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Innovative Exhibit Interpretation Using Mobile Applications

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INNOVATIVE EXHIBIT INTERPRETATION USING MOBILE APPLICATIONS

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Abstract

London's Science Museum sought innovative ways to interpret important artifacts, such as James Watt's workshop, which contains many objects far removed in time and experience from modern visitors. To assess the suitability of new interpretive tools, this project surveyed a wide range of potential technologies, and then carefully assessed in two stages a prototype iPod Touch Multimedia Guide. The result is a promising new interpretative tool that allows visitors to explore a wide range of objects within multiple interpretative dimensions.

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Executive Summary

Most museums today recognize that visitors' experiences are defined as much by how the objects are conveyed as by the objects themselves. In preparation for the reopening of James Watt's Workshop, the London's Science Museum sought innovative ways to interpret important artifacts, such as those found in the workshop, which are far removed in time and familiarity from modern visitors. To assess the suitability of new interpretive tools, this project surveyed a wide range of potential technologies, and then carefully assessed an iPod Touch Multimedia Guide. The result is a promising new interpretative tool that allows visitors to explore a wide range of objects within multiple interpretative dimensions.

After assessing a wide range of fixed and mobile, established and cutting-edge technologies, the project team identified the iPod Touch as the best candidate technology to test. A set of criteria was created for the list of technologies to be evaluated against. This was done so that the Science Museum would be informed about the technologies that the project team felt had done better in the evaluation and could weigh in specific Science Museum needs in order to make a final decision on the technology to prototype. The tests themselves were conducted in the Making the Modern World gallery because the James Watt's Workshop was not open to the public. A review of a prior summative evaluation of the Making the Modern World gallery showed that this gallery embodied enough of the defining qualities of Watt's Workshop to be a suitable substitute.

The project team developed and evaluated two prototypes of the iPod Touch Guide, using the findings from the first prototype to develop the second. The first prototype was a laptop-based PowerPoint presentation which emulated some of the interactive features of an iPod Touch. Visitors liked the ability to choose specific content that interested them:

> *"[The guide] takes you through… easy to use, and skips through to the parts you're interested in…."* – Male, age 15, part of a family group

The non-linear aspect of the iPod Touch guide gave users the ability to learn and explore the gallery at their own pace. Visitors also appreciated that the guide featured particular items instead of providing the full range of objects to the visitor:

> *"[The] case is so full of stuff, to have something to draw attention to just one object makes it easier to look at*" – Female, age 23, independent adult group

The iPod Touch Guide was designed to create a personal and lasting connection with a few objects rather than covering a wide variety of artifacts. The results from the first prototype demonstrated clearly the tremendous promise of the iPod Touch to offer a non-linear narrative and to feature selected content. The evaluation of the first prototype also suggested improvement in the design of the user interface.

The second prototype was implemented on the actual iPod Touch device. The project team created a series of iPod Touch optimized web pages. Since the second prototype was on the iPod itself, the project team was able to test mobility, interaction with the device (rather than a mock-up), and the social interaction potential of the iPod device. Figure 1 presents an example screen from the prototype, which shows an interactive panoramic image of the display case to allow visitors to locate objects. Another major feature of the second prototype was video content. Figure 2 shows an image from one of the videos in which a museum staff member explains objects in the display case.

Figure 1: Interactive panoramic image of case

Figure 2: Video of staff member explaining case

Interestingly, we found that the second prototype encouraged greater social interaction, especially among those couples who chose to share earphones. Such couples shared the screen and many of them discussed the objects that they viewed together. This indicates the visitors' desire to share the experience of the guide. All visitors also found the guide to be best suited for them, regardless of age. In a family group that consisted of a 14 year-old boy and his father, the boy answered that, *"[The iPod guide would be suited for] kids with iPods, maybe 13 or 14, around my age."* His father quickly jumped in indignantly, *"…and all the way up to my age, around 50."* The iPod guide was able to successfully cater to the Science Museum's target audience. The project team found that the usage time of the iPod guide was an average of 25 minutes. This is more than three times the average dwell time in this gallery (seven minutes) when visitors do not have the iPod guide. Visitors were drawn into the content and were genuinely committed to learn about the objects. When playing videos from the iPod

Touch, all visitors would take the time and effort to find the objects shown or mentioned in the videos in the actual gallery. A couple in their mid-thirties thought that the videos *"bring the objects to life."* The iPod guide acted as a supplementary tool for experiencing the objects rather than a replacement for the objects.

Based on the findings from both prototype iterations, the project team compiled conclusions and recommendations to the Science Museum. The recommendations included remedies for technical issues, content reorganization, way-finding improvements, and suggestions to improve and foster social interaction. The final deliverables of this project are the conclusions and recommendations to the Science Museum in the form of an evaluation report, the second prototype's web page content, and finally documentation for setting up and operating the second prototype.

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1 Introduction

Museums continually strive to improve the experiences of their visitors. Over the years, research has provided museums with a better understanding of visitor learning styles, and motivated them to adjust the interpretation methods they use in their exhibits. The twenty-first century science centers continue to maintain collections, support research, and promote education, but new insights about visitor learning have motivated a shift from a traditional, didactic ways of presenting artifacts, to exhibits that allow a more free-form approach to learning. In addition, new technologies have offered innovative ways of presenting content to visitors. Technology-based programs create a learning window for the public to discover and understand the latest developments in science. The London Science Museum is among the modern science centers that are seeking innovative ways to use technology to enhance the experiences of their visitors. The museum's curators invited the IQP team to investigate some of the cutting-edge technologies to find a feasible solution for using innovative methods in interpreting its James Watt workshop.

Some shortcomings still exist in interpreting and evaluating both the traditional and new exhibit displays and methods of conveying information to the public. Prior to meeting the sponsors, the IQP project team investigated the gaps in the museum research and determined the aspects of effective exhibits. Aside from exploring various forms of technologies, the group also focused on innovative interactive designs and future trends. The group developed a set of criteria for assessing the technologies in order to determine the most viable solutions that enhance visitor experiences. After presenting the research to the London Science Museum, the curators and the team narrowed down on iPod Touch video tour that they believed would both answer the project objectives and gain popularity among the visitors. The user testing of prototypes alpha and beta of the video tour revealed that most visitors were positive about the idea of having such an iPod guide.

About a third of the visitors surveyed had the proper technology to potentially view the tour on their own devices. The audience liked the fact that the guide offered information in an interactive way and offered them the flexibility to skip to the sections they were most interested in. Many visitors saw value in the idea of having stories. Visitors felt that stories were a good medium to convey information and made the objects more real. However, some commented that they wanted more guidance on locating the object in the case. It was important for visitors to look at the real artifact when following the tour. Social and family interaction, so important in the exhibit design process, was enhanced, not hindered by the guide. Whether the parent or their child dominated the use of the navigation of the device, both parties benefited from the discussions on the topics. Another important discovery was the average usage time of about twenty five minutes greatly exceeded the average visitor dwell time in the gallery of seven minutes.

The report is organized into three major sections: the background, methodology, and prototyping. The background section presents research about visitor learning and considerations for designing effective exhibits that was conducted by the team before meeting the sponsors. It also examines a few of the major technologies currently used in museums and some innovative, cutting-edge technologies that may be used in the future. The methodology section describes how a particular technology was chosen and describes the galleries in detail. The prototyping section represents the different stages of the project development: aims and objectives for prototyping, findings, and final conclusion and recommendations.

