning How to get the data we really want

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Practice

Introduction

Giasemi Vavoula
Department of Museum Studies, University of Leicester

Introduction to the Workshop on Research Methods in Mobile and Informal Learning

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 informal learning outside educational institutions. Moreover, this view exposes the complexities of mobile learning and the related difficulties of mobile learning research.

Studies of mobile and informal learning are often based on the learners' own accounts and metacognitive analyses of their learning, by means of semi-structured interviews, surveys, and diary studies. Such retrospective accounts of learning come with limitations, in terms of accuracy of recall and of the rationalisation or 'tidying up' that retrospective accounts may undergo. Moreover, younger learners may not possess the metacognitive skills necessary for producing adequate reflective accounts of their experiences.

Furthermore, mobile and informal learning research methods need to allow us to study not only the learning that occurs during the learning experience, but also how it develops afterwards. Learning does not result from single, individual experiences, but rather it is cumulative, "emerging over time through myriad human experiences, including but not limited to experiences in museums and schools; while watching television, reading newspapers and books, conversing with friends and family; and increasingly frequently, through interactions with the Internet. The experiences children and adults have in these various situations, dynamically interact to influence the ways individuals construct scientific knowledge, attitudes, behaviours, and understanding" (Dierking et al. 2003, p.109). The cumulative nature of learning makes it difficult to isolate a distinct learning event for inspection. The inherent inconsistency of the learning practice in mobile contexts in terms of activity structure and learning outcomes (Taylor 2006) makes such inspections even more complex.

The biggest challenge, thus, for the mobile learning researcher lies in capturing and understanding the context of the mobile learning experience and how it interleaves with the learner's life context. 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 the researcher has access to information about these context elements (often long) 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. This is a result of the relative stability of formal education contexts: the location and social setting are fixed, the learning objectives are pre-set and largely dictated by the curriculum, the learning method and activities are pre-determined by the teacher, the learning tools are familiar and set, and there are trusted procedures in place for assessing learning outcomes. In mobile, informal learning contexts, 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. Moreover, the learners themselves may not be known in advance as is the case, for example, when researching general museum visitors' learning. Finally, if the research 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. Thus, moving away from 'fixed', traditional classroom learning into more diffused, informal, mobile situations, the learning context becomes vaguer and harder to establish and document for the researcher. Table 1 below portrays this increased vagueness as we move from the classroom to a school museum visit, to general museum visits, to unspecified mobile, informal learning contexts.

This increased vagueness has implications on research design in terms of data collection and analysis, as well as in terms of assessing learning outcomes. A combination of carefully placed fixed video and audio recorders,

-- _____ 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.

observation logs and data logs may be adequate to capture learning in the classroom; however, doing the same with mobile learning can be very challenging. The fixed roles of teacher-learners in the classroom can guide the analysis of learning interactions; in informal learning contexts the learner(s) can be switching roles while their backgrounds and social dynamics may not be known. Finally, in the classroom there are well-established methods for the assessment of learning outcomes; mobile, informal learning outcomes are highly personal and can be elusive, difficult to pinpoint even for the learner themselves.
The aim of this workshop is to provide a forum for researchers of mobile and informal learning to exchange ideas about, and experiences with, overcoming the challenges discussed above. More specifically, participants will have the chance to attend presentations and take part in discussions and work-groups on three aspects of mobile learning research: (a) the tools and methods that are effective for the collection and analysis of data on mobile informal learning, (b) the appropriateness of different theoretical research frameworks and approaches, and (c) practical research design issues.
We hope that the workshop will inspire a fruitful discourse within our community on methodologies, methods, and techniques for mobile, informal learning research.

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Taylor, J. (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.

Part 1
Keynote Presentations

Professor Mizuko Ito

University of Southern California, USA; and Keio University, Japan

Chronicling Portable Practices in Urban Environments

Ethnographers studying mobile and portable technologies must reconsider basic methodological commitments towards observation and the framing of social and cultural context. As people's social relations and access to culture and knowledge becomes mediated by networked technologies, the ethnographer must consider the context for behaviour as a hybrid between the physical environment with co-present others and the networked "virtual" environment. What conceptual and methodological frameworks enable us to conduct this kind of real/virtual ethnographic research in networked and mobile worlds? This talk will review a number of studies conducted at Keio University's DoCoMo House research lab that utilize hybrid methods of observation, interviewing, and diaries to get at a range of different approaches to studying the use of portable technologies in urban space.

Bio Data

Mizuko Ito is a cultural anthropologist of technology use, focusing on children and youth's changing relationships to media and communications. She is part of a research project supported by the MacArthur Foundation, "Kids' Informal Learning with Digital Media," a three year ethnographic study of kid-initiated and peer-based forms of engagement with new media. She is also conducting ongoing research on Japanese technoculture, looking at how children in Japan and the US engage with post-Pokemon media mixes. Her research on mobile phone use in Japan appears in a book she has co-edited, Personal, Portable, Pedestrian: Mobile Phones in Japanese Life. She is a Research Scientist at the School of Cinematic Arts at the University of Southern California, and a Visiting Associate Professor at Keio University in Japan.

Professor David Livingstone

Ontario Institute for Studies in Education, Canada

Basic Research on Lifelong Learning: Recent Survey Findings and Reflections on 'Capturing' Informal Learning

The presentation will summarize findings from the 1998 and 2004 Canadian national surveys of lifelong learning and work, including profiles of and relations between paid/unpaid (domestic, volunteer) work and formal (schooling/adult courses) education and informal (job/housework/volunteer work/general interest related) learning. Features of the hidden informal part of the "iceberg" of adult learning will be emphasized, particularly the very weak links between formal education and informal learning. Methodological limitations of both survey and case study empirical research to date on informal learning will be noted,

with some reference to the ongoing computerization of everyday life. Implications for "tracking" or "capturing" informal learning in mobile contexts will be suggested.

Bio Data

Dr. D.W. Livingstone is Canada Research Chair in Lifelong Learning and Work at the University of Toronto, Head of the Centre for the Study of Education and Work at OISE/UT, professor in the Department of Sociology and Equity Studies at OISE/UT, and Director of the SSHRC-funded national WALL research network on "The Changing Nature of Work and Lifelong Learning" (see www.wallnetwork.ca). He was born in Vancouver, B.C. He holds an Honours B.A. in sociology from the University of British Columbia and a doctorate in social relations from Johns Hopkins University. He has also been the principal investigator of the OISE/UT Biennial Survey of Public Attitudes Toward Education in Ontario since 1978. His books include: Working and Learning in the Information Age (Ottawa: Canadian Policy Research Networks, 2002), Hidden Knowledge: Organized Labour in the Information Age (Garamond Press and Rowman & Littlefield, 2003)(with P. Sawchuk), The Education-Jobs Gap: Underemployment or Economic Democracy (Garamond Press and Percheron Press, 2004, second edition), International Handbook of Educational Policy. (Springer, 2005) (edited with N. Bascia, A. Cumming, A. Datnow and K. Leithwood). His current research interests include an array of studies of relations between paid/unpaid work and formal/informal learning, most notably combined surveys and case studies of relations between education and jobs. Forthcoming books include: The Future of Lifelong Learning and Work: Critical Perspectives (Rotterdam: Sense Publishers, 2008) (edited with K. Mirchandani and P. Sawchuk) and Education and Jobs: Exploring the Gaps forthcoming in 2008.

Professor Mike Sharples
Learning Sciences Research Institute, University of Nottingham, UK

Evaluation methods for mobile learning

Evaluation has been identified as a 'big issue' of mobile learning. Assessing the effectiveness of mobile learning may involve tracking groups and individuals moving under their own volition over a wide area, including private spaces, interacting with a variety of technologies, possibly developing skills and knowledge over long periods of time. In addition, both the technologies and the educational approaches to mobile learning are evolving rapidly, so formative evaluation methods are needed to inform the co-design of new combinations of learning and technology.
I shall discuss the evaluation methods for three major mobile learning projects – MOBIlearn, MyArtSpace, and PI: Personal Inquiry – and indicate how they addressed the issues of a) co-design of learning and technology,

b) evaluation of learning of individuals and groups across settings, and c) the ethics of running studies to monitor learning activity inside and outside the classroom. The talk will make particular mention of the socio-cognitive engineering approach of MOBIlearn, the multi-level evaluation for MyArtSpace and the ethical guidelines of the PI project.TBC.

Bio Data

Mike Sharples is Professor of Learning Sciences and Director of the Learning Sciences Research Institute at the University of Nottingham. He has an international reputation for research in mobile learning and the design of learning technologies. He inaugurated the mLearn conference series and is President of the International Association for Mobile Learning. As Deputy Scientific Manager of the Kaleidoscope Network of Excellence in Technology Enhanced Learning he coordinates a network of 1100 researchers across 90 European research centres. His current projects include PI: Personal Inquiry, a collaboration with the Open University UK to develop 21st century science learning between formal and informal settings, and a national survey of social networked learning at home and school. Recent projects include MyArtSpace for mobile learning in museums and the L-Mo project with Sharp Laboratories of Europe to develop handheld technologies for language learning. He is author of 160 publications in the areas of interactive systems design, artificial intelligence and educational technology.

Part 2
Track Presentations

Daniel Wessel
Knowledge Media Research Center, Tuebingen

Eva Mayr, Kristin Knipfer
Applied Cognitive & Media Psychology, University of Tuebingen

Re-viewing the museum visitor's view

Eye movements are not only important in research on natural human behaviour but also in research on mobile learning. We specify what mobile eye tracking can tell us about learning on the move. Potentials and constraints of mobile eye tracking as methodological approach for research on mobile learning are discussed. Exemplary data from our study are presented in which a small sample of visitors explored a museum exhibition with a mobile eye tracker. We argue that mobile eye tracking is a powerful data collecting method in research on mobile learning despite some limitations.

1. Mobile eye tracking in research on mobile learning

Why are eye movements interesting for mobile learning? "Eye movements provide an unobtrusive, sensitive, real-time behavioural index of ongoing visual and cognitive processing" (Henderson, 2003, p. 498). Most daily tasks involve visual input and people typically look at objects to acquire information. Thus, eye movements are not only important for research on natural human behaviour but especially on (mobile) learning.

1.1 History

Research on eye movements dates back to the early 20th century. It focused on scene perception and reading (for an extensive review see Rayner, 1998). Eye tracking was used only for the limited purpose of laboratory studies. Only in recent years researchers addressed more complex, daily activities in natural environment (e.g., Land & Hayhoe, 2001). This was enabled through the development of light-weight, mobile eye tracking technologies (Pelz et al., 2000).

1.2 Potentials

Data richness. Mobile eye tracking provides rich data about natural behaviour at a higher level of detail and accuracy than questionnaires or observation. In contrast to other tracking methods like logfiles, eye tracking additionally provides insight into planning behaviour that does not finally result in action.
Data validity. In contrast to external observation or retrospective questionnaires/interviews, mobile eye tracking gathers data online during actual behaviour and from the acting subject's perspective. The method provides insights into unconscious information processing that lie beyond introspectively accessible processes (Pelz et al., 2000). Validity of eye gaze recording is higher than validity of external observation which can only determine which direction a person is looking at but not where the eyes are fixated.
Non-reactive measurement. Data

collecting methods like questionnaires and interviews are considered to be highly reactive (Fritsche & Linneweber, 2006). In contrast, eye movements are natural behaviour that can hardly be manipulated by the tracked subject.
Statistical analysis. Like logfile analysis, eye tracking obtains highly structured data that allow for further statistical analyses, for example occurrences of specific events or gaze sequences like "scan patterns" (Henderson, 2003).

1.3 Constraints

Covert attention and mental spotlight. "The window of attention set by the parietal scan can take on different apertures, to encompass anything from a finely localized object to a global view of the surrounding scene." (Treisman, 2006, p. 4). Similarly, text reading research states that fixations do not directly indicate where the 'mental spotlight' currently is, i.e. what information is currently processed (for a review of different hypotheses concerning the relation of 'eye' and 'mind' see Kliegl, Nuthmann, & Engbert, 2006). Therefore, eye tracking delivers accurate data about fixations but does not always lead to correct conclusions regarding the focus of attention.
Limited conclusions on cognitive processing. Information about subjects' attitudes or reasons for their (visual) behaviour is limited because cognitive processes cannot be observed directly through eye tracking. "Whereas a given cognitive event might reliably lead to a particular fixation, the fixation itself does not uniquely specify the cognitive event" (Hayhoe & Ballard, 2005, p. 190). Eye movements are determined by two processes: bottom-up, stimulus-lead processes (salience) and top-down, cognitively-lead processes (knowledge, goals, cp. Henderson, 2003). Whereas influence of bottom-up processes can be modelled (Turano, Geruschat, & Baker, 2003), data on a person's attitudes or reasons for specific behaviour cannot be obtained as cognitive processes cannot be observed directly through eye tracking. Interpretations of eye movements are often based on assumptions and heuristics about underlying cognitive processes. This limits the validity of conclusions on underlying cognitive processes.
Obtrusiveness of measurement. The eye tracker itself is obtrusive: Participants know that their gazes are tracked, and looking through goggles might be unfamiliar. Other people who see the eye tracker will probably interact differently with a person wearing an eye tracker. These factors could influence behaviour during eye tracking.
Selective sampling. Mobile eye tracking devices are difficult to calibrate for persons with glasses or corneal irregularity. Visually impaired people are excluded from eye tracking studies and therefore generalisation to these people might be limited.
Limited temporal accuracy. The temporal resolution depends on recording. A 50 Hz PAL DVCR tape saves two camera images by alternating frames. This results in a resolution of 25 Hz. Since fixations as short as 33 ms were observed (Pelz et al., 2000), some fixations

can be missed.
Limited spatial accuracy. Eye tracking works best if the system is calibrated to the fixation distance but fixation distances vary continuously in natural environments. As a consequence accuracy might be worse than with eye tracking on computer screens.
Laborious data analysis. Automatic data analysis like in static eye tracking is difficult because the background changes constantly and persons' behaviours and gazes differ from each another. Therefore, each eye tracking video has to be analyzed manually unless software is developed that can recognize elements in the video feed and combine this information with eye tracking data. Thus, many studies use only short tasks where similar eye movements can be expected (e.g., Land & Hayhoe, 2001) which limits generalisation of eye tracking data for more complex (learning) tasks.
Price. Mobile eye trackers are very expensive – the version used in this study costs about 24 000 €.
Ethical concerns. Given the existence of unconscious or uncontrolled eye movements, even participants who have previously agreed may reveal information they would rather have kept private.

2. Re-viewing the museum visitor's view an explorative study

2.1 Aim of the study

To gain insight into mobile learning in science museums, we equipped some visitors with a mobile eye tracker. Our approach was mainly exploratory: Eye tracking allowed us to re-view the visitors' view – beyond observational or questionnaire methods. We wanted to examine what eye movements tell us about exploration behaviour and cognitive elaboration on exhibition content.

2.2 Method

Our sample consisted of three students who visited a small exhibition about nanotechnology with an ASL MobileEye eye tracker (see figure 1). They were instructed to visit the exhibition as they would normally do in a science museum. Prior to exploration of the exhibition the eye tracker was calibrated for a distance that visitors would probably keep while looking at exhibits.

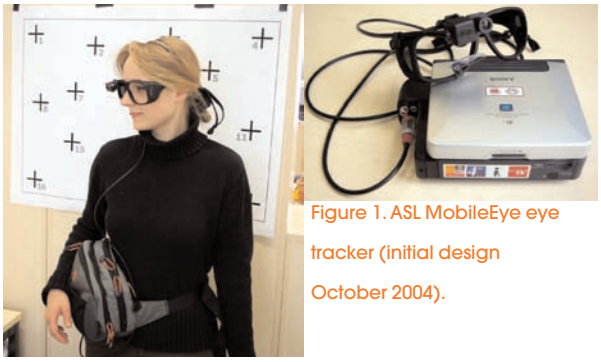

Figure 1. ASL MobileEye eye tracker (initial design October 2004).

Recordings were transformed into .avi-files and analysed by one rater with Videograph©. Similar to Turano and colleagues (2003), we did not analyse eye movements based on xy-coordinates but on categories. For our purposes, fixations within the same category were of higher interest than proximity of fixations. Also, background changes influence xy-coordinates but not categories. The categories were developed according to the visible elements of the exhibition (see figure 2). Each exhibit or text unit

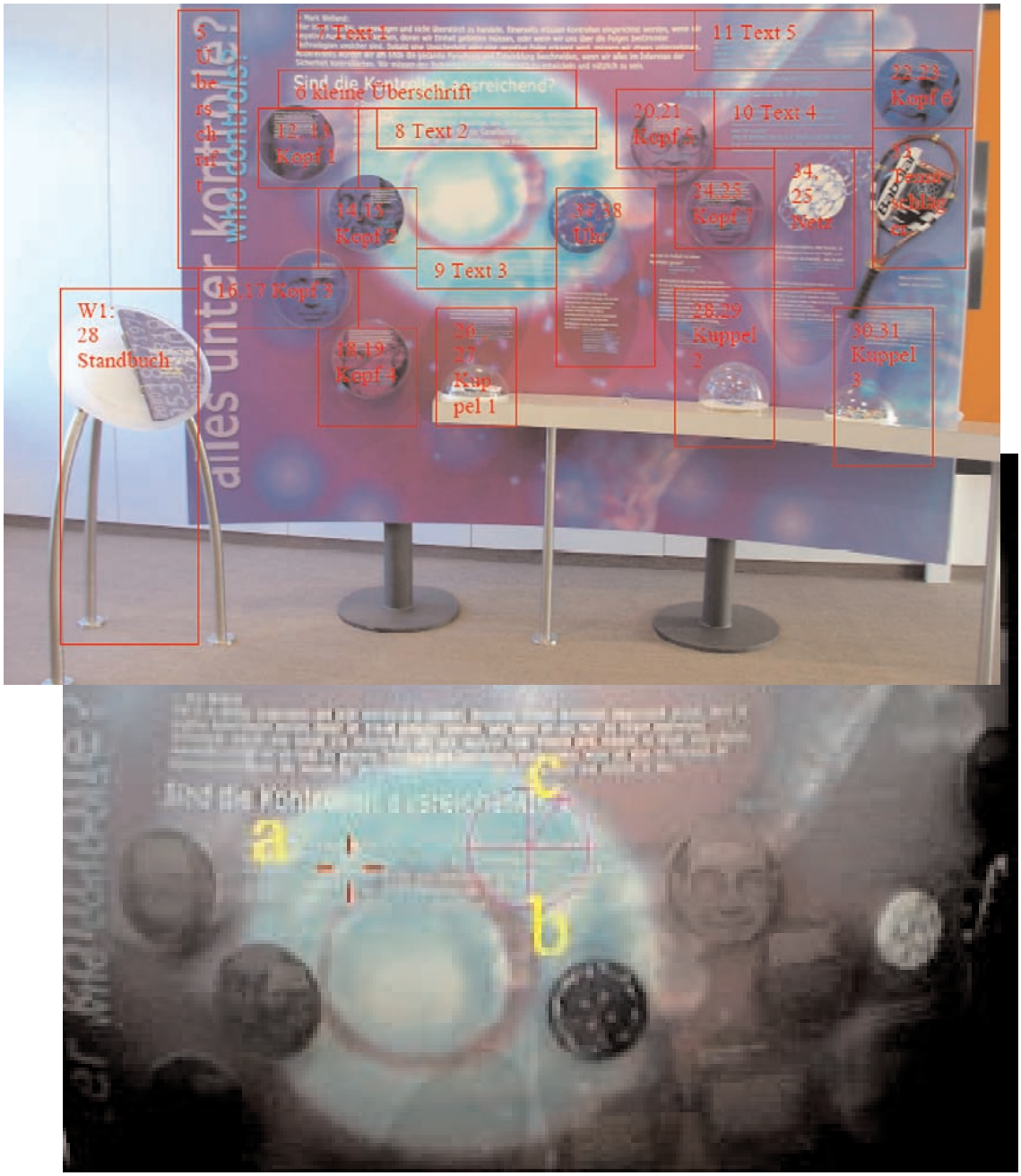

Figure 2. Exhibition wall categories (top) and sample eye tracking image (bottom). On the eye tracking image the red crosshair (a) shows where the measured eye is fixated at this moment, the purple circle (b) shows the position of the pupil and the small purple cross (c) the position of the master spot.

was a category. Categories might be grouped in larger categories like "exhibits with corresponding labels", "all labels", or "exhibits on the same concept" afterwards. After exploration of the exhibition, a structured interview provided insight into visitors' subjective experiences and introspective thoughts on reasons for their exploration behaviour and on ongoing cognitive processes.

