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► **To cite this version:**

Laura Naismith, Mike Sharples, Jeffrey Ting. Evaluation of CAERUS: A Context Aware Mobile Guide. mLearn 2005, 2005, Cape Town, South Africa. hal-00190142

**HAL Id: hal-00190142**

**<https://telearn.archives-ouvertes.fr/hal-00190142>**

Submitted on 23 Nov 2007

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# Evaluation of CAERUS: a Context Aware Mobile Guide

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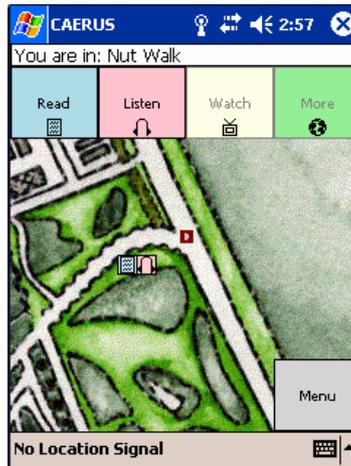
**Abstract:** This paper reports on the results of a user evaluation of CAERUS, which is a complete context aware educational resource system for outdoor tourist sites and educational centres. CAERUS consists of a handheld delivery application and a desktop administration application and provides a visual interface to add new maps, define regions of interest, add theme-based multimedia tours, and deliver this information to visitors through Pocket PC devices with GPS capability. Fourteen participants used CAERUS in the University of Birmingham's Botanic Garden at Winterbourne in May 2005. Participants reported high satisfaction with the location-based content provided, particularly the audio commentary. Significant problems with positioning and navigation were experienced, especially amongst the participants using the system in 'guided tour' mode. Younger and older visitors differed in opinion as to how easy CAERUS was to learn and the clarity of the user interface. The main effect of CAERUS with respect to learning was to increase the participants' engagement with their physical surroundings.

**Keywords:** *tourism, informal learning, context aware, museum*

## 1. Introduction

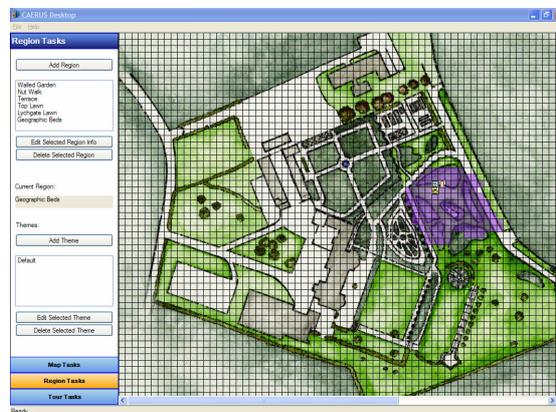
The main aim of outdoor museums and field centres is to encourage learning within an authentic context (University of Birmingham 2001; Birmingham City Council 2004). Visitors are encouraged to explore and discover in order to learn the processes of inquiry and even of learning itself (Hawkey 2004). Due to a lack of preparation and follow-up (Oppermann and Specht 1999) and supporting materials that cannot easily adapt to the range of visitor interests and needs (Not and Zancanaro 1998), visitors often do not make good use of the range of learning opportunities available within these sites. Mobile technology presents the opportunity to support educational visits by providing both location-based information and guidance through this information based on the visitor's interests and needs.

CAERUS is a working implementation of a complete context aware educational resource system for outdoor use. Location-based multimedia content and activities are presented to visitors through Pocket PC handheld computers with GPS capability. The visitor can view his or her location on the map-based interface (Figure 1) and is presented automatically with audio content upon entering a region of interest. Visitors can then select to view additional multimedia content for that particular location, capture their observations or continue with their exploration or tour.

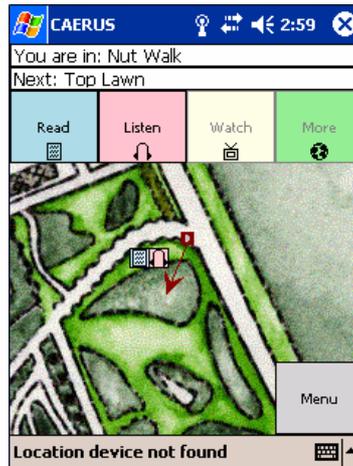


**Figure 1: CAERUS Handheld Interface (Theme Mode)**

Administration of location-based content is accomplished through the CAERUS desktop application (Figure 2). Maps in any image format can be imported into the desktop application and calibrated with the assistance of the GPS-enabled handheld application. Once calibrated, the curator can divide the map up into *regions*, which correspond to physical areas within the site. Each region may be associated with one or more *themes*. Themes provide a specific perspective (such as “history” or “environment”) on a multi-faceted artefact or exhibit and can be used to group media such as text descriptions, audio, video and HTML. The system supports both free exploration based on a selected theme and ‘guided’ tours, where the next region of interest is suggested to the learner. Figure 3 illustrates the handheld application interface for a guided tour. A standard synchronisation procedure is used to transfer information between the desktop and handheld applications.



