

Assembling History:

Achieving Coherent Experiences with Diverse Technologies

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Abstract. This paper describes an activity designed for a site of special interest in which clues to its history are gathered as visitors explore the site before interacting with two displays which reveal details of key past events. We investigate a design approach in which electronically tagged paper is used both to weave the visit together and configure the interactive displays so as to provide variable access to a common information space. An analysis of visitors' interactions throughout a week's public exhibition shows how features of our approach can support people in making connections between displays, locations, and historical events. In addition to situating our work in relationship with CSCW's emerging concern for technologies and collaboration in museums and allied public settings, we examine general questions of how to design activities to establish coherence of experience across diverse interfaces. This is a timely issue as interactive technologies proliferate and take on ever more variable physical forms.

Introduction

Many researchers, following Weiser (1993), suggest that computers are more and more mass-market products with the potential of becoming part of the fabric of

everyday life, rather than tools requiring expert skill and encountered in laboratories or high-tech offices. Our encounters with information technology are less exceptional, more everyday, and increasingly domestic, leisure-related and in public places. This proliferation of interaction devices and information displays raises new problems. In particular, how are these technologies to be coherently interrelated in ways which make sense to, rather than overwhelm, their users? Accordingly, CSCW and HCI research is beginning to complement its interest in the design of individual devices and displays with a concern for how they might be *coherently assembled*. It is this problem of the practical assembly of artefacts to support coherent experience that we focus on.

Assembling Visiting Experiences in Museums

Museums, exploratoria and galleries are relevant areas to study how information can be assembled, as well as promising domains for evaluating designed solutions. Indeed, several researchers, have begun to examine people's encounters with technologies in such public places. Büscher et al. (1999) describe a media art exhibition space and characterise the ways in which people move between artefacts, learn about them and cooperate with each other in making sense of them. On the basis of these observations, the authors make proposals for the design of technical infrastructures which intelligibly interconnect large scale, multi-user virtual environments. While Büscher et al. are concerned to inform requirements for general purpose platforms on the basis of studying public places, we are interested in effectively deploying technologies within those places themselves. We share the insight though that exhibition spaces are sites where multiple interactive artefacts may be found, whose interrelations are not always coherently designed.

Traditional museums have commonly utilised multiple displays (cabinets, vitrines etc.) for showing items from their collections. Presenting items in separate displays enables taxonomies of items to be made visible, or comparisons between items to be made with respect to particular highlighted features. As collections grow, many museums experience a problem of selecting what to display and what to keep in storage. New displays are introduced to accommodate new acquisitions and to house visiting exhibitions. These must coexist with a legacy of older displays, embodying older taxonomies or design aesthetics.

For many museums, interactive exhibits offer an alternative to traditional ideas of museum pedagogy and principles of exhibition (Benelli et al. 1999, Caulton 1998, Bitgood 1991). For example, an 'interactive' may enable a richer impression to be given to visitors of the history or use-context of an artefact which the mere display of the artefact alone might not make so clear. Multimedia applications can also bring items (virtually) 'out of storage' (Ciolfi et al. 2001). Consequently, museums have often been at the forefront of deploying new interface technologies, ranging from immersive displays to extend the imaginative presentation of artefacts, to mobile devices that present information in context and in a personalised or intimate way as part of a museum tour (Aoki and Woodruff 2000, Benelli et al. 1999, Grinter et al. 2002, Schnädelbach et al. 2002). However,

such innovations introduce further displays into the museum environment that might uneasily coexist with traditional display techniques.

Whatever the value of these introductions of information technology, the practical condition many museums find themselves in is one of multiple coexisting displays and devices of varying age, rationale, design aesthetic and material manifestation. Displays differ in terms of the kinds of activity they support, personalisation, physical scale, cost, portability, commodity or bespoke, and many other factors. And yet, they also need to be embedded within an overall visiting experience which can be collaboratively made sense of by groups of co-visitors. We aim to provide *assemblies* of artefacts to support a coherent experience for visitors. How can visitors make connections between their experiences at different displays in order to gain new insights or make sense of complex information? As we will shortly describe, we designed a site-specific experience involving an assembly of technologies to investigate these issues.

Designing Public Experiences

In addition to the goal of assembling displays and interaction devices into a coherent experience, our work is also informed by several key issues in the design of public visiting experiences which emerge from social scientific studies of museums and related settings.

vom Lehn et al. (2001, see also Heath et al. 2002, Hindmarsh et al. 2002) describe how people engage with a variety of interactive exhibits. They reveal how companions shape each others' experience and how passers-by often draw on the activities of others to learn how to use and appreciate interactive exhibits. Interaction, then, should not refer to just the interaction of a single 'user' with an exhibit but should address the multiple ways in which people engage with each other in, around and through the display. Our work builds on this and other sources (e.g. Caulton 1988) on visitor conduct and exhibit design. In particular, we were concerned to:

- support a range of ways in which our assembly of artefacts could be oriented towards (casually, as fun, or for serious visitors and organised school trips)
- encourage collaboration within small groups, often composed of children and adults
- recognise that the overall experience must be managed (coping with bottlenecks, failures, special needs)
- be sensitive to questions of costs and scalability
- recognise the need to provide 'take home' materials (for use in schools or as souvenirs)
- allow flexibility in how the overall experience could be acted out (i.e. avoiding a fixed order of activities)
- explicitly provide for different means for engaging with our artefacts (hands on, overseeing, passing by etc.).

