Using mobile technologies for multimedia tours in a traditional museum setting

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Abstract

Mobile technology was used to deliver learner-centred experiences to visitors at a geology museum without compromising the museum's aesthetic appeal. Two Flash-based multimedia tours were developed for the Hypertag Magus Guide system and trialled with 25 visitors in November 2005. Trial participants found the system fun and easy to use, though they requested headphones in order to hear the audio clearly. Several suggestions were provided to improve the tours including creating stronger links between the tour and the museum's objects and incorporating more interactive and competitive elements. A structured multimedia tour approach is appropriate for visitors who can connect with the museum's narratives, though more flexibility is required to meet the needs of other visitor types.

Introduction

The Lapworth Museum of Geology at the University of Birmingham is one of the pre-eminent geology museums in the United Kingdom. Established in 1880, its collections now number around 250,000 specimens, with particular strengths in vertebrate and invertebrate palaeontology and mineralogy. The collections are characterised by having a particularly large volume of supporting historical information (e.g. documents, photographs and maps), that is housed in the museum's archives. As shown in Figure 1, the principal display area for the collections is the Main Hall of the museum. The Lapworth Museum of Geology is one of only two geology museums in the UK to retain its original Victorian/Edwardian design and fittings.

Figure 1: Main Hall of the Lapworth Museum of Geology, University of Birmingham

The museum is used as a resource by students at all levels of formal education, as well as by adult interest groups and the wider community. Hence, there is a broad variation in the experience and knowledge that visitors both bring to and take away from the museum. In attempting to provide flexible opportunities to support the range of their visitors, the museum is faced with several challenges. The building's II* listed status, in addition to historical and aesthetic considerations, means that the museum cannot be easily altered or extended. This limits the ability for the museum to easily introduction conventional interactive or multimedia displays. These design constraints also limit the content supporting the objects to a small amount of in-case information and traditional paper-based worksheets.

Learning in Museums

The Museums, Libraries and Archives Council of the UK provide a highly inclusive definition of learning:

> *Learning is a process of active engagement with experience. It is what people do when they want to make sense of the world. It may involve the development or deepening of skills, knowledge, understanding, awareness, values, ideas and feelings, or an increase in the capacity to reflect. Effective learning leads to change, development and the desire to learn more.* (MLA, 2004)

In museums, visitors are encouraged to explore and discover in order to learn the processes of inquiry and even of learning itself (Hawkey, 2004). The ultimate goal of this exploration is the creation of new knowledge and personal meaning - what Falk and Dierking (2000) term 'free-choice learning'. Free-choice learning "tends to be nonlinear, is personally motivated, and involves considerable choice on the part of the learner as to what to learn, as well as where and when to participate in learning" (p. 13). Museums support free-choice learning by helping to reinforce existing knowledge, helping to make abstract concepts 'real' and providing each visitor with a unique experience (Falk & Dierking, 2000).

Previous research suggests that there are patterns in how visitors select and engage with a museum's objects in order to create meaning. A study commissioned for the West Midlands

Science and Industry Collections Project (Morris Hargreaves McIntyre, 2004) revealed four distinct modes of this behaviour:

- **Browsers** first select objects at random and then require explanation. They are likely to select visually arresting objects that appeal to their sense of awe and wonder.
- **Followers** are attracted to the explanatory narratives offered by the museum. These visitors are "keen to feel that they have learned something by the end of their visit." (Morris Hargreaves McIntyre, 2004: 12).
- **Searchers** collect information pertaining to particular collections or exhibits. They are likely to search by keyword rather than by thematic narrative.
- **Researchers** seek information relating to specific objects or a specific subject, including links to authoritative, scholarly commentary and information on the location of related collections.

Browsers and Followers, who made up the largest proportion of visitors in this study, do not need to interact with many objects in order to have a meaningful experience, while Searchers and Researchers want to be able to search across entire collections. Browsers and Followers are likely to prefer information delivered in a rich sensory format, while the principal need of Searchers and Researchers is easy access to detailed information.