**Figure 2: CAERUS Desktop Interface**



**Figure 3: CAERUS Handheld Interface (Tour Mode)**

### ***1.1 Design Methodology***

The main aim in the design and development of CAERUS was to produce a system that could be applied in both tourism and education contexts. In addition to providing an engaging end user experience, a key requirement was that individual sites be able to manage location-based information and scenarios themselves and transfer this information to the handhelds efficiently.

Requirements for the design of the handheld CAERUS application were solicited through a questionnaire and focus group consisting of 8 regular visitors to the University of Birmingham's Winterbourne Botanic Garden. All participants were willing to trial a location-based handheld application but only if it 'just worked', indicating a low tolerance for technology failure. Specific design challenges from the perspectives of designer, implementer and user are described more fully in (Naismith and Smith 2004).

A preliminary user trial was conducted with a group of six participants, primarily to assess the usability of the handheld application. An issue that arose from this user trial was, again, a very low tolerance for technology failure. Audio content was preferred due to the rich visual nature of the botanic garden, echoing the findings of (Oppermann and Specht 1999). Participants stressed the requirement for the audio to be very high quality and specifically relevant to what they were seeing.

## **2. Evaluation**

Fourteen visitors to the Winterbourne Botanic Garden participated in a trial of the CAERUS Handheld System in May 2005. The trial consisted of four sessions and was conducted on two separate days a week apart. A planned activity was designated for each session and all participants within the session performed the same activity.

Table 1 describes the organisation of participants in the trial.

**Table 1: Trial Organisation**

	Day 1		Day 2		Total
	Session 1 (Theme)	Session 2 (Tour)	Session 3 (Tour)	Session 4 (Theme)	
Number of Participants	3	5	3	3	14

Trial participants gathered in a central meeting space for a scripted overview and demonstration of the CAERUS handheld application. At this time, they were also asked to give a short statement of their knowledge of the garden. The appropriate option for the particular session was selected from the title screen (Figure 4), and then the trial participants were free to wander around the garden and use CAERUS as they wished. Informal observations were made while the participants were in the garden. Participants were instructed to return to the central meeting space when they were satisfied they had experienced the full functionality of the system. A short questionnaire was then administered, followed by a semi-structured interview on their experiences.



**Figure 4: CAERUS Handheld Title Screen**

The main objectives of the trial were to:

- Assess general usability of the system.
- Assess how the different modes (theme, tour) affect user behaviour and ability to navigate around the garden.
- Assess desirability of the system amongst different user groups.
- Assess desirability of different types of content amongst different user groups.
- Gather evidence for learning.

## **2.1 Equipment**

Three handheld devices were used during the trial, all running the Pocket PC 2003 operating system. Two of the handheld devices were Mio 168 DigiWalker models with integrated GPS. The other handheld device was an HP iPAQ 5500 series with a Navman GPS 3300 in an expansion sleeve. The CAERUS handheld application was preloaded on all devices.

Except for Session 2, each participant was loaned a handheld device and earbud headphones for individual use. In Session 2, there were two pairs and one individual. The pairs in Session 2 opted not to use the headphones.

### 3. Results

The trial participants covered a range of demographic groups. Table 2 shows a breakdown of the trial participants by sex, age, experience of the garden and handheld device ownership. Trial participants spent between 30 and 45 minutes in the garden.