A Set of Principles for Assembling Artefacts

Let us introduce our approach for addressing these requirements. First, coherence is given to the experience by defining a *unifying overall activity* in which the visitors are to be engaged. In our case, we indicated to visitors that they would be doing a ‘history hunt’ in which they would collect ‘clues’ around the site. Secondly, an underlying *common information space* (cf. Bannon and Bødker 1997) is designed which contains a variety of interrelated items that can be revealed as the activity progresses. In our case, this concerned two different historical events which implicated different parts of the site. Thirdly, *an assembly of interactive displays* is used with each display supporting a particular part of the overall activity and revealing a sub-set of the common information space. We describe these shortly. Our aim was that the progressive unfolding of events using different displays would give an intrinsic ‘structure of motivation’ (see Bowers 2001) for engaging with the overall activity and discovering a variety of details about the site. Fourthly, to promote the coherence of the experience, *common interaction techniques* are provided across different displays. In our case, we rejected standard desktop multimedia interaction techniques and devices throughout in favour of designing a set of overlapping techniques which were idiomatic for the site and the clue-seeking activity. Finally, to further enhance the integration of the visit, a *portable artefact* is provided to enable visitors to accumulate a record of their visit and support their identification as they move around the site.

Paper as ‘Glue’

Our approach to assembling multiple displays is to use paper as the glue that holds an experience together. Museum visitors are provided with sheets of paper on which they make a visual record of the locations and displays they have visited. These sheets are pre-printed with information to guide and structure the visit, for example clues, maps and suggested activities. Each sheet is also electronically tagged using RFID technology so that it can be used as input to various interactive displays (Want et al. 1999), and can hold a computer-readable history of the visiting experience. Visitors engage in a series of different activities throughout a visit, some of which involve following suggestions from the paper, others annotating the paper with information that they have found, and yet others using the same paper to obtain further information from interactive displays.

The key idea is that the combination of a visual record and an electronic record on a single artefact – a piece of paper – can provide both visitors and displays with the information required to assemble a coherent experience. For the visitor the instructions on each piece of paper can be part of a unifying overall activity (e.g., a treasure hunt, mystery or scientific field trip). For the display, the tag on each piece of paper can index into a common information space, and can also provide valuable context information in terms of previous displays visited (and activities at these) that can be used to shape and personalise their experience.

There are many possible approaches to interaction across different displays, for example, directly picking and dropping digital information (Rekimoto 1998). Our

approach builds upon previous research in which paper has acted as the interface between the physical world and digital content. The Campiello project explored how different kinds of paper (tourist guides, maps, flyers and newspapers) could be associated with digital content (through computer-readable check boxes, stickers and DataGlyphs) and used to support community activities within a city (Grasso et al. 2000). In PaperLink, a highlighter augmented with a camera allowed people to manipulate digital information on physical paper (Arai et al. 1997). Others have focused on augmented desks (Wellner 1993) and books (Back et al. 2001) that mix paper with digital content.

These projects have been motivated in large part by some of the important features of paper: it is inexpensive, adaptable, foldable, annotatable, familiar, scaleable, durable, failsafe, shareable, legible, and portable. In our particular application, paper allowed the right kind of flexibility in the ordering of component activities (sheets could be shuffled); was easily shareable amongst a small group; was familiar to adults and children alike; was inexpensive and flexible as a medium for both writing and drawing; and could be taken away afterwards. In short, we felt that the use of paper as a portable artefact would address the exhibition specific requirements bulleted above while – with tagging technology – support the technical integration of an assembly of artefacts.

The History Hunt

We have tested our approach by creating a public exhibition in collaboration with Nottingham Castle Museum, a heritage site at which many significant historical incidents have occurred over several centuries. Our goal was to enable exploration of the complex ‘layered histories’ of this site, comparing key events across time and space. Our experience has taken the form of a ‘history hunt’, in which visitors explored the castle grounds, gathering clues and interacting with a number of displays, in an integrated, yet flexibly structured, activity that revealed historical events.

We designed and staged our public experience over the course of four months. The research process included consulting museum personnel over exhibit content and requirements. As many visitors are families or groups with children, we also staged a number of preliminary trials involving a head teacher and a class of 10 year-old school children. The final exhibition was open to the general public during a week in the summer of 2002.

The Historical Background

The castle was first built in 1067. Over the past millennium, various significant historical events have taken place at different locations around its site. Following the end of the English Civil War, the year 1651 marked the destruction of the Castle. Around 20 years later, the Duke of Newcastle built a Renaissance-like ‘Ducal Palace’ on the site of the castle remains. Notably, what is left on the site bears little relation to the more complex medieval castle. In order to give visitors

some sense of the castle, the museum (now primarily housed in the newer building) employs various mechanisms and technologies such as slideshows, medieval artifacts with associated text, interactive kiosks, signposts, guides, brochures and textbooks. Nonetheless, museum staff are constantly searching for further ways to help visitors to understand the castle as it used to be, and the part it played in key historical events. As part of this process, previous work has exhibited the castle's medieval form as a 3D reconstruction accessed through a mobile location-sensitive display (Schnädelbach et al., 2002).