2.3 Exemplary Results and Discussion

Individual scan patterns indicate that exhibits that conceptually belong together are likely to be fixated successively (see figure 3) and also several times alternately (see figure 4). This may indicate that people integrate multiple information units into an

underlying concept (Rayner, Rotello, Stewart, Keir, & Duffy, 2001) or at least do not process these information units independently from each other (Schwonke, Renkl, & Berthold, 2007). Our exit interview also showed a different explanation for alternate fixation of objects: One participant stated that she was not comparing the content but the design when confronted with her eye movement episode.

Analysis across all individuals showed that overall, some exhibits were less likely to be explored than others. This might be due to limitations in exhibition design as research showed that probability of visual exploration depends on graphical salience of objects (e.g., Holsanova, Rahm, & Holmqvist, 2006). An alternative explanation is that these parts of the exhibition were attended to without direct fixations (cp. Treisman, 2006).

A common pattern we identified was that all participants first scanned each exhibition wall as a whole, and then began to explore single exhibits in their vicinity.

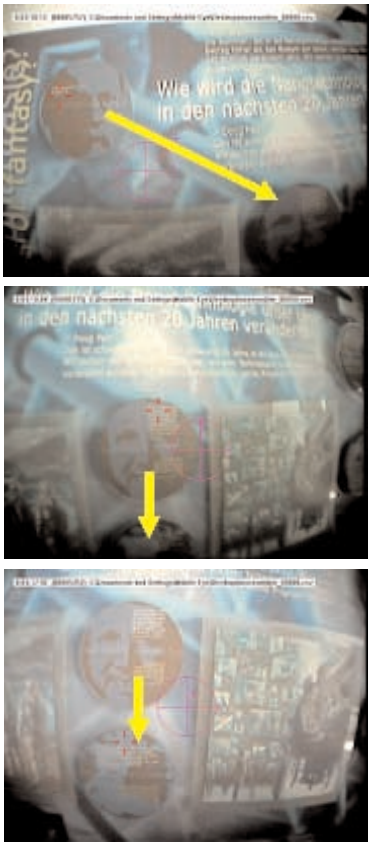

Figure 3. Sequence of one participant focusing on three exhibits conceptually belonging together and exploring them successively (the plotted arrow shows the scan path).

Research suggests that the first process serves as initial selection of information and visual search and is rather automated. At early processing stages, pictorial information or text is quickly skimmed and scanned before late processing like reading text or exploring details of objects occur

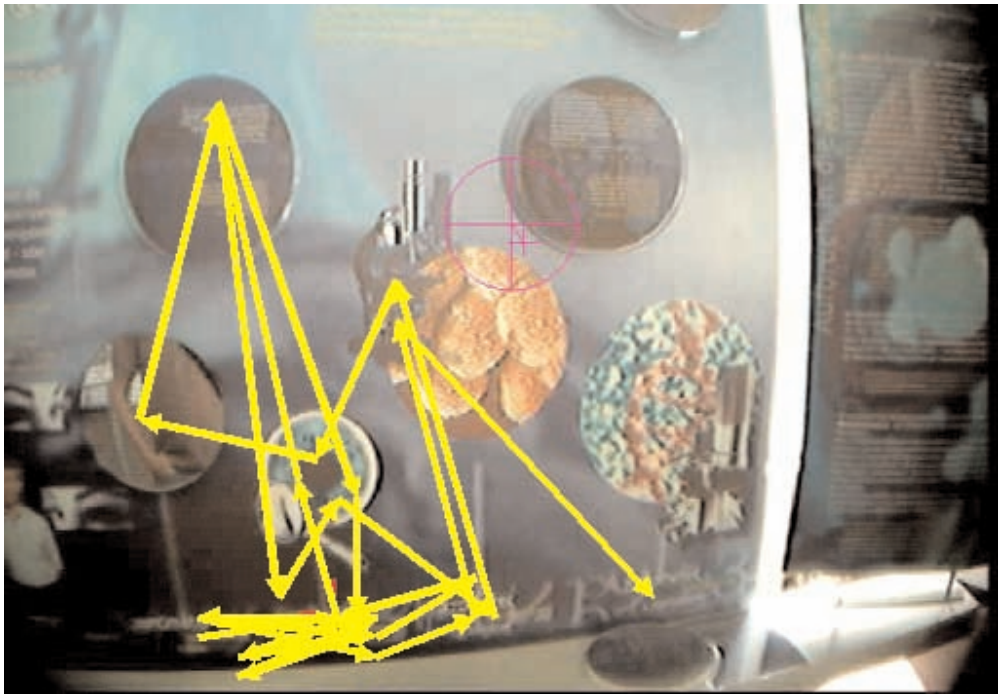

Figure 4. 17-seconds episode of one participant fixating objects conceptually belonging together several times alternately (the plotted arrow shows the scan path).

(Holmberg, 2004). However, Holsanova and colleagues (2006) found multiple reading patterns for newspaper readers. More subjects are necessary to validate the assumption of a common elaboration pattern within the context of our exhibition.

3. Conclusion

Eye tracking is not a stand-alone-method but should be combined with other methods for valid interpretations. Conclusions from eye movements on underlying cognitive processes are error-prone. Clear hypotheses about cognitive processes and their influence on eye movements are indispensable. Interview and questionnaire data about a person's interests and knowledge can be used to examine hypotheses with the data at hand. An important question is whether data should be analysed intraor interindivdually. As eye tracking data is very rich, big samples are rare (for an exception see Wooding, 2002) and the degree to which results from small samples can be generalised is limited. Still, case studies can provide important insight how information is processed and how informal and implicit learning happens on the move.
Further technical development of mobile eye tracking devices will probably eliminate some of the technical constraints reported above. Still, software is needed to analyse real-world-videos with changing angles, views, distances, and objects to reduce complexity of analysis of eye tracking data. Despite some limitations, we think that mobile eye tracking is a powerful data collecting method in research on mobile learning. In our exploratory study we gained valuable insight on the exhibition itself and on the exploration behaviour of its visitors which we would have hardly achieved otherwise.

Acknowledgements

This research was conducted within the research project "Learning in museums: The role of media" (see http://www.iwm-kmrc.de/museum/) funded by the "pact for research and innovation" of the German Federal Ministry of Education and Research.
We would like to thank Viktoria Schuster for her help in analyzing the data.

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University of Patras

Analysis of an informal mobile learning activity based on activity theory

This paper presents a method of collecting and analyzing data for collaborative activities supported by mobile technologies. Collection and analysis of data was focused in studying all elements of an activity according to the Activity Theory. A variety of sources was combined in order to study the deployment of the activity. Results and problems that emerged during a case study in an actual museum setting are also presented. It is argued that this approach, with modifications proposed in this paper, can contribute in deeper understanding of the educational use of mobile technologies.

1. Introduction

An increasing use of mobile technologies to support learning has been reported during the past years. Studies have been deployed in order to investigate the effects of use of mobile technologies to support learning activities. A variety of methodologies, research objectives and questions have been introduced. The ubiquitous characteristics of mobile technologies often produce limitations in the effort for an in depth study of the learning procedure. In this paper, we present a methodology to collect and analyze data in the frame of an informal mobile learning activity. The methodology presented is based on the Activity Theory.

2. Research design and methodology

2.1. Objectives and research questions

The methodology presented in this paper was developed in the frame of a case study of a collaborative learning activity created for a local historical museum, the Museum of Solomos and Eminent Zakynthians, located in Zakynthos, Greece. Its main objective was to introduce students into a new form of interaction with the historical exhibits of the museum. 17 children (11 girls and 6 boys of 10 years of age) participated in the frame of a visit of their classroom to the museum. The students collaborated in groups of 4 and 5 members. The experimental procedure took place in one of the rooms of the museum. The scenario included data collection and manipulation in order to solve a given problem. The students were asked to collect and combine data extracted from the examined exhibits in order to identify a desired exhibit as described by the learning scenario. Support was also available by a facilitator (Tselios et al., 2007). The study focused on the use of the tools (technological and symbolic) involved and on the interaction of participants in the activity. The research questions addressed were: (a) how the students collaborate and perform high level actions through low level operations? (b) What is the role of

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the facilitator of the activity? (c) Can we identify a pattern in student's actions throughout the activity?

2.2. Methodology

The activity was closely observed and monitored using a variety of instruments. Voice recorders were used to record dialogues among the participants and their activity was videotaped and screen capturing of the PDA took place. The Activity Theory model was adopted for the analysis of the collected data since in this case of museum education activity; knowledge construction is mediated by cultural tools in a social context. According to the Activity Theory an activity is consisted by low-level operations and goal-oriented actions (Kuuti, 1995; Waycott et al., 2005; Zurita and Nussbaum, 2006). The data collected were analyzed using the Collaboration Analysis Tool (ColAT) environment. ColAT supports a multilevel description and interpretation of collaborative activities through fusion of multiple data (Avouris et al., 2004). It provides researchers the ability to organize and synchronize data of different sources through "Projects" that are grouped in "Studies". In "Projects" data concerning specific subjects can be synchronized by setting appropriate time delay for each source and can be transcribed and analyzed in three different but connected levels. Activity data can be described and commented by entering suitable "Typologies" to the "Study". Appropriate Actors and Tools can also be determined by the researcher which confront to the requirements of the adopted analysis methodology.
In our case study dialogues, user actions with the applications and observations derived from the

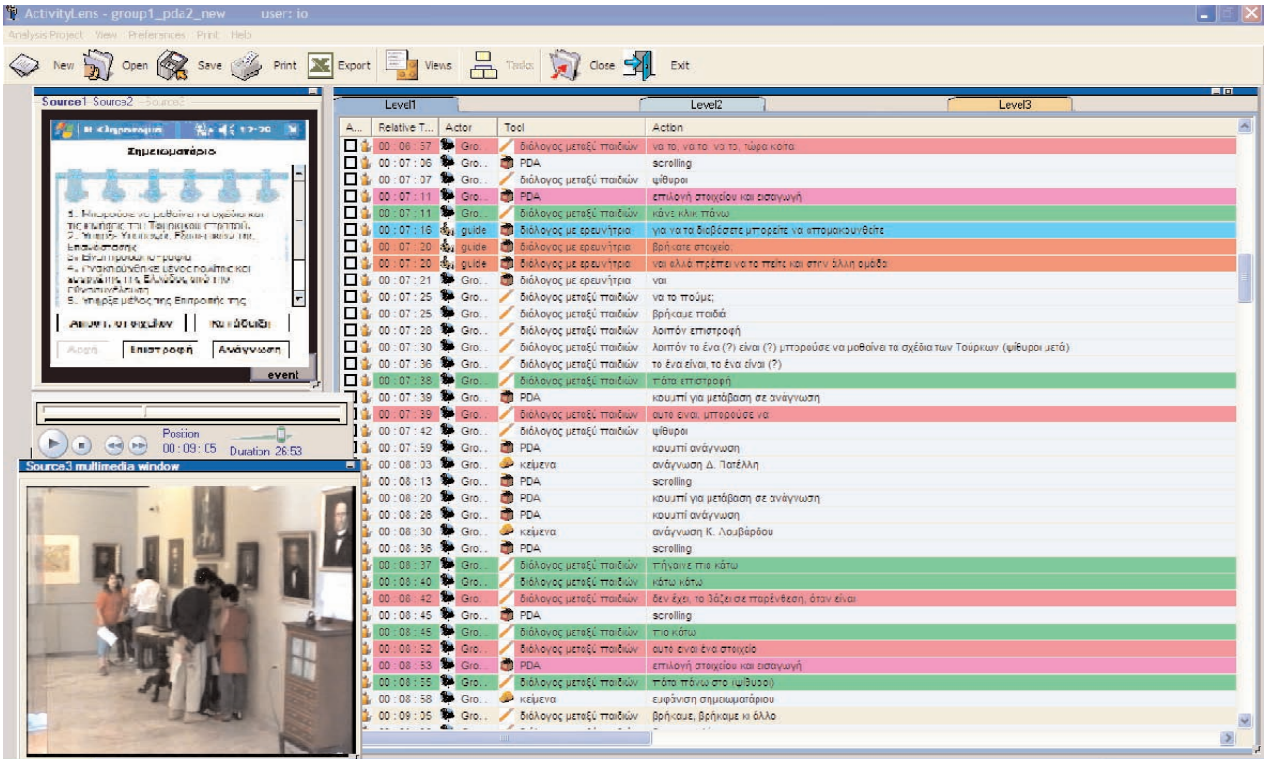

Figure 1 Data analysis environment

videos were transcribed in this first level of analysis (see Fig. 1). Typologies were defined in order to characterize these first level operations of subjects. The analytic tool which was created was influenced by a similar analytic tool used for studying collaborative modeling activities (Ergazaki et al., 2007). Some representative typologies adopted were "Reading of information", "Clarifications concerning the use of the application", "Clarifications concerning the object of the activity", "Negotiation for the next action", "Reading of Clues", "Sending Clues".

In a subsequent level of analysis, lower level operations were grouped in intended actions. Actions such as "Support", "Data Search" and "Reasoning" were identified. The identification of these intended actions was achieved by the combination of the actions and dialogues that led us to identify three different goals guiding the participants. For example, reading of text was some times intended to find hints necessary for the solution of the problem while, in other instances of the activity, reading of text was intended to support reasoning: While reading information about an exhibit, in some occasions, they mentioned that they didn't see a hint inside the information. In other occasions they referred to previously discovered hints and compared these hints to the information they read. In the first case participants aimed at finding data necessary for the solution of their problem. In the latter case the participants tried to reason about the information they were reading by using the hints they had already collected.

The third intended action that was identified throughout the procedure was support. This action consisted of episodes where support about the activity' scenario or the use of the application and devices was requested or delivered accordingly. For example, a presentation of the activity and the use of devices took place in the beginning of the procedure. During the procedure, the participants asked the researcher about the way they can send hints to the other team or how they can save hints in the notepad provided by the application. Also support was also provided by students to other students during the procedure.

Analyzing data using this analytic tool gave us valuable insight about the interactions of the participants, the role of the facilitator and the patterns of the students' actions. The role of the facilitator was to provide support throughout the activity. A pattern was identified in the participants' actions. In the first part of the procedure participants focused on collecting data. In the second part participants focused on reasoning and asked for support at every stage of the procedure.

3. Discussion

In this paper we presented a methodology based on Activity Theory, used to study a mobile learning activity. Data collection aimed in the detailed monitoring of the procedure. As derived from our experience analyzing the learning outcome of the activity,

the combination of different sources of data though can facilitate further study and deeper understanding of the tools' usage and the students' interaction with mobile technologies.

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Reconstructing an Informal Mobile Learning Experience with Multiple Data Streams

One of the benefits — for both learners and researchers — of using mobile technologies in informal learning is the ability to capture the process as well as products of learning, plus elements of the surrounding context. Thus, we have used a combination of tools including a purpose-built mobile learning system, audio recordings, video, text messages, photos and web server logs. The post-session reflection used all of those methods, and we introduce what we believe is a new research tool, the Photo Story. From a research point of view, constructing a cohesive story from multiple streams of media is challenging. In addition, we have observed interesting differences in learner-captured vs. researcher-captured media and its perceived value during analysis. We present initial findings and issues from recent work in this area involving mobile and static learners aged 10-12 in an indoor/outdoor summer camp activity. We conclude with some issues raised for discussion from the experience and of the data captured.

1. Introduction

Evaluating the impact of mobile learning with handheld technologies in multiple contexts presents research challenges and tradeoffs in what data is captured and for what purpose. Our previous and related projects have involved learners interacting outside in small groups, often accompanied by an adult facilitator, with mobile technologies designed to guide and prompt their activities and collect work output, e.g. Ambient Wood (Rogers et al., 2005), SENSE (Smith et al., 2005), e-Science Public Understanding (Underwood, 2004), Chawton House (Weal et al., 2006) and Personalised Learning Trails (Walker, 2007). In our current e-Science Usability project we investigate these areas further and our focus is capturing sufficient data to reveal:
What learners are doing;
What they discuss during small group activities;
What aspects of their environment are attended to and stimulate their thoughts;
Where they are at that time;
What work products result
whilst paying attention to social factors such as adults, helpers and interaction with those not connected to the running of the experience; and how technology mediates the learners' activity.

Motivations for capturing these multiple facets of the learning experience are two-fold: firstly by replaying aspects of their own experience (e.g. video, photos), learners are reminded of key points and are able to reflect on those in the context of the whole experience. Secondly in order to understand what aspects of the learners' activity and contextual cues contributed to the learning taking place, we seek to capture as much data as is readily available to allow the reconstruction of the learners'

Data type	Purpose of data and users of it	Useful for	Capture method	Example learner behaviours revealed
5 video tapes: 3 of outdoor trail, 2 of the lab-based activity before and after the trail	Capture environment of learning (indoors and out). Learners trail tape, researchers – complete set	Reflection and review by learners Analysis of activities by researchers	Manual by researcher, facilitator or participants	Dialogue as clues are solved and items spotted Stimuli to the dialogue Purpose of interaction with technology
Mobile phone logs – time and message content	To track movement along trail, maybe location. By central base	Communicates progress and indicates next clue or task required	Messages saved to phones, messages and timestamp captured manually	Learner teams' descriptions of items found
Gallery of saved photos (taken through mobile phones) on-line plus text annotations created afterwards	For creating group summary of what was found / captured. Learners and researchers	Reflecting on experience and creating findings summary	Automatically by web-service, manually re-arranged by learners	Highlights of experience, understandings about items found
Audio files	Capturing what was interesting and can be improved. Learners and researchers	Learners interviewing each other for feedback on experience	Manual	Views on content and overall rating of experience

Table 1. Sample of data sources captured of M3 experience

experience and re-design a future learning experience.

2. The 'M3' learning experience

The My Mobile Mission (M3) trial was conducted in an attempt to better understand mobile technology as a mediator in e-Science learning activities. Six learners (in three pairs, with one or two adult facilitators to each pair) engaged in an outdoor treasure-hunt activity, with each group using two mobile phones and a video camera. On one phone learners received clues as text messages leading them to find examples of sustainable energy on a university eco-campus. Learners used the other phone to take photographs of the objects they found and save these using a data-capture service for later web-based review, reflection and summary construction once back at base. The researchers were responsible for manually coordinating mobile phone communication. This involved sending clues to the children via SMS and receiving their answers.

3. Putting it all back together for analysis

Reconstruction of the treasure hunt trail and learners' reflection activities enables us to understand more deeply the interplay between task, environment, action and technology beyond our initial impressions. To facilitate this, the complete dataset has been collated (Table 1 shows a sample), initial passes of the data were undertaken individually followed by group researcher reflection around a large screen on interesting aspects, missing data and future analysis plans. Currently we are experimenting with the construction of data-stream 'photo stories' for the experience (See Figure 1 for an example).