Using Mobile Technology to Support Museum Learning

When designing technology for museums, Fernström and Bannon (1997) advocate that the focus should not be on the technology itself, but rather on how the technology may be used to enhance the visitor experience. A common problem faced by museums is that visitors often do not make good use of the range of learning opportunities that they offer. Various reasons have been cited for this, including a lack of preparation and follow-up (Oppermann & Specht, 1999) and supporting materials that cannot easily adapt to the range of learner interests and needs (Not & Zancanaro, 1998). Mobile technology can support visitors by providing both location-based information and guidance through this information based on the learner's interests and needs.

Museum learning has personal, physical and sociocultural dimensions (Falk & Dierking, 2000). Mobile technology may also be used to build more engaging learning experiences by directly facilitating these dimensions by their personal, portable and networked nature. Previous work has shown that mobile technology can help to increase engagement with the visitor's physical surroundings (Naismith et al., 2005), increase the confidence, motivation and involvement of pupils and staff visiting art museums (Burkett, 2005) and promote interactivity with artworks (Proctor & Tellis, 2003).

The following requirements for the design of mobile technology and content for a general audience were gathered from the literature:

- Technology should be easy to use and unobtrusive; it should enable the experience rather than detract from it (Hawkey, 2004).
- Content should work to direct the visitor's attention to the objects (Fisher, 2005).
- Visitors should be offered choice wherever possible (Falk & Dierking, 2000).
- Visually arresting objects should be incorporated in order to help *Browsers* make the transition to *Followers* (Morris Hargreaves McIntyre, 2004).
- A strong narrative should be provided to help structure the content. Multimedia should be incorporated where possible and appropriate (Morris Hargreaves McIntyre, 2004).
- When using multimedia, ensure that the audio and video is coherent (Proctor & Tellis, 2003).

- The use of specialist language should be avoided where possible. Unfamiliar terms need to be explained (Fisher, 2005).
- Promote engagement with objects through personal challenge (e.g. quizzes) and play (Fisher, 2005).

Aim of this Study

The primary aim of this study was to explore the use of mobile technology to deliver learner-centred experiences to visitors, while retaining the traditional ‘look and feel’ of the museum.

Methodology

Overview

The Main Hall of the Lapworth Museum occupies approximately 200 m^2. Most prominent are the four large wooden display units, each containing 16 display cases, which are arranged into two rows in the centre of the room. There are 8 additional wooden display units, containing a total of 24 display cases, as well as 60 display cases along the perimeter of the room. Objects may also be placed on temporary displays, or mounted directly to the wall. In total, there are 148 different display cabinets or display areas. The display cases are glass-fronted, and there is usually at least 6 inches between the objects and the glass. Many of the cases have no low voltage power available within them and there are few power sockets available towards the middle of the room (Shucksmith, 2005).

The current configuration of the museum suggests to the visitor an essentially linear path through the museum’s displays. This corresponds to viewing the objects in chronological order. Mobile technology, however, affords the opportunity to tell different stories about the museum’s objects, without extending or altering the museum’s infrastructure.

Study Design

Selection of Positioning Technology

It is important to preserve a “sense of place” when using mobile technology (Exploratorium, 2005). In order to achieve this, appropriate positioning technology was sourced in order to support context sensitive delivery of information and activities based on physical location.

In order to cater to the needs of visitors at different educational levels, content would be provided in the form of tours. A tour would consist of a series of ‘stops’ that were linked to either specific cases or individual objects. Positioning technology would then be used to identify to which stop the user was closest, in order to provide relevant information.

The small size and compact layout of this indoor museum prevented any serious consideration of absolute positioning techniques, as were used in the CAERUS project with the Winterbourne Botanic Garden (Naismith & Smith, 2004; Naismith et al., 2005), as it would be necessary to determine in which direction the visitor was facing. Instead, various low or no-power ‘tagging’ technologies were considered. These could be used either at the ‘case’ level or at the ‘object’ level. As it would be necessary for the visitor to take some action in ‘activating’ the tag, it could be fairly certain that the correct location would be identified.

