

Re-tracing the Past: Mixing Realities in Museum Settings

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ABSTRACT

Interactive exhibits are now commonplace in museum settings, providing 'edutainment' for visitors. However, many technologies co-exist uneasily with more traditional methods of display. In this paper we describe a design strategy for mixing realities in museum spaces. An approach is adopted for designing interactives which complement rather than replace conventional methods. Our approach is explored through an exhibition which provides visitors with the opportunity to hear and leave opinions on unclassified historical artefacts. An analysis of visitor interaction reveals that avoiding simulation of established methods can allow visitors to weave novel and traditional practices. These results indicate designs for mixing realities in broader settings.

Keywords

Museums, mixed realities, public-oriented design, opinion systems

1. INTRODUCTION

From various perspectives, it has become fashionable to present the hybridisation of the physical and the digital as a vision of future computing environments. 'Augmented reality', 'augmented virtuality' and 'mixed reality' are all attempts to capture these concerns and to articulate new opportunities for technological innovation. Demonstrations of the interplay of physical and digital have been offered in domains such as tele-medicine [12], education [14], entertainment [16] and the arts [1]. Spectacular though many of these designs are, it is important that longstanding questions of usability and usefulness continue to be articulated by researchers [cf. 2] even as we extend ourselves to design 'mixed reality experiences' alongside more traditional 'task-oriented' scenarios.

A number of researchers have begun to look at museum settings as a potentially relevant application domain for mixed reality entertainment while also attempting to deliver experiences to the public of genuine cultural worth [3, 5, 6, 7, 15]. The museum

setting seems to bring together a number of features which make it most appropriate for study. First, for some time, museums have embraced the use of interactive exhibits alongside more traditional methods of display of the physical objects which make up the museum's collection. Digital solutions have been offered to such well-known curatorial problems as how to make publicly available objects otherwise held in storage or how to bring alive what is known about the use or history of an object which the exhibition of the 'mute' object alone does not make possible. In turn, a number of equally well-known problems with 'interactives' have emerged. Museum staff express concerns that digital artefacts can detract from a visitor's imaginative appreciation of the actual physical objects [5, 9] in much the same way as extensive textual labelling is often held to do [13]. Further, multimedia museum presentations are most commonly built as single-user applications leading to concerns that engagement with them can sometimes disrupt the sociality of the museum visit [10]. Finally, digital solutions can be controversial if they seem to replace or 'de-skill' the role of museum helpers, interpreters or docents (as they are variously called). In all these respects, museums offer us a microcosm of fundamental issues in technology design and deployment, allowing us to address naturally what might otherwise seem abstract matters such as tradition and innovation, skill and automation, the digital and the physical, the social and the individual, and so on.

In this paper, we report on work which takes seriously the challenge of designing complementary interactive digital technologies, rather than detracting from a visitor's appreciation, both sensory and imaginative, of museum objects. Equally, we present a design which recognises a key role for the museum docent in enriching visitors' experience of museum objects while leading visitors through the interactive experience of them. Finally, we are explicitly concerned with protecting, supporting and extending the sociality of the museum visit. In short, we are concerned to explore *complementary* (rather than substitutive) technologies, which respect *local expertise*, while recognising and enhancing the intrinsically *social-interactive* nature of the museum visit. In all this, we hope to derive design strategies which might have use beyond our specific domain and into other applications of so-called augmented or mixed reality technologies.

1.1 Enhancing Appreciation, Enabling Imagination

Rather than diverting attention from a detailed understanding of the nature, use and history of museum artefacts, it is important to

enhance the visitor's appreciation of such matters. Jackson et al. [8] describe handling sessions which many museums conduct whereby visitors are allowed to touch and explore the physical nature of museum objects, thereby becoming immediately aware of such matters as an object's weight, materials and construction in a way that a simulation could at best only approximate. While such sessions can enhance visitor appreciation of objects which were handled by their original users, they also introduce the visitor to the art of handling which forms an essential part of the practical skills of a curator. Such studies convince us that the importance of appreciating the tactile or other sensory features of objects can provide a boundary condition on the applicability of digital technologies.

