LEARNING THROUGH TREASURE HUNTING: THE ROLE OF MOBILE DEVICES

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ABSTRACT

In this paper we present a descriptive account of children's interactions with mobile technology in a non-school context. The My Mobile Mission (M3) trial was conducted in an informal setting with the aim of better understanding the role of mobile technology as a mediator within science learning activities. Six children, aged 11, were asked to complete an outdoor treasure hunt activity using a combination of two mobile phones and a video camera. They were required to solve clues, discover examples of sustainable energy, and document their findings. We analyzed the treasure-hunt activities to determine how mobile devices were integrated into the learning activity, to identify the extent to which children were able to construct meaning using mobile technology, and to better understand the roles which emerged. Our findings have clearly demonstrated that children were able to successfully incorporate mobile devices into their learning activities and were strongly motivated to do so. While children were able to effectively construct meaning as they explored their environment, the mobile technology could have better supported reflective processes. A key motivating feature of the M3 activities was the flexibility provided by multiple devices which allowed children to take on a range of roles.

KEYWORDS

Mobile learning, e-Science, informal learning, collaboration.

1. INTRODUCTION

How can we understand children's relationship with mobile technology as tools for learning? Do we examine the functionality of the technology and propose suitable learning activities, or should we seek to discover how the interplay between children and these devices, as 'artifacts in use' (Bannon & Bødker, 1991), fosters learning? Within the emerging research on mobile learning is a growing awareness of the complex relationship between task, environment, action and technology. Such concerns have led to a theory of learning which considers the interplay of children and technology in a learning system (Sharples et al., 2007) and acknowledges the active role of the mobile device as mediator. In examining the issue further we report on the M3 trial, describing children's interactions with mobile technology in a non-school context.

The M3 trial aimed to engage young people in informal scientific enquiry activities and was conducted to better understand the role of mobile technology as a mediator within e-Science learning activities. Based within the context of a university-held summer camp, children completed an outdoor treasure hunt activity using a combination of two mobile phones and video camera. Activities focused on solving clues and exploring within the local environment to find examples of sustainable energy on a university eco-campus. Our descriptive account of the M3 activities is focused on the relationship between the learner and the

learning tasks as mediated by the mobile technology. We centre our analysis on the *mobile learning activity*, viewing the mobile devices as artifacts that only attain functional and educational qualities as they are integrated into the learning activities (Christensen, 1995). Consequently, the analysis of treasure-hunt activities was underpinned by three key research aims:

- to examine the agency of mobile devices as artifacts integrated into and interpreted within a learning activity;
- to explore how students build representations and construct meaning using mobile technology; and
- to better understand the roles which emerge through the complex interplay between the technology, the activities and the children.

In examining the relationship between children and mobile technology we adopt a learner-centered definition of mobile learning; a characterization of mobile learning as learning which occurs when it is not in a fixed location or happens when a learner takes advantage of learning opportunities offered by mobile devices (O'Malley et al., 2003). Our previous and related projects have involved learners interacting outside in small groups with mobile technologies designed to guide and prompt their activities and collect work output (Rogers et al., 2005; Smith et al., 2005; Underwood et al., 2004; Walker, 2007). In our current project we investigate these areas further. The M3 trial focuses on the opportunities offered by 'mobility within a physical space' (Sharples et al., 2007) as children move through buildings on a university eco-campus to discover examples of sustainable energy in use. Location is directly relevant to the learning experience and the physical dimensions of the learning space are brought to the centre of the analysis. Chan et al. (2006) describes the way in which children alternate between different mobile devices as 'seamless learning' with children learning across scenarios using the mobile device as a mediator. We are interested in this 'mobility of the technology' (Sharples et al., 2007) and how the portability of mobile phones and video cameras supports children as they construct meaning within learning activities.

The M3 trial builds on the work of Scanlon et al. (2005) in examining the intersection of informal learning, science and mobile learning. By positioning scientific learning activities in a real eco-friendly context beyond the classroom and involving children in observation, data collection, and processes of discovery and documentation, our M3 activity meets the needs of an emerging 'real science' curriculum. Mobile devices in this context are used as authentic tools for communication, data gathering, knowledge construction and reflection. Our situated study of mobile devices acknowledges the importance of context within the learning experience (Vygotsky, 1962), mobile technology *in use* (Sharples et al. 2007; Engeström, 1987), and the contribution of reflection and review activities in a variety of locations (Hartnell-Young, 2007) to the learning experience. By studying the way in which children create persistent artifacts using mobile technology, we broaden our understanding of the dynamic, evolving and ad hoc nature of their use as mediators within learning experiences (Henning, 2004). Learning activity is revealed as both process and product in our analysis of the M3 activity.