Tour Design and Development

The primary motivation behind the focus on tours was to promote non-linear exploration of the museum. Visitors can also be assisted in the transition from *Browsers* to *Followers* by incorporating some of the museum’s visually arresting objects (e.g. the Tyrannosaurus rex) within a narrative theme.

The limited capabilities of the inbuilt browser on Pocket PC handheld devices presented challenges to the development of sophisticated multimedia content in HTML. An alternative to HTML content creation is the use of Macromedia Flash. Flash uses the concept of a movie, and allows control of content layout on a frame-by-frame basis. A simple scripting language can be used to control movement between frames. Flash also has the advantage of supporting the import of media files and producing a single output file, as opposed to the multiple files required with an HTML-only approach.

It should be noted, however, that Flash outputs a file with a SWF extension, which cannot be displayed on the Pocket PC handheld device without additional software. A free ActiveX control from Adobe (http://www.adobe.com/devnet/devices/development_kits.html) can play the SWF file if it is embedded within an HTML file. This control is licensed for development purposes only, and is not available for commercial release.

Visitor Evaluation

The next stage of the study was to evaluate the demonstrator system for efficiency, effectiveness and satisfaction. The objectives of this evaluation were to:

- assess the general usability of the system.
- assess how the system affected user behaviour and ability to navigate around the museum.
- assess desirability of the system amongst different user groups.
- assess desirability of different types of content amongst different user groups.

Twenty-five visitors to the Lapworth Museum participated in a trial of this system in November 2005. Table 1 describes the organisation of participants in the trial.

Table 1: Trial Organisation

Visitor Type	Tour	Number of Visitors
A. Adult Visitors	Climate Change	5
B. Undergraduate Students	Climate Change	6
C. School Visitors	Predators and Prey	14

Eight iPAQ handheld devices were used during the trial, six running the Pocket PC 2002 operating system and two running the Pocket PC 2003 operating system. The Hypertag Magus Guide application and Macromedia Flash Player ActiveX control were preloaded on all devices, along with the content for the particular tour.

Trial participants gathered in a central meeting space for a scripted overview and demonstration of the Magus Guide system. The trial participants were then free to wander around the museum and use the Magus Guide as they wished, though it was suggested that they attempt to follow the tour as set. Informal observations were made while the participants were in the museum. Participants were instructed to return the handheld devices when they had either completed the tour, or were satisfied that they had experienced the full functionality of the system. A short questionnaire was then administered, followed by a semi-structured interview on their experiences.

The trial participants covered a range of demographic groups. Table 2 shows a breakdown of the trial participants by sex, age and experience of the museum. Trial participants spent between 15 and 30 minutes in the museum.

Table 2: Trial Participant Demographics

Sex	Male	21
	Female	4
Age	under 20	14
	20-29	5
	30-39	1
	40-49	0
	50-59	1
	60-69	3
	70-79	1
Experience of Museum	First Time Visitor	11
	Returning Visitor	14

Results

Selection of Positioning Technology

Table 3 provides a summary of the three main technologies evaluated: barcodes, RFID and Infrared.

Table 3: Comparison of Positioning Technologies

	Barcodes	**RFID**	**Infrared**
1. Supplier	Socket Communications	Socket Communications	Hypertag Magus Guide
2. Cost of demonstration kit	Low	Medium	Medium
3. Aesthetic appeal of tags	Low	High	Medium
4. Ease of activating tag	Medium	Low	High
5. Requires reader for each handheld device	Yes	Yes	No
6. Power required for tags	No	No	Yes (battery)
7. Requires additional software development	Yes	Yes	No

Barcodes are an established and familiar technology, and have been used extensively for many applications, including purchasing food and general stock control. Pridden (2003) provides an extensive review of the advantages and disadvantages of using barcodes in a traditional museum setting.