**Table 2: Trial Participant Demographics**

Sex	Male	8
	Female	6
Age	20-29	5
	30-39	3
	40-49	0
	50-59	1
	60-69	3
	70-79	2
Experience of Garden	First Time Visitor	5
	Returning Visitor	9
Handheld Device Ownership	Own a Handheld Device	4
	Do not own a Handheld Device	10

Trial participants were asked to rate a series of statements on a five-point Likert scale. Table shows the mean and standard deviation of the response to each 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. Five statements show a significant difference from 'Neither Agree nor Disagree' ( $P < 0.05$ ):

- CAERUS was easy to learn (a)
- It was not difficult to manipulate the push button interface (c)
- Participants did not feel like they were in control of CAERUS (d)
- Participants did not feel self conscious using CAERUS (h)
- Participants would recommend CAERUS to other visitors (k)

**Table 3: Mean and Standard Deviation of Responses to a 5 point Likert Scale**

Statement	Mean	SD	N
a. Using CAERUS does not require much training.	3.55*	0.69	11
b. It was easy at a glance to see what the options were for each screen.	3.31	1.03	13
c. It was difficult to select the option I wanted with the touch screen.	2.15*	1.14	13
d. I felt that I was in control of CAERUS.	2.46*	0.78	13
e. CAERUS responded too slowly.	3.50	1.22	14
f. I found it difficult to read the text on the screen.	2.46	1.27	13
g. CAERUS helped me to navigate around the garden.	2.71	1.20	14
h. I felt self conscious using CAERUS.	1.93*	1.07	14
i. The way that CAERUS presented information was clear and understandable.	3.50	0.94	14
j. It was difficult for me to determine where I was in the garden.	3.79	1.37	14
k. I would recommend CAERUS to other visitors.	3.57*	0.94	14

Starred items are significant at  $P < 0.05$

The Mann Whitney U Test was used to compare the responses between groups. Comparisons of First Time Visitors versus Returning Visitors, Handheld Device Owners versus Handheld Device Non-Owners, Theme Participants versus Tour Participants and Male versus Female did not show any significant differences of opinion. Comparisons between the group of participants over 50 and the group of participants under 50, however, showed a significant difference of opinion for the following statements:

- Using CAERUS does not require much training (a) – older participants slightly disagreed (mean response 2.8), while younger participants agreed (mean response 4.0).
- It was easy at a glance to see what the options were for each screen (b) – older participants disagreed (mean response 2.5), while younger participants agreed (mean response 4.0).

Overall, the reaction to CAERUS was positive. Participants found the content provided during their visit to be both interesting and informative. As with the previous trial, audio was the preferred method of delivery. Several participants commented that the audio commentary was particularly clear. Participants described their experience with CAERUS as novel and liked the experience of looking at something while being talked to.

Problems with navigation and positioning, however, were paramount. GPS was described by the participants as slow and imprecise. Participants felt that too much mental effort was required to navigate and didn't want to have to look at a map to find interesting and relevant information. These problems were compounded by the fact that the handheld device screen was very difficult to see in bright sunlight.

Usability issues with the application itself were prevalent amongst the over 50 age group, with several participants citing a need for individual tuition (the application was demonstrated to the group). A common usability problem across age groups was that it was very easy to switch into 'demo' mode by touching the map area of the screen. In this mode, the GPS receiver is turned off so that the user can access information for other parts of the garden, without having to physically move. The demo mode is indicated to the user by a change in icon, but could be difficult to see, especially if it was done unintentionally. Participants can return to normal mode by clicking 'Find My Location' on the menu bar.

When asked what they would change, most participants requested enhanced positioning capability and information for more points in the garden and at a greater level of detail. While most participants said they would use CAERUS again in another location, a few of the older participants expressed dissatisfaction with the general concept and stated they would prefer a no-technology solution such as a paper map or leaflet.

## **4. Discussion**

### **4.1 Comparison between different modes**

All participants using the Tour mode made an initial effort to follow the suggested tour points in order, but all experienced difficulties with positioning and or navigation. Participants employed a number of different strategies to overcome these problems:

I started off using it trying to follow the guide, but then it just got infuriating, cause it pointing in the wrong direction, didn't go where I wanted to go and the GPS was inaccurate. So in the end I just forgot it and walked around. (male, 20-29, tour, first time visitor)

I looked for the icons and I walked to them. (female, 20-29, tour, first time visitor)

So I still used the suggested route, but I used the demo mode instead, towards the end. I roughly know where I am on the map, so I walked towards the point. (male, 20-29, tour, first time visitor)

The tour points consisted of both points within regions, and thus with attached content, and waypoints, with no attached content. Some visitors expected content to be available at all of the suggested points and were confused when no content appeared at these locations:

We tried to follow the tour; that was where we started having the difficulties. The tour sent us to places like go to the path towards the terrace, well what can you say about the path towards the terrace and it didn't say anything. (male, 60-69, tour, returning visitor)

The application didn't have a significant impact on the movement of the participants using the Theme mode. These participants were more likely to follow the natural paths in the garden, and wander between regions based on what visual sights piqued their interest.