2 Background

2.1 Introduction: New Model of Engagement

> "I hear and I forget
> I see and I remember
> I do and I understand
> Confucius (551 – 479 BC)"
> (Lewis & Martin, 2006, p. 107)

This Chinese aphorism reflects the new model of visitor engagement that has guided the evolution of science museums over the past decades. An example of such museum is the Ontario Science Centre (OSC), which opened to the public in 1969 as one of the first of a new generation of science "museums" of its time. It was designed to actively engage the visitor through hands-on, interactive experiences by utilized technology in its exhibits, programs, and demonstrations. The Ontario Science Centre, like many other science centers, museums and art galleries around the world entered the twenty-first century challenging itself about how to further engage the public. In this period the museum primary focused on the youth who, unlike the previous generations, had technologies to allow them to connect with their peers on a worldwide basis. Other museums soon saw the ability to explore these technologies and thereby engage with teens and their parents in a whole new way as a key strength in connecting with these audiences. (Lewis & Martin, 2006)

The new philosophy among museums stretched beyond developing a new visitor experience to changing the thinking about informal science, discovery, and communication. Today, "technology-based programs and services abound in museums, whether the institution's focus is art, history, science, natural history, zoology, youth or general audiences" (Din & Herminia, 2007, p. 9). This technology is no longer an isolated tool aimed at performing a specific task, and has become essential to many exhibits as well as museum operations. Museum visitors encounter technology-driven programs immediately upon arrival in forms of electronic welcome signs in a variety of languages, digital displays presenting the events of the day or touch-screen kiosks with images, text and maps to help plan a tour for each visitor or family member. Further inside the museum, visitors may come upon flat-panel displays showing orientation videos. Visitors may also encounter display stands that offer audio guides with extensive information or perhaps handheld devices that can track the visitor's location. (Din & Herminia, 2007, p.

10) Video screens, exhibition kiosks, media art installations, web interfaces and cameras are just some of the modern technologies that allow museums to display and interpret exhibits in new ways today.

2.2 Evolving Mission

Many of these technology-related experiences are designed not only as learning tools but also to promote social interaction among visitors. Twenty years ago only about one in ten Americans went to museums with any regularity. Today museums rank along with shopping and sports as one of the most popular out-of-home leisure experiences in America. (Falk & Dierking, 2000, p.44) Not only has museum-going become more popular, but the level of user engagement and communication with one-another has also increased. Website, blogs, wireless technologies and podcasts extend the museum beyond its walls. By using various technologies museums have transformed from being attraction-based places to visit, to being leaders in building relationships beyond the site, beyond the visit (Lewis & Martin, 2006, p.109). The museum's mission has shifted from simply maintaining collections, research, promoting public education and teaching to playing a greater role in the visitors' lives. Today museums are striving to shift its audience from visitors to participants who gain confidence through offered activities to be creative problem solvers (Lewis & Martin, 2006, p.109).

The ways in which museums achieve their mission have also changed over the years. In the past, museums adopted a "transmission-absorption" model in which museum experts built exhibits that conveyed the information the visitor "should" know (Falk & Dierking, 2006). This notion of learning describes the museum experience as visitors absorbing information that has been transmitted to them. This is similar to the teacher- student model of the formal education sector. More recently, however, museums have moved to a more visitor-centric model in which the museum tries to determine what interests and engages the visitors and build exhibits and programs accordingly (Hein, 1998, p. 35). Technology has uniquely positioned the science centers to provide an interactive learning window for the public to understand and explore the latest developments in science, and also to explore themselves and become a true participant within the process of science (Lewis & Martin, 2006, p. 110). In 2006 the Ontario Science Centre has extended the aphorism that has guided it for thirty years, which is reflective of the new museum visitor-centric model. A modern science museum caters exhibits to address visitor's curiosity and interests:

"I hear and I forget
I see and I remember
I do and I understand
I create and my mind opens
I innovate and the world opens"
(Lewis & Martin, 2006, p. 109)

2.3 Museum Audiences

The audiences of the new approach towards learning fall into different categories, such as educators, families, adults, and teens. The London Science Museum, for example, welcomes 2.5 million visitors each year, 1.3 million of which belong to family groups. Thirty-six percent of visitors are 16 or under. Most visitors come from the USA and Germany, but many others are from elsewhere around the world (London Science Museum: Facts and Figures, 2006). These visitors, who vary enormously in age and ethnicity, also diverge in interests and learning styles. Personal, socio-cultural, and physical contexts are important. In order to create a rewarding experience for a wide range of visitors, the museum must provide exhibits that appeal to different age groups, educational levels, personal interests, and technical expertise (Falk & Dierking, 2008). Several studies have been conducted by the Museum of Anthropology at the University of British Columbia in Canada concerning visitors' memory seven, fifteen, and twenty years after attending a cultural site. Out of seven research factors, socio-cultural identity was the dominant factor affecting the types of information that museum visitors absorb and retain. Professor Anderson, who conducted the research, concluded that who we are mediates what we see. (Suchy, 2006)

Whether visiting as a group or alone, visitors expect to mentally, and perhaps physically, interact with the museum artifacts. Museums have to design galleries, way-finding systems, exhibits and programs that cater to these diverse needs and promote "free-choice learning." "Informal" and "free-choice" learning are terms which describe the learning that occurs in museums, in which individual interests and motivations guide the learning, in contrast to the more didactic approach to learning that traditionally occurs in classrooms (Ucko & Ellenbogen, 2006, p.241). Technology and interactive media allow people visiting in groups to be able to share their experience in one way or another by collaborating and conversing together. Do visitors typically come to a museum or exhibition with a predetermined notion of what they are going to do or do they put themselves in the hands of the museum? Museum goers usually desire both freedom and structure. The unique characteristics of individual visitors can be addressed by allowing some variability in the ways information is accessed and presented. The need to evaluate how effective exhibits are in meeting the different needs of diverse audiences is an important part of museum evolution. (Falk & Dierking, 2008)

2.4 Aspects of Effective Exhibits

In order to further their missions as institutions of learning, museums must continually evaluate their exhibits and strive to design ones that better educate and engage visitors from diverse backgrounds. There are many aspects that contribute to the creation of an "effective" exhibit. Even as museums move towards using new technologies for exhibit interpretation, these aspects continue to be paramount.

At the highest level of abstraction, the one of the keys to effective exhibit design is an understanding of how visitors learn. One of the most recurring, fundamental concepts about learning is that it requires engagement. Humans learn much more effectively when they are curious and interested in topic and they can see how the new information relates with and builds upon their existing knowledge. According to Falk and Dierking, humans have the fundamental "need to make sense of the environment, to find patterns and make order out of chaos… the search for meaning… and the consequential need to act on the environment" (2006, p.65). Falk and Dierking (2006) also write that "humans are highly motivated to learn when they are in supporting environments" and "when they are engaged in meaningful activities" (p.32). Moreover, "new learning is always constructed from a base of prior knowledge" (Falk & Dierking, 2006, p.33). The work of Rennie and Johnston (2004) also supports these claims that engagement, context, and motivation are key elements of human learning. It is therefore imperative to design exhibits that engage visitors and interpret the information in ways that encourage visitors to the material.

Humans are social creatures by nature, and it is therefore no surprise that social environments also play a role in human learning. It may seem like a truism, but Rennie and Johnston's point out that:

> "Feeling comfortable is important. Visitors who feel intimidated by the number or intellectual tone of the exhibits, the noise level, an unfriendly physical layout, or apparently aloof attendants, will be less motivated to learn than those who feel free to do as they wish." (Rennie & Johnston, 2004, p.S7).