4. Photo Story

The 'photo story'(page 22), created using Comic Life, provides a snapshot view of a self-contained segment of collaborative learner activity. It combines stills taken from the video stream with learner dialogue, contextual descriptions and researcher annotations, relevant learner-created products, and time codes from the video. The intention is to concisely and coherently communicate key features of the activity drawn from one or more researchers' analysis of the data.

For researchers, the process of creating and collaborating around such photo stories prompts us to look for and reflect upon the most relevant moments of learning and interaction during the segment, and represent these in a meaningful and readily understandable 'story.' This facilitates our own analysis and also eases presenting results to others. For learners this same process of presenting a comic like representation might be an engaging way to prompt and support reflection on a learning activity — particularly for the learner demographic for whom this is a readily understandable and interesting representation.

5. Discussion and questions raised

Photostory

Our ongoing analysis of data from the M3 activities highlights the following issues and points of interest:

What mechanisms affect which technology is attended to and desirable within the learner group? e.g. a device being perceived as not working, lower reading ability making text message reading and sending de-motivating

How accurately can we synchronise the multiple data streams?

What learners did not enjoy in the session e.g. text messages not being immediate in delivery to them. One of our trial groups made use of the delays by standing-still and discussing associated environmental benefits of the item. This kind of learner impatience has led on to experience re-design to alter the learners' expectations of immediacy and prompt reflection or activity during the waiting time.

How do creative uses of available resources (technology, environment etc.) whilst carrying out tasks contribute to learning? E.g. through experimenting with resources in unexpected ways: one facilitator encouraged the learners to be creative in capturing photos; a group member spotted a 3D model layout of the campus in a foyer which was used by the group to review where they had been and plan new directions more easily than with their small paper map.

How can collated activity be made available and engaging for its continued use, learning and development in learners' non-school contexts?

Our analysis activity and results will be discussed further at the workshop, and we are interested to hear others' views on the following:

What methods have been used to access the new knowledge that is being built within the experience by learners? Specifically analysing

conversations in pairs and groups, using appropriate prompts during such conversations, and stimulating learner-generated products.

What aspects contribute to the trade-offs between resources available for capture, quality of the data and the utility of those resources for future analysis e.g. the need to not overwhelm learners by many observers accompanying them, resources available to analyse the data (e.g. full versus selective transcription), researcher-captured versus learner-captured data, etc. The contrasts between video and audio captured depending on who is holding the camera include news report versus playful documentary style; what learners are willing to narrate to camera during the experience and possibly the engagement level with the recording during post-trail reflection and review activities.

What data that was not captured would have been good to capture in various situations? E.g. reflective accounts, after a time-period, on technology, process, activity. What supporting resources could we have on hand?

What tools and methods others have found particularly useful for research analysis e.g. synchronisation, analysis and re-player tools such as Replayer (Greenhalgh et al., 2007), the VidGrid prototype tool (Fraser et al., 2005) and the Homework project analysis tool (Underwood et al, 2006).

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Are they doing what they think they're doing? Tracking and triangulating students' learning activities and self reports

Researching mobile learning requires studying learners' activities that take place across multiple contexts (formal and informal). However, collecting data that reflects on learners' activities in different contexts is difficult as learners could not be followed and tracked across all these contexts. In addition, learners' self reports could not be trusted as the only source of data. This paper discusses a methodology for mobile learning research that enables studying learners' activities that take place in and across contexts and ensures the accuracy and validity of learners' self reports.

1. Background

Numerous studies in the literature that explores mobile learning rely mainly on learners' self reports, collected through questionnaires and interviews, to provide data about the utilisation of devices in formal and informal settings (e.g. Hennessy, 2000; Waycott, 2002; Corlett et al., 2005). However, using self reports as the main source of data is insufficient because, first, the collected data lacks detailed description of students' activities that take place in different contexts. Second, differences can be found between what learners say they have done, or will do, and what actually they did, or will do. For example, a study conducted by Waycott (2002) investigated the possibilities and constraints introduced by PDAs that can change the activity of reading course material. The researcher collected data through telephone interviews and questionnaires. Waycott (2004) admitted that relying on self report methods to collect the data was limited especially in terms of determining the accuracy of the collected data. In addition, the researcher acknowledged that it would have been beneficial if she have conducted in-depth observations of the activities under analysis to resolve this limitation. Therefore, researching mobile learning requires, first, using research methods that can provide detailed description of learners' practices and enable studying the longitudinal pattern of these in and across contexts (formal and informal). Second, other research methods should be used to collect data that triangulates and adds a valuable secondary perspective to the interpretation of the data collected through self report methods.

2. Methodology

Considering the limitations of the methodologies implemented in the studies in the literature, three studies were conducted in two Institutes of Higher Education to investigate the concept of mobile learning and explore how students' utilise portable devices (old and new) to accomplish their learning activities in and across formal and informal settings. Two studies were conducted in a university that

implements a campus wide laptop program. The university provided all students and academic staff with laptops to be used to accomplish their routine tasks. A third study was conducted in a university that did not implement such program. In these studies, first, the participants were asked to complete a questionnaire which aimed at providing a general idea about their utilisation of portable devices in formal and informal settings. Then, the participants were observed in multiple contexts to collect more description of their utilisation of devices for learning in these contexts. The observational notes also helped with triangulating the validity and improving the accuracy of the data gathered through questionnaires. At the same time, system-monitoring software was installed in students' laptops to provide information about their activities in different contexts, especially in locations where students' could not be observed. Determining the activities that the students pursued through the log files, consisted of a set of screenshots captured from students' laptops, was done by studying the applications that a student used, the purpose of using these applications and the continuity of these across contexts. Activities such as reading course materials, revising lecture notes, working on course works and communicating with colleagues were determined using the log files. At the end of the studies, students were interviewed to clarify some of the unclear issues in the observations and the log files. A total of 12 students agreed to for the software to be installed in their laptops most of which answered the questionnaire and were observed and interviewed.

3. Challenges and concerns

The methods used to collect the research data raised a variety of ethical concerns. First, students' informed consent to install system-monitoring software in their laptops to gather data about their laptops' usage was obtained before installing the software. Students were also notified of the reason of such recording, the usage of its outcomes, and their agreement on releasing the outcome. Second, students' informed consent to be observed in formal and informal settings was obtained. Third, students' anonymity and privacy was considered by keeping students' identities and the gathered data confidential. This was done by removing students' identification form the data, especially log files, once collected and ensuring that the collected data is not accessible to anyone other than the researcher.
The studies also encountered a number of ethical and practical challenges. First, getting the university's agreement to observe students in informal settings and install system-monitoring software on students' laptops. The universities were concerned about students' confidentiality and privacy. Second, getting students' consent to participate in the studies and install system-monitoring software on their laptops. Students' main concern was also their privacy and anonymity. Third, some technical

problems were encountered as a result of conflicts between the security software installed on students' laptops and the system-monitoring software.
Moreover, the studies were faced by a number of methodological challenges. Using observations as a method to collect research data have some limitations. Students might behave differently and may not engage in the activities they usually accomplish when they are not observed. In addition, the observer may misinterpret what students are doing or might be affected by past experiences. Moreover, the researcher may not notice some detailed changes because of observing students for a long time. However, looking at the repeatability of observations over time can assess the reliability of the collected data as it can show that the observed instances are not unique but happen all the time. The same applies to the data collected through system-monitoring software as students' practices may have been altered by their awareness of the software running on their laptops.

4. Discussion

The methodology used in these studies allowed for learners' longitudinal patterns of use, collected through observations and log files, to be explored in depth. The methodology also enabled self reports, collected through questionnaires and interviews, to be triangulated by data collected through other methods (observations and log files). Here is an example that illustrates how the methodology used in the studies helped with studying mobile learning. Observations of a student backed up with log files collected from her laptop showed that the student's questionnaire responses regarding using her laptop in formal and informal settings are valid. The student reported that she uses her laptop to engage in learning activities and discussions with colleagues through instant messaging software in formal and informal settings. The log files showed that the student used her laptop to view lecture slides in the classroom, revise these at home and use them to facilitate group discussion during a group meeting. The spaces where the student was in were determined based on the observational notes and log files which showed the conversations that took place between her and people through instant messaging software (as she mentioned where she was) and comparing the time logged in the log files with the student's timetable to determine whether the student was in a formal or informal setting. The student was also interviewed to provide more information about the purpose of the group meeting and how portable devices were used. Learning in the case was considered mobile as the student pursued learning activities that are directed towards the same learning objective, understanding a topic, in different contexts such as the classroom and home. The methodology also helped with studying students' learning activities in relation to the context (physical and social) of the space where these took place. Detailed description about the physical and

social contexts was gathered through interviews and observations. In addition, the relationship between context and learning activities was studied through questionnaires, interviews and log files.

It is also worth mentioning that students' self reports in the studies were, in general, honest. Most of students' responses were validated through observations and log files. However, some instances where students' responses reported in their questionnaires contradicted what they actually did were found. For example, one of the participants reported in his questionnaire that he never uses his laptop in formal settings to communicate with others through instant messaging software. Nevertheless, when the student was observed, also shown in the log files collected from his laptop, the student frequently used instant messaging software to communicate with others inside and outside the classroom some of which helped with problem solving. This shows that log files and observations can help assess the validity of students' self reports, provided that these investigate a wide variety of students' activities that take place in different contexts.

In addition, in the studies, students' self reports generally lacked detailed description of their utilisation of portables in different contexts. The observations and log files provided information about students' utilisation of technology that was not mentioned in their questionnaires or interviews. For example, a student mentioned that he usually uses his laptop to visit websites related to the topics discussed in the classroom. The log files supported by the observations showed that some of the websites that the student visited were suggested by the instructor during the class as the web addresses were shown in the lecture slides. This shows an example of details that students may underestimate and might be essential for some researchers.

5. Conclusion

The studies showed that mobile learning can be studied by investigating learners' activities that are directed towards achieving the same objective and take place in and across multiple contexts, embodied as the combination of the physical and social setting of the learning activities (Wali et al., forthcoming). The studies also showed that studying mobile learning requires using research methods that provide descriptive data and enable collecting longitudinal data about students' learning activities in and across different contexts. The methodology should also enable triangulating students' self reports to ensure the validity and accuracy of the collected data.

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Designing Mobile Games that Explore Novel Learning Practices with Co-Design

Co-design practices have been the focus of current research efforts in the field of educational technologies but not as prevalent in mobile games to support learning. By focusing on the entire experience of game based learning including the design process richer opportunities for data collection and evaluation can be gathered. The flow of mobile activities can be "caught" by using techniques like automatic and collaborative tagging technology that combine users' active contributions, reflections with the exchange of data between devices and systems. This paper presents how co-design offered insight to the design and evaluation of a mobile game called Skattjakt (Treasure Hunt in Swedish) and the benefits it can have for future learning activities. The outcome of our activities over the last year with 2 completed trials and 3rd in progress has provided us with valuable results that can help us to bridge the gap between learning in informal and formal settings. Moreover, we believe that involving children in the design process of mobile games may give us new insights regarding the nature of their learning practices while learning with these games.

1. Introduction

New forms of mobile communication and collaboration are rapidly being adopted and integrated into young people's everyday lives on a global scale. Multimedia capable mobile phones, MP3 music players, digital cameras, and GPS devices are merging into single powerful units that rival the computational power of laptops at the fraction of the cost with genuine portability. These devices have provided new opportunities for researchers, educators, and enterprise to explore how mobile games can be used to support learning practices. Recently mobile games have begun to be taken seriously within the educational arena. These recent proliferation of mobile games makes them a fertile ground for the development of new resources to support learning (Facer et al., 2004). Mobile games can promote children getting involved in different tasks such as exploration, content generation, collaboration, problem solving and navigation in space; all these activities can be seen as important components that support a wide variety of cognitive and social skills. By adopting a design approach for mobile learning activities that takes in consideration the diversity of mobility and context. By focusing on the entire flow of the learning activities where mobile technologies are just part of the activities can provide richer opportunities for data collection and evaluation. The flow of these mobile activities can be "caught" by using techniques like automatic and collaborative tagging

Figure 1. The game map with markers and detours with the mobile game interface below

technology that combine users' active contributions and reflections with the flow of data between devices and systems. Learning and other activities can be designed where students reflect and co-create new mobile content that is used by others in different activities. These efforts may result in new dynamic visualizations that can be part of the toolbox for students, educators, and researchers to explore the emergent properties of the group (Dron, 2007). In my current research I have approached the design through iterative cycles where the mobile applications have become one of the tools in the learning activity. My research goal is to assess the value of co-design for the implementation of new mobile learning activities as one of the ways to analyze and understand the nature of these novel learning practices and outcomes that impacts the future design of new activities.

2. Game Description

The paper presents Skattjakt (Treasure Hunt in Swedish), a game that has been conceived and implemented to promote physical activity and collaborative problem solving. The game is inspired by the ideas behind treasure hunt activities and the sport of orienteering, a traditional Scandinavian running sport involving navigation with a map and a compass. The activities in the game explore informal skills such as learning about local history, reading maps. The game requires different degrees of collaboration between team members to solve the mystery. Up to six teams can simultaneously compete using mobile phones, as they progress through the playing field with detours for wrong answers. The playing field is spread out over the university campus with seven locations. A strong narrative drives the players to help a ghost solve a mystery about her lost husband who built the castle on campus. The mobile interface includes an interactive map with the different marked locations where the players can zoom in, out, and pan to see the entire playing area. Figure 1 illustrates the full map of the playing field with the detours and the mobile game interface. Children playing the game can communicate with the game server that provides the logic and scoring for the game.

The game has been part of two completed trials in 2007 in February and June. Currently the game is part of a third trial in the fall of 2007. The game has been a central part of informal learning activities and iteratively developed, for the first as a proof of technology and part of co-design effort for a university course on mobile games. For the second trial part of weeklong summer school class for girls (aged 13-15) where the games acted as a starting point for game design course where the outcome was two student created game concepts. Currently the game is being used in an elective class at a local middle school (aged 13-15) where the outcome will be a new co-designed game to run in December 2007 for other students. The game has acted as a catalyst to get the students and teachers involved in the design process providing a bridge to more formal learning activities.

3. Approach

The pedagogical design of Skattjakt has been inspired by recent social constructivist perspectives (Jonassen et al., 2002) that regard learning as enculturation, the process by which learners become collaborative meaning-makers among a group defined by common practices e.g. language, use of tools, values, beliefs, etc. Social constructivism asserts that a particularly effective way for knowledge-building communities to form and grow is through collaborative activities that involve the design and construction of meaningful artifacts as well as the exchange of information. An implication of this view on learning with regard to the design of novel educational activities supported by mobile technologies is that effective and meaningful learning may not take place if these technologies are used only in traditional ways. Thus, designing and implementing learning activities that truly support innovative educational practices is a challenge.

Co-design can be defined as highly facilitated, team based process in which teachers, researchers, and developers work together in defined roles to design an educational innovation, realize the design in one or more prototypes and evaluated each prototype's significance for addressing an educational need (Penuel et al., 2007). The co-design process relies on teachers' ongoing involvement with the design of educational innovations, which typically employ technology as a critical support for practice. But at times these design approaches do not necessarily use the inherent qualities of mobile technology to catch empirical data that can be used in the evaluation process or involve the students directly into the design process. Inspired by design-based research that combines educational theories and practices to look how individuals and groups interact in complex settings (Hoadley, 2004). The Skattjakt project is using social constructivism perspectives with the methods of co-design and design-based research to explore how informal game activities playing and making can be used to better understand how to design new mobile game-like learning

activities.

4. Assessment

The game with the surrounding activities has provided us with a way to look at informal learning practices that improve our understanding of the different aspects of the learning processes and its outcomes. Skattjakt has also enabled us to look at co-design and other participatory methods that can have a big influence on the future design of mobile games and learning activities by allowing the students to become actively involved in the design of their own learning material. We have written field notes, made interviews, have been "hanging around," collected documents used in the different learning situations, and in addition have had deep interviews with teachers and learners. The aim of using ethnographical methods has been to "come closer" to learning in real settings, find out "how learning is taking place" – how artifacts are used, how the content of learning is established, what the interaction between the participants looks like, and so on. Over the course of two trials and with ongoing classes we have used surveys for the players and stakeholders, simple observation forms for researchers, provided additional mobile phones for the players for photographic self-documentation with GPS tagging, and simple data files generated by the game system for collecting data. In the later trials this content was visualized and reviewed to create new content for future games. The top row of figure 2, are images from the 280 self-documented photographs the students in the second trial took while playing the game. The bottom row is the workshop in progress and a detail of a student created game concept.

Figure 2. The photographs below present the images taken by players in the second trial and images of the workshop conducted during the summer school.

According to Vavoula (2007), mobile learning should be evaluated according to the following 3 levels namely: a Micro level: assessing user's experience of the technology including usability aspects and utility of functions, a Meso level: looking at the user's learning/educational experience and a Macro level: in which the evaluator tries to understand the impact on learning/teaching practice as well as the appropriation of the new technology and new practices. All these different levels can help understand some of the on-going learning processes as well as they can also assist us to identify problems and further requirements. For assessing the value of co-design we have primarily worked in the Meso and Macro levels utilizing the ethnographical approaches presented above. Figure 3 presents how different data can be caught and used together with the co-design process to explore how design and evaluation can be used to "catch" the flow of the learning activity that takes in consideration the additional challenges of mobility. Using this approach enabled us to use various methods for data collection about the different activities with a loose framework for evaluation. In the first pilot trial we used surveys only and for the second trial along with surveys we used, the photographic self-documentation with additional mobile phones, the use of simple observation conducted by researchers, and a daylong workshop for 10 of the players, which resulted in new game concepts. By looking at the results, we begin to see some patterns across the surveys, interviews, and the photographs the students made during the experiment. The patterns between how the different stakeholders viewed the perception of collaboration between the players, the observers, the researchers, and the teachers. The data from the interviews was a selection of six girls from the second trial where four of them also participated in the workshop activity. The interviews where conducted during the workshop the day after the game. We also used observation and procedures sheets developed in one of our other projects that helped the observers to look at aspects such as attitudes, engagement, collaboration, understanding of the task, the game experience, roles of players, and cultural issues.

MICRO (Usability)	MESO (Experience)	MACRO (Impact)
Survey, Observations, & Interviews	Game Workshop	Game Workshop Game Class
Game Data	Survey, Observations, & Interviews	Survey, Observations, & Interviews
	Self-Documentation with camera phone & GPS	Self-Documentation with camera phone & GPS
Co-Design		

Figure 3. How co-design is used across the learning activity

The six observers were a mixed group of researchers, university students, and members of the local orienteering club. In the current trial 11 students are participating in the class. They have played the game with 10 additional students from another school. Surveys, interviews, observations, along with the game data have been collected during the game. Exploring the co-design practices has provided additional information beyond the data we collected from the surveys and interviews. By working with the students in the post game activities we could see how learners want to become engaged in the activities by connecting the skills of playing games to making games and relating this knowledge to other learning domains. The preliminary indications of our results offer promises for understanding how informal mobile games can be used as learning tools in traditional educational settings by actively involving students in the design of their own learning activities. This can provide ways to understand the learning practices of the students and at the same time provide digital competence of game design and production with more authentic experiences. The game with the surrounding activities has provided us with a way to look at informal learning practices that improve our understanding of the different aspects of the mobile learning and its outcomes.