Of course, not all museum activities are artefact-centred in this sense. Schnädelbach et al. [14] describe the problem that museum staff at Nottingham Castle (UK) have with disappointed visitors who expect to see the mediaeval castle which figured greatly in English history and myth but was destroyed over 300 years ago – in a sense, the 'artefact' they have come to see is absent. Fraser et al. [6] designed an interactive experience in which visitor groups explored the castle grounds by following clues which linked parts of the site to key historical events. After this exploration phase, visitors could access information about the site through various interactive installations, including projected 3D models of the castle which reconstructed its appearance at the historical time and from the locations present in the clues. In this way, visitors were aided in making imaginative connections between their exploration of the site and its contemporary and past form and significance.

1.2 Assembling Sense and Opinion Making

Our current work seeks to build on [6] by encouraging the imaginative participation of visitors. It is commonly objected that traditional factually-oriented museum displays often inhibit visitors developing their own opinions about museum objects. Indeed, in some cultural criticism, such observations form part of an 'ideology critique' of museums as authoritative institutions which, perhaps unwittingly, inhibit open debate about the significance of the collection, the meaning of the past, the nature of cultural difference and so forth. Though forceful in some cases, this line of argument should not lead us to ignore the palpable differences which can exist between experts or the fact that much of what visitors actually do in museum settings involves actively formulating understandings of artefacts and negotiating, sometimes debating, their opinions with co-visitors. In the terms of [6] and [8], people are 'assembling a sense' of their visit thoughtfully combining information from different sources while artfully interacting with a range of artefacts.

Nevertheless, there is considerable scope for focusing exhibition design precisely on objects whose nature is controversial or mystifying and presenting information about them in an open-ended way. Opinion formation and comparison become topicalised for the visitor who might then further deliberate upon how expert opinion gets formulated and settled (when it is). Interactive digital technologies might have a role in this as traditional devices such labels and text are commonly used specifically for the dissemination of factual affairs. As McManus [11] observes, many museums exhibit disputed

objects without assistive information, rather than weaken the 'factual voice' that labels and text typically have.

1.3 The Sociality of the Visit

There exists a growing body of empirical social scientific research documenting the social-interactive nature of museum visits [10]. Visits are commonly made by small groups of friends or family members. Museum objects are commonly appreciated in and through the interaction of co-group members as they draw each other's attention to features of interest. Visitors also commonly maintain an awareness of what other groups are doing, perhaps observing from afar how others deal with an exhibit before directly engaging with it. While it is often acknowledged that interactive exhibits designed for a single user will awkwardly fit into this texture of social interaction, design work is only just beginning in HCI which is noticeably sensitive to the sociality of the visit. [6] expressly proposed their 'history hunt' as an activity for a small group while their displays allow interaction to be shared. [3] describes a system where an on-line shared virtual environment depicting a real-world exhibition space is proposed to support interaction between museum and on-line 'visitors'.

Our work builds on these efforts in two significant respects. First, we recognise a substantive role for museum docents (interpreters) in the activities we are designing digital resources for. [6] argues that visitors did not seem to spontaneously combine the various clues they had been given to create an overall sense of a given historical period – additional 'scaffolding' often being needed to help visitors assemble 'the big picture'. While [6] explored deployments of sophisticated mixed reality technologies, this scaffolding role is redolent of traditional docent responsibilities. Second, while [4] is concerned to encourage interaction between real and virtual visitors, it principally does so 'synchronously' by enabling just those real visitors that happen to be at the museum to communicate with those virtual visitors that happen to be on-line at the same time. Essential to our design is that visitors can add to an archive of opinion which they can also access in engaging ways. Combining opinions left over time with traditional physical and expert explorations might enhance appreciation of artefacts, whilst simultaneously providing museums with opportunities to engage the public in background research.

Overall, then, we intend to show that the traditional richness of handling and exploring physical objects can be appropriately coupled with the digital display of information to allow the visitor, in interaction with co-visitors and local experts, to formulate a valid opinion on an object whose nature is not known. We intend that the visitor's appreciation of museum objects and the professional work of understanding them will be deepened. To do this, we need to bring about a subtle balance between physical and digital in resourcing social interaction whose success should be informative of mixed reality applications.

2. RE-TRACING THE PAST

'Re-tracing the Past' was created in the <anon> Museum in <anon> and ran for ten days. This museum is based on a private collector's house, and therefore consists of an eclectic selection of artefacts acquired over his lifetime. This has led to employing classification systems which may be at odds with historical

themes. For example, instead of displaying artefacts according to their period or design relationships, they may be assembled according to their previous proximity within the collector's house.