Similarly, Falk and Dierking (2006) find that “sociocultural context” must be carefully considered when designing exhibits, particularly where new technologies are involved. At the same time, Sue Allen and Joshua Gutwill observed that “multiple interactive features of equal priority can overwhelm visitors (Allen & Gutwill, 2004). In their study of the “Light Island” exhibit—an exhibit consisting of multiple tools to view different behaviors of light—the users were not sure where to start (marking lack of priority), which tools to use (inundation of information), and if the tools were meant to be used together or separately. Interviews later showed that 83% of the visitors of the exhibit felt that they had not learned anything (Allen & Gutwill, 2004).

These observations concerning human learning have direct implications for the design of effective exhibits. The most effective exhibits are the ones that engage the visitor, giving him or her motivation and context for learning the content, while maintaining a “comfortable” environment conducive to learning. Many leading museum experts have created guidelines for evaluating exhibits and determining the types of characteristics that make them effective. One example of such a set of guidelines is the “Excellent Judges Framework”, developed in part by Beverly Serrell (2006). Serrell explains that this Framework consists of a hierarchical structure of criteria. Exhibits should be designed to be “Comfortable”, “Engaging”, “Reinforcing,” and “Meaningful” (Serrell, 2006, p.17). Another example of a system for creating exhibits is the Exploratorium’s “Active Prolonged Engagement” (APE) model, which was developed after extensive visitor research funded by the National Science Foundation (Exploratorium 2005). The APE school of thought reflects changes in views about how visitor learning should occur. Rather than providing a pre-planned, predetermined environment for learning, APE aims to have visitors develop critical thinking skills through independent discovery. The word “Active” refers to the attempt to get visitors to become self-driven, thoughtful learners. This model also aims to “Prolong” visitor attention, which is necessary for learning, since, as Rennie and Johnston point out, “learning takes time” (2004, p.S7). The “Engagement” aspect aims at getting the visitor involved and motivated in order to better learn the content. (Exploratorium).

There also have been overzealous attempts to create interactive exhibits. Allen and Gutwill (2004) point out that exhibits may have too many interactive features, and the goal is to design exhibits with an appropriate range and type of interactive elements. Their solution is three-fold: limit functionality, segment functionality, and create a hierarchy of salience. By limiting functionality, the developer is weighing against the increased interactivity and the reliability of the interaction to achieve the goal of deepening the visitors’ knowledge. Segmenting functionality cuts down on overly complex exhibits that cause visitors to be frustrated and confused and breaks the exhibits into manageable compartments of information that can be digested more easily. Finally, by creating a hierarchy of salience, it will become easier for the visitor to focus on the important part of the exhibit that will lead to discovery, learning, and a better experience overall. (Allen & Gutwill, 2004)

The "Excellent Judges Framework", "Active Prolonged Engagement", and Allen & Gutwill's guidelines are just a few of the many attempts that have been made to encourage the design of better exhibits by highlighting key attributes of effectiveness. All of these systems address the key issues of visitor learning in some form or another: how exhibits engage visitors, how they make visitors feel comfortable (such as by aesthetics, absence of material intended to offend or insult any particular group), and how exhibits must be designed in order to cater to the needs of a diverse audience. The aspects of museum exhibits, and the effects that these have on visitor learning, lead ultimately to the success or failure of the museums' missions.

2.5 Family Learning

In context of family learning, museums can be described as "environments where adults and children learn together, develop lifelong interests, and build shared memories."(Borun, 1998) It is important for museum practitioners to provide equally insightful programs for all audiences. Successful exhibitions add to a person's knowledge, skills, and beliefs. However, the most prominent ones also add a social dimension to an ordinary museum visit. Such visits enrich the family culture and inter-generational learning by allowing the family members to share the associations stimulated by exhibits immediately, or even long after the museum visit. Museums can stimulate families to discuss new experiences, ask questions, and share memories. But, how can family learning in museums be measured and identified? What attributes of museum exhibits encourage family learning? To seek answers to these questions, the Academy of Natural Sciences, the Franklin Institute Science Museum, the New Jersey State Aquarium, and the Philadelphia Zoo formed the Philadelphia-Camden Informal Science Education Collaborative (PISEC) and embarked on the *Family Learning Project*. This three-phase investigation into family learning in museums had three phases, each a response to a research question:

Phase 1: What is family learning and how can it be measured?

Phase 2: Do specific exhibit characteristics facilitate family learning?

Phase 3: Do exhibits that have the seven characteristics of family-friendly exhibits produce measurable increases in family learning?

Family Behaviors

PISEC defined a family as a multigenerational visiting unit of no more than 6 members, with at least one child between 5 and 10 years of age and one adult, age 19 or older. While this definition excluded groups of cousins or sibling, it was broad enough to include many other kinds of family groups. The study included traditional nuclear families (parents and their children), single parents with children, and extended families including grandparents, aunts, uncles, cousins, nieces, and nephews. Based on the previous studies (Bitgood,1992; Diamond, 1981; Dierking, 1987; Hike & Balling, 1985), a list of behaviors associated with learning was formulated: [1] (Borun, 1998)

- Approach/withdraw from the exhibit
- Engage in hands-on activity (interactive only)
- Call someone over
- Point at the exhibit
- Climb on the exhibit
- Read text aloud
- Read text silently
- Comment on the exhibit or explain how to use it
- Ask a question
- Answer a question
- Express "like" verbally
- Express "dislike" verbally

Observation Methods

Research methods were tested and data collection strategies were modified until a method was created to accurately capture the behavior of family groups.

What Didn't Work:

- Recording live action at the exhibit onto a coding sheet (with codes corresponding to different family behaviors).
- Placing a stationary microphone on the test exhibit.

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[1] The team has worked out its own observation technique, but used these behaviors as guidelines for observing visitors and asking them questions about their experience with the technology.

- Placing a lapel microphone on a data collector.
- Narrating behavior and repeating conversation into a hand-held directional microphone.

What Worked:

- Narrating behavior and repeating conversation into an *unnoticeable* microcassette recorder easily hidden in the palm of the hand. Using the recorder, the data collectors stood inches behind the visitor and described behavior without being noticed. Families were also videotaped by a stationary camera mounted on or near the exhibit.

Results

The PISEC study cited several statistics, which help understand family interactions. It was found, for example, that 66% of family behavior at an exhibit was about acquiring or transferring information and an additional 5% was about relating this information to past or future experience of other family members. One mother said, “I try and relate exhibits to things in their [my children’s] own environment. They learn better if they know it’s something that touches them every day. It’s more interesting for them.” It was noted that highly interactive exhibits promoted attention-focusing behaviors such as questioning and explaining, which are frequently associate with learning. For these kinds of exhibits, parents were often noticed to be reading the labels and commenting on their children’s actions. It was found that families do learn from exhibits, and that the level of learning is associated with specific observable behaviors. The observations of these behaviors resulted in a list of seven characteristics of family-friendly exhibits. The seven characteristics are rarely present in any one science museum exhibit. A walk-through survey in June, 1997, of more than 250 interactive displays at The Franklin Institute Science Museum revealed that only 6% incorporate all seven characteristics. However, they can serve as guidelines for designing new and effective exhibits in museums that are interested in attracting family audiences. (Borun, 1998)

2.6 Turning Points in Museum Technology

For over forty years, museums have been providing audio guides to visitors. The technology of audio guides has evolved from reel-to-reel tape, to cassette tape, to digital RAM, to MP2, and finally most recently to MP3. By the mid 90s, there were only two major changes in audio guides. The first was the compact cassette in the 80s and the second was the analog to digital transition in 1994. (Proctor & Tellis, 2003) Museum technology has since dramatically improved. The technological boom in mobile devices within the last decade gave rise to the integration of technology in museums. Having a late start in adopting new technologies, museums tours are far from ideal. With the rapid development of technology, museums have to worry about "future–proofing" and keeping their tours up-to-date, adaptable, and flexible. The Science Museum had enough foresight to recognize the swift advancement of technology and has continually tried to improve their visitors' experiences. The research and analysis of old, current, and up-and-coming technology will be critical in coordinating the Science Museum's own adoption of new technology and methods for museum touring.