A Tour through the Experience

The history hunt involves two different kinds of activity. The first is searching the castle grounds for information about a key historical figure and recording this on paper. The second is electronically tagging the paper and using it to reveal more information about this figure at two interactive displays, the Storytent and the Sandpit. A typical experience unfolds as follows.

Arrival: Visitors arrive at a gazebo located near the main entrance to the Castle. They are given a pack of paper clues and informed that they are on the trail of a historical character who featured in a particular period of the castle's history (either Richard I or Edward III). There are three or four clues in each pack, and it is made clear that visitors can complete as many as they like in any order that suits.

Searching the grounds: The clues guide them to locations that feature in the story of their character. These places today often only minimally resemble their appearance in history. For example, the Castle Green, now an open area of grass, was once the location for a large building called the Great Hall. The clues ask visitors to record some information, either by drawing a key feature (e.g., an image of a sword on a wall, a bridge, a heraldic lion) or making a rubbing (the Green in particular has several engravings set into the paths for just this purpose).

Tagging the clues: the visitors return to the gazebo where a member of the project team attaches an RFID tag to each completed clue. The identity of each tag has already been associated with the unique combination of character and location for this clue (e.g., Richard I at the Gatehouse). It would be possible to pre-tag the paper clues before the experience. However, we opted for a manual process in this first attempt in order to reduce the number of tags required. This also created an opportunity to capture information from the visitors about the number of clues answered and to manage the flow of visitors to the next stage.

At the Gatehouse: the visitors now make their way to a room in the gatehouse where they encounter two different interactive displays that tell them more. The Storytent (Green et al., 2002) reveals a single scene related to each clue (e.g., a scene showing Richard I laying siege to the Gatehouse). The Sandpit allows visitors to dig for other pictures that are more broadly related to either the character or location associated with each clue (e.g., other images associated with either Richard I or with the Gatehouse).

Depart: visitors take their paper clues with them.

We now describe three essential elements of the experience in greater detail: the clues, the Storytent and the Sandpit.

Drawing on Paper Clues

Although all the clues in a pack could be assembled into a whole story, each clue was designed to be standalone so that visitors with little time did not need to complete all the clues to participate. The clues shared a common structure as shown in figure 1. The bottom section directed the visitor to a location around the castle, and instructed them to draw or rub an image of a prominent feature. The middle section provided space for this drawing or rubbing. The top section contained some further information written in ultraviolet ink so that it was not normally visible, but could be revealed under an ultraviolet light in the Storytent later on. A map of the castle grounds was copied on the reverse to help visitors navigate around the site. The RFID tag was attached to the reverse of the paper using a small Velcro tab to allow re-use.

On occasion, clues were scanned and reused as part of the content of the Sandpit so that visitors might encounter previous visitors' drawings.

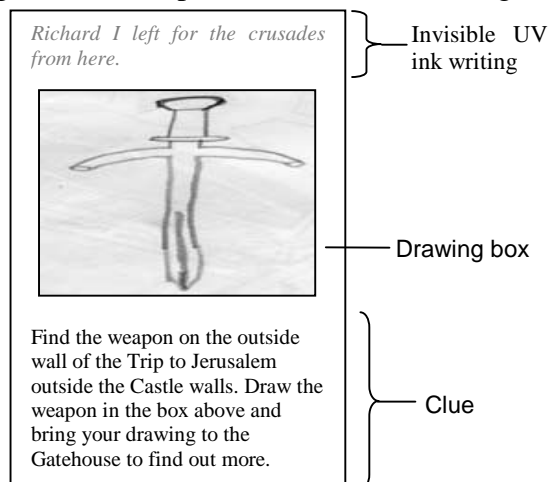


Figure 1: Paper layout design for clue

Revealing Scenes in the Storytent

The Storytent is a projection screen in the form of an A-frame tent (see figure 2). Two projectors throw different, but synchronized, images onto its surfaces while surrounding speakers play out sounds. Visitors can either sit inside the tent or stand outside in order to view its images. The overall effect is to establish a more personal and intimate space inside the tent, set within a larger, more public space outside, but with access to its information available from both.

Visitors entered the Storytent and placed their clues one at a time on a turntable device, a rotating platform that uses a potentiometer to sense its movement, contains an embedded RFID tag reader, and has an ultraviolet lamp pointing onto its surface (see figure 2 inset). The tag reader would then identify the clue and

load the corresponding images and sounds associated with its combination of character and location. One side of the tent would now display a 3D reconstruction of the Castle as it would have appeared at the time of this character, viewed from this particular location. Visitors could rotate the turntable in order to rotate their viewpoint within the model and so explore it in some more detail. The other side of the Storytent would display an image depicting a key event from history involving this character and this location. These images were usually taken from the museum's collection of paintings and tapestries. Ambient sounds relevant to the event would also be played.