5. Discussion

What the surveys, interviews, and self-documented photographs point to is the high value of collaboration between players in the teams and in the workshops. During the summer school course the students' expressed to learn more about technology to extend the game features and viewed the running and problem solving as positive. Being able to participate in designing the game in combination with actually playing the game is described from the interviews as an enjoyable creative challenge for the students. The combination of making up a story and creating tasks for the players is something that the girls say could be used in integrating different school subjects, such as physical education, environmental, math, and science studies. In previous work (Kurti et al., 2008) with mobile outdoor learning activities for students and teacher students they have not been directly involved in the co-design process. Skattjakt has helped to evolve the research by enabling richer evaluation opportunities that can help the design future mobile learning games and learning activities through this involvement.
From these nascent results we can see promise in a co-design approach to alleviate some of the challenges faced such as designing activities that take advantage of mobility and context that have value beyond traditional learning and begin to address some of the new literacies afforded by this technology (Lankshear & Knobel, 2006). Skattjakt's game based learning approach integrated with co-design can provide children with powerful opportunities not only to learn through experiences, but also to

develop meta-level reflections on strategies for learning by making new games (Facer et al., 2004). At the same time this provides relevant design input by the inclusion of students / players in the process that provides additional insight to evaluate the learning process.

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Track 2
theoretical frameworks

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In the Workplace: Learning as Articulation Work, and Doing Articulation Work to Understand Learning

This paper offers an account of a methodological approach to understanding and developing learning that has been successfully used in a research project on mathematical skills in workplaces. The approach is based on the concept of articulation work, which is concerned with the processes of coordination and integration by which different social worlds intersect and negotiations take place between them, and the role of symbolic boundary objects as mediators for negotiation.

1. Introduction

This paper is a work-in-progress which involves using the concept of articulation work in the development of a methodological framework that builds on the results of a project which investigated mathematical skills in workplaces, and developed novel forms of learning interventions to support employees in developing new skills.

The concept of articulation work was developed by the sociologist, Anselm Strauss (1993), to account for the under-valued and often "invisible" forms of work (particularly, for him, the work of women at home and at work) which are nevertheless critical to the completion of tasks in everyday life, or in workplaces. In Strauss' terms (cf. Hampson & Junor, 2005; Suchman, 1996), articulation work is the coordination and integration that must go on such that organisational arrangements between the "social worlds" inhabited by people are established, maintained and revised. Strauss (1993, p. 212) defines a social world in terms of there being a primary activity (or more than one); sites where the activity occurs; technology that is involved; and organisations that evolve to further one or more aspects of the world's activity. Here "organisations" refers to both formal organisational structures of, say, a workplace, but also the informal structures that evolve amongst employees to maintain the practice[1]. "Interactional" processes are central to articulation work, including negotiating, compromising and educating. Social worlds intersect along "fluid boundaries" which are continually negotiated, and I am particularly interested in the technological and mathematical artefacts through which these boundary negotiations take place. In research on mathematical skills in workplaces, my colleagues and I[2] were interested in the role of mathematical skills in a range of workplace types, one of which was

[1]There are similarities here to the "cultural-historical activity theory" approach, which we have used in previous writings (Kent et al, 2007; Bakker et al, 2006). In order to keep my thread of argument simple, I will not discuss these similarities in this short paper. (Cf. also Fjuk, Nurminen, and Smordal, 1997.)

[2]Techno-mathematical Literacies in the Workplace project, 2003 – 2007. See www.lkl.ac.uk/technomaths.

customer service call centres for financial services companies, which were providers of pension, investment and mortgage products direct to customers (Kent, Noss, Guile, Hoyles, & Bakker, 2007). Articulation work is central to this work, since it is all about the employee's ability to articulate between the informational needs of the customer and the IT-based information systems which hold the customer and product information. We found that the articulation work of customer services was very often compromised by a lack of mathematical understanding on the part of employees; indeed, their roles had generally been setup not to require such understanding. This is perhaps not surprising, given the shortage of mathematical skills in the labour market, and the wage premium employers must pay to obtain them. Thus, among the social worlds within a company which interact around the IT system, there has been an intentional system design on the part of managers and financial-mathematical experts such that the mathematical models and relationships used for the calculations within the IT system have been made to be invisible, except to those expert employees. Why should this matter for companies? The informational needs and expectations of customers are changing; customers want to know more, and this puts a pressure on customer service employees to explain more, which challenges the mathematical understanding of both employee and customer. An example of lack of understanding that we observed involved pension customers seeking information about the annual pension statement which had been sent to them, which contained a projected value of their pension at the point of retirement (see Figure 1). The projection was based on a mathematical calculation (compound interest) that was unknown to the employees; thus they could only provide scripted responses to customer questions (likely not to satisfy the customer), or pass the customer query on to technical departments (an expensive exercise for the company).

Our research involved trying to find means of developing employee understanding of some of the mathematical calculations that featured in the IT systems they worked with. They reported dis-satisfaction in that they perceived calculations as "just magic", and we wanted to replace such perceptions with a solid (although necessarily limited) understanding of what was happening. A need for informal learning presented itself: informal in the sense of being unlike (formal) school maths (any attempt to introduce this would alienate most employees, and fail to take account of the complexities of the workplace context), and drawing on employees' personal experiences and understandings. Informal, also, in that our time with the employees could only be very short, thus we wanted to offer tools and ideas to the employees which would allow them informally to work on changing their own practice.

The key to this approach to mathematical learning is to make use of the "symbolic boundary

Statement date: 24 April 2005
Date of birth: 19 April 1956 Pension age: 60

Your fund at the statement date is: £14,223

Projected benefits at pension age:

	Lower rate (5%)	Mid rate (7%)	Higher rate (9%)
At age 60 your fund would be	£23,100	£28,400	£34,900
This could buy a pension of	£623 pa	£1336 pa	£2337 pa
OR			
A tax-free lump sum of	£5,770	£7,110	£8,720
and a pension of	£467 pa	£1002 pa	£1753 pa

These are only examples and are not guaranteed — they are not minimum or maximum amounts. What you will get back depends on how your investment grows.

Figure 1: A simple example of a pension statement "symbolic boundary object".

objects" that form part of practice, that is, the graphs and numerical tables that are the inputs and outputs of the IT systems. Figure 1 shows an example of a pension statement that proves problematic for communication between employee and customer.
We generally sought to adapt and modify boundary objects for the specific purposes of learning, incorporating them within software-based mathematical learning tools and simulations which we designed. In this case, an appropriate mathematical software tool was a spreadsheet (Microsoft Excel) which is ideal for the construction of tabular data, and it allows users to do algebraic constructions through the use of "point and click" formulae, so that explicit algebraic language may be avoided (but it is there if users wish to look for it), and moreover the spreadsheet will do the work of carrying through the algebraic manipulations and calculations for particular numbers. Thus in dealing with pension statements, we asked employees to re-construct a pension statement such as Figure 1 in a spreadsheet, starting with the most simple case and then building in additional details (e.g., management charges of various forms). An additional advantage of the spreadsheet is that it is software which most employees have access to on their own computers, and already use in the most basic fashion for consulting information. Thus we could hope that employees might take on board the ideas we showed them for re-thinking their understanding of mathematics in their routine practices.

2. Learning as articulation work

If work is interpreted as articulation work, then attempting to extend the capabilities of employees through learning interventions can be seen as an exercise in articulation work

in which employees attempt to integrate the results of learning into their existing practices. We thus came to use articulation work in three connected ways:

- as an analytical description of how mathematical knowledge and skills become integrated within working practices;
- as a principle for the design of software-based mathematical tools to support learning in workplaces; and
- as a methodological principle for conducting workplace research which may probe into the nature of mathematical learning "in context".

Symbolic boundary objects and their mediation of articulation work play a central coordinating role among all three ways. The third way implies that we as researchers are also doing articulation work, as we bring our social world into intersection with the social worlds of the workplace. In some sense, it is obvious that researchers must do this, but I would like to stress how necessary we found it to think of ourselves in this way, adopting the position of co-developers and co-teachers with company trainers and technical experts, rather than as outside educational experts who ("objectively") observe the situation and deliver a learning "solution".

A telling example of this occurred when we opened our learning sessions with the following short exercise:

Geoff and Susan book themselves a "last minute" long weekend break in New York City. Going into shops, they find it a bit confusing that all prices are given without "sales tax" added, and then a sales tax of 8% is added when they pay at the till.

In one electronics shop, they find a special offer of all digital cameras with 15% discount. They decide to buy a camera which has an original (pre-discount) price of $250. At the till, the shop assistant takes 15% discount from the original price and then adds the sales tax.

Geoff is not happy with this and complains to the manager: he thinks the assistant should add the sales tax first, and then take off 15%, because that way he will get a bigger discount.

Who is right Geoff or the manager and why?

A common employee response to this question was to insist that only one way could be legally correct, an interpretation that simply did not occur to us in designing the exercise: "The 8% tax has to be on the price paid, so the customer is not right." In our reading of the exercise, we looked through the hypothetical context to what mattered to us, the mathematical relationships involved, and understanding Geoff's situation in mathematical terms. This shows that the "why" of the context is as crucial as the "what", and that "mathematical experts" should not expect to understand what matters mathematically in the context, without doing the detailed articulation work of negotiation with the social worlds of the context. And I think it is appropriate to call this articulation work, because researching in workplaces really did involve for us a continual negotiation and a very gradual, emergent coming-to-

understand of the context.

3. Conclusions

In summary, the research described here typically involved looking for workplace situations where there are "intended" boundary objects, through which sharing and communicating about knowledge are intended to happen, but fail to happen because of a lack of knowledge in one or more of the communities involved, or an effective means of mediating the knowledge for all. In such cases, we worked on learning interventions which aimed to introduce new boundary objects which: (1) helped us initially to learn about the nature of the (mathematical) knowledge in the situation, and (2) were intended to "repair" the flaws in the situation by introducing new software-based forms of mediation for the (mathematical) knowledge.
I will conclude with a few points about how the methodology described in this paper may have wider relevance for research on informal learning. The articulation work and boundary object approach has strengths in the following ways:

- to make visible what is ordinarily invisible – both to employees/learners and to researchers of learning, which is particularly important for domains of technical knowledge which the development of IT systems tends to render invisible; by introducing a designed symbolic boundary object, you create a need for the employee to externalise their knowledge and understanding;
- looking for changes in practice over medium-term timescales as evidence of learning – as the learner seeks to integrate boundary objects with their existing practice;
- to seek long-term sustainability of learning interventions, by engaging companies and organisations in a way that encourages them to take control of what begins as a researcher-led intervention.

What I particularly like about this approach is that there is a continuous, coherent flow from initial observation of workplace practice around symbolic boundary objects, to the design of boundary objects which "capture" the mathematical concepts at issue in the practice, testing these through learning interventions, towards the sustainable introduction of the tools and ideas into workplace training and practice.

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Mobile Learning Evaluation The Challenge of Mobile Societies

This paper looks at the apparent difficulty of the mobile learning community to develop an adequate portfolio of rigorous and appropriate research methods with which to support the evaluation of mobile learning and then tentatively proposes that this difficulty lies not wholly in a failure of the imagination or the confidence of the community to develop these tools and techniques but rather in the gulf between modernism and postmodernism represented respectively by the expectations of evaluation and the aspirations and alignment of mobile learning.

1. Efforts to Date

Recent publications (Kukulska-Hulme et al, 2005; JISC, 2005), and conference proceedings (for example, Attewell and Savill-Smith, 2004) have put a large number of case studies documenting trials and pilots (and their evaluations) into the public domain. They show that mobile learning is now poised to build on these trials and pilots and break through the barriers of scale, embedding and durability and to deliver greater inclusion, opportunity, participation and equity in learning. (Other initiatives, such as the Microsoft Mobile Learning Summit in Seattle in August 2005, the launch of MoLeNET in London in September 2007 and the establishment of the International Association for Mobile Learning in Melbourne 2007, might corroborate this impression.) However evaluation that is rigorous in the eyes of the necessarily increased range of stakeholders is a prerequisite for the necessary resources, funding and support. The tools and techniques for such evaluations are part of the wider repertoire of research tools and techniques. Several recent papers by Traxler and Kukulska-Hulme (2005, for example) explore and assess the current philosophies and practices of evaluation in mobile learning and highlight a number of concerns. One of these concerns is the tension or pay-off between the trustworthiness of tools and techniques for evaluation on the one hand and their appropriateness to the novel mobile environment on the other; a related concern is the small number of evaluations using techniques and tools indigenous to mobile learning. So there are challenges to the development of credible and authentic tools and techniques for the current generation of pilots and trials. The evaluation of mobile learning must however also face the challenge of moving from informal and impressionistic accounts to the sort of large-scale and longer-term studies that are the prelude to sustained and widespread deployment supported by government, and thus to the move into the domain of evidence-based decision-making (and 'evidence-based decision-making' is itself problematic, see Sanderson (2004) for a critique). These are all considerable technical challenges but the purpose of this current paper is rather different.

2. A Different Perspective

In looking at evaluation efforts to date and seeing a picture of only partial success, there is a possibility that what we see is not purely the outcome of insufficient confidence and inadequate imagination in meeting the challenges of researching mobile learning and developing evaluation techniques and tools local to mobile learning, be it innovative or large-scale. We may be seeing something more profound, a mismatch between the (implicit) ethos of much mobile learning and the (implicit) philosophy of most of its research (and specifically, evaluation) methods

Mobile devices, systems and technologies are the symptoms and causes of societies and cultures in motion (not just literally), and we would make the case in passing that mobile learning should perhaps be defined most generally, durably and powerfully as learning aligned to these societies and cultures in motion (rather than, for example, being defined as learning delivered by these devices or to learners whilst in motion or whilst they cross contexts). These societies and cultures are changing profoundly, they are in fact becoming recognisably *postmodern*[1] societies and therein lies the root of the difficulties with evaluation, not at the technical level but at the philosophical level. Evaluation however, specifically in terms of its philosophy and methods, is a *modernist*[2] project taking place in a progressively more postmodern environment, in a postmodern environment catalysed and propelled in a significant way by ubiquitous mobile devices, systems and technologies.

The purpose of this paper is to explore the possible relationships between mobile learning and postmodernity (and post-structuralism[3] to a lesser extent)

[1]Postmodernism is not an easy concept to competently define, not least because its many manifestations may be linked only as a reaction to modernism (or the 'modernist project'), and to a range of cultural and intellectual movements growing out of a century of global warfare and the perceived inadequacy of the dominant and 'isms' of the preceding two centuries. Butler (2002) gives some insight into the problem of definition, saying, "postmodernists ... do not simply support aesthetic 'isms', or avant-garde movements such as minimalism or conceptualism ... They have a distinct way of seeing the world as a whole, and use a set of philosophical ideas that not only support an aesthetic but also analyse a 'late capitalist' cultural condition of 'postmodernity'. This condition is supposed to affect us all, not just through avant-garde art, but at a more fundamental level, through the influence of that huge growth in media communications by electronic means ....And yet, ...most information is to be mistrusted, as being more of a contribution to the manipulative image-making of those in power than to the advancement of knowledge. The postmodernist attitude is therefore one of suspicion ....." (p3) and "A postmodernist view of the social changes that have most affected contemporary society would therefore ... emphasise such matters as the extraordinary compression of time and space through the new media." (p117)

[2]Modernism is briefly best described as the cultural and intellectual climate in Western Europe arising out of the Enlightenment and characterised by logical positivism, empiricism, rationality etc

[3]Post-structuralism is a further issue and could be characterised as a philosophical (that is, epistemological, ethical and ontological and hence methodological), response to the condition of postmodernity. Belsey (2002) explains it as follows "Poststructuralism names a theory, or a group of theories, concerning the

insofar as they raise issues for the research tools and techniques. Some relevant aspects of this emergent postmodernity include:

• Mobile technologies are reconfiguring the relationships between public and private spaces, and the ways in which these are penetrated by mobile virtual spaces. This is increasingly documented in the literature of mobilities (see for example Plant (2000), Katz & Aakhus (2002), Ling (2004) and Brown et al (2004) for a range of accounts and instances; also for example Cooper's (2002) remark that the private "is no longer conceivable as what goes on, discreetly, in the life of the individual away from the public domain, or as subsequently represented in individual consciousness", Sheller and Urry (2003) who argue "that massive changes are occurring in the nature of both public and private life and especially of the relations between them." and Bull (2005) who says that "The use of these mobile sound technologies informs us about how users attempt to 'inhabit' the spaces within which they move. The use of these technologies appears to bind the disparate threads of much urban movement together, both 'filling' the spaces 'in-between' communication or meetings and structuring the spaces thus occupied.")

• Mobile technologies are redefining discourse and conversation (see the sources mentioned above and for example, Murtagh's (2002) account of the use made of a wide set of non-verbal actions and interactions with the mobile phone in public)

• Mobile technologies are eroding established and largely European, perhaps Protestant notions of time as the common structure (see for example Plant's (2000) remarks about the 'approx-meeting' and the 'multi-meeting', Sørensen's (et al, 2002) remarks about 'socially negotiated time' and Ling's (2004) remarks about the 'microcordination of everyday life' alongside the 'softening of schedules' afforded by mobile devices)

• Mobile technologies are also eroding physical place as a predominant attribute of space (see Gergen (2002) for his remarks about "absent presence", and Plant (2002) who has noted that mobile phones have created "simultaneity of place": a physical space and a virtual space of conversational interaction, and an extension of physical space, through the creation and juxtaposition of a mobile "social space".)

• Mobile devices facilitate learners' direct experience of - 'messy', 'noisy' – 'reality', challenging the reductionism and foundationalism of established educational orthodoxy that attempt to manage and control how 'reality' is represented in the classroom (what Helen Beetham

relationship between human beings, the world, and the practice of making and reproducing meanings. Onthe one hand, postructuralists affirm, consciousness is not the origin of the language we speak and the images we recognise, so much as the product of the meanings we learn and reproduce. On the other hand, communication changes all the time, with or without intervention from us, and we can choose to intervene with a view to altering the meanings which is to say the norms and values our culture takes for granted." (p5)

calls the 'dual paradigms')

- Mobile devices, systems and technologies, as the media and containers of knowledge and information, are creating new and highly individualised ontologies – learner/consumer choice turned into what was, at a recent meeting, called the 'neo-liberal nightmare', and fragmented learners in a 'fragmented society' (to use Bauman's (2001) phrase in an accurate but narrower sense than he intended).
- Mobile devices, systems and technologies are creating communities and groupings, sometimes transient and virtual ones, arguably at the expense of existing and traditional ones (captured in Howard Rheingold's (2003) defining book); and new norms, expectations, ethics and etiquettes (for example, see Ling (1997, 2004)); and are possibly shifting ideas about the self and identity)
- Mobile technologies are converging with social software, accelerating the growth of user-generated content and decentralising and fracturing the production and control of ideas and information (the growth of citizen-journalism (Owen, 2005) is one example)
- Mobile devices are creating new politics and political groupings, and are creating new and transformed notions of exclusion and disadvantage (see Reinhold (2000) for the most visible account of some of these groupings and accounts of the protest actions against President Estrada in the Philippines (Katz & Aakhus (2002) for one specific example)
- Mobile technologies provide increased levels of surveillance and oversight, even in the course of delivering and supporting learning (Many of the current authors cite Lyons (2001) in this respect.)
- Mobile technologies facilitate the generation of new knowledge, intruding a new dimension into the debate and dichotomy between utilitarian and liberal views of education, perhaps challenging the modernist notion of education as a modernist meta-narrative (postmodernism's 'incredulity at meta (grand) narratives' (Lyotard, 1999) is important here in challenging this idea of a widely, if not universally, accepted corpus of knowledge that is education)
- Mobile technologies deliver knowledge and information in ways that challenge formal learning, its institutions and its professionals, specifically in their hegemonic roles as gate-keepers to learning and technology

This presentation will explore the implications of these observations for the research and for the evaluation of mobile and informal learning and will suggest that perhaps the mobile learning community should explore the research ideas of, for example, constructionism, narrative analysis and critical psychology (see Denzin and Lincoln (2005) for one of the most authoritative accounts of these themes). One specific example might serve as a point of departure and an example of the direction that the mobile learning community should explore.