The British Galleries of the Victoria & Albert Museum in London opened in November 2001 with interactives juxtaposed with objects over 400years old. Interactives were defined as exhibits that promoted visitor interactions. These interactives were designed to deepen visitors' engagement with the collections. (McIntyre, 2003) The interactive elements ranged from physical construction projects to computer applications to videos. The report noted positive results from the visitors, with only 6% negative responses. (McIntyre, 2003) McIntyre did notice that although the response was largely positive, there were indubitably downsides to the interactives. First, the exhibits were sometimes hidden due to the large influx of visitor flow. Second, as with many devices, instructions are not read by visitors—leading visitors to be confused about the device. The need for instruction also indicates that the interactives may not have been designed intuitively enough for visitors to use them easily. Finally, the interactive exhibits restrict physical access to tight spaces because they are most often occupied by a single user or group (e.g. a family). The response may have been positive but in order to convey an educational message to a wider audience simultaneously, the design of the interactive exhibits were unable to address these problems effectively.

In 2002, the Tate Modern, London's National Museum of International Modern Art, began testing a breakthrough device for modern museum touring. Sponsored by Bloomberg, a global, multimedia news and information company (Tate Modern, 2000), the Tate Modern Multimedia Tour Pilot delivered a multitude of features that were thought to address problems unsolved by standard audio guides. "The pilot was specifically designed to define the limits of the current generation of wireless technology, and therefore involved an ambitious combination of location-based and interactive applications" (Proctor & Tellis, 2003). The device had an interactive survey and response system that allowed the museum to collect feedback about certain selected exhibits to determine its popularity. Visitors were provided location-specific content, automatically receiving audio and/or video information when arriving at certain exhibits. Location tracking was built into the devices so that staff would be able to locate visitors that needed technical assistance. The location tracking also provided museums with visitor statistics and profiling that would allow them to see which exhibits garnered the most attention and time. Visitors were able to email exhibit information directly from their Tour Pilot for later reference. The Tour Pilot was generally well received, over 70% of the visitors spent longer in the gallery, and the blend of audio and visual elements and interactivity kept the visitors more engaged. Despite its success, feedback from the visitors showed that almost all had some sort of technical difficulties with the user interface. Long videos and interactivity were considered a distraction while passive audio had a much high tolerance level. Though the features were unpolished, the Tate Modern was ahead of its time in demonstrating the immense potential of using a mobile device as a tour guide.

One technology has recently emerged amongst museums, due to its increasing affordability, is RFID (Radio-Frequency Identification) tags. In 2002, San Francisco's Exploratorium began testing RFID for their eXspot system. The eXspot consisted of RFID reader package mounted on or placed next to museum exhibits connected to a wireless network. The visitor upon entering the museum would register at a kiosk and receive an eXspot RF tag. The RF tag would be used to interact with the RFID readers.

> "At [an] exhibit called the 'Heat Camera,' visitors see thermal images of themselves and get to explore the parts of their bodies that are hotter than others. eXspot RFID readers attached to the exhibits allow visitors to use their RFID cards to trigger cameras to take digital images of themselves, as well as to capture the thermal images… from the exhibits." (Hsi, Fait, Hsi, & Fait, 2005)

The eXspot also allowed users to "bookmark" particular exhibits that the visitor wishes to learn more about by scanning their RF tag. Upon registration, a web page is dynamically generated for the visitor where content created or bookmarked by the visitor at the museum is saved. This feature can also be utilized by sending a text message to an exhibit-specific number (as discussed later), or by using an iPhone or iPod Touch tour. The Tate Liverpool offers the UK's first tour designed specifically for these devices (Tate Liverpool, 2008). Similar to the Tate Modern Multimedia Tour Pilot, it was able to retain users at exhibits for a longer time and allowed many critical visitor statistics to be recorded, both within the museum and beyond, via the personalized web page.

Fixed displays, mobile devices, and RFID are just some of the many technological breakthroughs that museums have leveraged to increase visitor learning. As new technologies are introduced and adopted by museums, old fashioned audio tours and text labels are also being reinterpreted with new hardware. Having a balanced consideration review on both established technology and cutting edge will provide a well-rounded perspective in determining a best-fit technology for the Science Museum.

2.7 Technology Research

The design of an effective exhibit also requires the appropriate choice of interpretive technology: that which is most conducive to learning, and articulates the widest range of knowledge. There are a wide variety of technologies that could potentially be applied for use in museums. Of these, certain technologies are more readily adaptable, in terms of engaging a wide variety of visitors and effectively presenting the exhibit content. The following sections present the current technological state-of-the-art, summarizing the advantages and disadvantages of different technologies, and providing examples of how some of these technologies have already been applied in museum settings.

We have split our technology research into two categories: Mobile technology and 'fixed' or static technology. Mobile technology is that which many museum visitors already own. This includes cellular phones, iPods and other MP3 players, and more. The visitors would bring these devices to the museum, and, through some kind of interface or network, be able to view or hear information about museum objects and exhibits. Alternatively, museums sometimes choose to lend out mobile devices (such as iPods), pre-loaded with rich content, which they feel would add significant value to the exhibitions. In some cases, museums may also have to purchase technology to increase connectivity, such as wireless or Bluetooth networks. Fixed technology is that which is owned and maintained by the museum. These technologies range from simple video screens to high-tech multi-touch surfaces. This category can also include technology which is technically 'mobile' (such as Augmented Reality tours, described later), yet require a complex network provided by the museum, and is not widely available to the public.

One of our major goals is to determine the advantages and disadvantages of each type of technology, and then compare each type based on a selection of criteria, and eventually settle on a technology to be used in the Science Museum.

Audio Tours

One of the more common mobile technology applications in museums is the audio tour. This feature can be used through iPods, cell phones, or museum-provided guides. At some locations, such as the San Francisco Museum of Modern Art (SFMoMA), identical tours are available on all three platforms. To use this feature via phone, the visitor dials a toll-free number to access the audio tour, and then dials a further three-digit number for each object he or she would like to hear about. When using an iPod or other music player, the audio tour must be downloaded at the visitor's home before arriving at the museum. Some museums have even offered admission discounts to visitors who bring their own MP3 audio tours (Proctor, 2007). However, the service must be highly publicized to be effective. During one trial, it was found that 49% of visitors to a specific gallery didn't take a cell-phone audio tour because they didn't know it existed (Proctor, 2007). Most tours first provide the basic information, and then ask the visitor if they would like to hear more. The tour can be taken in any order and over any period of time.