Given this variety of classifications, we worked with the museum curators and docents to design an exhibition that supported exploration of the issues related to the interpretation of the museum objects. Specifically, we wanted to support reflection on the many artefacts in the <anon> Collection that have been mis-classified or with on-going debates as to their identity or intended use. Visitors were challenged to further propose their own interpretation of one or more mysterious objects through interaction with different exhibits. Each element of the exhibition revealed particular evidence about the object that contributed to the visitor's own interpretation. These objects are shown in Fig. 1.

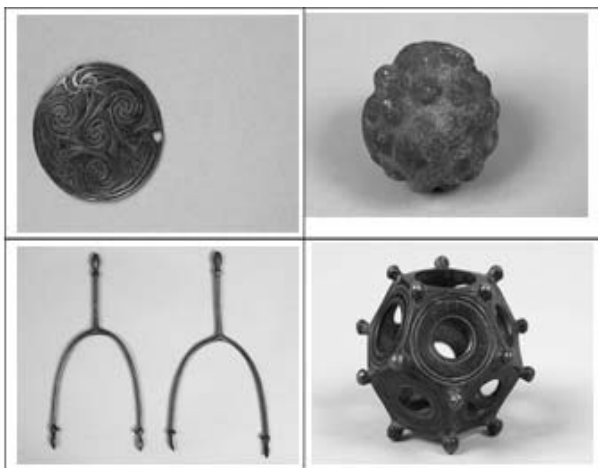


Fig. 1. The four objects featuring in 'Re-tracing the Past'. Clockwise from top left: Oxford Disc, Carved Stone Ball, Dodecahedron and Y-shaped Objects

A gallery on the lower ground floor of the museum was reconfigured into two connected spaces for the exhibition (fig. 2). The first space, the *Study Room*, enabled visitors to explore the backgrounds of the mysterious objects by revealing several kinds of evidence that can be used to interpret them. The second space, the *Room of Opinion*, contained accurate physical reproductions of the objects, and allowed visitors to record an opinion on the objects' possible use, contributing new ideas for future visitors.

We maintained some free space between the real walls of the Gallery and the wooden partitions that enclosed the Study Room and the Room of Opinion (gray shaded area in fig. 2). The partition frames were lined with cardboard, creating fake walls. These were then wallpapered in the Study Room and covered with black felt hangings in the Room of Opinion, in order to hide away visually unattractive pieces of equipment such as cables, batteries, CPU boxes, etc. This approach also allowed researchers to control and troubleshoot the installations scattered around the gallery space from 'behind the scenes' without interfering with the visitors experience.

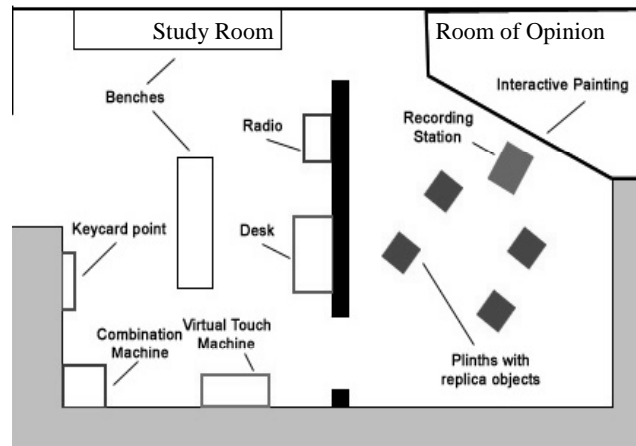


Fig. 2. Ground plan of 'Re-tracing the Past'

2.1 The Study Room

Groups were met at the entrance by a guide, who was to monitor and support the visit, assist in exploration or offer expertise if required at any point. Visitors could choose one or more objects to investigate. Each mysterious object had a corresponding *keycard*. The keycard was a small colour-printed laminated card showing the picture and the original museum label for the object (fig. 3). Each keycard also contained a Radio Frequency Identification (RFID) tag. The embedded tag allowed visitors to control each exhibit, primarily to activate or de-activate each installation and to explore the associated information.