As the barcodes would be placed on the individual cases or objects, the iPAQ would need to be equipped with a barcode reader to identify the code and take appropriate action. A SD-compatible barcode reader, and supporting software, was acquired from Socket Communications (www.socketcom.com). As the iPAQs used in the trial have an inbuilt SD slot, it was possible to use the barcode reader without any additional supporting hardware.

Barcodes were ultimately deemed unacceptable due to a number of factors. Though the process of generating the barcodes is relatively straightforward and inexpensive, it would be necessary to purchase a separate barcode reader for each iPAQ used by the museum. Additional software development would also be necessary to use the barcode number to display the appropriate multimedia content. The barcodes would need to be affixed to the cases with some kind of adhesive, which could potentially cause damage. The barcodes themselves are also easily damaged and, as they are quite familiar in industry, may project a “low-tech impression to most visitors” (Shucksmith, 2005: 5). Barcodes are also “visually intrusive” (Pridden, 2003: 4), which may compromise the museum’s aesthetic appeal.

RFID is also used extensive in the manufacturing industry. Hsi and Fait (2005) describe a custom-designed RFID application that was used to enhance visitor experiences at the Exploratorium science museum in San Francisco.

A RFID demonstrator kit was acquired from Socket Communications. A selection of passive (i.e. unpowered) tags was provided, each with a read distance of approximately 2.5

inches. The tags were smaller and more visually appealing than the barcodes. The reader, however, was CF-compatible (as opposed to SD) which required an additional expansion sleeve for the iPAQs. As with the barcode reader, it would be necessary to develop additional software to use the RFID code to display the appropriate multimedia content.

Following the trials, RFID was also deemed unacceptable. The total cost of ownership was higher than that of barcodes, without providing any additional benefits. The iPAQ, expansion sleeve and RFID reader together were quite bulky and difficult to manipulate. The RFID sensor was actually located on the back of the reader, meaning that the user had to hold the iPAQ flat over the tag, as opposed to the more intuitive 'point and click' operation of the barcode reader. The short read distance of the tags meant that it would not be possible to place them in the cases, thus the same problems with affixing the barcodes to the cases would be encountered.

Ultimately, the Hypertag Magus Guide (http://www.hypertag.com/igsolutions.html) system was selected for this study. Fisher (2005) evaluated this system in four different UK museums, so there was already some indication of its possible effectiveness. The Magus Guide system includes custom-designed battery-powered infrared tags, as well as supporting software both to identify the tag and to display the appropriate multimedia content. Infrared capabilities are inbuilt into nearly all handheld devices, and have traditionally been used to 'beam' information from one device to another. This meant that it was not necessary to purchase a reader for each device, which substantially lowered the total cost of ownership. According to Hypertag, the batteries are suggested to last one year under normal operation.

Figure 2 shows a sample tag. Activating a tag required pointing the handheld device at it. When activated, the tag flashed a blue light, accompanied by an audible 'click' in the software application. As the tags had a read distance of approximately 1 metre, it was possible to place them inside the display cases. In total, 17 of these tags were acquired for this study.