Advantages

Studies have shown that about 30% of people retain information from audio tours compared to only 6% from text labels alone (Schwarzer, 2001). This is certainly a benefit to museums that wish to promote information retention regarding their exhibits. Also, using mobile audio tours negates the high cost, time, and staffing needs of standard audio tour devices or docents (Nickerson, 2005). Some iPods have a feature called "Museum Mode," which uses the notes section to store a separate presentation for each stop on the tour. (Breen, 2004) One company even allows visitors to "talk back and record feedback to the guides" (Russell, 2006).

iPods now offer more than just audio tours. The iPod Video offers a full multimedia experience, including text, images, audio, and video (Breen, 2004). In trials done at the Cleveland Museum of Natural History, it was determined that about 88% of visitors prefer media-rich video iPod tours, as opposed to labels or audio alone. Interestingly, in this study, more people preferred text labels to audio-only tours (see Figure 3). Visitors noted that that the added level of interpretation helps them to "better comprehend and relate to the exhibits while they are in physical proximity, thus providing a higher level of appreciation." (Impact Communications, 2006) This study seems to counter the notion that technology in museums will only serve as a distraction.

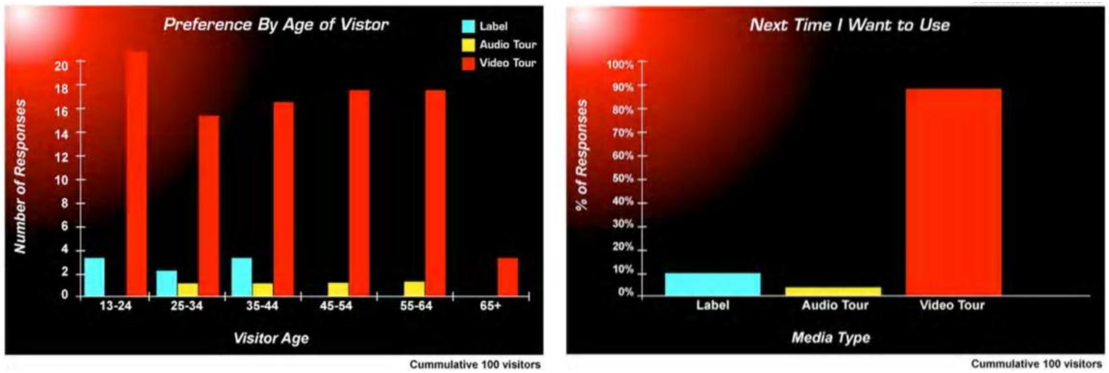

Figure 3: Impact Communications Survey of Visitor Preference of Tour Devices[2]

Disadvantages

The greatest drawback of iPod and cell phone tours, especially those which include multimedia presentations, is the "Heads-down vs. Hands-on" effect, where the visitors are more focused their devices than they are on the exhibit (Collins, Mulholland, & Zdrahal, 2008). Also, some visitors have been confronted by security personnel who mistake the cell phone audio tour for a conversation in galleries where phone use is banned (Russell, 2006). Furthermore, since tour phone calls may last a long time, museums must concern themselves with the high charges that foreign visitors would incur, as well as the large number of domestic visitors in Europe that use 'pay-as-you-go' plans. Jane Burton, a curator at the Tate Modern, explained that "The reason we've held off trialing a phone tour until now is the difficulty in telling people how much their call is going to cost – and with pay as you go and roaming charges, that could be a significant amount of money." (Proctor, 2007).

When taking an MP3-based audio tour (i.e. one that is downloaded to an iPod), it would be difficult for visitors to share the experience. However, there are more immediate usability issues. It is sometimes more difficult to customize the order in which one takes these tours. The most common form of iPod audio tours – the podcast – is a linear tour that is basically as sophisticated as a cassette tape. It is usually a single track that the listener pauses between locations. To be able to take the tour in a different order, the tour must consist of multiple files. In addition, loading a tour onto one's iPod before visiting a museum takes time and forethought. Visitors surveyed for the study at SFMoMA reported the lowest satisfaction with podcasts in terms of being able to "access information as needed,"

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[2] http://www.impactcommunications.com/pilot/Video_iPod.pdf

as shown in Table 1 (Samis, 2007). Finally, due to the great cost and fragility of the devices, few museums choose to invest in them. (Breen, 2004).

Reason for choosing device	Device		
	Podcast	Cell Phone	Audio Guide
I am familiar and comfortable with the device	56	40	62
It enabled me to access information as needed	33	46	34
I thought it would be easiest to use in the museum	22	17	50
I prefer to use my own device rather than renting	44	40	N/A
It was cheaper or free	33	33	6

Table 1: Satisfaction with different forms of audio tour Museums and the Web 2007[3]

Text Message Bookmarking

The next mobile application to be explored involves creating a "personalized set of online resources" by 'bookmarking' an item via text message (Collins, Mulholland, & Zdrahal, 2008). As described above, a website would be created for each visitor that uses this feature. A visitor could then send a text message to a number that corresponds to his or her favorite exhibit. Additional content about this exhibit would then be added to the user's webpage, and could be viewed at any time. This application would be found on mobile phones, which have a very high ownership rate in the Britain. In the United Kingdom, 84% of people own cellular phones. This number is higher in urban areas, and is increasing at about 3% per year (Nations and Regions Communications Market Report Summary, 2008). However, an important point to note is that, while European cell phone use is higher and more widespread than in the US, usage of cell phone-based tour applications and the like has been much lower (Proctor, 2007). This approach is much less distracting than a standard audio or visual presentation, which would have the visitor looking at their device instead of appreciating the art or object. In this case, the visitor can enjoy the exhibit knowing that much more information is waiting to be viewed at their leisure.

Advantages

Another advantage to using this bookmarking feature is the amount of time it saves museum-goers. As any museum aficionado will tell you, you may spend your entire life exploring one museum

[3] http://www.archimuse.com/mw2007/papers/samis/samis.html

and never see everything it has to offer. However, for those who would like to try, this feature allows one to spend less time absorbing all the information available on-site, and more time exploring, while still being able to learn it all eventually. Similarly, the visitor will only be shown the information that he or she wants to see, but can explore more if desired.

Finally, the knowledge base would be very easy to maintain, change, and append. The information could also be displayed in myriad languages or even spoken aloud for the illiterate or blind. Applying this technology to the London Science Museum specifically would be very simple. The museum is already testing an 'ObjectWiki' – a Wikipedia-like database of many of the objects in their collection. This database includes not only facts and history about the objects, but also personal memories of people who may have interacted with the objects through history. This knowledge base is user-editable, which "motivates its ongoing content production" (Collins, Mulholland, & Zdrahal, 2008)

Disadvantages

For those visitors who do not own cellular phones (or simply do not want to read extra information after their visit is over), the standard signage, or other alternative must still be maintained. Another shortcoming that should be mentioned is one that is inherent in all mobile phones: reception. This is especially a concern in European museums, where thick stone and metal façades could make sending a text message frustrating or simply impossible. In fact, the structure of British museums is a contributing factor to the lack of mobile phone-based tours in the region: "Many museums in Europe are housed in thick-walled, historic buildings where cell phone reception is poor, and the cost of adding internal repeaters to improve reception is prohibitive" (Proctor, 2007).

Quick Response Codes

A similar technology, popularized in Japan, is just now emerging in the West. Called Quick Response (or QR) codes, this technology allows users to simply swipe their camera phone over a two-dimensional bar code known as an HCCB (High-Capacity Color Barcode) and be instantly taken to a website, presentation, or other application linked to the specific product (Figure 1). The barcode is designed to hold more information than a standard vertically redundant barcode.