Finally, the ultraviolet lamp just above the turntable would reveal the secret writing that tied the clue, the drawing made by visitors, the different images and sounds together. For example, on placing the clue for 'Richard I at the Gatehouse' on the turntable, the tent would display a 3D image of the Gatehouse as it would have appeared in his time, a 2D painting of him laying siege to the castle and play a battle sound. The secret writing would then explain how Richard fought a battle at this location to capture the castle back from his brother John.

Overall, there were seven different clues (four for the time of Richard I and three for the time of Edward III) that would trigger seven different scenes. The scenes could be viewed individually as stand-alone fragments, although the combination of scenes for each character would tell a complete story.



Figure 2: The Storytent, with close-up of the turntable interaction device with a clue placed on top

Sifting for Images in the Sandpit

Our second display, the Sandpit, is an interactive floor projection. Visitors stir up sand in order to sift for buried images. In this case, the sand is a graphical simulation and sifting is achieved by pointing the beams of flashlights at the image on the floor. The flashlight beams are video tracked in the manner of Green et al. (2002), so that each controls a cursor (a sparkling light) that appears to dig into the sand. After digging for while, visitors begin to uncover digital images that then move up to the surface before fragmenting, spinning around and disappearing

(figure 3). Two flashlights can be used simultaneously, in which case visitors can more effectively dig together.

Next to the Sandpit is a small raised sandbox covering an RFID tag reader (figure 3 inset) Placing a tagged clue into the sandbox selects a set of images to be buried in the sand. These images are related either to the character or the location associated with the clue. The Sandpit generates sound for ambience and also feedback to indicate when a tagged clue has been recognised.

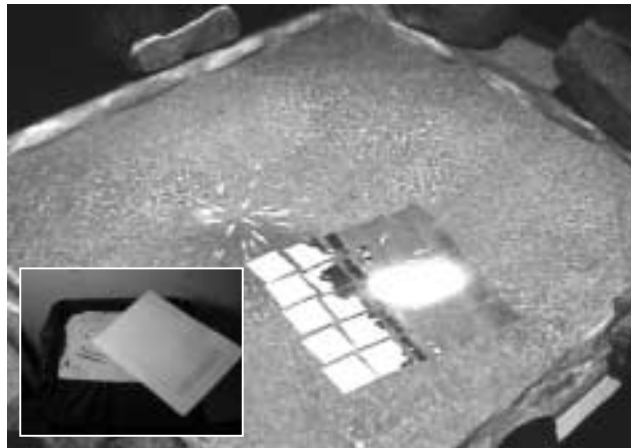


Figure 3: The Sandpit, with close-up of the sandbox device and a clue placed on top

The Sandpit was positioned in the gatehouse, opposite the tent, and separated from it by a distance of approximately two meters. The Storytent was configured so that the side showing the 2D images became the ‘public facing’ side, directly facing the sandpit (that displayed some of the same images). The side showing the 3D model was the more private side that was hidden away from the Sandpit.

These two displays have been designed to play complementary roles within the overall assembly that is the history hunt. In particular, they support different ways of accessing a common database of historical information. This database is organised as a time-space matrix, currently defined by two times (the times of Richard I and Edward III) and five locations (the Green, the Drawbridge, the Gatehouse, the Trip to Jerusalem Inn and a secret passage called Mortimor’s Hole). Each clue indexes into one cell of this matrix (i.e., a specific combination of character and location). The Storytent focuses down on a particular event by retrieving and displaying information from this cell. The Sandpit on the other hand, suggests connections to other events by retrieving information from neighboring cells (same time or same location).

We now turn to an evaluation of the history hunt, focusing on how visitors were able to make connections between the different activities and displays.

Making Connections

Our exhibition was open to the public for three and a half days between 10am and 4pm. In that time, more than 200 visitors tried out the experience. Visitors ranged from individuals to groups of seven or eight; and from very young children to

elderly citizens. Some participants completed all the clues, some completed only one or two.

We have conducted a qualitative analysis of the role of our paper clues in binding visitors' activities into a coherent experience. We have focused our analysis on audio-video recordings of the displays in the Gatehouse. Where possible, we have supplemented these with observation and further video recording of visitors exploring the grounds. We also asked some visitors (primarily children) to recount the stories that they had discovered after the experience.

Our primary analytic concern has been to look for evidence of whether visitors can understand and assemble a coherent experience through their use of the paper clues. We have focused in particular on the role of the clues in visitors making connection between their activities, the displays and the history of the museum.

Our observations reveal three broad kinds of connections:

- **Activity connections:** associations made between the displays and visitors' activities from the exploration phase.
- **Event connections:** associations made between displays and historical events related to those activities.
- **Display connections:** associations made between displays.

These connection types are not mutually exclusive, nor are they entirely exhaustive. However, they do provide a useful vehicle to study how visitors assemble a coherent experience. In the following sections, we describe how such connections occur, illustrating this with examples from the Storytent and the Sandpit. Our illustrative examples primarily come from a single group: 'J' and 'L' are two 10-year old girls and their mother is 'C'. This group's interactions included many of the key connections we have repeatedly observed throughout the data.