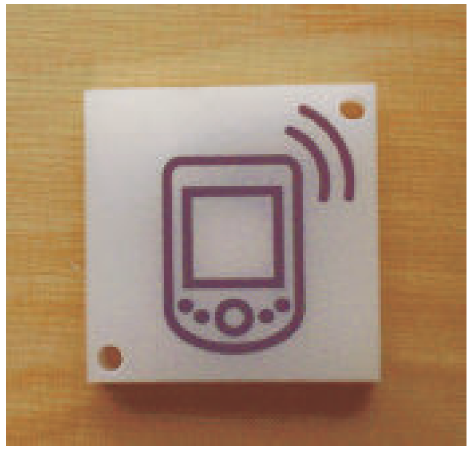
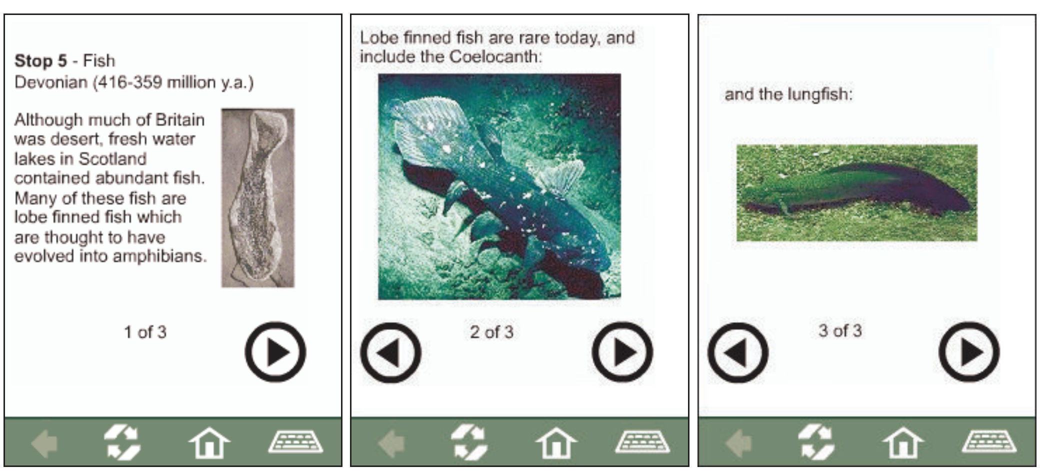


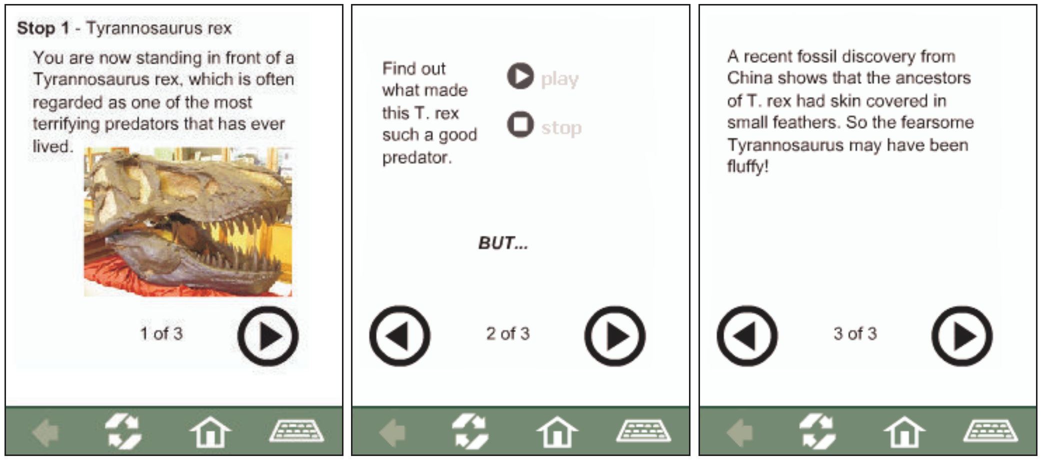
Figure 2: A Sample Magus Guide Tag

Tour Design and Development

Two multimedia tours were developed, a 14 stop 'Climate Change' tour directed at a general, non-specialist audience and an 8 stop 'Predators and Prey' tour directed at a younger, non-specialist audience. The Climate Change tour contained text, images and audio, while the Predators and Prey tour contained text, images, audio and video. Figures 3 through 8 illustrate screen shots from each of these tours.



Figures 3, 4 and 5: Screen shots from the 'Climate Change' tour



Figures 6, 7 and 8: Screen shots from the 'Predators & Prey' tour

As the Lapworth Museum did not have wireless network coverage, it was necessary to store the files on the iPAQs. This is supported by the 'Local Redirect' feature of the Hypertag Magus Guide. It was originally intended that each tour would be developed as a single Flash SWF file and embedded into an HTML file. Code could then be included in the HTML file to play the Flash file at a specific frame. Unfortunately this feature did not seem to be supported on the iPAQ and it was necessary to create a separate SWF file for each stop on the tour.