Figure 4: A Quick Response Code which links to the London Science Museum homepage[4]

In Japan, use of QR codes is widespread: Seventy-three percent of Japanese consumers have used QR Codes at some point in their lives. Among teenagers the figure rises to 90 percent. The codes can be found on everything from groceries and fast-food wrappers to movie posters and business cards (Norrie & Bibby, 2008). Originally created in 1994 to track car parts, the codes are now being tested by Microsoft and, for now, anyone can create their own Microsoft Tags for free.

Advantages

Because QR codes are so wildly popular in Japan, there is little doubt that Europe and North America will soon see an influx in this technology. It could quite possibly be the wave of the future. Also, because there is nothing to type in, information can be accessed almost instantly. Also, as was true for text-message bookmarking, the QR Codes could be linked to the Science Museum's ObjectWiki. If this was done, the only cost would be to print and install the tags.

Disadvantages

At the moment, and for the foreseeable future, only smart phones (i.e. iPods, Blackberries, etc) will be able to download the software necessary to read codes. While many people in Asia may own these devices, this number is severely limited in other parts of the world. Of those in the UK who bought mobile phones in the third quarter of 2006, 7.5% chose smart phones. In the US, that number was only 3.3% (Nielsen Mobile, 2006) However, during only the past two years, smart phones have become much more popular, thanks in part to the iPhone and its competition. By the middle of 2008, smart phones represented 16% of recent mobile device acquisitions in the US. (Nielsen Mobile, 2008). It is unknown whether or not smart phones will penetrate the market enough to be used for museum interpretation. It is less likely that museums will provide cell phones than they would iPods and the like, due to the universal need for data plans and possibility of misuse.

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[4] www.tags.microsoft.com

Multi-Touch Surface

The multi-touch surface is doubtless the most advanced piece of information interpretation technology available today. Popularized by the Microsoft Surface, these advanced touch-screen monitors recognize gestures, pressure, object shapes, and even Radio Frequency Identification (RFID) chips. Users can interact with pictures, videos, maps, text, and nearly anything else the owner can think of. The surfaces are completely customized to the needs of the particular institution. A smaller version of the multi-touch surface can now be found in Apple's iPhone and iPod Touch. In the future, mobile devices (such as cameras, MP3 players, and PDAs) placed on the surface will be recognized and wirelessly connected, and digital content can be viewed, shared, and saved. (Microsoft, 2008)

While it may seem that Microsoft has a monopoly on the multi-touch industry, there are in fact multiple companies developing their own brands. Ideum, en exhibit design firm, created the MT2 multi-touch table specifically for use in museums. This table's size and resolution are greater than those of Microsoft's Surface. The device is rugged – it's built with aircraft-grade aluminum – and should be able to withstand the constant flow of users. (Ideum, 2009) Being designed with museums in mind, the table meets all ADA (Americans with Disabilities Act) requirements, and is completely automated (it turns itself on in the morning and shuts down at night).

Advantages

One of the largest contributors to the multi-touch surface's success is its intuitive gestural interface. Users instinctively know how to use it when seeing it for the first time. In addition, the public has been already been introduced to multi-touch surfaces without even knowing it: CNN's 'Magic Wall,' usually piloted by John King, is one of the most famous multi-touch surfaces in the world. (Selker, 2008) Also, multi-touch surfaces encourage sharing between visitors. Because the screens are laid out horizontally, and because these surfaces can recognize dozens of touch-points (as opposed to standard touch-screens, which can recognize only one at a time) multiple visitors can use the device at once. According to Jim Spadaccini, Director of Ideum "The table is both a physical and social platform, it does what the traditional computer kiosk cannot do."(Ideum, 2009)

The feature that may be most attractive to museums is the ability to "place physical objects on the surface to trigger different types of digital responses." (Microsoft, 2008) The surface uses visual and infrared cameras inside the surface to detect objects, such as fingers or replicas of museum artifacts. The computer then activates whatever program is linked to the specific object, such as a video presentation, interactive game, etc. Similarly, when an object is too fragile to be touched by the public, multi-touch surfaces can be used to manipulate and explore digital models of anything from complex machines to ancient artifacts. Because manipulating 2D objects on a 3D surface is non-intuitive, a French company, Immersion Technology, has developed an even more innovative way of interacting with three-dimensional objects and environments via the multi-touch surface. The iLiGHT Cube allows users to manipulate 3D environments – such as Google Earth, 3D models, even brain MRI – “in a more instinctive way” (Davies, 2009).

Disadvantages

The obvious setback to selecting a multi-touch surface is its high cost. While Ideum hasn’t released any official pricing information, the cost of a Microsoft Surface is usually upwards of $10,000. While the appeal of multiple visitors interacting in a social manner is easily equated with increased learning, this is not necessarily the case. In a study done by the Exploratorium, the “Spinning Blackboard” exhibit was chosen for its ability to support multiple users. The exhibit consisted of a spinning plate with sand spread evenly throughout the surface of the place. The objective of the exhibit was to let multiple users touch the sand with tools or their hands to generate complex patterns. The result of having too many users was that even a simple pattern would be destroyed by a neighboring visitor (Allen & Gutwill, 2004). The parallel can be drawn that too many multiple users using the surface may in fact decrease the visitor experience through interference of the task at hand.

Augmented Reality

The famous Musée du Louvre in Paris has partnered with a Japanese corporation (DNC) to create the Louvre-DNC Museum Lab. The joint project seeks to “explore new approaches to artworks, particularly through the use of multimedia tools” (Louvre-DNC Museum Lab, 2008). In essence, the lab examines the practicality of using the most cutting-edge technologies in a museum setting. Currently, the lab is testing an application knows as Augmented Reality, or AR. Augmented Reality uses a combination of visual sensors, accelerometers, and location-based hardware in an Ultra-Mobile PC to combine both exhibit interpretation and wayfinding. AR in essence overlays a computer-generated image or animation (say, for example, a virtual tour guide) over an exhibit piece which it is programmed to recognize. These animations provide a wealth of information about the exhibit that labels, audio, or video could never achieve. The ‘tour guide’ (and, vicariously, the visitor) can interact with the object, showing how it has changed over time or pointing out important details that might otherwise be missed

(See Figure 1). Imagine peeling back the layers of the Mona Lisa to see everything da Vinci had ever painted on that canvas. The animations are automatically started when the device comes within a few feet of the specific exhibit. The Museum Lab decided to use a character for their AR technology guidance system, in order to “share a sense of ‘familiarity,’ ‘surprise,’ and ‘wonder’ with the user,” especially children. (Miyashita, et al., 2008).

Figure 5: An Augmented Reality system overlays a broken plate above the reassembled artifact

Alternatively, instead of visitors carrying heavy, fragile, and expensive individual devices, the Museum Lab also has AR ‘stations’ near the exhibits they believe would be best suited to more in-depth presentations. These stations not only lessen the risk of damage, they also eliminate the problems of battery life and theft. In addition, all the components needed for Augmented reality are now included in the iPhone. It has a large, high resolution screen, a camera, an accelerometer, and a wireless network.(Louvre-DNP Museum Lab, 2008)

In addition, between exhibits, the AR interface can guide visitors to the next artifact. The order of the tour can be determined by the museum or the user (Lee & Park, 2007) For example, the visitor can ask the device to create a tour that includes all exhibits related to flight or all paintings by Kandinsky. At the Louvre-DNC Museum Lab, the virtual tour guide steps into a miniature hot-air balloon and leads the visitor to the next destination. The lab hopes that AR-based guidance will be an improvement over their previous, audio-only application, which only achieved a 9.7% success rate (Miyashita, et al., 2008). In addition, even if the entire museum is not AR-enabled, the handheld devices can switch to PDA/audio guidance mode to further assist in wayfinding, until the device detects that the user is back in an AR-enabled zone (Oh, Lee, Park, Park, Kim, & Son).