Activity Connections

Activity connections are those made between the information revealed at the display, and the paper-based activities undertaken during the exploration phase. Our interest in activity connections lies primarily in finding out how important drawing and exploring were to the overall experience.

Activity connections were made frequently by almost all visitors. In the Storytent, such connections were made with both the 2D images projected on one side of the tent and the 3D views projected on its other side. For example, J and L are sitting in the tent watching the 3D view, and placing their clues onto the turntable (figure 4).



J: puts down clue with drawing of sword on Turntable

J: "Look there it is", as she points at the 3D Trip to Jerusalem on the side of the tent.

L: looks where J is pointing.

Figure 4: J (closest to camera) points out the connection between the 3D model and their drawing

As with the real inn, the 3D model of the Trip to Jerusalem has a sword hanging on the wall. It is unclear from the video whether J is pointing at the virtual sword itself (although this seems likely), or the inn as a whole. Nonetheless, J can animate the 3D graphic for L, at the same time showing that the 3D model bears a direct relationship to their earlier drawing activity. J is able to indicate a relationship between current and past activities to set the scene for L. We have also seen examples of visitors relating the 2D images presented on the tent to their activities during exploration.

Examples of activity connections also occurred frequently at the sandpit. In this case, J (on the right in figure 5) and L (on the left) are both using torches to uncover images in the sand. L's digging has uncovered the image of another child's drawing of a lion.



L: "There's the lion"

J: (inaudible)

C: "It's not as good as yours"

Figure 5: C points at the picture of a lion, saying to J "its not as good as yours"

C situates the appearance of the lion picture within the context of the group's own drawing activities. The comparison by C can also be heard as confirmation to the girls that this is not just any lion, it is indeed *the* lion, the lion of their drawing experiences. This last comment also reveals the value of the drawing. It is personalized, owned and worthy of comparison with others.

What is key to these examples is how important the activity of drawing on the clue is to making subsequent connections. The paper acts as both a record of activity and a reminder of the location of events depicted in using the displays.

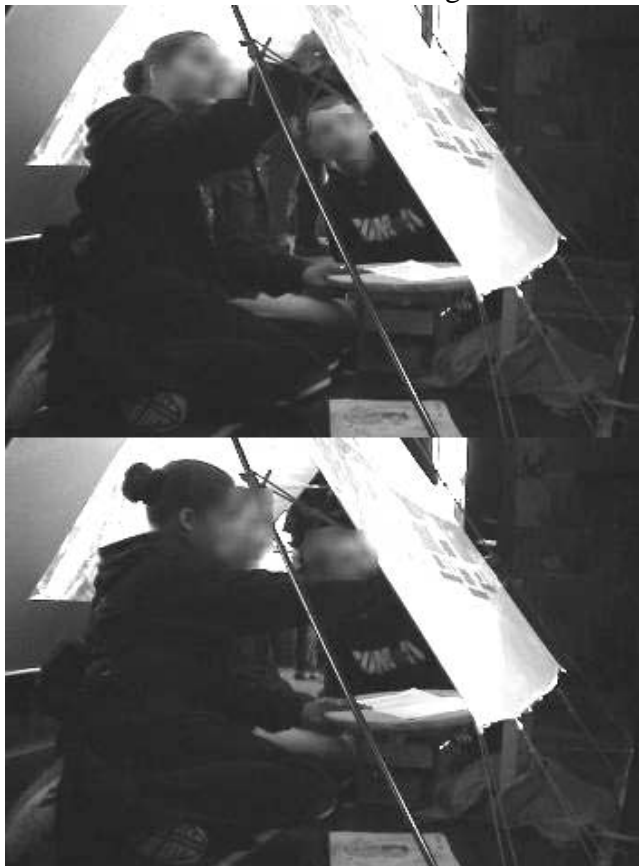
Also, the act of drawing on the paper represents a significant investment in time and effort by visitors and they are rightly interested in obtaining a suitable

reward for this. Our data repeatedly show that visitors entering the Gatehouse were keen to interact with technology so as to understand more about their clues (the first example in the Storytent above occurs immediately after the group has arrived at the gatehouse and entered the tent). There is a sense in which, by investing in their drawings, visitors buy into the experience at the outset. Rather than approaching the interactive displays cold, they are already 'playing the game' when they arrive at the Gatehouse and so may be better prepared to use the technology to make connections between different parts of the experience.

Event Connections

While activity connections are useful ways for visitors to make the experience more coherent, we were interested in whether and how visitors could make sense of the underlying historical events. Event connections go further than activity connections in the sense that they relate the paper clue and the information revealed at the display to the historical events being hunted.

Event connections occurred relatively often during the use of the displays, although generally they were not as common as activity connections. We found many examples of visitors making event connections for one another. In one example, three teenage children have just entered the tent. They begin by placing a clue on the Turntable and rotating the 3D view.