Visitor Evaluation

Table 4 shows the mean and standard deviation of the response to each questionnaire item, in the range from 1 (Strongly Disagree) to 5 (Strongly Agree). A one sample t-test was performed on each mean, with 3 (Neither Agree nor Disagree) as the constant value. All statements showed a significant difference from 'Neither Agree nor Disagree' ($P < 0.05$).

Table 4: Mean and Standard Deviation of Responses to a 5 point Likert Scale (1 = Strongly Disagree, 5 = Strongly Agree)

Statement	Mean	SD	N
a. Using the handheld device does not require much training.	4.04	1.06	25
b. It was easy at a glance to see what the options were for each screen.	4.38	0.50	24
c. It was difficult to select the option I wanted with the touch screen.	1.88	1.24	25
d. I felt that I was in control of the device.	4.17	1.27	24
e. The device responded too slowly.	1.79	1.18	24
f. I found it difficult to read the text on the screen.	1.92	1.28	24
g. The device helped me to navigate around the museum.	3.88	1.05	25
h. I felt self conscious using the device.	2.17	1.31	24
i. The way that the device presented information was clear and understandable.	4.24	0.78	25
j. It was difficult for me to determine where I was in the museum.	2.17	1.07	23
k. I would recommend the device to other visitors.	4.48	0.79	23

All items are significant at $P < 0.05$

Positive Aspects of the System

Most visitors found the experience of using the Hypertag Magus Guide system to be fun and engaging. Participants were able to stay on task during the trial and did not seem to attempt to use the handheld device for other purposes. They found the action of ‘swiping’ the tags easy and intuitive and felt that they could use the system independently in the future. The mix of media present in the designed content was highly desirable, particularly the audio segments.

From a management perspective, the tags themselves were small and easy to set up and move around the museum as required. Though battery powered, there was no need to replace any of the batteries during the trial.

Negative Aspects of the System

The audio was very difficult to hear clearly in the changeable environment of the museum, and many trial participants commented on the necessity of headphones. Headphones were also felt to promote a more personal experience and address the potential embarrassment factor of using the system alongside other museum visitors. It was also observed that the application itself is quite noisy, with many clicks and beeps, which could disturb other museum visitors.

The original decision not to offer headphones was made in an attempt to promote social interaction and prevent isolation and a 'heads-down' experience (Hsi, 2003). Proctor and Tellis (2003) identify the same issues in the decision by a museum to offer either a headset or wand for an audio-based tour. They conclude that the decision is a personal choice and that the "effectiveness of these educational experiences is based on the appropriateness of the technology used for the stated educational or interpretive goals".

Aspects of the System that Need Improvement

The introduction to the system was a bit too informal for many participants and there was some initial confusion as to where they should start and what buttons (if any) needed to be pressed. The digital map on the handheld device was both difficult to read and labour intensive to produce. Suggestions to address both of these problems included having a large poster or a handout that both outlines the use of the system and labels the stops in order.

During the trial, the white square tags were sometimes difficult to distinguish from the labels in the cases, and many participants commented that they would have appreciated more obvious visual indicators. They suggested that this could be accomplished by painting the tags in a distinctive colour, numbering the tags or both.

While the content was generally well received, some of the images selected were not well suited for the small display screen. There was also a tendency for participants to become so engaged in the experience of using the handheld device that they did not look at or interact with the actual objects in the cases. Participants commented that this could be remedied through direct instructions (e.g. "Look at the xxx in the case"), stronger linking between the object labels and the information available on the handheld device (e.g. sometimes just the common name was used in the tour, whilst the label contained the scientific name) and incorporating short quizzes. Increased interactivity and competition was particularly desirable amongst younger visitors. This aligns with Fisher's (2005) recommendations for designing content that works with the objects and having a screen that promotes engagement through personal challenge and play.