The main contribution from this study is a better understanding of the importance of device appropriation by children within the mobile learning experience. While children successfully used mobile devices to complete tasks, the mobile devices significantly impacted on the learning roles of children as they performed activities. Our findings have clearly demonstrated that children were able to effectively integrate mobile devices into their learning activities, and were strongly motivated to do so within the engaging treasure hunt context. The key to motivation and engagement was the flexibility provided by the technology to allow children to take on a range of roles as they progressed through the experience. Each device, with its clearly defined purpose, permitted children to choose a favorite role and to flexibly switch between roles. The devices clearly impacted on the experience in both positive and negative ways. Less clear is the effectiveness of the mobile devices in supporting students as they build representations of knowledge and construct meaning. In this area, we believe further refinement of both the activity and the mobile application is required.

2. THE M3 TRIAL

The M3 trial was conducted in an attempt to better understand mobile technology as a mediator in e-Science learning activities. The particular learning goal was to explore issues around sustainable energy. The trial involved six 11-year-old children, five boys and one girl, working in pairs to engage in an outdoor treasure-

hunt activity. Each pair was accompanied by one or two adult facilitators and was given two mobile phones and a video camera to support the hunt. Two controllers, based at the M3 headquarters (HQ), were responsible for manually coordinating mobile phone communication. This involved sending clues to the children via SMS and receiving their answers. A Nokia 6680 mobile phone provided for the two-way communication between the controllers and groups. It was used by the children to receive text message clues leading them to find examples of sustainable energy on a university eco-campus. A mobile phone running OOKL[1] software (OOKL phone) was provided for data collection. It allowed children to take pictures and write comments which were automatically uploaded to the OOKL server for later web-based review, reflection and summary construction once back at base. This use of two phones was a deliberate design choice. Our aim was to facilitate role-play and turn-taking by providing separate devices with clearly defined functionality. In addition a video camera was provided for saving narration, sounds, and data reflection allowing children and/or the adult helpers to video aspects of the treasure hunt.

2.1 M3 Trial Activities

The M3 activity lasted three hours and was divided into four distinct sessions: introduction, treasure hunt, OOKL review session, and interview. For the introduction, a whole-group activity outlined the afternoon's activities and then introduced children to concepts around energy consumption and sustainability. Activities included watching a video on renewable energy, and discussions of examples that they had seen being used. At the end of this introductory session the treasure hunt activity was described in detail. Children were introduced to the three devices supporting them in their hunt, and a map.

Following the introductory session, the children completed as much of the treasure hunt outdoors, in pairs with their adult facilitators, as was possible within one hour. Up to seven tasks and clues were available, each designed to locate examples of sustainable energy concepts in use (see Table 1 for examples). Tasks involved deciphering the message, finding an example of the object alluded to in the clue and then documenting the discovery using images and text. Conversation around the task occurred, or was encouraged by facilitators, whilst waiting for text messages to send or clues to arrive.

On completion of the treasure hunt, groups returned to the M3 headquarters to create an OOKL gallery using the data that they had collected during the treasure hunt. We motivated the idea of creating an OOKL gallery as a way for them to explain to their friends about the sustainable features they had seen during the treasure hunt. Each group spent approximately 40 minutes arranging their photographs and creating captions for their documentation. The final activity of the M3 trial involved children using iPods to record interviews with each other about their experiences during the afternoon.

Table 1: Sample clues and tasks sent from controllers to the treasure hunt participants.

Object	Clue	Task
Wind cowls 	We look like part of aeroplane and there are 8 of us. We turn according to the wind direction. As the wind passes through it produces a negative pressure, which pulls stale air from the building, replacing it with fresh air. Spot us on the roof.	Take pictures of the wind cowls including their bottom from the top of a round stairwell.
Grass roofs 	I am like a rooftop garden, but I would be very difficult to mow or dig. Planted with grass, mosses and flowering plants, I help fight the battle against global warming! Spot me from the top floor of the Exchange building!	Take pictures of the grass roof and think of ways in which grass roofs can help cut the carbon footprint.
Solar cell 	My name suggests a "sunny prison", but I am really a device that converts solar energy into electrical energy. I make interesting patterns on the glass roof.	The solar cells on the glass roof generate electricity required for the air ventilation fans. Take pictures and think of how solar electricity may be used for your home.