Grounded theory is an established social research technique; it is

however established around a 'realist' or modernist perspective (Strauss & Corbin, 1998) and this is now challenged by a constructionist alternative (Charmaz, 2002)

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Whither case-based approaches to understanding off-site and on-campus mobile learning?

This paper reports on the preliminary findings of a qualitative study of the use of high-end mobile phones for off-site and on-campus mobile learning. The aim of the study was to investigate how mobile devices are being integrated by learners in their informal/private 'space' and what use they make of mobile devices in formal learning contexts. The focus of this paper is the research methods used in the study, the preliminary case study results and a related discussion. The methodology of this study draws on a range of different approaches to qualitative data analysis focusing in the main on subjective and perceptual aspects of students' personal and study-related experiences in using mobile phones. This study, in our view, has demonstrated not only the appropriacy but also the efficacy of the use of narrative and case-based approaches to the study of mobile learning, with a focus here on data analysis, and we will endeavour to refine this methodology in further studies.

1. Introduction

This paper reports on the preliminary findings of a qualitative study of the use of high-end mobile phones for off-site and on-campus mobile learning.

The use of mobile devices in UK Higher-Education (HE) is an under explored area. Our preliminary research (Cook, Bradley, Lance, Smith & Haynes, 2007) took the stance that a productive pedagogical vision is one that views the cultural emergence of innovative educational practice in terms of what Bakardjieva (2005, p. 34) calls "user appropriation" or "technology-in-use-in-social-situations", and what we are terming 'learner-generated contexts' (Cook, 2007; LGC, 2007). Although the preliminary study generated interesting results through the use of a survey, we recognised that the analysis had only scratched the surface of the notion of 'appropriation'. Therefore, three students, who appeared to represent a broad range of views, were invited to be involved in follow-up interviews.

The context for this research is UK HE, where students who were taking an MA module, were given an assignment task which required them to gather data in the form of video clips and photos from an off-campus event. Each student was loaned a Nokia N91 phone for a 7-week period to help with the assignment. They also had to answer certain questions (i.e. fill knowledge gaps) that were posed by the so-called events checklist, a didactic intervention in the form of a mobile learning object pre-installed on their phones. The learning design underpinning the events checklist intended to provide an appropriate mix between guiding learners' experiences of remote informal contexts and providing formal

assessment opportunities for their activities. Furthermore, the wider learning design also provided the opportunity for social construction of knowledge through a shared uploading environment (mediaBoard), and it included an explicit formal judgment on their attainment of the intended learning outcomes (see Cook et al., 2007 and Laurillard, 2007 for a detailed discussion).

The aim of the study reported here, therefore, was to investigate how mobile devices are being integrated by learners in their informal/private 'space' and what use they make of mobile devices in formal learning contexts. In particular, we were interested in the bases of the appropriation of new mobile communications systems. We expected to find early users demonstrating agency in relation to discovering the relevance of mobile learning to their own contexts.

The focus of this paper is the research methods used in the study, the preliminary case study results and a related discussion. The paper will conclude with a brief examination of the utility of our approach for investigating informal mobile learning.

2. Study set-up

These interview questions framed our interests within the format of a semi-structured interview, to ensure that each student would as far as possible be asked the same questions and that all our research interests would be covered in each interview. Initial questions were focussed on putting the interviewee at ease and asking about their first uses of mobile phones to provide useful background contextual information.

The interviews were conducted on a one-to-one basis by the researcher in the team, who was already known to the students from earlier evaluation activities during the study. The researcher was not part of the teaching or assessment team. Each interview was scheduled to last about an hour. It was recorded and transcribed verbatim to preserve the precise language used by the students.

The questions that guided our research were:

1.What are the learner's personal stories?

a.Where does the learner's fascination with technology come from?

b.What are the affective issues (do they think it is cool, fun, etc)?

c.How would the learner change the technology if they could?

2.Could learners see themselves using this mobile learning technology regularly for personal, work-based and/or more formal educational use in the future?

3.Was there an appropriation of the technology (which represent new communications devices) by motivated learners?

3. Methodological orientation

The methodology of this study draws on a range of different approaches to qualitative data analysis focusing in the main on subjective and perceptual aspects of students' personal and study-related experiences in using mobile phones. The methodology

can best be described as being 'eclectically purposive' drawing loosely on narrative and case-based approaches underpinned by grounded theory. By eclectic we mean the process of the deliberate selection of those components to the various approaches to data analysis which seemed to best suit the aims and objectives of our study without feeling obliged to adhere slavishly to methods in the way their leading proponents might have prescribed. This we do not see as 'selling out' to methodological relativism, rather as ensuring fitness for purpose of the chosen methods in relation to what the study set out to achieve. Strauss & Corbin (1990) suggest that grounded theory is especially useful for complex subjects or phenomena where little is yet known – as is the case in our study. This is because of the flexibility of the methodology which can cope with complex data and which is characterised by continual cross-referencing; this allows for grounding of theory in the data, thus uncovering previously unknown issues. We have found grounded techniques useful as a way of guiding our research, where concepts are classified and grouped together under higher order, more abstract formations called categories. It is noteworthy that there is a productive tension between initial theories (e.g. Bakardjieva, 2005) that guide the formation of research questions and the putting of such preconceptions on hold whilst the data is analysed to build, possibly new, concepts out of that data. The main body of data informing the part of the study reported here is drawn from what might be called 'student narratives' elicited through a set of narrative interview questions from which sample cases of three learners were collected. The interview transcripts were analysed qualitatively using an iterative inductive approach to the data whereby themes were allowed to emerge through systematic reading by three coders, the authors of this paper. The themes were then used to categorise the data (see the discussion section below for the emergent themes).

Our methodological approach was modelled on Daly, Pachler, Pickering & Bezemer (2006). In common with Daly et al. (2006), we were in an ongoing dialogue about the "principles of meaningful interpretation, or what constitutes a 'good story' in terms of yielding meanings which have value" (p. 5) in the context of the research questions. And, we also deemed Greenhalgh's (2006, pp. 9-12) criteria to be indicative of a good story of 'mobile learners' (quoted here from Daly et al. 2006, p. 5):

Aesthetic appeal: the narrative is pleasing to hear and recount; it contains an internal harmony

Coherence: the narrative is clear and makes a logical whole; it contains a 'moral order' or sense

Authenticity: the narrative has credibility, based on the experiences of the listeners/readers

Reportability: "the 'so what' value" of what is narrated; its significance

Persuasiveness:the narrative convinces of the teller's own perspective

In the research reported here, these criteria are not so much seen as characteristic of the learners' narratives (as these were circumscribed by a number of specific interview questions), but rather of the sample cases we constructed out of the interview data. In contrast with Daly et al. (2006), we applied the narrative methodology only to the data analysis, not the data gathering. We also drew on Shulman's (1996) case-based learning which, whilst rooted in teacher education and development, is of interest to us in the context of research in mobile learning for the structure it affords to document mobile phone use and mobile learning practices, thereby making them less ephemeral and rendering them accessible for analysis and discussion. Shulman rightly posits (1996, p. 199) that cases "take advantage of the natural power of narrative ways of knowing". Shulman views cases as "ways of parsing experience so that practitioners" – and researchers, we would argue – "can examine and learn from it".

4. Discussion and analysis

Three case studies were generated, but only one is featured in this paper for space (please see the Appendix). The three students are not necessarily representative of the large mobile phone user base and confined to a small sample of female international students in their mid twenties who, whilst not early adopters, have all been part of the early large wave of mobile phone users. All three participants are well educated and belong to a particular socio-economic strata, and provide a fascinating tapestry of attitudes to and practices of mobile phone use. Whilst we make no claims here that our – necessarily brief – analysis of the rich data is generalisable more widely, we can see a number of broad categories emerge from the data that constitute variables that impact on existing mobile phone use and conceptualisations of potential uses, namely:

- user biographies;
- technical skills of users and functionality of devices as barriers or facilitators;
- 'techno-centricity' of users, and how this relates to conceptualisations of identity;
- attitudes towards learning;
- user attitudes towards social networks.

Émilie's mobile phone practices (see Appendix) in social and learning contexts, for example, appear highly bound up with her attitudes towards technology as well as her conceptualisation of herself as a social being. She has perceptual barriers about informal learning: her fraught relationship with advanced technical functionality coupled with her inability to use manuals to acquire new skills sets as well as, even more importantly her seemingly high affective filter about informal learning conspire against her ability, and willingness, to conceptualise imaginative mobile phone uses and practices, particularly for informal learning.

5. Conclusions and implications

This study, in our view, has demonstrated not only the appropriacy but also the efficacy of the use of narrative and case-based approaches to the study of mobile learning and we will endeavour to refine this methodology in further studies.
The cases we were able to construct in this study based on qualitative user data suggests to us that, in order to maximise our insights into the potential of mobile devices for formal and informal learning there is great benefit in explicitly engaging learners in discussions about possible uses as well as attendant barriers, inter alia through scenario building.
We plan to follow up the analysis of this paper by developing the broad themes briefly outlined above by a more fine-grained analysis which will seek to identify sub-categories within the broad themes. We will do so with reference to sociological concepts, in particular Bourdieu's notion of 'habitus' (Lizardo, 2004) and Bakardjieva's (2005) notion of 'appropriation'.

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Learner Centred Design: Applying MobileHCI and Mobile Design Research Methods in Mobile and Informal Learning Contexts

This paper is a survey of research and design methodologies used for understanding individual (human) mobile behaviour used by developers within the MobileHCI (Human Computer Interaction) and Mobile Design research communities. This paper summarizes the most commonly used and emerging research methodologies and suggests which methodologies are ideally suited for researchers within informal and mobile learning contexts to help garner the crucial data to help make informed decisions about the design of learner-centred informal and mobile learning environments.

1. Introduction

The purpose of this paper is to briefly survey research methods from Mobile Human Computer Interaction (MobileHCI) and Mobile Design research to ascertain if research methods from these disciplines could effectively be transferred to Mobile Learning and Informal Learning Design research. Furthermore, this paper should be viewed as an attempt to make a small contribution to help enhance existing research methods and help inspire the development of new and novel research methods for the Mobile Learning and Informal Learning Design communities.
The methods highlighted in this paper have been chosen on the basis that they could assist in collecting useful, if not crucial, data in order to assist in the evaluation of the effectiveness of mobile learning and informal learning scenarios. The crucial data in question refers to any data that accurately measures the effectiveness of mobile and informal learning scenarios. Therefore, the crucial data sought by Mobile Learning and Informal Learning Design Researcher can be revealed through the application of well-suited methodologies that potentially help garner the key data that will help make informed decisions about current and future designs of learner-centred informal and mobile learning environments and scenarios.
The research conducted for this paper is exploratory in nature, and thus, will not be able to cover in depth many of the methodologies, concepts and topics surveyed. It is helpful to view this work as a medium to encourage thoughtful discourse and to continue an ongoing dialogue regarding how MobileHCI and Mobile Design research methodologies can be implemented by Informal and Mobile Learning Researchers to gain the crucial data to help inform how individuals learn within the context of mobility and informal learning contexts.

1.1. The Context of Mobile and Informal Learning Research

One of the greatest challenges

facing Informal and Mobile Learning Researchers is gathering large sets of quantitative and qualitative data from various observable and non-observable phenomena within a specific context or setting. The purpose of gathering such data can be seen as crucial in helping to evaluate the appropriateness and effectiveness of informal learning and mobile learning scenarios. Additionally, due to the ubiquitous and pervasive nature of mobile and informal learning it is no easy task to conduct quantitative research in natural and context specific settings with large numbers of study participants. Therefore, it is essential to identify and apply the most effective and appropriate research methodologies in order to achieve the desired results of gathering useful data within a specific setting and context. Bearing this challenge in mind let us reflect and ask what research methods can help Mobile Learning and Informal Learning Design Researchers gather the data needed?

According to Jensen & Skov (2005) it is useful to investigate research methods derived from different disciplines as these research methods can help inform on future directions and influences on a particular discipline. This paper argues that the research methodologies of Mobile HCI and Mobile Design are ideally suited to Mobile Learning and Informal Learning Design and will help face the challenge of gathering large sets of quantitative and qualitative data within a natural setting and context in order to evaluate the effectiveness and appropriateness of informal learning and mobile learning scenarios.

1.2. Real world learning

It can be observed that recent advances in mobile information and communication technologies have not only increased individual mobility, but have empowered and enabled individuals to harness mobile technologies for the purpose of using them to augment and enhance formal and informal learning contexts. Smaller more powerful mobile devices with network connectivity are enabling individuals to engage in novel learning situations that are not easily observable due to the ubiquitous and pervasive nature of informal and mobile learning contexts. Additionally, it can be argued that the very mobile information and communication technologies that enable these new modalities of learning can also be used to help Researchers observe and gather data on informal and mobile learning scenarios.

Many MobileHCI and Mobile Design research methods harness the mobile technologies and engaged the users themselves to assist in the evaluation of the accessibility, usability, and appropriateness of mobile devices and services. Therefore, one of the unique characteristics of the very technologies associated with Mobile Learning and Informal Learning is that the technologies used can be harnessed to help Mobile Learning and Informal Learning Design Researchers conduct large-scale quantitative research to help gather important

(crucial) data from real world mobile and informal learning scenarios which will could ultimately help broaden and advance current methodologies used to evaluate informal and mobile learning contexts.

2. Harnessing MobileHCI Research Methods

The following MobileHCI and Mobile Design research methods highlighted are grounded within the methodological theories of: Action Research, Ethno-methodology, Participatory Design and User Centred Design, which can be harnessed by Informal and Mobile Learning Researchers in order to gain the data which will inform the effectiveness of mobile learning and help evaluate informal learning situations. The "different research methods have been adapted in research projects ( ). This is no different than other disciplines, but it is important to understand how research methods have been adapted in different disciplines as it potentially informs us on future directions and influences on the discipline (Kjedskov & Graham, 2003). Wynekoop & Congor (1990) have conducted a review of research methods in which they created a classification scheme to help in their analysis. A summary of existing MobileHCI /Mobile Design research methods (See Table 1.) has been adapted from the research of Kjedskov & Graham (2003), and Jensen & Skov (2005) to reflect the Wynekoop & Congor classification of the most common research methodologies. This summary highlights the strengths, weaknesses and uses of various methods based upon the

Environment:	Method:	Strengths:	Weaknesses:	Use:
Natural Setting	Case Studies	Natural setting, Rich data	Time consuming, Cannot be generalized	Descriptions, explanations, developing hypothesis
	Field Studies	Natural Settings, Replicable	Difficult data collection, Unknown sample bias	Studying current practice, Evaluating new practices
	Action Research	First-hand experience, Applying theory to practice	Ethics, bias, time consuming, Cannot be generalized	Generation & Testing of Theories / Hypotheses
Artificial Setting				
	Laboratory Experiments	Control over variables, Replicable	Limited realism, Cannot be generalized	Controlled experiments, Theory/Scenario testing
Environment Independent	Survey research	Easy, low cost, can reduce sample bias		
	Applied Research	Learning scenarios can be evaluated	May need further design to make learning scenario applicable	Scenario development, testing hypothesis and concepts
	Basic Research	No restrictions on solutions, Solve new problems	Costly, time demanding, may produce no solution	Theory building
	Normative writings	Insight into first-hand experience	Opinions may influence outcome	Descriptions of practice, building frameworks

Table 1. Summary of existing research methods. (Adapted from Kjedskov & Graham, and Jensen & Skov)

environmental setting the research is conducted.

The research of Hagen, Robertson, Kan and Sadler (2005) demonstrates the emergence of new research methods used within the MobileHCI and Mobile Design communities. These methods are categorised and presented as an extension and combination of existing MobileHCI and Mobile Design research methods that evaluate mobile technology usage. Three main categories highlighted in their research "represent various approaches to accessing and making available data about different aspects of mobile technology use, (and) entail different roles and responsibilities for both researchers and participants." (Hagen 2005)

The following three categories are as follows and have been annotated to apply to a learner centred context and setting:

1.Mediated Data Collection: In which participants (learners) and mobile technologies mediate data collection about use in natural settings and situated learning context.

2.Simulations and Enactments: simulations and enactments are used to make available experiential information sensitized to real contexts of use.

3.Combinations: existing methods, and/or mediated data collection and/or simulations and enactments are combined to allow access to complementary data. (Hagen, 2005)

A summary of the above mentioned approaches are highlighted below (See Table 2.) including the description and derivation of use from established methods from which these new approaches are borne.

The above summary of existing and emerging research methods used by the MobileHCI and Mobile Design communities highlights many new and novel approaches in acquiring quantitative and qualitative data in order to evaluate mobile technology usage. In conclusion, the question remains as to why and to what extent and under what circumstances are the specific MobileHCI and Mobile Design research methods and approaches are (or, are not) transferable to the research conducted by the Mobile Learning and Informal Learning Design communities.

APPROACH:	DESCRIPTION:	DERIVED FROM:
Mediated Data Collection	Where access to data about actual use practices is mediated by both Learner & technology combined	
• Learner-centred	Learners conduct the data collection using mobile devices.	Self-reporting, Diaries, Probes
• Automated	Learners engage in learning (m-learning scenarios) while data about use, content and metadata is logged automatically	Use/Data logs
• Mobile recording	Learners go about their normal routines while wearing sensors or cameras.	Video-observation, Use/Data logs
Simulations & Enactments	Methods for allowing immersive scenarios in which data about existing or potential use is accessed through some form of pretending.	
• Simulations	Physical, ergonomic or environmental props are used within a controlled environment in order to simulate m-learning scenarios.	Lab tests, Scenarios, Heuristics, Prototypes, Emulators, Simulators
• Enactments	Mobile-learning scenarios are played out through visual imagery or storytelling in order to observe potential outcomes.	Prototyping Scenarios, Role-playing, Work shopping, Storyboarding
Combinations	Various established and/or new methods are combined to enable access to complementary data.	

Table 2. Emerging Research Methods in MobileHCI. (Adapted from Hagen, et.al.).

3. Conclusion

This paper has briefly surveyed research methodologies from the fields of MobileHCI and Mobile Design in order to suggest and evaluate the applicability of these methods to Mobile Learning and Informal Learning Design research. In order to determine if research methods from MobileHCI and Mobile Design could effectively be transferred to Mobile Learning and Informal Learning Design research it is important to question as to why and to what extent and under what circumstances are MobileHCI and Mobile Design research methods and approaches transferable to Mobile Learning and Informal Learning Design research. Furthermore, it is important to question which specific criteria can be used to judge transferability and investigate if there are specific reasons why MobileHCI and Mobile Design methods would not be transferable to Mobile Learning and Informal Learning Design? This paper will not be able to address these questions here at this time, but encourages further evaluation in subsequent papers in order to properly evaluate the transferability of the methods survey to the repertoire of Mobile Learning and Informal Learning Design research methods and approaches.

What is special about Mobile Learning and Informal Learning Design research in relation to MobileHCI and Mobile Design is the element of an embedded pedagogy (or learning design) inherent in the learning scenarios evaluated. One of the primary goals of Mobile Learning and Informal Learning Design research is to evaluate the learning and developmental outcomes of the individuals. Bearing this in mind it is possible that MobileHCI and Mobile Design methodologies are more suited to informing and evaluating aspects of usability and accessibility issues, but cannot truly evaluate learning and developmental outcomes of individuals.