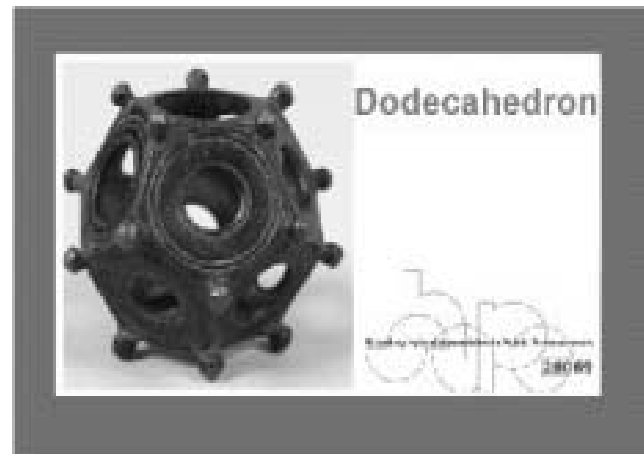


Fig. 3. A laminated keycard for the Dodecahedron object

There were four exhibits contained within the Study Room. Each was designed to provide information that visitors could progressively discover, without having to follow a prescribed sequence of actions. In the following sections we describe each exhibit in concentrating most closely on the exhibits which are used within the examples provided in our subsequent evaluation. First, we outline the *Combination Machine* and the *Virtual Touch Machine*. We then describe in detail the *Interactive Desk* and the *Radio*.

2.1.1 Combination Machine

The Combination Machine allowed visitors to discover some information related to how an object was discovered. An antique trunk contained a square framed piece of one-way mirror covering a flat screen monitor. An RFID aerial was concealed under the trunk. When a visitor placed a keycard on a labeled hotspot in the trunk, a Flash animation piece would convey information (e.g. the object was found at a religious burial site, such objects were usually found in pairs). If two cards were placed into the trunk together, some fictional connections between objects were suggested, to prime visitors' imagination and encourage creativity when recording their own opinions later in the visit.



Fig. 4. The Combination Machine with detail (inset)

2.1.2 Virtual Touch Machine

The Virtual Touch machine allowed exploration of the material qualities of the objects. A wall display (a framed back-projected screen) showed 3D textured models of the four objects. On an adjacent table was a black rectangular box with a depression in the middle to indicate where the visitor's keycard should be placed, concealing another RFID aerial. Visitors could rotate and tap against the models of the objects using a 'magic wand'. This device contained two accelerometers, which allowed the system to determine the orientation of the wand and to map this to the orientation of the model on screen. The visitor could therefore explore the shape and texture of the model. The wand also contained a Polhemus Fastrak magnetic position sensor, which allowed tracking of the velocity of the device. This velocity was combined with the object's material properties to generate the sound which would be made if the real object was tapped with a hammer.



Fig. 5. The Virtual Touch Machine in the Study Room

Interactive Desk

The Interactive Desk enabled visitors to trace the provenance of objects over the course of their journey to the museum. A physical map of Europe was placed on the desk with various places highlighted. Placing a keycard on these locations displayed information related to the objects' geographical origin and travels through Europe. A display on the desk consisted of an open book with blank white pages, with a projector concealed on a shelf located about 1m above the desk inside a cardboard box.



Fig. 6. Interactive desk in the Study Room with detail (inset)

An RFID aerial was placed in the drawer just under the desktop to detect the identity of keycards placed on the map. To detect the location of the card on the map, video was obtained from a web-cam hidden in the desk lamp, and image-processing software identified the rectangular contours of the keycard in the video stream. The co-ordinates of each rectangular contour were then compared to hotspot co-ordinates to see if a keycard had been placed on a map location with information about the related object. When a keycard was associated with a certain hotspot, a graphic and text would be projected onto the open book on the table. This would allow visitors to trace the journey of the object from place of discovery to the museum. The

Interactive Desk enabled visitors to trace the journey of objects to the museum over time. A physical map of Europe was placed on the desk with various places highlighted. A display on the desk consisted of an open book with blank white pages, with a projector concealed on a shelf located about 1m above the desk inside a cardboard box.

2.1.3 The Radio

The final exhibit in the Study Room was the Radio. This installation allowed visitors to listen to previously recorded opinions on the mysterious objects. Visitors, curators and docents left opinions, including theories of use and stories about the objects. Visitors could 'tune in' to channels that were available for each object and, within each, browse the collection of recordings made about that artefact.