There was also a need to offer more flexibility within the system. In addition to the logistical problems of having many visitors start at the same place, older visitors were somewhat resistant to following a 'prescribed tour' and wanted to be able to focus their visit on one or two areas of interest.

From a management perspective, installing the software and loading the content onto each iPAQ was quite time-consuming. It was necessary to repeat this procedure for each trial session, as the batteries on the handheld devices sometimes drained completely, losing all of the applications and content in memory.

Age Group Differences

The adult trial group consisted of regular visitors to the museum. Whilst there were some technical problems during this first trial that were later remedied, overall the participants were generally enthusiastic, thought that this system could add to the museum experience and were willing to try it again. Unlike the younger visitors, however, they felt that they needed someone in the museum to be 'on call' for technical support.

The adult visitors could successfully manipulate the technology but, as noted previously, there was some resistance to the idea of going on a 'prescribed' tour. As specialist visitors, they were more likely to adopt *Searcher* and *Researcher* roles rather than *Browser* and *Follower* roles. There was some concern that the range of visitor needs was going to make it difficult for the museum to cater to everyone.

The group of undergraduate students responded particularly well to the structure of the tour, and quickly adopted the *Follower* role. They felt that this approach helped the content to 'make sense' and that the content was pitched 'about right' for a general audience. There was some interaction between the students during the trial, but it was primarily an individual experience. With respect to the technology, there was some initial confusion about where and how to get started, but by the end of the trial, all of the students felt that they would be able to use the system again independently.

While the undergraduate students felt that this system enhanced the museum experience and made it more fun, they were pragmatic about their likely future usage of it. They would need the system to support them in a *Researcher* role in order that they could use the information provided for projects or essays. In their opinion, this would involve gathering specialist information on a select number of cases rather than a structured tour.

The school visitors were highly engaged by the technology. They immediately gravitated towards the handheld devices and did not wait for a formal explanation, preferring instead to figure it out as they went along.

This large group of 14 was split in two for the trial and very different behaviour was observed between the two groups, possibly due to the presence of the teacher in the second group. Not all of the students seemed to be following the tour, and several observations were made of students adopting a *Browser* role by trying to 'scan' for tags on objects they deemed interesting (e.g. the deer head). They were highly engaged by the device and the content, though their interaction with the actual exhibits was minimal. A common behaviour was to 'swipe' a tag and then find some place to sit and interact with the device.

Students in the school group made several brief, but supportive comments ("good", "really interesting") and the teacher remarked that this system was "the best thing I've seen" for museum visits. The teacher felt that more structure was needed, however, in order to transform it into an effective learning experience. He and the students were very keen on the idea of introducing competitions (with awards) in order to focus attention on the objects and exhibits. The teacher also felt that competitions could be designed in the form of 'levels' in order to cater to students with varying levels of ability. Students also suggested the incorporation of 'weird facts', a finding echoed by Fisher (2005), which may help to appeal to a *Browser's* sense of awe and wonder.

Conclusions

It is feasible and desirable to use mobile technology to deliver learner-centred experiences in the Lapworth Museum of Geology without compromising the aesthetic appeal of the museum. The structured multimedia approach taken in this project is appropriate for visitors who can adopt a *Follower* role, though more flexibility is required to meet the needs of *Browsers, Searchers* and *Researchers.*

The Hypertag Magus Guide provides an easy to use mechanism for visitors of all ages to access web-based content, which can be stored locally on handheld devices in the form of HTML or Flash movie files. It may, however, be necessary to provide headphones in order to hear the audio clearly. Overall, trial participants required minimal technical support and found the use of the system to be fun and engaging.

Limitations

The results of this study are based on a small trial consisting mainly of young male participants. The response of young females to this system is unknown. Additionally, all participants were geology enthusiasts to some degree. It is unknown if this system could be used to engage people with no previous relationship with either the museum or with geology in general.

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