[1] OOKL: http://www.ookl.org.uk

2.2 Data Collected

Data was captured in the form of video, audio, mobile phone logs and photograph galleries. Each of the groups used the video camera to capture interesting events during the treasure hunt. We also video recorded the introductory and OOKL sessions. This data was used to examine interactions and conversations during M3 activities. We particularly focused on the purpose of each of the interactions with the mobile devices, examined how these interactions enhanced or interfered with the experience and how each of the devices were appropriated during the activities. Mobile phone logs were useful in understanding each group's movement and pace during the treasure hunt activities; we were able to get a picture of how children used the mobile phones as communication devices within a learning activity. The OOKL galleries produced by each group were designed to act as a summary of what had been found and captured. We wanted to get an idea of how children were able to construct meaning around the data they had collected and how this physical representation of their learning experience promoted further discussion and reflection. Audio files were generated as a result of children's iPod interviews. These interviews contained information on children's impressions of the activity, including their view on the content of the M3 activities. We also received written feedback from the primary adult facilitator in each group.

3. FINDINGS

Judging by the children's enthusiasm, the M3 trial went very well. The children were active participants in the introductory discussion, they were keen collectors of 'treasure' during the treasure hunt activity, and generally worked energetically to produce their OOKL galleries. The activities allowed children to successfully engage with material that they may have seen previously in more formal learning sessions and the active, productive and creative aspects of the activities appeared to provide an intrinsically motivating platform for learning. More specifically, our analysis of the data collected has provided an insight into how the mobile devices were used by children and how, in turn, the devices influence the treasure-hunt activities. The analysis of 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.

3.1 Mobile Device Integration

Children used all three devices during the M3 treasure hunt. The children in group 1 decided they would swap the two mobile phones after each clue so that they both got to communicate with HQ and document their discoveries. The communication aspect of the activity was favored by this group and generated high levels of excitement. They preferred sending and receiving text messages to using the OOKL phone for documenting their finds. Both children were obviously comfortable using phones and were aware of the mobile phone user interface conventions. There were only a few minor interface issues; the most noticeable was the slowness with which children were able to enter data. Neither child in group 1 wanted to use the video camera outside. They appeared slightly nervous about using a completely new device.

Initially, the two step collect-and-send data gathering process required by the OOKL phone application confused the group 1 children. It wasn't clear to them why they couldn't just store the captured image on the mobile phone. However, once they were used to the concept, the photographing, commenting and sending processes worked very well. Group 2 also demonstrated that the OOKL data collection process was effective. Like group 1, the children in group 2 decided to take turns with the phones, however unlike the first group, they preferred the OOKL collection tasks to communication activities. Both children were slow at text input using the phones. One of the children in this group was quite excitable and impulsive; she found the delays in waiting for the next SMS clue frustrating.

While the children of group 3 were excited by the mobile phone technology they found it difficult to use initially. They became frustrated and moved to a model where they pressed lots of buttons to get something to happen. Understandably this style of interaction caused problems with the mobile phones. They found the OOKL phone more manageable to use than the Nokia phone. For this group, using the video camera became much more motivating than following the treasure hunt clues. Both children used the camcorder extensively to document their progress through the treasure hunt.

We found that across all groups, the children integrated data collection, discussion and communication tasks much more readily than we had expected. The treasure hunt design had us sending two messages to the children for each task. We would firstly send the clue, then upon receipt of a message from the children to say they had found the item, we would send another message asking them to take a picture and think about related environmental issues. Our observations, supported by feedback from our facilitators, showed that these two steps were unnecessary. The children would naturally take a photograph and discuss their findings when they reached the object they were hunting. They did not need to be instructed to do this; it grew out of their own interest and their motivation to use the mobile devices. As one facilitator highlighted:

> *In every case, my group took photos as soon as they found the object, as they thought this was the point of the exercise; they were then confused when they received the next instruction ("document the object"), and were unsure as to whether they had to go back and document it again or whether they could move on straight away.*

Figure 1 presents a photo story that demonstrates the integration of the two mobile phones into the active processes as children made discoveries, planned their activity, collected data, discussed environmental issues and communicated with M3 headquarters. As illustrated in the photo story children were easily able to switch from talking on video, to discussing methods for data collection. They were able to walk to a location to receive an SMS while making observations in anticipation. They received an SMS and then discussed its meaning. The children used a map to locate where they wanted to go and then ran to find their first treasure while discussing the strange content of the phone message. Once discovered, they were able to take a photo of the garden, send a text message to M3 headquarters and discuss what the purpose of the garden could be.

Figure 1: Integrated mobile device use during the treasure hunt activity.