G: "You can see it all - oh right so there's the castle, look - and so this'll be"

B: "Oh that's that pub"

G: "Yeh, that's the pub - so that's why ... Richard I set off from his crusades from here"

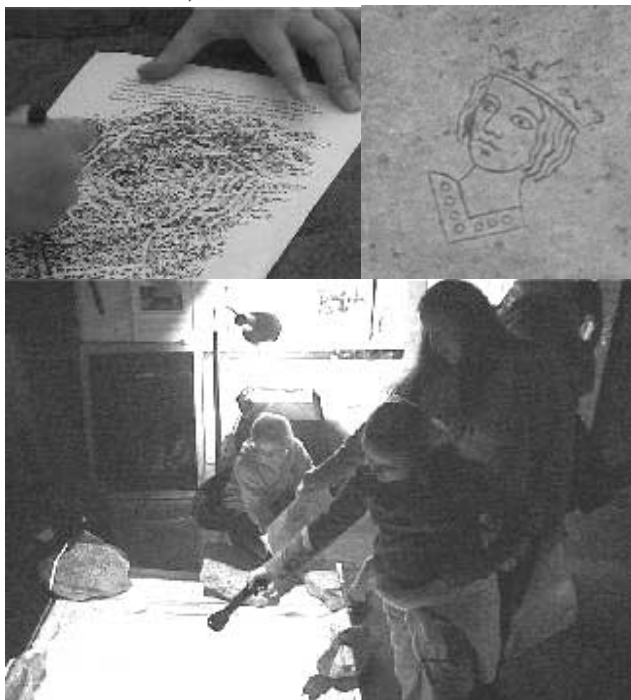
Figure 6: a) G (closest) points at the virtual castle, saying "so there's the castle"
b) G points at the pub model, saying "yeah that's the pub"

As G rotates the view, the model of the castle comes into view and she points it out (figure 6a). As the group 'get their bearings', B points out that "that's that pub". G agrees (figure 6b) and now moves her gaze down to the Turntable to read the UV writing, "Richard I set off from his crusades from here".

Here we see a number of features of the Storytent being used to make event connections. The ability to rotate the 3D viewpoint provided by the turntable, combined with the recognizable features seen in the model, as well as the associated sound events, allow the participants to connect their activities to the history being depicted. The UV writing which is now revealed on the clue (the artefact that triggered this 3D information) then provides the critical link to the historical event.

The sandpit can also be used to make event connections via the relationships between the images buried in the sand. Although it provides a less direct relationship between the use of the paper clue and the events in question, visitors do discuss some images as they might relate to hunted historical events.

Let us return to the example of L, J and C at the sandpit: L and J are still digging in the sand. L uncovers a picture of King John I (Richard I's brother and rival) etched into a paving stone in the castle grounds. During their exploration, the girls have used a crayon to rub this image. The clue relates to the location of the Great Hall, where John was banished to France by Richard.



C: "That's a rubbing isn't it. Down on the pavement wasn't it? On the Castle Green where the Great Hall was."

Figure 7: Above left: making a rubbing of John. Below: C points with a clue, "that's a rubbing" as L uncovers the original engraving (top right) with her torch

Here C points to the emerging image of John (figure 7). Her comments to the girls describe a range of hints to the historical event. Firstly, she provides an activity connection, "that's a rubbing" to remind the girls of their initial use of the relevant paper clue. Secondly, she notes the location of the activity, "down on the

pavement ... on the Castle Green". Finally, she describes what used to be located there in the time of Richard I: "where the Great Hall was".

Although the Sandpit and Storytent differ significantly in how they provide information, we see related activities in making event connections. The sandpit may also allow visitors to 'get their bearings'. In this example, C provides enough information for L and J to understand the elements of the historical circumstances.

Parents occasionally climb into the Storytent when in small family groups. However, some favor staying outside to allow their children to experience the display. This option may prevent parents from getting very involved and animating the historical event, often leaving the children to discover connections for themselves, supported by the UV writing (see Stanton et al. 2003). This example shows that, in contrast, the sandpit can be more open (in terms of both space for visitors, and the images shown), and therefore can provide parents such as C the opportunity to describe, reiterate and animate history through event connections.

However, there is less visible evidence that visitors were able to put together the 'bigger picture', i.e., to construct an overall narrative connecting events, locations and times of historical significance at the Castle. It was difficult to elicit this from casual visitors during the exhibition, for various reasons (e.g., them only completing one or two clues due to pressure of time, and dropping in and out at various points). It may be that by deliberately designing the clues to be 'standalone' so as to support a variety of visiting experiences, we ended up downplaying the relationships *between* events associated with different paper clues.

There were however, two opportunities to focus on this issue in more detail. One came from two formative evaluation sessions in which groups of children from a nearby school (not local and therefore unfamiliar with the Castle) participated in a school field trip prior to the public opening. These children (about 10 in each session) were given the clues in pairs, in random order. Once they returned to the gatehouse, they were asked to sequence the clues. They all achieved this successfully. They were then prompted, during their interaction with the Storytent, to explain what was going on in relation to the scenes they witnessed there. Given scaffolding from one of the project team, nearly all of the children managed to identify the 3D scenes with the actual locations visited, as well as their historical significance.

A second opportunity to evaluate this aspect of the exhibition came from monitoring 11 children who took part in the public experience (3 pairs and 2 groups of three, aged between 4 and 14 years). These children completed all of the clues. All bar one of the pairs (who were the youngest children) were able, with very little prompting, to construct accurate narratives linking the paper clues with the scenes they encountered using the Storytent. It seems that with some additional scaffolding, visitors are able to assemble an overall experience spanning multiple activities, clues and displays. We return to this issue below.