The importance of highlighting current and emerging MobileHCI and Mobile Design research methods is that they are grounded within the methodological theories of: Action Research, Ethno-methodology, Participatory Design and User Centred Design, which can be easily adopted, adapted and augmented into Mobile Learning and Informal Learning Design research. The flexibility of choosing research methods derived from different disciplines may open new doors to help gather the crucial quantitative and qualitative data needed in order to properly evaluate the effectiveness of informal and mobile learning scenarios; which ultimately will place the learners at the centre of research and design and help them achieve their learning and developmental goals through the appropriate informal and mobile learning scenarios.

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Researching Informal and Mobile Learning: Leveraging the Right Resources

Researching learning is a challenging undertaking and the possibility of learning while mobile only complicates matters. Changes in learning should be complemented with changes in the research questions we ask, the methods we employ, and the data we collect. Mobile devices can aid us in the latter, but at the same time we should not forget about the learner holding the device. After all, it is he/she who makes (mobile) learning happen and can provide us with some valuable insights into what it means to learn while mobile.

1. Introduction: Rethinking Research

Educational research is tricky business because learning is a construct that is difficult to measure. Many tried-and-true research methods and data collection strategies often fall short in getting us the data we want and need. Even in relatively controlled environments such as "traditional" classrooms or research labs it is difficult to isolate variables and establish causal or correlational relationships between interventions such as digital technologies and learning outcomes (Schenker et al., 2007).
Introducing the concept of mobility and the possibility of learning while mobile only complicates matters. Mobility expands learning across space and time and opens up many opportunities for learning that is neither sequential nor consistent. Mobile, networked, and digital tools broaden it even more by providing increased connectivity to people and information (Roush, 2005), augmenting physical environments with digital layers (e.g. Price, 2007), allowing for customization of learning, and offering tools to create, manipulate, and share a wide variety of electronic artefacts (see also Sharples et al., 2006; Walker, 2006).
In order to study learning in such a flexible and volatile context, we need to rethink what we research and how we do it:

- The changing nature of learning is forcing us to look more at process, not necessarily just product. Learning is a lifelong endeavour that doesn't just happen in formal educational settings, and is increasingly seen in that way by a larger population. Consequently, we should carefully reconsider what kinds of research questions we ask;
- We can no longer rely on tried and tested ways of doing research to get what we need. As the nature of learning and learners changes, so should learning research methods and strategies;
- We should consider how we can leverage digital and mobile technologies used by learners to get a better insight into what it means to learn while mobile.

2. Reconsidering the Questions We Ask

Good learning research starts with solid research questions based on established theories. Too many times we end up with invalid answers because we don't ask the right questions. This has resulted in a substantial amount of research concluding that digital tools produce 'no significant difference', because it is implied in the research questions that learning is either "a high-tech or no-tech phenomenon" (Oblinger & Hawkins, 2006, p. 14). Especially in the area of learning while mobile, it is obvious that learning occurs as a result of a lot more, including an active process, interaction with others, and transfer of learning to/learning in real-world situations. Research questions should be adjusted to accommodate this complexity.

3. Adjusting Research Methods and Strategies

Research methods and data collection strategies should be reconsidered as well. Two common pitfalls in research procedures have been dubbed the 'hobbled horse race' (handicapping the perceived better intervention for the sake of research "fairness"), and the 'trivial treatment' (i.e. minimizing the intervention). It should come as no surprise that when such research methods are employed, a statistically significant difference is rarely the result, let alone a practically significant one (Tinker, 2007). Employing either one of these procedures when studying the effect of technology on learning is senseless. Instead, maybe we should be asking different types of questions that get at the affordances that digital technologies provide.

Data collection strategies that are most common in learning technology research include surveys and pre/post tests which are often complemented by observations, interviews, artefact analysis, and more recently self-reports by learners such as reflective journals. While useful for researching learning that happens in relatively fixed locations, do they hold up when studying learning in mobile and unpredictable environments? According to Taylor (2006), research strategies in the area of learning while mobile need to be more adaptive, and include alternative approaches such as analysis of interaction logs and learner contributions to externalized constructions.

4. Using Mobile Technologies to Capture Mobile Data

Mobile and digital technologies can be used to capture a wide variety of data that can help us get (better) answers. Key questions to ask include

- What (combination of) information is of most worth, i.e. what types of data should we collect given the research questions we ask? When investigating learning while mobile, the following types of data should be considered:

Spatial data: Where are devices being used by learners? (e.g. using GPS)

Temporal data: When are they being used? (time stamping)

User data: What are they being used for? (patterns of use)

Learner data: What content is being accessed? What artefacts do learners create? How do learners know that they are learning and what they are learning (assessment)?

Connectivity data: Who do learners communicate with? What do they share?

- How do we most effectively use technology to gather this data? If learners are using mobile digital tools for learning, research can leverage these same tools for data collection purposes. All of the data sources above can be captured using mobile devices. The question is how to get it to the researcher in ways that don't impede the learning process.
- To what extent should learners be involved in the research design? Learners are becoming increasingly independent, active, and unpredictable. Because of their mobility, it is much more difficult to collect data such as observations, or have face-to-face conversations. Therefore, collecting data can and should no longer be an issue of concern for the researcher alone. Involving the learner and his/her technology is essential.

5. An Example

Let's apply what has been discussed so far to an example of learning while mobile. Frequency 1550 is a city game using mobile phones, GPS technology, and an ultra high-speed broadband mobile phone network in Amsterdam, the Netherlands. The game teaches teenagers about local history by sending them on a trip through the city, completing tasks along the way (Waag Society, 2007).

5.1. Reconsidering the research questions

A 'traditional' approach to researching learning in Frequency 1550 would look for end results and employ questions along the lines of, "Is learning about Amsterdam's history with mobile devices more effective than without them?" or "What is the impact of mobile phones on student achievement when learning about Amsterdam's history?" Other questions to be considered, at a minimum, should focus on the learning process, and include "How does learning of history change when learning while mobile as opposed to learning in more traditional settings?" and "How do learners assimilate their learning of Amsterdam's history into their own lives?"

5.2. Adjusting research methods and strategies

Given the research questions, we can now decide on data collection strategies. With regards to changes in learning, we could utilize tried and true ones such as surveys, interviews, and reflective journals. However, these data sources will be much more valuable if we can augment them with spatial, user, learner, and connectivity data. In fact, the latter can be used to help structure the former (Zhang, 2002). Finally, we should consider the level of learner involvement in the research design,

which would probably focus on the learning experience and learner expectations.

5.3. Leveraging mobile technology

Much of the "new" data can be unobtrusively collected by mobile devices and synced up with a remote database while learners are engaged with their devices, their context, and their learning. Examples of applications include Rubberneck, which aggregates time-stamped application use data on handheld devices; RedHalo, remote storage for artefacts that learners create; and Mobile Tools' eTaitava, a mobile feedback system for vocational, on-the-job training. Note that in each of these instances the technology used includes wireless mobile devices and a remote, centralized database for data storage. In our example, we would probably want to collect spatial, user, learner, and connectivity data (and maybe temporal), which could be analyzed for patterns and be used to probe learners for a deeper understanding of these patterns.

6. Issues and Challenges in Data Collection with Mobile Devices

Researching learning while mobile also creates unique issues and challenges that should be addressed during the research design phase. Some of these issues include but are not limited to:

- Access v. privacy: What data can researchers have access to without infringing on the privacy of the learner(s) under study? When do they have access to it?
- Ownership of information/data: whose is it?
- Control over the research setting: learners tend to be more independent and unpredictable

7. Conclusion

The original objective of this paper was to take a brief look at how we can leverage mobile technology to study learning that moves across space and time. However, we cannot look at particular data collection techniques in isolation. If we are going to re-examine them, we also need to reconsider everything that drives data collection in educational research, which includes the theories that frame our thinking, the questions we ask, and the methods we employ. Only then will we have a better chance of getting the answers that we are looking for and the data we need to yield those answers. In addition, it is increasingly important to consider social and cultural dimensions in which learning (and therefore learning research) takes place. Learning is becoming evermore personalized yet collaborative. Our research should reflect that (Balacheff, 2006).

Nevertheless, portable digital technologies can play an important role in the mobile learning research we do, and we should take a closer look at how we can leverage it to help us in our work. In the meantime, let's not forget the learner holding the device. After all, it is he/she who makes (mobile) learning happen and can provide us with some valuable insights into what it means to learn while mobile.

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Track 3
Practice

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Researching the world out there: how do we know about the users that do not tell us anything?

The OpenLearn initiative at the Open University (http://www.open.ac.uk/openlearn) offers free and open access to online material that previously was only available to registered students of the University. This material has been placed in on online environment based on the Moodle learning environment with additional tools for communicating with other users and creating knowledge maps. One of the design aims of the environment was to be low barrier to access so that all content is available without registration, though some tools and features will only work once registered. The result is that we are seeking to research a site that is publicly accessible and has a majority of users that do not identify themselves, many of whom spend a short time on the site. As a further challenge the content itself is openly licensed using Creative Commons (http://creativecommons.org/) and so can be taken and relocated on mirror servers, or accessed remotely through content feeds. The initiative has had to face this challenge and implemented a mixture of tracking, simplified surveys and the gathering of interesting stories. This leaves us able to spot interesting trends but remaining unsure about many of our users and their aims.

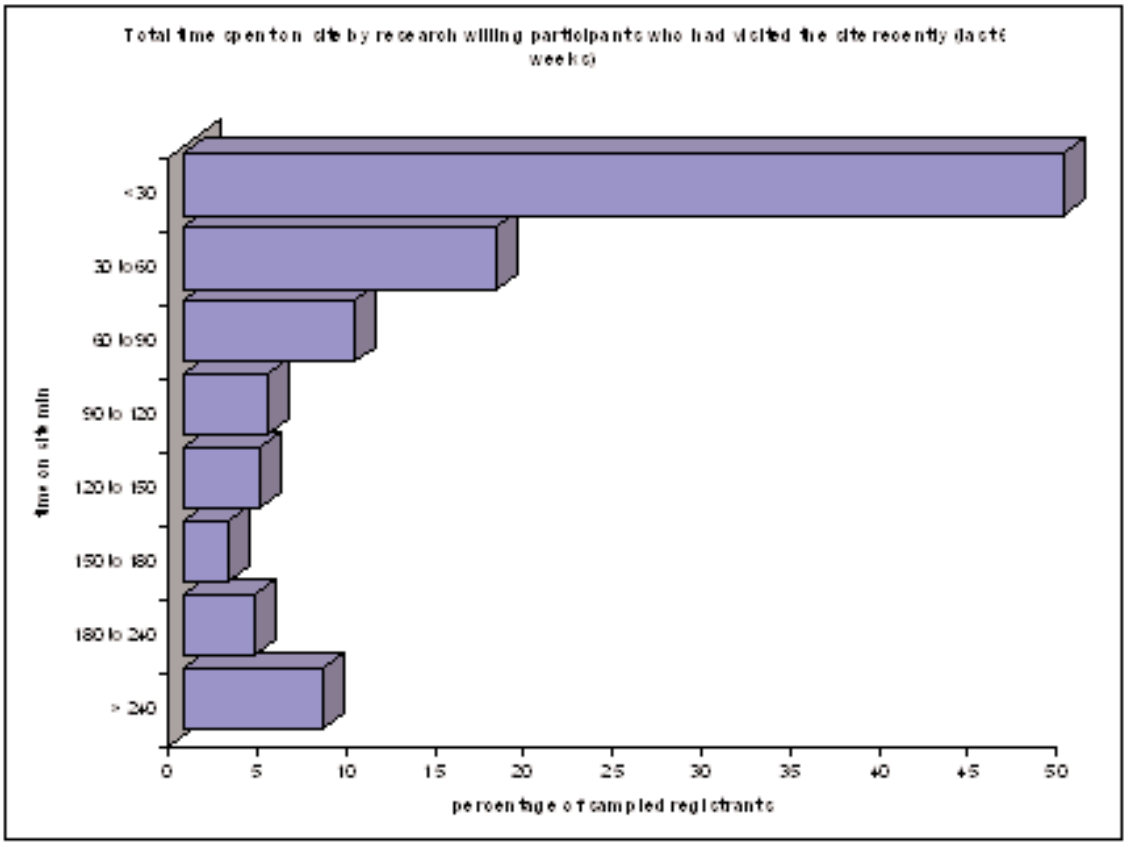
1. Planned approach

The original planning for the research of OpenLearn considered that we would have to take a three level approach to studying our users seeing them as visitors, registered and enthusiasts. The enthusiasts are those who are prepared to tell us what they do and indeed we have found that simply giving the avenue to report back data to us has enabled us to capture stories and investigate new ways to use OpenLearn. For registered users we can identify both their activity on the site, through logs in the Moodle system, and we request that they indicate to us if they can be approached for research purposes. In practice about half of those who register on the site give this permission. Even so registered users of OpenLearn are less than 3% of the overall users as measured by software tracing machine access. This means that for 97% of our users we have no direct measure of their activity and are only left with the tracks left from IP addresses and search engine hits. These are crude tools but should not be ignored in analysing use (Harley & Henke, 2007). In the case of OpenLearn, custom software was created to covert the log data stored by the Moodle learning environment into traced visits depending on machine address, the software then enables overall trends to be calculated and also visits to be examined. Examining the data for registered users showed that there was a distinction between those who spend a significant amount of time

on the site and those who visit quickly. Figure 1 below illustrates this for a particular sample over a 6 week period and is indicative of the overall shape of use. It is worth commenting that this data itself can only be an estimate based on the time between page impressions from the Moodle server. A conservative measure is used so that if the user only visits one page no time on site is recorded, though the user could have spent much longer reading that page. Analysis of visit data has given us a route to examine the lower end users from amongst those who are registered with a targeted survey and follow up questions. Similarly we have targeted the higher time on site users with a more extensive questionnaire. For some of those users we also have evidence of their engagement and use of the site through the artefacts that remain after they have made forum entries, enrolled in units and posted to their own learning journal.

2. User types from observation

OpenLearn does not apply a value-judgement in the access to the content, however it is easy to take the view that those who have spent more time on the site, registered and carried out tasks that leave evidence have gained more than those who visit once and do not return. Such "Google visitors", who are often landing from a search and so may have no expectations of the site, could well have found the simple answer to some questions, but we also suspect that the site needs to do more to appeal to this sort of visitor. We are now reviewing what it



1. Pattern of use of OpenLearn – based on 6 week sample of registered users.

means to be an OpenLearner, and so offer greater reason to register with the site and prepare to more fully use the opportunity to learn. Features associated with social activity are being explored that will separate out the dependence on subject-based content. In particular all users can record interests, collect things that interest them, spot what others like to do. To support this we are adding in a personal view of the site, tagging of content and personal interest, and a record of the users own action. These changes are primarily designed to further lower the barriers to use and increase the value of the site to learners. However they have the secondary benefit of making user actions apparent to the researcher so that we can understand where interests lie and the paths that users take through content.

3. Following a lead

When the OpenLearn site was developed it had an implicit model of the user that was drawn from the background of The Open University and influenced by the adoption of a learning environment that was focused on the concept of the student. At the same time we are giving permission to users to work with the content in any way they wished. This was made explicit in the provision of a separate "labspace" with extra facilities and the invitation to users to make changes to the content. What we did not expect was how innovations in use would take place away from our own site and be appropriated. Two examples from outside the OpenLearn team are the extraction of our content for reuse in distributed CDRoms/DVDs to provide local personalised learning environments in remote parts of the world (Esslemont, 2007) and the transfer of OpenLearn content through RSS feeds into other environments (Hirst, 2007). These users provide innovations that we did not plan for or had envisaged having a different purpose. The model of users as innovators is considered by von Hippel (2005) as an extension of his view of "lead users" that are going beyond the mass of users. Clearly in a small number of cases we have examples of such lead users and we have been able to draw on their experience and change our own work to benefit others. What is interesting to us is whether we have a greater mass of lead users amongst those who have not made contact with us. Attempts to monitor this have included automated notification of blog entries that refer to "openlearn", encouraging contact and being aware of potential connections, however it remains difficult to make an assessment of the level of participation and identify interesting activities. More direct appeals to draw innovators to the site have been more successful and this has now encouraged a group of educators to edit materials on the site. This gives us new material of benefit to all of our users, for example a translation into Catalan of an existing unit on genetics, but also provides us with a connection with users who are trying out new ideas. This suggests a model based on offering authentic actions on site that can also provide us with data.

4. Reflections for informal and mobile learning

The definition of informal learning established by Livingstone (2001) as "any activity involving the pursuit of understanding, knowledge of skill which occurs without the presence of externally imposed curricular criteria" would seem to encompass OpenLearn. Among our users there seems to be a continuum from chance arrivals who may pick up some knowledge, to those who are preparing to register for a course. The content is also suitable for use on mobile devices, with sample content transferred into the mobile content site wattpad (e.g. http://www.wattpad.com/24583-Global-Warming) and the underlying XML format suitable for transformation. However it is the open availability of the content that allows mobility rather than the device it is offered on and we expect advances to focus on the provision of a ubiquitous social environment rather than supporting particular devices. In this view we align with Taylor, Sharples and Vavoula (2005) in seeing "*the learner that is mobile, rather than the technology.*"

5. Conclusions

This view of researching informal learning has been based in the particular example of OpenLearn. However there are lessons that we believe are transferable to other similar projects and the mobile environment. Advice we would give are:

1.Realise that we cannot control all routes to access
2.Encourage all involved to be part of the experiment
3.Look in the data that you have to find patterns that can apply more widely
4.Build activities that are valuable to the user but provide you with data
5.Be prepared for the user that arrives anywhere
6.Start to make reasonable conclusion though you wish you had more data.

This advice is in itself tentative but can help to shape the interests of those involved in the production, use and reuse of open content and encourage informal learning – even when we are not sure quite how it is defined for those who are learning in this way.

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Using Personal Meaning Mapping to gather data on school visits to science centres

This paper describes how Personal Meaning Mapping, a variant of concept mapping, can be used to gather data from individuals on their thinking around a topic in science education. Using examples from a research study examining student learning when visiting an astronomy science centre in South Africa, the presentation explores the theory behind the practice of PMM, how it is conducted, how it can be analysed, and its possible uses in research and teaching.

1. Introduction

Personal Meaning Mapping (PMM) is a variation of concept mapping developed by John Falk and collaborators for use in informal learning environments (Falk, 2003). While concept mapping requires the technique to be taught to learners, PMM can be used with no prior experience on the part of the learner. This paper is based on an empirical study of school groups visiting an astronomical observatory near Johannesburg, South Africa (Lelliott, 2007). In the full study, 26 12to 14-year-old students across 4 schools visited the observatory as part of class field trips. The data collection involved structured interviews on astronomy concepts such as stars, the Sun and gravity (not reported here) and the students drawing Personal Meaning Maps with the phrase 'space stars and planets' used as the 'prompt' for investigating for their ideas on this topic. The technique of Personal Meaning Mapping is based on the concept maps developed by Novak and collaborators in the 1980s (Novak & Gowin, 1984) and subsequent variations (Leinhardt & Gregg, 2002; Morine-Dershimer, 1993).
I chose to use PMM as a technique to complement my other data collection method of structured interviews. The structured interviews focused on astronomy content, and could be regarded as a form of 'preand post-test' related to a traditional expectation of cognitive learning. In contrast, PMM is more suitable to the museum environment, and requires no preparation on the part of the participants (Adelman et al., 2000; Falk et al., 1998).