3.2 Constructing meaning with Mobile Devices

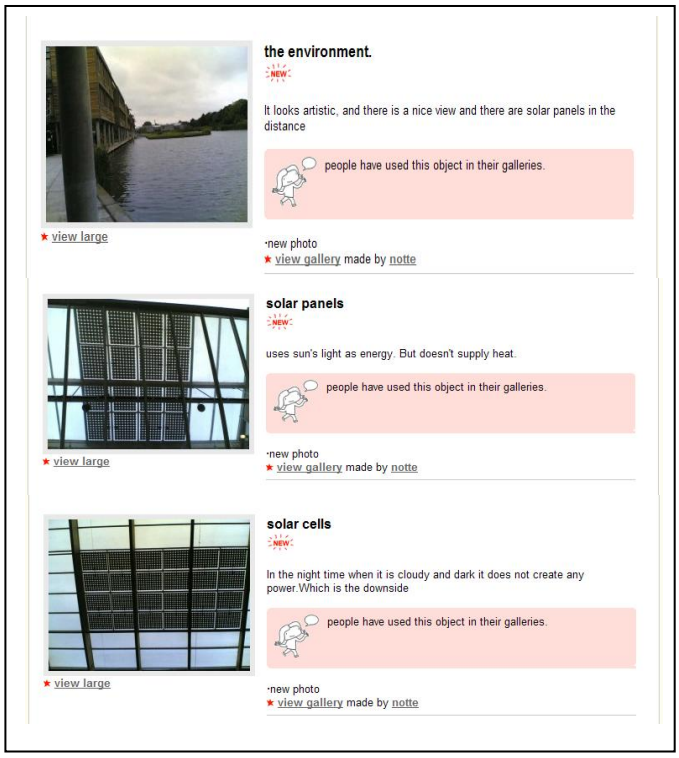
During the treasure hunt it was clear that children constructed meaning as they encountered examples of sustainable energy concepts in practice. A good example of this was during the hunt for the wind cowls (see Table 1 for the clue). Upon reading the clue all three groups assumed that they were looking for wind turbines. However, as they moved through the campus there was an emerging awareness that a wind turbine wasn't the treasure they were seeking. The following transcript demonstrates understanding that emerges over an eight minute period as a member of group 2 explores a building to find the wind cowls.

Oh, I think I already know what it is ... something to do with the air-conditioning ... I thought it was ... I thought it was like ... I've forgotten what you call them now ... they do something with energy ...like windmills ... turbines ... wind turbine ... that's what I thought it was originally, but then when I saw the last bit of it [pointing at the phone referring to the clue] *and then I thought hang on a second why would there be wind turbines here. Um, it's cos on the board you* [referring to the introductory session] *you had this one as an example, and I thought 'wind turbine' for that one ... I think it is these* [pointing to the wind cowls].

However, the use of OOKL meant that once children had taken a photograph they were unable to review it. It was not stored on the camera, but uploaded to the OOKL website. This was an issue as children worked to construct meaning out in the field. There were numerous examples where children wanted to look at the photos they had taken of a particular item. A facility which allowed review would have provided additional opportunities for discussion and reflection both within a particular task and across a range of tasks.

Each group created an OOKL gallery of their collected photographs at the completion of the treasure hunt. Figure 2 provides an example of the way in which groups put together photographs with captions to create their OOKL galleries. This sequence depicts three gallery entries, which focus on solar panels, created by group 1. The children not only include facts, they also added an opinion and created an emotive entry. Gallery entries show that the OOKL environment allowed children to express themselves using images, words, colors and fonts. However, while OOKL was a sound environment for creating a living record of experiences, it did not provide as many expressive opportunities as the children desired. At times during the OOKL session the children felt constrained by what they could do with the technology provided. For example, technical issues resulted in children being unable to add audio recordings to their OOKL galleries. While the children's interest in creating permanent representations of what they had discovered was demonstrated by the time and energy they devoted to the task, it was clear that they would have liked further expressive and creative ways to work with the data collected.

Figure 2: An OOKL gallery created by group 1.



3.3 Children's Roles

The role of treasure hunter was the most significant for all of the children during the activity; therefore the balance between collecting data and reflecting on the findings was skewed towards data collection, even to the point of suggesting finding *all* of the wind cowls (group 2) for example. Also many of the discussions during the activity were instigated by the facilitators rather than the students. A main reason for this was that all the children treated the treasure hunt as a competitive activity. On the one hand they were all highly motivated to make discoveries based on the clues they had been sent, as evidenced by animated discussions, running through buildings, and excited exclamations when they had found the 'eco-treasure'. On the other hand, the children knew that they had a set time limit in which to complete the treasure hunt activity and didn't like the idea of not completing some of the tasks. One of the facilitators commented that:

They were constantly pressuring each other to hurry up if one was writing a long comment or finding a good place for a photo, and were scared that they wouldn't find all the objects before the time ran out; they did not seem to believe me when I said that it was ok if they didn't find all

the objects, or if they found less than other groups. I think that they would've documented more if they had not been racing against the clock.