This installation was designed to help visitors shape their own opinions by contrasting their emerging ideas with those left by others, and appreciating that their own story would eventually become part of the exhibition itself. Listening to other people's stories should also motivate them and reinforce their involvement in the activity prior to their visit to the Room of Opinion.

Behind the front panel of the frame of an authentic 1940s radio was a flat screen. The panel had four strips representing each object. A strip was selected using a labeled dial on the radio, and highlighted in white, while inactive strips were black. Each strip had slim vertical red lines randomly spread across it, where each line represented an audio file containing a recorded opinion. A second dial on the radio allowed users to move their 'station selector' (a blue vertical line) across the highlighted strip. Once the station selector was over a red vertical line, the corresponding opinion was played over speakers that were also incorporated into the body of the radio. When new opinions were recorded in the Room of Opinion, they were automatically copied from the recording station across to the Radio, and updated on the display as a new line.



Fig. 7. The Radio

2.2 The Room of Opinion

Based on their explorations within the Study Room, visitors could then express their own opinions of the objects. Visitors were given a chance to examine exact physical replicas of the objects (the originals were too delicate and valuable to allow handling) before recording their opinion and leaving their own mark on the exhibition. The room contained a murmuring sound which moved through the room and drew on visitors' recorded opinions.

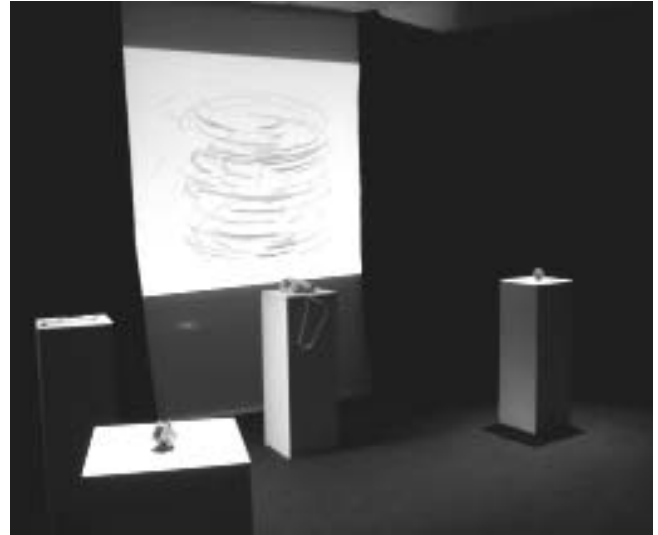


Fig. 8. Room of Opinion with plinths and Interactive Painting

2.2.1 Replica objects

The visitors were able to physically handle an accurate replica of the object they had been researching before recording their story. They could also see other objects and perhaps consider repeating the experience with another.

2.2.2 Recording Station

The visitors could record their opinion by dropping their keycard in a slot speaking into a phone. The recording subsequently became part of the collection of opinions available on the Radio in the Study Room. A new element was also added to the Interactive Painting (see below). Recording an opinion made the murmuring sound in the room increase in volume and travel across the room, while fragments of the audio smoothly 'settled' into the murmur to become part of the 'pool' of opinion. At the end of each day, a museum expert edits out 'noise' comments from behind the scenes, such as swearing and repetition.

2.2.3 Interactive Painting

A visualisation was back-projected into the room that represented the collection of visitors' opinions. After recording a story, a visitor could see a graphical brush stroke become part of the painting, contributing to the swirling pool of opinions. The painting was designed to make visitors aware that their contribution had a role in shaping the exhibition and it was now part of the collection.

3. ANALYSIS

Four video cameras and five microphones were concealed across the space during a week of the final exhibition, recording interaction at the various installations within both rooms. The video streams were mixed down using a picture-in-picture device to synchronize views, and the audio streams were routed through a mixing desk.

In the following excerpts taken from this data, we provide illustrative examples of interaction around the exhibition. Throughout, we focus on how existing museum approaches (such as the use of physical artefacts and experts) were understood by visitors in relation to the digital systems (such as the Study Room installations and opinion recording). We focus on four key forms of relationship between digital and physical interaction: engendering opinions with physical artefacts; assembling the sense of objects across the exhibition; interacting with co-visitors; and drawing on experts. For each, we illustrate how digital possibilities co-exist with physical museum activities.