Interestingly, several Theme participants requested greater guidance:

If you suggest to me you should go this way or that way and see this plant, that would be helpful. I would like to follow it. (female, 30-39, theme, first time visitor)

## **4.2 Navigating in information space**

CAERUS requires visitors to navigate simultaneously through both physical and information space. A variety of factors impeded this process for trial participants including a lack of labelling both on the digital map and in the garden, a static map that didn't respond to changes in the user's orientation, difficulty seeing an overview of the garden on the handheld device and inconsistent performance of the GPS receiver.

Several participants used physical movement to verify they were navigating properly within the information space. This ranged from standing still while rotating the handheld device to match the visual surroundings to repeatedly walking back and forth along a particular path in the garden.

The participants felt that significant mental effort was required to use the application, which correspondingly led to a large amount of 'heads-down' interaction (Hsi 2003). The use of the handheld application was far from seamlessly integrated with the visitor experience:

It's not a physical experience; it's still attached to a device. (female, 30-39, theme, first time visitor)

Participants suggested a range of navigational aids to facilitate this process. These included simple solutions such as increased labelling, providing an accompanying map on a paper leaflet and an overview wall chart map available at the garden entrance. Technical solutions included enhanced positioning, displaying an arrow indicating the user's current direction of travel and automatically orienting the map to the user's current direction.

## **4.3 Evidence for learning**

This trial did not attempt to measure learning against on a predetermined set of outcomes. Measuring the free-choice learning that occurs in informal settings is difficult for a number of reasons. Visitors come in with a range of prior knowledge, interests and motivations and continually interact with the physical and sociocultural settings in unique ways (Falk and Dierking 2000).

After their experience in the garden, however, participants were able to cite specific examples of things they had seen or heard:

The bit about the metasequoias, the history of the trees down there, and also a bit more about the history of the house. (male, 20-29, theme, returning visitor)

I might've heard about the petal garden, but the shapes of the petals, I didn't know that. (female, 60-69, tour, returning visitor)

The two on the balcony the two [wisterias], one goes clockwise and the other goes anti-clockwise. Little things like that stick in your head. (female, 20-29, tour, first time visitor)

Participants also reported increased knowledge of the layout and organisation of the garden:

I worked here and I didn't know where the petal garden was. (male, 60-69, tour, returning visitor)

The garden is larger than I thought. I went down there and there's a natural path down there that isn't actually part of the garden, but you can walk along it to explore. (male, 20-29, tour, first time visitor)

CAERUS also prompted at least one participant to explore further:

I did look at some of the other information and I did actually try to find some of the trees as well. Just out of interest. (male, 20-29, tour, first time visitor)

Perhaps the best evidence for learning is that fact that most of the participants expressed a strong desire for more information, in multiple media formats:

I was just saying on the way back that although I didn't particularly want to listen to it at first, cause I thought I knew it anyway, it was so interesting and it could've been longer, even twice as long would've been fine. (male, 60-69, tour, returning visitor)

I want to know more about the rose collection. (female, 30-39, theme, first time visitor)

You really need [more] photographs as well to make it a good experience. Something in blossom now will not have blossom later. (male, 20-29, tour, returning visitor)

## **5. Conclusion**

CAERUS uses mobile technology to support visitors to outdoor tourist sites and educational centres by providing location-based information and guidance. Visitors using the CAERUS Handheld application on a trial basis reported high satisfaction in receiving location-based audio content and reported the use of CAERUS Handheld to be a novel and informative experience. A statistically significant difference in opinion was observed between older and younger visitors as to the amount of training required to use the application and how easy it was to see what the options were at a glance.

Significant mental effort was required for participants to navigate successfully through both physical and information space, leading to heads-down participation and detracting from the rich visual environment of the garden. Participants experienced particular frustration trying to use the Tour mode functionality, while those using the Theme mode expressed a desire for further guidance. This suggests that a rethinking of the Tour mode implementation is necessary, in conjunction with an investigation of both technical and non-technical navigational aids.

While the trial did not seek to comprehensively evaluate participant learning, participants cited several examples of things they had seen or heard that were of interest to them. They also showed a generalised increase in their knowledge of the layout of the garden and a strong desire to obtain more detailed information in multiple media formats.

## **6. Acknowledgements**

The design and development of CAERUS was supported by funding from Microsoft UK Limited and the Birmingham City Council to The Centre for Educational Technology and Distance Learning (CETADL) at The University of Birmingham, UK.

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