The individual ways in which children embraced the different mobile devices, and the roles they took on as a result, was a key finding during the M3 study. While one group of children was much more interested in the communication facility of the Nokia phone, a second group liked using the OOKL phone to take photographs and make comments. Group 3 was much more interested in the camcorder as a tool for capturing thoughts and ideas. For this group, the treasure-hunt experience centered on the use of the video camera and the commentary which occurred as a consequence. The child in control of the camcorder would ask interview questions, describe what had been found for 'the audience' and use on-camera shots to say things like "and now we are going outside to video it", "more next week" and "have a nice day". The facilitator for this group felt that this focus on the video camera may have had a detrimental effect:

Using the video became much more fun than following the clues. As the time went on it was the video that had all the attention.

She suggested that the serious questions that were asked "amongst all the fun" were difficult for the children in her group to answer, both because there wasn't a lot of time for discussion and because there were so many activities and technologies for the children to focus on. For group 3 there was a clear shift in roles that was motivated by the technology. Before they discovered the video recording facility they acted much like the other two groups in their focus on digital photograph data collection and text message communication. These roles became peripheral when they discovered the videoing capabilities of the camcorder. The children became filmmakers: commentating, interviewing, creative with their camera-work.

A similar phenomenon was observed with the iPod interviews. The children became the interviewers. As a result they strove for perfection; all of the groups had numerous 'takes' for each of the interview questions. If a mistake was made in asking or answering a question, a child would do it again. What is important from a learning perspective is how natural it was for the children to take on this role, how seriously they took the job at hand, and how the technology acted as the key motivating influence in them assuming the role.

4. DISCUSSION AND CONCLUSION

The success of the M3 trial was driven by the simplicity of the treasure hunt activity combined with its intrinsically motivating attributes and has highlighted issues around device appropriation within a mobile learning experience. Three key technological/interface issues were highlighted during the trial:

1. Text input can be slow and laborious even for children familiar with mobile phone technology;
2. Opportunities to review collected material in the field is important; and
3. More responsive communication from M3 headquarters would have improved the experience.

From a learning perspective we focused on three areas: device integration, knowledge construction and children's roles. The study demonstrated that the integration of the technology into the experiences was particularly effective. The devices were familiar to the children and there was something to interest each of them, whether it was the communication via text messaging, using video to record events, or data capture and annotation. Children were easily able to switch between activities, from those that involved the use of technology to those that didn't. They became involved in scientific processes of discovery, data collection and documentation and readily used the technology provided as tools in these processes. A second key finding was the influence that the technology had on the roles that the children assumed. They became engrossed in the clue-driven data collection because of the relative immediacy and excitement of personal SMS communication, they collected and annotated data using the features provided by the phones and they became interviewers when using iPods. The combination of the M3 trial as both an active and productive experience was instrumental in creating a positive environment for learning. In a majority of cases, the mobile technology facilitated rather than hindered these active and productive experiences. The distinct roles of the different technologies allowed children to assume a particular role, providing variety and allowing for individual preferences and for exploration of different ways to make use of the technologies.

Context was clearly important for learning: new understanding emerged as children moved through the campus environment. However, the outdoor activities did not naturally present opportunities for children to reflect on their emerging knowledge and the racing nature of the treasure hunt, while motivating, did detract from more focused and considered reflections on what had been observed. The facilitators therefore played

an important role in instigating more reflective discussions. Overall, maintaining a balance between *"diving in" and "stepping out"* (Ackermann, 1996) remains a challenge and there are still ways we can improve the use of mobile devices as objects-to-think-with. For example, by providing children with opportunities to create their own clues and plan treasure hunts for others, we could more naturally encourage children to reflect on their thoughts and ideas while still maintaining the motivating context of the treasure hunt.

In conclusion, the M3 trial, while small in scale, has provided valuable insight into the complex relationships between task, environment, children and technology; all these elements need to be considered in combination to investigate the reciprocal relationships which emerge. In particular the study points to the need to balance competitive motivation with opportunities for reflection and meaning making both during the mobile learning task and through the presentation tools used afterwards.

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