3.1 Experiencing artefacts

Exact replicas of the objects were provided on plinths in the Room of Opinion to support hands-on encounters with artefacts. We hoped that engaging with these objects would provide an opportunity to experience the rich detail and texture that traditionally museums have favoured through object handling sessions. In the following excerpt, a man (M) and woman (W) are standing in the Room of Opinion near the plinth with the Dodecahedron replica atop.

Excerpt 1¹

W: **what do you think it is?** ((picks up Dodecahedron))
M: **could be like for** ((takes replica from W)) **determining how far away something is** ((holds up to eye to demonstrate)) **like (2.0) look through the holes where it fits** ((rotates deliberately and returns to W who also holds up to eye))
... ((M & W investigate other replicas))
M: ((places Dodecahedron keycard in recording station and lifts phone receiver)) **I think its used for determining how far away something is whether it's a star or a- an object** ((replaces receiver))

This excerpt shows the way in which interaction between visitors using the physical object can inspire the characterisation of opinions for others. In this case, M uses the physical artefact to *embody* the possible use of the object as a distance-measuring device. W is able to draw on M's demonstration by mimicking him, using the physical artefact to investigate on his perspective. M also later duplicates his own description, drawing on his use of language in the earlier physical enactment to provide his opinion for others to hear. M's portrayal provides both W and future visitors with a resulting opinion. Not only do visitors manipulate artefacts to characterise a projected use, they also pick up, rotate, feel, check the weight of, and rub artefacts. The

hands-on nature of the physical artefact provides for re-exploration and opinion formation.

3.2 Assembling insight

Given the richness of embodied performance provided by using physical artefacts, it is important that background information encountered in the Study Room is applied in the context of experiencing objects. We do not simply wish to engender fascination with physical artefacts, but also to have them used as an opportunity to reflect on previously encountered information. In the following excerpt, a man (M) and a woman (W) been visiting the rest of the museum and traversed through the Study Room using their Dodecahedron keycard to explore the installations. They arrive at the Dodecahedron plinth.

Excerpt 2

M: ((picks up Dodecahedron and shows it to W)) **these ones these really exist they're they're upstairs**
W: **what do you think?**
M: ((pauses as rotates Dodecahedron in hand)) **well, if it was modern I'd say it was for (0.3) sizing screws (0.4) bolts** ((rotates and taps replica at different holes)) (1.4) **hmm**
W: **yeh (0.3) its just cos the Romans were so into water that I'm starting to wonder whether you know its (0.2) whether that's got anything to do wivit**
M: **so it was exclusive to Rome was it?**
W: **yeh (0.3) well- wherever they'd been**
M: **Roman Britain**
W: ((nods)) **Roman**
M: **Roman**
W: **and they did roads**



Fig. 9. "If it was modern I'd say it was for sizing screws"

As with the previous excerpt, the replica is used to embody the use of the object, in this case a tapping motion at each hole indicates the presentation of screws or bolts. However, M and W also draw on their experiences thus far to form opinions of the object's use. M says he has seen real versions of the Dodecahedron in the museum already. A conversation then

¹ Numbers in brackets show approximate pauses in seconds. Double brackets indicate comments by transcriber. Bold text indicates conversation.

ensues on its possible uses, as M continually rotates the replica in his hand. W introduces information discovered at the Interactive Desk, noting that the object was originally Roman (or at least, discovered in a archaeological dig relating to Roman Britain). Encounters with both the original Dodecahedron in the museum and information obtained from the Interactive Desk are woven to produce an account of the object's possible use.

This excerpt shows that substantial interplay is possible between traditional object handling and digital information provided across the previous installations. These visitors are able to appreciate the replica whilst using it as a vehicle for forming *informed* opinions. The very turning, weighing, handling and tapping actions performed with the object by M bring alive background information from the Interactive Desk. Building on the use of the keycard to create a theme across the installations, the physical artefacts provide an *opportunity for assembly*. In other words, the coherence of the visit is maintained in the experience of the object.

3.3 Visiting together

As the previous two excerpts have shown, visitors may draw on the physical artefacts to assemble rich and informed opinions. Both excerpts also have a third key feature in common - they involve the *collaborative creation* of opinion. Co-visiting is of key importance to groups of who animate opinions for one another. Excerpt 3 shows two women in the Room of Opinion. P is leaving an opinion on the Dodecahedron at the recording station.