2. Personal Meaning Mapping: theory and practice

PMM is a technique in which an individual's knowledge and views about a particular topic are investigated prior to the person entering the museum and again after the visit. The technique is based on the concept maps developed by Novak and collaborators in the 1980s (Novak & Gowin, 1984). In concept mapping, a subject is taught how to map out their own understanding of concepts on a sheet of paper, and relate concepts to each other with appropriate connectors. In the analysis of concept mapping,

there is sometimes a 'correct' concept map, drawn by an expert, against which the subject's map can be compared and scored. Much of the concept map analysis that has been developed over the past 20 years is based on this type of comparison (McClure et al., 1999) and it has proved a useful technique for both pedagogy and the study of conceptual development, especially at the school and tertiary education level. There have been a number of variants of concept mapping since the technique was first developed by Novak. Techniques used by Morine-Dershimer (1993) and Leinhardt and Gregg (2002) are probably the closest to PMM. In a study of conceptual change, Morine-Dershimer asked student teachers to make a concept map depicting their view of the important components of teacher preparation by providing the phrase "teacher planning". Two semesters later, the students repeated the task, and then compared their post-course map with their original map. Leinhardt and Gregg used a similar method with pre-service teachers visiting a museum.

Critiques of concept mapping have been made by Kagan (1990) and Ruiz-Primo and Shavelson (1996). Kagan noted that they were used to assess short-term change rather than long-term gain and remarked that studies often compared subject maps with a target 'master' map. Many studies made claims that the map reflects an individual's actual cognitive structure, while Kagan considered that the maps may reflect their ability to "reproduce the structure of the discipline" (p 451) rather than show real changes in students' cognitive structures. Ruiz-Primo and Shavelson (1996) sounded warnings about using concept maps for assessment purposes, and stressed the need for further research on the relationship between the maps and students' cognitive schema. Apart from the fact that I used PMMs to demonstrate short-term rather than long-term gain, these criticisms do not apply to my study, as I used the maps principally as a basis for further questioning rather than analysing their structure.

One key difference between many analyses of concept mapping and PMM is that there is no 'correct' map developed at any stage, against which the PMM is scored. In fact Falk (2003) maintains that such a form of analysis would be counter to the philosophy of PMM in the context of museum learning. For Falk, there is no 'correct' answer or series of answers that a museum visitor can be expected to come up with in relation to their visit. Unlike the school classroom, or the university lecture, where the students would be expected to learn particular scientific concepts or facts, the learning which takes place in museums is personal, context-bound and idiosyncratic. A PMM is therefore postulated to be an individual's personal construct of whatever learning took place as a result of their visit. As Personal Meaning Mapping is a relatively new technique, and has mainly been carried out by Falk and collaborators, no analysis or evaluation of the technique has yet been published

Specifically, PMM is carried out in

the following manner:

1. Prior to the visit to the museum, the person is given a sheet of paper, in which a word or phrase is written in the centre. He or she is then asked to write or draw anything that comes to mind in relation to the word or phrase. This can be factual information, ideas, beliefs, or any other related opinions, and is written in a specific colour on the paper (e.g. blue).
2. The investigator then has a short interview with the individual, and, investigates the ideas he or she has already written on the paper, recording any elaboration of ideas in a different colour ink from the original (e.g. red).
3. After the visit, the person is given their original paper, and asked to make and changes or additions to what they have already written on the paper. This is done that they do not feel that the investigator is 'wasting their time' by asking them to repeat what they have already done, and it allows them to alter their original ideas. This contrasts with methods normally used in concept mapping. The corrections and additions the individual makes to his or her map use another colour ink (e.g. black).
4. Finally, the investigator carries out another interview, based on the alterations and additions carried out in step 3. The investigator writes these (again using the person's own words) in a different colour ink (e.g. green).

Personal Meaning Mapping has been used in a number of informal learning environments, but mainly in museums and science centres (e.g. Adelman, Falk, & James, 2000; Falk & Storksdieck, 2005). In these studies quantitative measures of four dimensions of learning: extent, breadth, depth, and mastery were used. Extent referred to the number of relevant words used, while breadth measured the quantity of appropriate concepts. Depth assessed the richness of concepts using a scale while mastery was a scalar holistic judgement of a learner's understanding. All four measures were analysed using statistical tests.

3. Analysis

As shown in section 2, a PMM is postulated to be an individual's personal construct of whatever learning took place as a result of their visit. My study being qualitative in nature implied that I forego extensive quantitative analysis, and make individual learners the units of analysis. In this respect the personal meaning maps and accompanying interviews were very helpful, as they provided details of the sort of learning not captured in my structured interviews. In addition, although not analysed for all the dimensions suggested by Falk, I was able to use the PMMs to assist with some descriptive statistical data, such as the number of astronomical vocabulary words (extent in Falk's terminology) used by each participant in the study.

3.1. Gugu's learning

One of the students participating in the study was Gugu, a 13-year-old African girl from a township in Johannesburg. Gugu's personal meaning map (Figure 1) drawn before her visit to the science

centre was similar to those of many other students in my study. She listed the nine planets together with some brief facts about several of them. For example that Jupiter is the biggest planet and Mercury is the closest planet to the Sun. She referred to stars as being "a lighting thing" created by God, and that they are our "friends, family and negbour" (sic). She also referred to stars being at the galaxy and Milky Way. She stated that space consists of open space, containing planets, stars, galaxy and the Milky Way. When probed about her PMM, she confirmed that "God created stars so that it can shine at night". Although she knew the term galaxy she was unable to explain its meaning or its relationship to the term Milky Way. She further referred to a spaceship and rocket, although she found difficulty in expressing herself here. She also appeared to have differing ideas on aliens. Having said she doesn't believe in them in the structured interview, she mentioned in the PMM that some planets have aliens.

After her visit to the science centre, Gugu added considerably to her PMM, filling the reverse side of the paper with numerous facts. Several of these facts were a repetition of her pre-visit PMM, such as her reference to the nine planets, Pluto being the coldest, Mercury being the hottest and stars being in the galaxy. However, she wrote down several new pieces of information,

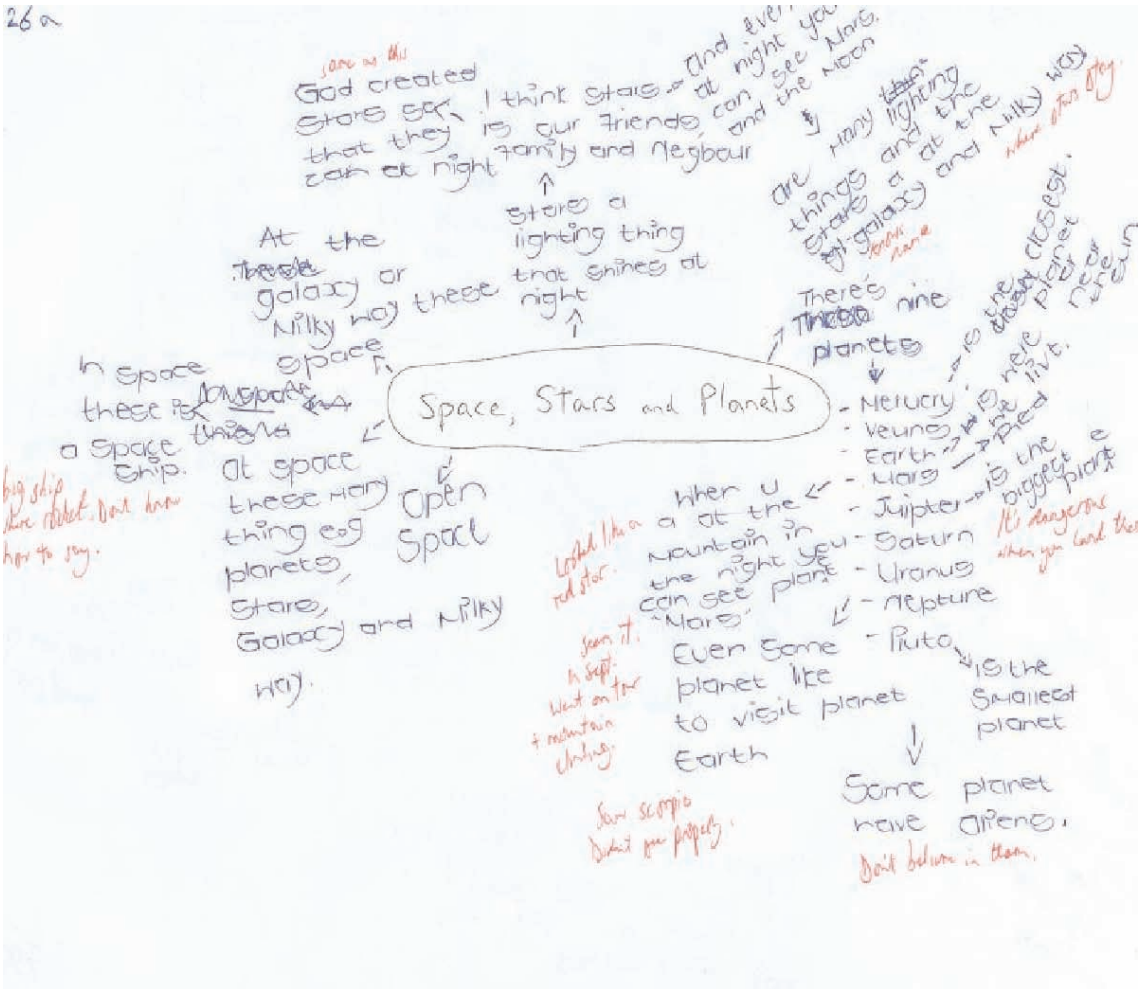

Figure 1. Gugu's Pre-visit Personal Meaning Map

including the following:

- She "saw which bottle goes high and low". This was reference to the 'Coke bottle rockets' which students used in an activity at the observatory.
- Additional planets to the nine named ones: "there are more planets out there"
- Additional facts about the nine planets. E.g. "Pluto is the coldest planet"
- Black spots on the Sun: a reference to sunspot images demonstrated at the observatory.
- Various features of Mars: water, land, and orbit – seen during a Mars presentation.
- A description of the Moon landing and the time taken to get there: described during a slide show.
- A star bigger than the Sun: there was a discussion at the observatory of different types of star.

4. Implications for Personal Meaning Mapping in research

The reason why I considered these additions to Gugu's PMM as important is that when questioned about aspects of space and stars during the structured interview data collection, Gugu showed no improvement in her knowledge or understanding. The structured interview could be regarded as a more traditional preand post-test of astronomy knowledge, which demonstrated a range of ability across the 34 students in the study. Gugu was at the bottom end of this range, suggesting that the visit had made no difference to her knowledge of astronomy. However, the use of PMM, in which there was no expectation of specific prior knowledge, showed that Gugu had acquired several facts about astronomy which might not have been identified by traditional tests or questionnaires. This is particular importance in informal learning environments where measures of learning are difficult to administer. Personal Meaning Mapping might have uses in normal classroom settings, as well as the way is it currently used in out-of-school learning. Teachers could, for example, ask their students to complete a PMM prior to starting a topic, in order to determine the prior knowledge of the class. A relatively brief analysis would enable a teacher to tailor his or her teaching to the class' prior knowledge, as well as target individuals and groups for enrichment or remediation.

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Mr. Jon Trinder, Dr Scott Royk, Dr Jane Magill

Have You Got Your PDA With You?...Denials and Accusations

This paper describes some of the problems encountered during a series of mobile learning projects conducted at the University of Glasgow in the Departments of Electronics & Electrical Engineering and the Robert Clark Centre for Technological Education. We believe that the problems encountered with data collection may highlight difficulties in other measurements of mobile learning and their underlying causes may be equally disruptive to the collection of other mobile learning data. This paper provides a manifesto for future research
The initial objectives of the projects were to investigate the education potential of mobile devices with specific focus on mobile Computer Aided Assessment (CAA) and to determine what else the devices were used for. The assessment was to be formative and took the form of a quiz application containing course revision questions. The earlier phases of the project are described in (Trinder, Magill and Roy 2005)
Before attempting to measure any additional benefit of the devices it was considered essential to determine if the usage of the devices could be reliably proven. It was envisaged that the most problematic area of measurement would be determining the educational impact of the devices whereas determining if the device was used would be relatively trivial – however interestingly this was not the case and provided a more subtle problem than we had anticipated. The main aspects considered in this paper are the problems of collecting and analysing usage logs and apparent sociological factors.

1. Introduction

As with the earlier phases of the project the plan was to distribute PDAs to students along with a simple quiz application to be used to provide simple on-demand formative Computer Aided Assessment. For this phase of the project the student group chosen was a cohort of foundation level Technology students in the faculty of education. This course is typically taken by students who are likely to become school science teachers. At the time there was growing interest in the use of mobile devices in schools and the project team had a, perhaps naïve, belief that future teachers would be interested in such developments.
Evaluating how a personal mobile device such as a PDA is used in education presents a number of difficulties due to the way in which such devices are used. It is impractical to follow a user around and asking them to keep a diary relies on their memory after the event, also the act of recording what they were doing may be significantly longer than the task the device is used for. To reduce the burden on the user an automated logging system was installed on each PDA to record the times at which applications were used. The logging software was written by

one the project team specifically for the project and it has been refined during earlier phases.

Prior to distributing the PDAs the course tutor and researcher explained to students the purpose of the project, what data would be collected and who would see the data. It was made clear that none of the personal data on the PDA would be visible to the research team or their tutors. Many institutions have policies prohibiting installing games on university computers but it was made clear to the students that they could install games on the PDAs. The device chosen had features that were believed to make the device both appealing and useful to the students combining both a camera and an MP3 player. In addition it was considered the camera would have useful educational potential for use throughout a product design course to collect a folio of work. The students were asked to complete a short questionnaire, to evaluate their knowledge and competence with mobile technology, the results of which suggested that the students were "technology savvy".

2. Logging and Data Collection

The logging system recorded time-stamped system events such as the device being switched on and when an application was started. Processing of this log file provided the duration of each session of use. From session information it is then possible to derive a rich combination of characteristics of how a device has been used. Examples of the type of information that can be derived are: the "most used" applications (either by number of uses or cumulative time), number of applications used, distribution of application run times

The logging system only indicates how long an application usage session was and at what time; it does not show what is done within that application or how actively the application was used. For the project aims this granularity of detail was considered to be adequate.

The collection of these logs required that the students periodically "synced" their devices to suitably configured lab computers. The syncing process stored the logs in an area accessible by members of the project team. In previous phases of the project the problems of collecting the logs from the students had appeared to be either technical such as logs being lost due to battery problems or convenience i.e. the lack of machines to which students could sync their devices. During this project phase the devices used retained data when the battery was discharged and an entire computer cluster was available for students to sync their machines at times convenient to them. It was also planned that students would be allowed and encouraged to sync their PDAs during scheduled labs so that the process could be supervised and any problems identified and resolved.

Gathering the data proved to be problematic as the students chose to not sync their machines whilst on campus. The students appeared to

be very "marks strategic" and getting them to do anything that did not directly and obviously benefit their course results was difficult. Introducing a new technology is problematic in many ways. To enforce the use of the new technology raises issues of inclusion. In addition it can be argued that the use of the devices should not be made compulsory unless the students have been told this when they enrolled for the course. The catch 22 situation being it could not have been incorporated into the course without affecting the course validation and no one is likely to want to include unproven technology.

As there was no means of forcing the students to sync their PDAs but they were encouraged to do by explaining to them the benefits for exchanging and backing-up data. In the first few weeks when the students appeared to have the PDAs regularly with them it was apparent that most had installed games on their devices and it was thus likely that at least some of them were syncing their devices at home. As a further incentive to sync in the labs and thus to transfer the log data, a weekly prize draw for a commercial game was held for all students who had synced their PDA during the previous week, but this did not even produce a marginal improvement. When at scheduled labs they were asked to sync their devices most said they did not have the device with them and when questioned about their use of the device they were often vague or evasive. This gave the impression that the students were not carrying the PDAs with them though as we found out much later in the project this was not always the case.

As the students were unwilling to sync their PDAs in the labs an alternative means of collecting the logging data was devised. The logging application was modified to enable “beaming”, a transfer using infra-red or Bluetooth, to the tutors PDA. After these changes had been made a few logs were successfully collected but the students normally claimed to not have their PDA with them.

It was planned to interview the students throughout the project and the problem of obtaining their co-operation and involvement was apparent when we tried to arrange this. To generate any interest for this we had to offer food and drink during the morning lecture to encourage them to spend a short time being interviewed by the researchers. A random selection of students was asked to take part in short interviews about the project. During the interviews it became apparent that the PDAs were being used and carried by the students more frequently than enquiries and requests to sync had previously indicated. It was also found that the students had found imaginative ways of using the PDAs

In the weeks following the interviews it was discovered that when students were individually asked if they had brought their PDA they diverted attention from themselves and “accused” colleagues of having got a PDA with them, the accused often then indicated that their accuser had also got a PDA with them. This denial suggests that their actions may have been influenced by

sociological factors. Such problems have been predicted in other evaluation situations "Evaluation may raise issues of self-esteem, social standing and status" (Traxler and Riordan 2003). It is our belief that the introduction of the PDA had disrupted the peer groupings that had formed beforehand. There was an impression that the students' competence and knowledge of technology was much less than our objective analyses had shown, it is therefore possible that they were nervous of being seen to make mistakes in the use of the PDA in front of either their peers or academic staff. It is also possible that there was a certain element of guilt or embarrassment that they were not fulfilling our expectations of using the PDAs for much other than games, even though we had told them that was ok. Those that were more open in their use of PDAs were those perceived by their peers a 'geeky' and were more competent with technology.

3. The Results

The small amount of data that was collected from the students PDAs exhibited characteristics which potentially obscured the data we were seeking. A problem encountered when exploring the log data is the large number of relatively short duration events. When shown graphically the raw data shows few meaningful patterns. There are also spurious events, such as launching the wrong application that obscure normal application use. Also the usage patterns of certain applications can obscure more general usage trends for example, values such as the average and median of a session lengths were used as an indicator of how much a device had been used but these values were seriously distorted by the use of the media applications which tended to be used for very long periods of time. Thus rather than concentrate on one figure to indicate how much a device has been used the focus is now on how different types of application such as media player, organiser, document viewers etc have been used.

For this phase of the project the original intention had been to convert the logs for analysis with various statistics tools but this method was found to be too slow. To investigate subtle patterns of device use required a more interactive means of exploring, visualizing and filtering the data. As no suitable applications existing to fit our requirements an application was developed to perform these functions. Similar to analyzing any other noisy signal, once some suitable filtering has been applied more meaningful patterns become apparent. The difficulty with such log data is determining the filter parameters. Useful means of locating interesting clusters of activity have been various three dimensional plots and animating the data by 'playing back' sequences of the logs whilst plotting simultaneous charts. An additional feature of the log analysis software is the ability to plot and overlay arbitrary parameters on radar chart to provide means of quickly comparing data for groups of users and to determine if there are

families of user 'types, this method can also useful to highlight unusual usage patterns.

An interesting challenge is to identify what is a useful application and how to detect it. There are some obvious usage patterns that can indicate an application is useful to someone: e.g. it is used frequently or used for a large amount of time. However there are other patterns of use, that are less easy to detect, that may also characterise a useful application. For example an application that is only used once per day or less, such as to-do list of goals or objectives, could be invaluable to a user but its usefulness that may not be obvious from a usage log. Also such events can easily be confused with spurious events, such as launching the wrong application.

A PDA or other mobile device may be used in isolation in which case it may be necessary to swap between applications to achieve a particular objective. In these circumstances learning activities can potentially be detected from the pattern of usage e.g. on one device it could be seen that whilst using the quiz application the user had utilized the calculator presumably to determine the correct answer. It seems likely that devices such as PDAs may in many cases not be used in isolation so when looking at the usage of the device we are only seeing part of the story. To investigate this, the PDA usage logs are currently being compared with access logs from the on-line learning system.

At the outset logging was seen as a solution to the problems of relying on users memories, it appears that logging, although automatic and transparent to the user, still relies on their co-operation. For some the knowledge that 'something' is being recorded albeit relatively trivial information, can be a barrier. This is interesting as almost all web access is traceable but that does not stop students using it, but perhaps for students it is the knowledge that the person who will see the information is someone nearby who "knows" who they are.