Above all, Augmented Reality is the most immersive of all museum technologies. It provides a sense of interaction and captivation that standard audio tours and video presentations simply cannot achieve, which are “important factors in understanding and enjoying the exhibitions” (Oh, Lee, Park, Park, Kim, & Son). AR is meant to “enhance a traditional museum visit, without turning it into a science presentation.” The system was constructed such that “visitors can concentrate on the artwork and the augmentations without noticing the technical complexity of the system” (Miyashita, et al., 2008).

Developed in the early 2000’s by Unifeye and Metaio corporations, Augmented Reality has already become relatively wide-spread commercially. It can be found in advertisements, on product packaging, and even children’s pop-up books. In addition, the 3D modeling package Google SketchUp contains a feature that can convert user-created models into augmented-reality tags. The beauty of Augmented Reality is that it can be programmed to recognize any image or object in any orientation to an accuracy of 1 mm. This is known as “Markerless Tracking (Miyashita, et al., 2008). However, when employed on objects with little to no texture, the tracking system is often inaccurate and slow. For this reason, the Museum Lab chose to test the technology on the intricate patterns of Islamic pottery.

Advantages

The quality of learning and engagement of Augmented Reality is unparalleled. When queried on their impression of AR technology, most visitors reacted favorably. They said that they “felt motivated to examine the artwork more closely” (Miyashita, et al., 2008). Users especially liked being able to view the inside or reverse of the objects, something never before possible. From the museum’s point of view, AR is favorable because they never even have to touch the exhibits (Miyashita, et al., 2008). In addition, when designing the graphics, designers can use any method or format. AR is compatible with all types.

Disadvantages

Visitors took issue with the weight of the devices, as well as the fact that the virtual tour guide didn’t ‘look’ at them (just their most probable location). In addition, in the video press release, users are seen walking around the museum with their screens held in front of them, engaged and oblivious to the world around them. In fact, visitors “found it difficult to turn their gaze from the AR system’s monitor to the real artwork” (Miyashita, et al., 2008).

3 Methodology

The purpose of the IQP was to provide the London Science Museum with a new and fresh perspective on how to engage its visitors. Using the documentation compiled on possible technologies, the team worked with the museum to select the most promising technology to test: an iPod Touch guide. The project team conducted visitor research in the Making the Modern World gallery – the gallery most similar to the Watt Workshop – in order to test the prototype and to identify issues with the technology and barriers to visitor learning. (For more information on James Watt and his Workshop, please refer to Appendix H: The James Watt Workshop on page 101.) The team performed two iterations of prototype revision and testing with visitors in order to formulate a set of recommendations for the Science Museum about the iPod multimedia guide. This chapter describes the design decisions, the testing methods, and the findings of the entire prototyping process.

Prior to meeting the sponsors, the IQP project team investigated the gaps in the museum research and determined the aspects of effective exhibits. The group looked at both cutting-edge technologies and also ones that have already been implemented in museum setting to develop a set of criteria for assessing the technologies in order to determine the most viable solutions that enhance visitor experiences. In an effort to bring the Science Museum new perspectives on interpretive technology, the team presented the research to the museum's audience research department. Several technologies were chosen by the department as best matches for the goals of the project. Among them were Augmented Reality and iPod Touch video tour. With careful consideration, the department and the team decided that Augmented Reality may not be the best way of presenting the particular single-standing objects to its audiences. An iPod video tour seemed a better candidate for bringing new perspectives to the museum; as a mobile tool it would also allow visitors to move around the gallery and have more freedom in choosing which objects they wanted to learn more about. Concurrently with the team's efforts in London, a member of the group collected information about the potential technologies by talking to exhibit designers in the U.S. One particular interview with the Boston Museum of Science curators provided the team with exceptional insight into developing exhibits using new media and helped narrow down their choice of technology to the iPod Touch video tour.

The London Science Museum had never before tested iPod technology in exhibit interpretation and the curators directed the team to prototype several versions of the video tour in their Making the Modern World gallery. The section of the gallery that the team focused on contained objects behind glass from the 18^{th} century. Among them were children's toys, medical instruments and belongings used for leisure activities, such as musical instruments and games. The team focused on creating context for all of these objects by downloading detailed pictures from the museum's website and conducting general research about the century in order to develop storylines involving the themes of the gallery. The first prototype took the form of a PowerPoint that was presented to the visitors during consequent user testing. The context was laid out in a simple storyline about a few of the objects. Users were observed "over-the-shoulder" and later asked a few questions about their experience. Drawing from the feedback on the first prototype, called alpha prototype, the team developed a prototype beta in a form of web pages that could be viewed on the actual iPod Touch. The audience enjoyed the fact that the tour was mobile and many preferred it to other types of museum guides. The team collected and organized the final visitor's feedback and results and formed a set of recommendations for the museum to follow when developing the technology further for use in the James Watt workshop.

The next section, "3.1 Prototype Technology Selection," discusses the details of the selection process and how the team ultimately settled on an iPod video tour. Following sections provide the background of the James Watt workshop and Making the Modern World gallery. Many of the problems that this project has attempted to tackle become obvious in those chapters. Making the Modern World chapter, for example, talks about the crowded glass cases with many visually uninviting objects. The prototypes developed by the team aimed at making the objects easier to relate to by showing them in more detail on the iPod Touch and also setting the context for the era that they come from. These and other prototyping details can be found in Section 6.3, which focuses on aims for the overall prototyping process, as well as details about target audiences and visitor needs.

The chapters following methodology go into further detail about our research at the Boston MoS, our prototyping implementation, testing, and findings. The team found many similarities between the London and Boston museums of science and was able to bring fresh perspectives from the outside. The findings were considered when designing the two prototypes and evaluating their successes. For example, the Boston MoS exhibit designers have emphasized that it is important to interest the user early on and conveyed the process by which their prototypes are refined. All other important findings and aims of the project are directly reflected in the Prototype Alpha and Beta chapters. These chapters are followed by a "Conclusions and Results" chapter highlighting major findings about the overall experience of the team building an iPod multimedia guide.

3.1 Prototype Technology Selection

In this phase of the project, the team worked with the Science Museum to select the candidate interpretive technologies that would bring new perspectives on technology to the museum, while at the same time addressing visitor needs. The project team first presented the results of their background investigation to the audience research department at the Science Museum. The team evaluated many different technologies (including audio and video tours, text message bookmarking, quick response codes, multi-touch surfaces, and augmented reality). The comparison matrix that was used for their evaluation consisted of categories, such as the cost of implementation, ease of use, and effect on social interaction. The team presented the museum staff with a concise assessment of each of the potential technologies and their possible advantages and disadvantages as interpretive tools. In the end, the department was eager to pursue the iPod video tour and the augmented reality. The Science Museum had never before tested either of these technologies, and the audience researchers felt that these technologies held significant potential to improve interpretation in the Making the Modern World gallery and in the future James Watt Workshop exhibit. The project team worked with the audience research department to explore how these two technologies might supplement and enhance established forms of interpretation.