Excerpt 3

P: ((picks up phone)) **I think the Dodecahedron is (0.2) a clock** ((replaces receiver, noises from interactive painting, both stare at it))
 J: (2.2) **oh look there you are** ((points, both laugh))
 P: ((inaudible))
 J: **Wait to hear yourself (1.2) there you go** ((points at screen again))
 P: ((points to interactive painting but looks at J as though listening)) **Yeh that's me!**



Fig. 10. J: "Oh look there you are"

After leaving her opinion, P joins J to watch her opinion enter the collection. Firstly, J notices a new graphic representing the

opinion entering the Interactive Painting and draws P's attention to it. Secondly, the sound of P's opinion is played back within the room, slowly settling it back into the mix of auditory opinions. J is aware of this procedure, having already left an opinion, and again draws P's attention to it. The co-visitors animate the appearance of embedding opinions, such that the outcome is shared.

At the Radio installation, visitors may hear their own, their co-visitors', or strangers' opinions. The Radio displays contributions left over time such that co-visiting need not be a direct experience but rather can be supported by mutual contribution. For example, in this excerpt a son his mother are listening to opinions on the Oxford Disc. They come across an opinion recently left by the father who is still next door within the Room of Opinion.

Excerpt 4

W: **Oh its dad**
 ((Radio playing audio recording)): **"I think the Oxford Disc is a pendant used for a necklace it has a hole in the top..."**
 M: ((pointing at radio and looking at W)) **That's what everyone says! (1.2)** ((M hits his own leg with his fist 3 times))



Fig 11. M: "That's what everyone says"

M's feigned anger can be seen as frustration with the repetitive nature of the many opinions on the disc as a necklace pendant. However, not only does the Radio allow M to reach this conclusion, it also illustrates a key point - visitors like to collaboratively form new and unique ideas about the objects. The fact that M's dad has not contributed something unique to the exhibition is notable in his reaction. This shows the challenge involved in collaboratively participating in the exhibition - it is not simply enough to be happy with one's own opinion, but there is also a responsibility involved. Drawing on the background research and the physical experience of the artefact should give new exciting opinions for co-visitors.

3.4 Acquiring expertise

Finally we discuss how museum staff and guides are able to participate in the formation of rich and collaborative opinions as a novel opportunity to fulfill their traditional role. Docents are frequently asked for and offer their opinions on objects within the museum. Indeed, we found that many of the docents at the museum left their own opinions in the exhibition for visitors to hear. Nonetheless, we wanted to see if the traditional work of the guide was treated differently in the presence of the exhibition, and in what ways it was perceived as an opportunity to explore opinions, both expert and novice. In the following excerpt, a guide (D) is engaged by two visitors, a man (M) and a woman (W) in the Room of Opinion.

Excerpt 5

W: So what have other people said that they think that is?

D: lots of different things, you'll you'll see- hear that now in a minute on the radio, errm (0.8) they think its used as a weapon ((picks up replica, starts rotating it in hands)) they think it could be used as a measuring device (0.5) cos all th- the holes are different sizes

W&M: mmm

D: they think it could be used something to do with the sea

M: mmhm

D: umm lots of different things really (0.4) nobody real- actually knows which is the beauty of the whole thing (1.2) so would you like to leave your opinion on th-

M: I don't really have an opinion on it ((inaudible)) you thought it was a game didn't you

W: yeh ... ((continues to discuss game idea))

In this excerpt, D takes the opportunity to animate the replica Dodecahedron for the two visitors, for example by discussing features of the holes it contains. We also see the docent and visitors treating the encounter as an opportunity to discuss the opinions of other visitors that have passed through. However, all three treat the discussion as concerned with opinions left in the system rather than expert opinions that D might offer. So, for example, D initially recurses to W and M's future encounter with the Radio as being the primary source of the answers to their questions. Nonetheless, D is able to pick up and animate the replica for M and W and suggest along the way what (and occasionally why) other opinions have been formed.