It was not until the end of the project that we realized there were important and subtle social factors at work and could not investigate this in as much detail as it required. The conclusion from this phase of the project was that -

"*It appears that the successful introduction of mobile personal technologies is critically based on the very interpersonal networks and skill that are naively assumed to be unimportant when dealing with personal technology*" (Trinder, Magill and Roy 2005)

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Mobile Enabled Disabled Students: Widening Access to Research Participation

MEDS (Mobile Enabled Disabled Students) is a research project currently being undertaken at the University of Bradford, funded by the ALPS CETL[1] Research Capacity Investment. This twelve month study commenced in October 2007 and aims to inform the ongoing work and development of ALPS in relation to the specific needs of disabled students when using mobile technologies for learning and assessment in practice settings.

ALPS is a collaborative programme between five HEIs[2] and aims to develop and improve assessment, and thereby learning, in practice settings for health and social care pre-registration students from sixteen professions which include, for example, Optometry, Social Work, Dietetics, Medicine, Nursing and Midwifery. Practice settings for these professions are hospitals, clinics and a wide range of community locations including clients own homes. ALPS is working towards an inter-professional programme of assessment of competencies that have to be achieved for entry to any of these professions. Communication skills, team working and ethical practice have been identified as common competencies across the professions and are being incorporated into the assessment tools.

The assessment tools and learning materials will be delivered in mobile form as learning objects that are automatically 'Pushed' to or requested by users of Smartphone, PDA and potentially, other mobile devices. Five pilot case studies have already been undertaken, investigating the use of mobile technology and its fitness for purpose in practice based learning environments, with a range of mobile devices used and methods of data collection employed; these are reported elsewhere (Dearnley & Haigh, 2006; Haigh et al 2007; Taylor et al 2006;)

Between July and December 2007, ALPS will have issued nearly 900 mobile devices each with unlimited data connectivity (via the T-Mobile 2G and 3G mobile phone network) to students and staff undertaking practice based learning and assessment across the ALPS partnership. The supplier consortium, in collaboration with ALPS, is currently implementing the mobile services infrastructure (based on Nokia Intellisync) to manage the devices and data synchronisation, as well as developing the PC software to create mobile assessments and learning objects, and the mobile client to enable use and management of the learning objects and assessments on mobile devices to students on a

[1] Assessment & learning in Practice Settings (ALPS) is a centre for Excellence in Learning & Teaching (CETL) funded by the Higher Education Funding Council for England (HEFCE) http://www.alps-cetl.ac.uk/

[2] Universities of Bradford, Leeds, Huddersfield, Leeds Metropolitan and York St John University College

large scale. Plans are underway for the evaluation of that activity using a wide range of traditional and 'new' approaches.

The focus of this paper, however, is specifically on the work of MEDS. Mobile communication and access offer immense potential for disabled people because they offer a flexible approach to study and an increasing variety of medium by which to interact with virtual learning environments (VLE). Unlike more established technologies, such as the web with the W3C standards, there is currently little in the way of existing guidelines or standards that relates directly to accessibility on mobile devices. The unique features of PDAs and Smartphones such as small keyboards and touch screens present a whole new set of challenges and potential benefits for accessibility. MEDS aims to establish what works well for disabled students who currently use mobile devices and to identify the challenges that mobile technologies present to them.

The MEDS team will work closely with ALPS, recruiting disabled users to trial the use of the mobile devices, the software and new assessment tools as they are developed, to assess their impact and identify changes that need to be made for disabled users. The project team are also working closely with the commercial suppliers to ensure that field test versions of the software can be used in the project and that the findings are used to inform development of later versions. MEDS has already helped inform the development of an 'alpha prototype' and held a focus group to test the software with the devices. The next stage in the process is to field test the devices and software with health and social care students with disabilities for a longer period.

In order to achieve its aims, MEDS has proposed a range of methodologies. Some 'traditional methods' such as the initial focus group to establish common uses and obstacles, and final stage individual semi-structured interviews have been included and the latter will be video recorded so that they will stand alone as individual case studies. However, a range of 'alternative approaches' will be used to support and enhance these methods. Crucially we are asking participants, with a range of disabilities to use the mobile devices with which they will be supplied, to maintain a diary in a format of their choice – audio –videotext/blog. It is anticipated that this will supply us with 'live data' capturing the real essence of the lived experience as the participants reflect 'in action' rather than 'on action' with its resulting reliance on recall. Thus we hope to achieve a very rich data set.

The differences in these approaches are worth exploring. Traditional approaches require a lot of advance preparation such as developing the questions to be asked, agreeing these with the project team and having them endorsed by a Research Ethics Committee. The extent therefore to which research undertaken in this way can be truly inductive or participant driven is questionable. Control remains very firmly in the researcher domain. Conversely, it might be argued that using web

cams and electronic diaries (either text, audio or video based) puts the locus of control firmly in the participant domain. The question for the researcher therefore, is related to this control and how much they need to maintain in order to achieve the outcomes of the research and how much they can relinquish. Researcher control might still be maintained to some extent by the guidelines given to the diary sample of participants as they commence their journey. These might include for example, how many entries the participant is expected to make over a given period of time or things that the researcher really wants to know and should be reported on and perhaps even things they are not at all interested in and would prefer not to be recorded. Without such guidelines the amount of data gathered could be momentous and unmanageable; with extensive and over prescriptive guidelines, the participant voice may be quashed. The challenge therefore is not dissimilar to the challenge of semi structured interviews, where the questions need to be open enough to allow for and even encourage unexpected findings, but prescriptive enough to ensure that they will illicit data that will allow the researcher to answer the research question. We can therefore draw on our experience of using 'traditional' methods of data collection to develop enhanced new methodologies. When requesting participants to maintain an electronic diary, the emphasis must surely be on the emergence of material driven by the participant's experience. The data itself can only be anticipated to a small degree. Analytical techniques put in place to address this will therefore be far more general than traditional approaches; because of uncertainty related to the nature of the data we will collect, planning will necessarily, if unconventionally, occur after the data is created. We have adopted a participatory approach to this research and have participant representation in our team. It is anticipated that electronic methods of data collection will enable us to apply this philosophy thoroughly to this study.

We would like to share our work to date with conference delegates, to share our experiences of initiating and managing this study, to explore some of the challenges and how we have overcome them. We look forward to discussing current or ongoing challenges to establishing a mobile methodology at the workshop and to seeking solutions where possible.

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Mobile phone technology use in school science enquiry indoors and out-of-doors; implications for pedagogy

Outdoor experiences are infrequent because of limited time, limited resources and lack of support to manage large groups out-of-doors. UK initiatives, e.g. Manifesto for Education Outside the Classroom, expect curriculum integration of outdoor education and children linking scientific observations out-of-doors with lessons indoors. Also relevant are current debates about argumentation in school science; focusing on learning facts and concepts diminishes time for enquiry and argumentation to clarify conceptual understanding. This study aimed to determine whether mobile phone technology (MPT) could reveal the ways in which children learned during scientific enquiry both indoors and out-of-doors. It also focused on teachers' pedagogy and engagement with mobile technology.

1. Mobile phone technology use in schools science enquiry indoors and out-of doors

EU promotion of enquiry-based science education (IBSE) is expected to increase children's interest in science and take-up of scientific careers. Teachers' pedagogy that focuses on desk bound, passive learning of facts and concepts diminishes time for both IBSE, fieldwork and argumentation in groups that encourages clarification of conceptual understanding (Driver et al. 1996; Driver et al. 2000; Millar & Osborne, 1998; Harlen 1999).
UK initiatives, e.g. The Manifesto for Education Outside the Classroom, (House of Commons Education and Skills committee, 2005) expect children to connect scientific observations out-of-doors with lessons indoors. Children may then be able to link observation made in botanic gardens with lessons indoors (Barker et al. 2003). Skills learned in either situation depend on teachers' pedagogy.

1.1. Implications for pedagogy

Learning goals must expand outwards from conceptual understanding to encompass improved reasoning skills which, with enhanced social skills, will enable co-construction of knowledge from observed evidence out-of-doors (Johnson, 2004). Only through changes in teachers' practice can learning change (Hargreaves, 1994).
A study of children's use of mobile phone technology (MPT) provided evidence of engagement with plants, development of scientific skills and preferred learning styles. The potential teachers' saw for MPT in teaching and learning was also identified.

1.2. Methods and sample 2006 and 2007

To make the greatest impression on environmental literacy the process must start in the early stages of education (Nundy, 2001).
Children's conceptual

understanding gained during scientific enquiry indoors and out-of-doors at Kew was explored using mobile phone technology (MPT). It was embedded in a study of 4 schools participated in the PlaSciGardens EU funded project in June 2006 and 2007. Prior to the visit, teachers organised children (9-10 year olds) into small groups. In 2007 children were shown a phone and its functions explained prior to the visit. They were excited because their collected item would appear on a website (http://www.ookl.org.uk) accessible at school.

Nokia mobile phone, adapted to exclude call functions, were given to each group to provide more data collecting options than children would normally be offered; camera, audio recording, texting and a call-up from an information store. The Kew information store was accessed by entering 2 letter codes displayed in the garden. Children learned to use these functions quickly because most owned a mobile phone. In 2007 groups were given their password and login to get back into the system if it crashed; a frustration recognised in the 2006 pilot. Children shared a phone but they could use the functions as they wished and collect data at will.

Indoors, plant parts and morphological characteristics of a single plant were revised briefly. A range of vegetables was set out and each group was given a "family box" e.g. pea family. The children examined vegetables, cut them open, looked at life cycle pictures and, after discussion, placed specimens of their allotted family in the box. Each group then compared this collection with plants growing in their family order bed and vegetables growing in Kew students' allotments.

Out-of-doors children looked for common taxonomic features in family order bed plants e.g. similarities in flower structure. In the allotments they decided whether their initial selection was correct or that it included members of other families.

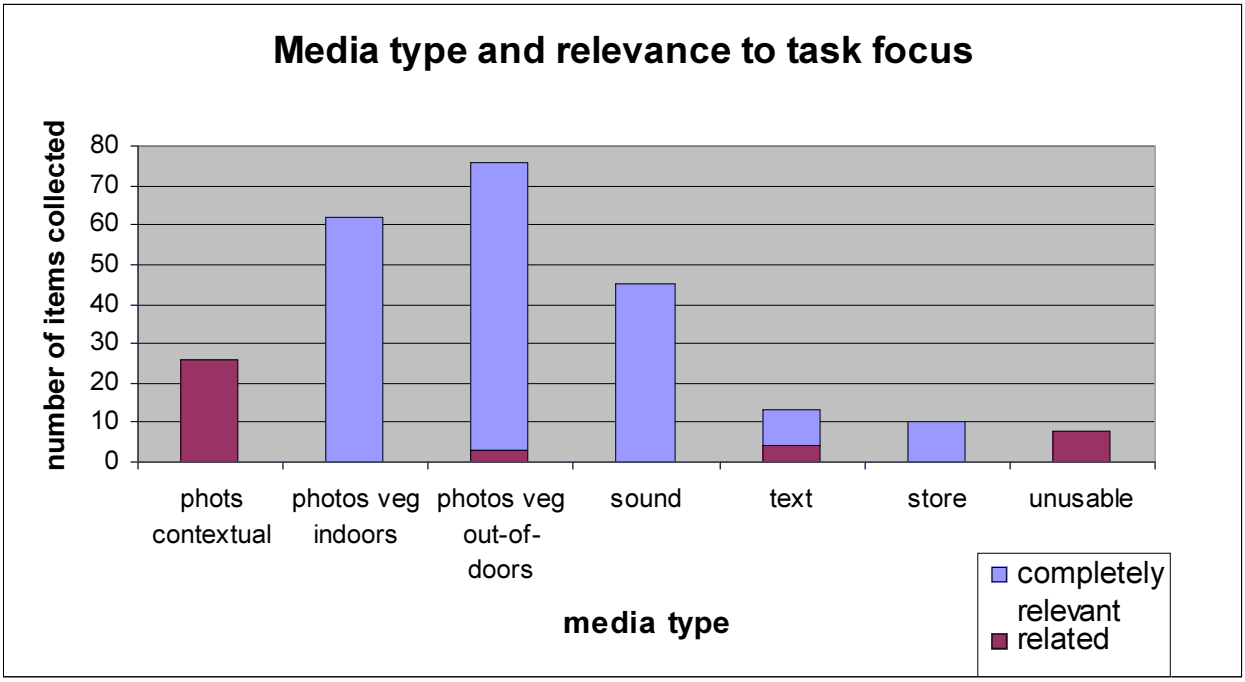
Groups recorded their findings using MPT. Placed automatically in a "linear gallery", learner-created series of data were available for analysis. Evidence of observation and collection was expected. Progression to investigation and discussion of evidence relevant to plant family characteristics was anticipated.

2. Results

Individual children added items to the group plant family "gallery", in a self-managed collaboration. The linear nature of input needed careful analysis to follow a line of reasoning. Data plotted chronologically could be assessed qualitatively in terms of media type and relevance to the task focus. The proportion of task related contributions was considered in terms of sequence of input, whether children generated their own questions, and whether recordings were reflective or factual.

In 2006 children preferred taking photographs. Besides photographs of the Kew context, taken between sessions or at lunchtime, the remaining photographs fell into 3 broadly defined categories;

Figure 1. June 2007, The Green School: collection of data indicating media type and relevance to the focus of the task.



recorded for retrieval later; their experiences and assembling evidence. All groups opened one or more stored items. In 2007 there were more audio recordings than in 2006 and children completed more complex evidence gathering individually or in pairs. Fewer groups added text messages in 2006 compared with 2007. Texting was less prevalent than audio recording or photography but some texts linked sequences of data. Texts also anticipated future use e.g. spelling plant names, or were reflective.

3. Discussion

3.1. Learning outcomes

Kew teachers restricted the enquiry sites thereby influencing the plants available to investigate. Tasks set were narrowly focused but children investigated in a self-managed sequence. During their scientific enquiry they generated ideas i.e. what to look for in each garden to complete the task. They used a sequence of enquiry skills, observing, comparing, pattern seeking, and recorded their line of reasoning. Audio recordings in Table 1 are explanations to clarify actions especially those taken after reflection on the evidence gathered.

Teachers observed these activities and encouraged them on the day. Formative assessment was integral to the project in which this research but difficult to achieve on the day. Collective and individual contributions to the website provided access to evidence of outcomes, task focus, level of participation and conceptual understanding. They could also identify misconceptions in the texts or audio recordings and addressed them in later lessons.

3.2. Teaching outcomes

Teachers' comments in interviews indicated a positive reception for MPT. They appreciated that audio

Table 1. Gallery tabulated for Kew group 14: 36 items, of which 30 focused on specific vegetables or classification of the tomato family

	Photographs	Audio recording	texting	Call-up
indoors	2. ½ squash showing seeds	16. We have discovered that tomatoes and deadly nightshade are in the same family because of the shape of the actual plant [flowers?] *(fact)*	7. It is in our group *(fact)*	5. and 6. tomato
	3. box - chilli, squash, tomato, red pepper, potato 4. general view of vegetables	17. The flowers are very similar to a courgette flower but much, much… the courgette flower is absolutely huge. *(fact & reflection)*	29. We take it out. *(fact)*	8.Pea (comment - It's exciting to look at) 10. cucumber
out-of-doors	9. aubergine plant	22. Tomatoes are very juicy and are not vegetables they are actually a fruit, so if you see a tomato tell your friends or your mum it's a [recording ends – fruit?] *(fact)*		14.and 15. mint (comment - It's cool)
	11. tomato plant with flowers	25. We have decided to take out the squash/pumpkin because of the scale of the flower and the look of the flower. *(reflection)*		Lunch time collected 32. potato 33. cabbage 34. carrot 35. bean 36. mandrake
	12. green tomato fruit - comparing with red one in box	30. We have kept the pepper, chilli and the tomatoes. *(reflection)*		
	13. green/red tomato fruit comparing better view 21.green tomato fruit 23. courgette flower 24. tomato flower 26. green plum tomato 27. veg plants nearby 28. comparing green plum tomato with red tomato			

recording allowed all children to participate effectively because writing ability, particularly amongst boys, can restrict their access to science. Children who have English as a second language also benefit because spoken language makes it easier for them "to show what they could do". Teachers valued the call-up function because of their own and children's lack of taxonomic knowledge.

Making MPT available at the site overcame teachers' lack of resources and people for dynamic group work out-of-doors. One teacher commented that MPT made the children feel "really special" because they were "trusted to use them". Another was surprised by their concentration on the plants and the task "They didn't take pictures of themselves."

3.3. Pedagogical outcomes

Experiences out-of-doors are infrequent because teachers perceive their minimal pedagogical outcomes (Foskett, 2001). Here children used collecting and investigative skills meaningfully and MPT aided their engagement. Lack of support to manage a class out-of-doors was overcome by use of MPT; used mostly independent of a teacher. Pedagogy relevant to management of whole classes out of doors, plant science education and use of ICT post-visit was mentioned by one of the twelve teachers involved. Technophobia i.e. not being absolutely sure how to access or present data was overcome by the innovative teacher who let the children find out for themselves. By not visiting the website teachers disregarded pedagogy relevant to children's ownership of contributions, their scientific understanding and misconceptions.

3.4. Technology outcomes

MPT is marginal if teachers perceive that it is their responsibility to present children with all of the information they need. The MPT functions available relate to pedagogical outcomes that can be achieved without the teacher.

Call-up information:

- allows children to "discover knowledge" about a plant while standing next to it. They can observe characteristics mentioned themselves;
- is written by plant experts;
- overcomes teachers' lack of knowledge;
- can prompt further activities (if well constructed).

Photography:

- records scientific evidence and close observation;
- replaces inaccurate, laborious drawings with real-life images;
- shows sequences of observation and pattern seeking;
- shows planning for future use.

Audio recording:

- encourages thinking about what to record and how; statement, interview;
- prompts active engagement and scientific approaches to plants encountered;
- encourages decision making; what to accept or delete (here play-back was required before saving – listening prompted thinking about quality and content);
- is a preferred way of recording data for some.

Texting:

- records unfamiliar word
- allows rapid "txt" writing.

The majority of children interviewed recalled the functions of the MPT and how they used it at Kew up to 6 months after the visit. Prompting recall is crucial to engagement in argumentation and future learning.

3.5. Limitations of the methodology

Besides a few operational issues there were pedagogical limitations. Outcomes for MPT relied on children sharing phones. Poor collaboration was unresolved for one group (2007) and grouping criteria teachers used needs consideration. Some helpers were eager to tell children what to photograph but they need to decide what is relevant themselves. Helpers in general are a mixed blessing if they are not well briefed. Kew educators were concern that the technology might interfere with observation but, it was agreed afterward, that this was not the case (Walker 2006). Visit facilitators must hold constructivist attitudes to learning with MPT.

Advantages outlined were outweighed by teachers' failure to either access the website to evaluate learning or to integrate children's findings into post-visit lessons. Consequently, children were not asked to explain their actions or clarify scientific understanding and reasoning. Only 1 class (2007) accessed the site to review and evaluate their work; they chose and organised their contributions for presentation to a whole school assembly.

4. Implication

Enquiry-centred learning challenges traditional pedagogy, especially learning out-of-doors. Teachers will need access to tools that support engagement with the environment, information collection and organisation, and can show children's investigative ability, inductive reasoning and conceptual understanding.
If future environmental literacy is to be mediated by technology, it must be developed in tandem with appropriate pedagogy.
Continuing Professional Development with opportunities to use MPT out-of-doors will be essential.

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