Display Connections

Display connections are those directly made between different displays in the exhibit. As noted above, we had aligned the Storytent so that the side showing the 2D images faced the Sandpit (that displayed some of the same images drawn from the shared database). We observed a few examples of visitors spotting connections between the images on the two displays. For example, when J first starts to use the Sandpit, she uncovers an image that had appeared on the ‘public’ side of the Storytent earlier while the group was waiting its turn. She states to L “that one’s on there”, making an (asynchronous) connection between the displays.

For the same image to appear on the Storytent and the Sandpit *at the same time* requires what seems like a fairly unlikely set of conditions to occur (the clue on the sandbox relates to the clue on the turntable; and the correct image is then uncovered at the Sandpit). Nonetheless, we have seen examples of visitors making immediate connections between the two displays. For example, J uncovers an image of Edward III’s coat-of-arms at the same time as it is showing on the side of the tent. C (figure 8, rightmost in circle) turns to the tent, notices the coat-of-arms on display, and points to show J (figure 8, leftmost in circle).



C: "That's the same as on there look"

Figure 8: C points “that’s the same as on there look”

In the example above, the visual association indicates that the group using the Storytent and the group using the Sandpit are both using clues for, and finding out about, Edward III. The connection made by C therefore presents at least the possibility to the girls that there is a deeper connection discoverable between the displays and possibly even between the groups of visitors. As a further note, display connections are almost always made while at the Sandpit as the tent is a more intimate and immersive environment that usually shields visitors aurally and visually from the majority of occurrences ‘outside’.

Summary: Assembling the Bigger Picture

In summary, our analysis suggests that some features of the history hunt do support visitors in making connections between activities, displays, and historical events:

- the initial activity of making drawings and rubbings seems highly significant. Not only might it aid recall, but it enables visitors to invest in the experience before they reach the interactive displays.
- the use of the paper clues to directly trigger information on the displays may serve to emphasise connections. The displays further reinforce these by revealing more information on the paper clues (the Storytent) or showing other visitors' clues (the Sandpit).
- physical proximity combined with content drawn from a common database may help establish a sense that individual displays are part of a larger whole.

However, while making such connections may well be part of the overall work of assembling a coherent experience, our analysis suggests that more work needs to be done before visitors (certainly casual ones) are easily able to assemble the 'big picture', a sense of the clues connecting to an instructive episode of past history.

Discussion

In this paper we have described the assembly of technologies which we designed for an interactive exhibition at Nottingham Castle. In particular, we have highlighted how multiple displays and devices can be integrated into a coherent experience by the use of a simple familiar portable artefact – paper. This artefact not only enables related information to be retrieved and viewed in contrasting ways on different devices, it also allows that information to be related to the exploration of the site visitors had previously engaged with. In this sense, paper 'glues' together the technically mediated and 'on foot' parts of the visitors' experience as a series of historical events are revealed. Let us bring out explicitly a number of features of our analysis which may have further implications for the design of visitor experiences and more generally for the coherent integration of multiple public displays in cooperative settings.

Flexibility of Activity Organisation

Informed by relevant social scientific studies of visitors to interactive exhibits (e.g. vom Lehn et al. 2001, Heath et al. 2002, Hindmarsh et al. 2002), we set out to design an experience which could be engaged with in a variety of ways. We wished to support both single visitors and groups of varying sizes. We wished to accommodate visitors with varying amounts of time at their disposal. Also, we wished to provide something that would be engaging for inter-generational groups and which also might stimulate serious scholarly visitors. To accomplish this, we decided to organise the overall activity in an 'atomic' fashion. That is, one searched for clues which could vary in number depending upon one's available time or patience. A pack of clues could be dealt with more or less completely and in any order. It was not essential for one clue to be understood in sequence with any other. However, if multiple clues were investigated, a combined picture of historical events might (in principle) emerge in the understanding of the visitors. That is, the item-by-item, atomic nature of clues did not rule out people, in their understandings, combining the clues into some overall sense of the historical

period. Indeed, we hoped the possibility that an understanding might emerge from particulars was further reinforced by the clue metaphor.

This approach could be contrasted with one where a narrative or some similar overall organisation is given to the experience such that one element needs to be encountered for subsequent ones to make sense. Although so-called ‘non-linear’ highly branching narratives can be devised which are flexible in their order of composition, we opted for the even more loosely structured approach of ‘clues’ to maximise flexibility in the face of the practical exigencies of working on-site under unpredictable conditions. Our experience of participatory events suggests that an approach with flexible technical structuring while allowing latitude for participants to themselves make, suggest or guess at connections has a lot to commend it.

However, it must be admitted, as discussed above, we did not note people spontaneously connecting together the clues to construct a historical narrative for themselves particularly frequently. This does not mean that we are forced to give up our flexible approach in favour of a more fixed narrative structure for activities. A possibility to examine in future work might be, for example, to identify a role for a human helper in engendering a historical narrative sense from given fragments (compare with the role that actors and invisible ‘stage hands’ had in the on-line participatory narrative described by Drozd et al. 2001). Alternatively, the clues or displays themselves might provide greater scaffolding by, for example, directly suggesting relationships to other clues or encouraging visitors to return outside to explore the site some more. However, this has to be balanced against meeting the needs of the short-term visitor.