4. CONCLUSIONS

We have presented *Re-tracing the Past* – an exhibition specifically designed to explore ways in which appreciation of museum objects can be enhanced through a mix of information gleaned from interactive artefacts and encounters with replica objects. We particularly focused on mysterious museum objects whose nature is a matter of dispute so as to enable visitors to add to the accumulation of opinion about them. Throughout we recognised a role for the museum docent (interpreter) in stimulating visitors' opinion formation, offering answers to further queries, and as a guide to the use of the interactive artefacts. We have presented analyses of interaction between participants to help us understand what people made of our design work. In summary terms, our analysis suggest that:

- retaining physical objects within the mixed environment allows hands-on appreciation which helps visitors to assemble and formulate their own opinions
- digital components can effectively deliver information which enriches subsequent hands-on exploration
- visitor opinions are an integral part of the experience, with opinions formed collaboratively with co-visitors.
- museum personnel are supported in their discussions and presentations of objects with a rich set of background information and visitor opinion.

Let us now bring out some discussion points of more general significance from our work.

4.1 Separation and Coherence

It is important to note that we separated people's encounters with real, albeit replica, objects (in the Room of Opinion) from their background information gathering supported by the interactive digital artefacts (in the Study Room). This separation in space and time helped ensure that appropriate attention was given to the real objects when they were encountered. The abstract animated painting and the murmuring sounds in the Room of Opinion accompanied but did not disrupt handling the objects. In this setting, it seems likely that methods of augmenting the real objects (e.g. with projected overlays) would have deterred handling and detracted from direct engagement. Separating technically mediated from physical encounters with objects can sometimes promote requisite attention to both.

However, in principle, this separation of components to the exhibit could problematise the overall coherence of visitor experience. To ameliorate this, we provided our visitors with what [6] call 'an integrative portable artefact' – in the current case the RFID tagged card. This configured the different interactive artefacts to give information about the mystery object that the visitor was currently exploring while ensuring that the final recorded opinion was appropriately classified. It is also important to emphasise how visitors' encounters with the real objects served to retrospectively integrate the experience. Seeing and handling the real object provoked visitors to recall what they had picked up earlier and incorporate it in their discussions and recorded opinions. In this way, the tagged card and the encounter with the object itself complement each other in creating a coherent experience.

4.2 Practically Mixing Realities

Re-tracing the Past mixed physical objects and interactive digital displays in a number of ways. The screens of the Combination Machine are hidden within a trunk. Computers dedicated to sound recording and processing are hidden behind a telephone and the fascia of a 1940s radio. In each of these cases, an interactive digital artefact is 're-housed' to more strongly suggest how its should be interacted with and/or to mesh with the overall aesthetic of the exhibition. Other mixes of the physical and the digital are more suggestive still – for example the manipulations of keycard over map and the appearance of projected writing on the book at the Interactive Desk. However, these different ways of designing a mix of familiar everyday physical objects and digital interaction are only half of the story, as it is people in their understandings of the exhibition who have to connect up its different parts no matter how they are rendered. Visitors need to combine information from different sources and use this to inform their handling of the real objects and their opinion formation. The docents need to be sensitive to how visitors are doing this while they variously help visitors around the exhibition. There is a significant sense in which people in their understandings of the exhibition and the objects within it are 'mixing realities' – combining heterogeneous sources of information and experience as they go. No mixing of technical components, no matter how ingenious, will suffice if understandings are not possible to come by. On this view, design becomes a matter of supporting people as they practically accomplish mixed reality [cf. 3].

4.3 Tradition and Innovation

Re-Tracing the Past and the orientation to design for museums discussed in the introduction to this paper involves a mix of technical innovation with a respect for traditional museum practices. We do not seek to disrupt visitors' experience of objects, rather we have sought to embed object inspection and handling amongst their encounters with interactive exhibits. We do not seek to automate the local expertise of museum personnel out of the picture, rather we wish to support them in presenting objects to the public which are otherwise hard to speak of due to their unsettled nature. The aesthetic of the exhibition also reflects our concern to give weight to both traditional and contemporary design sensibilities (e.g. the Study Room decorated and furnished in an 18th century style versus the more abstract lines of the Room of Opinion).

In all these respects, our strategy has been to balance tradition and innovation through varied deployments of physical and interactive digital components, allowing them to merge in interaction between participants. This has involved an approach to computation which emphasises providing participants with rich informational resources rather than automating features of existing practice. While embedding mixed reality technologies into public spaces like museums, key considerations for designers must include the broader implications of innovation for existing practices. For us, this seems especially important as a counterbalance to the visionary agendas for the future of computing which are commonly articulated nowadays. Alan Kay famously urged us to predict the future by inventing it. To do this, perhaps, we also need to re-trace the past.

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