Assembly as a Social Accomplishment, Technically Provided For

Our analyses of people interacting with the displays in the Castle Gatehouse have focussed on how people make various connections in their talk and gesture as they engage with the displays and devices we have set before them. Visitors make connections between the activities they have been engaged in while exploring the site, the historical events that occurred at those various locations, and invisible writing, images, sounds and 3D models which are presented at the Gatehouse. Through making these connections, participants assemble some sense of the history of the site and how they have hunted it down during their visit. Naturally, the depth and sophistication of this sense varies between visitors, in relation to their interests and whatever they have actually done during their visit. The point here is that in assembling such understandings participants are assembling relations between different displays, devices and the site itself. In this sense, ‘assembling’ is a practical social interactional accomplishment which is technologically provided for (cf. Hindmarsh et al. 2002).

Such sense-assembling *activities* are supported by an organised collection of technologies – an assembly in the *technical* meaning. We wished to combine displays and devices in a systematic fashion to enable visitors to create a coherent visiting experience for themselves. The manner in which we did this is, we

believe, instructive and worthy of investigation in other contexts. We provided a sense of a *unifying overall activity* with an underlying *common information space* explored using an *assembly of interactive displays* which manifest *common interaction techniques* and are integrated by means of a simple *portable artefact*. We do not wish this to be thought of as a universal recipe for getting technologies to interwork coherently in public settings regardless of the details of the application domain. Rather, it highlights five areas of design concern which would need to be addressed in realising a particular strategy for experience design – one where activities are flexibly structured and latitude is recognised for participants to develop their own sense of what is going on.

Paper

Our ‘portable artefact’ is none other than paper. We have exploited a number of features of paper in our work: its portability, shareability, familiarity, its ability to be a medium for drawing and so on. These features have been written about in the CSCW, HCI and allied literatures before. What is more novel with our approach is how we use paper artefacts to integrate a variety of devices and displays in a flexible fashion. By attaching tags, pieces of paper can be used to configure devices and retrieve information and, because a common information space has been used, this enables subtle relations between displays to be noticed and explored, at least in principle.

In a sense, we are rediscovering a well-known feature of paper but are drawing less common design conclusions from it. It is often noted that people make use of paper for swift and convenient note-taking while working with information displays (cf. Luff et al. 1992). Such written paper notes can then be consulted when a fresh screen-full of information appears rather than rely on memory, or be carried to other, physically distant displays to enable their contents to be compared. This enduring use of paper to support the juxtaposition of display contents is often taken as an indication of the requirements portable digital artefacts (PDAs, digital paper and such like) have to meet or the applications which are worth developing for them. Our current work has a different orientation (see also Mackay 2000). Rather than design advanced portable artefacts on the basis of what we know about how paper is used, we have used paper itself to support the coherent integration of assemblies of advanced technologies (cf. Grasso et al. 2000).

The portability of paper could be further exploited in encouraging reflection and assembly of a sense of the history of the Castle off-site after the visit. For example, a class back in school could use the clues to assemble the bigger historical picture as an interactive wall display for the classroom. Children back at home could create an interactive storybook so that they could recount their visit to family and friends. Such further assembly would require developing new interactive displays: walls and desks for the classrooms and interactive books and souvenirs for the home. Eventually these might also exploit the electronic tagging of the clues, although in the short term it would be easier and more cost effective for the clues to also contain manual links to the digital content (for example, URLs for accessing the 2D and 3D images from the museums website). In these

and other ways, we can think of deepening our exploitation of interactionally relevant features of paper in simultaneously supporting the interworking of technology and human sense-making activities.

CSCW and Designing for Museum Settings

Increasingly CSCW research is broadening its purview beyond work settings narrowly conceived to study cooperative activity in leisure, domestic and entertainment settings. Our work is consistent with this trajectory in its concern for a public setting where leisure-related and educational activities take place. However, we believe that investigation of such settings brings issues of general importance to CSCW into focus. How to combine a variety of information displays and interaction devices in an integrated fashion is a matter of general concern and not confined to museum settings. How to technically support activities coherently while flexibly allowing participants to manage local contingency has been a core CSCW issue at least since the early days of groupware and structured computer-mediated communication systems (cf. Bowers and Churcher 1988). Here, we are attempting to strike a balance between technical provision and giving participants resources with which they can assemble their own sense-making activities – a notion of what ‘computer support’ might mean in CSCW of more general applicability. We have worked with rich digital materials and physical interaction techniques in relation to a real historical site. As such our work furthers the concern in CSCW for ‘mixed reality’ research. However, we have been most conscious of the practical exigencies of bringing such technologies into the wild and, accordingly, developed a use of paper as a means for bridging mixed reality design with intelligible public experience. In all these respects, museums are far from being institutions frozen in the past but offer CSCW timely research opportunities of genuine technical, conceptual and practical value.

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