The project team planned to develop prototypes of the iPod Touch video tour and an augmented reality system and to test these prototypes with visitors. Both prototypes would contain content about the same set of objects from the Making the Modern World gallery, but each prototype would present the information in its own, unique way. The choice to test two different interpretive technologies with the same content in the same exhibit would allow the project team to juxtapose the two. This would allow for more control over the experimental factors and thus would reduce the effects of confounding the quality of the content with the intrinsic merits of the interpretive technologies.

However, after much further research and discussion, the team decided to forego testing the augmented reality in favor of dedicating more time to testing the iPod multimedia tour. It was difficult to show that the way in which the team intended to use augmented reality in the Making the Modern World Gallery would have any significant advantages over other established interpretation methods (such as touch screens). Additionally, the project team had a limited amount of time (less than seven weeks) to create the prototypes and test them. The open-source software required to implement the augmented reality appeared to require a significant amount of time and effort to develop. Closed-source software alternatives would possibly require long-term commitments with the companies that create these technologies. In the interests of time, the project team decided to pursue the iPod multimedia tour because it had a much clearer path to successful prototype implementation.

The audience research department eventually decided that they would rather pursue a single interpretive technology more deeply, rather than partially testing two different technologies. Also, the Science Museum had never tested an iPod video tour. Although iPod tours have been tested in a few museums, they have mostly been tested in art museums, which have an entirely different environment from the Science Museum (different types of exhibits, different missions, and different types of visitors with different motivations for going to the museums). The audience research department at the Science Museum believes that these types of mobile interpretation are the future for museum interpretation, and the department was therefore greatly interested in testing an iPod video tour.

For these reasons, the team decided to focus on prototyping the iPod tour extensively in more depth. We created an iPod multimedia guide in stages, iteratively testing the prototype with visitors at each stage and then refining it for the next stage and conducting more testing. For convenience when referring to the prototype, we called the first stage of testing Prototype Alpha, and the second stage of testing Prototype Beta. These tests were conducted in the Making the Modern World gallery, which acted as an effective substitute to the James Watt Workshop.

3.2 Making the Modern World

Figure 6: The Making the Modern World Gallery

The gallery is organized into four sections: Historical Themes, Icons, Models, and Technology in Everyday Life. The Historical Themes section displays “objects both curious and ordinary that illustrate changing attitudes towards science and technology." The Icons are objects which are intended to be symbolic or representative of major milestones in history and include some of the larger objects in the gallery, such as the Stephenson's Rocket steam engine or the Apollo 10 space capsule. The Models section displays scale miniatures of important machines from the past several centuries, such as trains and automobiles. Lastly, the display cases in the Technology in Everyday Life section contain various historical objects intended to show how technology has influenced daily lives. The objects in the Technology in Everyday Life cases are arranged chronologically and range anywhere from furniture to bicycles to carpentry tools to telephones.

The Science Museum conducted two summative evaluations of the Making the Modern Gallery, in 2001 and 2004. The 2004 Making the Modern World summative evaluation identified several issues and challenges. One of the major challenges is that there are many historical objects in the gallery which are obscure, monochromatic and old. Visitors do not recognize what these objects are, what their function was, how they worked, or how they might relate to contemporary objects and processes. The Technology in Everyday Life 1750-1820 display case is particularly unsuccessful. One example from the summative evaluation showed one mother, desperate to make meaning about an old chair and some carpentry tools in the case, explained to her child that "those are torture instruments and that's an early electric chair" (Science Museum, 2004, Making the Modern World Summative Evaluation Report). Visitors tend to be drawn away from the Technology of Everyday Life: 1750-1820 case and towards the display cases with more modern objects, particularly the cases containing objects from the20th century, which include colorful objects that are more recognizable and have nostalgic value for many visitors. Furthermore, the sheer number of objects in the Technology of Everyday Life case is overwhelming. The visitors tend to walk past the case because they do not know which objects to look at. The visitors need a way to sort, limit, or classify the objects so that they can begin to make meaning. However, one of the issues identified in the summative evaluation is that few visitors read the signage in the gallery so they do not understand how the gallery is arranged.

Another issue with the Making the Modern World gallery is that the 'iconic' objects in the gallery may not be as iconic to visitors as museum staff believed they would be. Visitors do not recognize some of these objects (Science Museum, 2004). Other iconic objects give the visitors incorrect impressions about the purpose of the gallery; many visitors believed the gallery was about the history transportation because many of the iconic objects are cars, steam engines, and airplanes.

The summative evaluation found that most visitors do not recognize that the gallery is organized chronologically, intended to explain the development of technology over time and how it has affected people's lives. Visitors have difficulty understanding the historical context and time period for the objects within the gallery; they have trouble relating the objects they see in the gallery with their own, prior knowledge of historical facts (Science Museum, 2004, Making the Modern World Summative Evaluation Report).

3.3 Prototype Development

The first major step in any prototype development process is to clearly define the aims and objectives for prototype development and testing. The project team worked with the audience research department at the Science Team to first define the target audiences of visitors who would be using the prototype and to then clearly identify the needs of these groups of visitors. The project team next defined clear aims and objectives for the designing the project and testing the project. The project team followed these aims and objectives in order to make sure that the iPod multimedia guide technology was developed in such a way that addressed visitor needs. In addition, since the team developed the testing to verify that the prototype met these aims and objectives, the team ensured that they maximized their time testing the prototype with visitors as efficiently and effectively as possible.

This section of the chapter defines the target audiences, audience needs, and prototyping aims that guided the team's prototyping process. These audiences, needs, and aims apply to both the Alpha and Beta iterations of the prototype testing. Later chapters of this report will describe in detail how the team took these audience needs and project aims into account as they designed Prototype Alpha and Prototype Beta.

Target Audiences

The audience research department identified the following target audiences for the iPod multimedia guide prototype testing:

- **Independent adults, ages 19-35.** Independent adults are defined as adults that do not have children with them in the museum. The term "independent" does not imply that the adult needs to be a solitary museum visitor.
- **Family groups with at least one child age 11+.** A family group is defined as a visitor group with at least one adult and at least one child.

These two audiences are major demographic groups at the museum and therefore the audience research group needs to collect data about them. Moreover, the Science Museum has selected these audiences as the main target audiences for the future James Watt Workshop exhibit. Since the Watt Workshop and the iPod multimedia guide share the same target audiences, the findings and recommendations from the prototype testing can be applied to the design of the Watt Workshop exhibit.

Visitor Needs

The mission of museums is to recognize and meet the needs of its visitors. It is essential that the needs of the visitor drive the prototyping process. As the project team selected the interpretive technology for the prototype, the team considered which technology best met visitor needs, rather than letting the choice of technology drive the process. As the team developed the prototype, the team continued to weigh visitor needs when making design decisions. The following are a few of the many visitor needs that the project team considered throughout the prototyping process:

- Visitors need “both an engaging and educational experience” (Burch 2009, p.9)
- Visitors come to museums for social reasons and therefore need a social atmosphere.
- Visitors need the content to have some structure so that they can begin to make meaning.
- Visitors need the freedom to explore.
- Visitors need context and need to see relevance to their own lives.
- Parents need support so that they can guide their children’s learning

Prototyping Aims

The overall aims of this project’s prototyping process were to:

- Identify barriers to meeting the visitor’s needs with the interpretation
    - How does the interpretive technology affect social interactions within the group?
    - How does the structure and presentation of content help the visitor to establish the context required for learning?
- Determine ways in which the new interpretation methods can address challenges in the Making the Modern World and the James Watt Workshop exhibits
- Suggest directions for further development and research

In addition, the audience research group helped the project team to identify five visitor learning outcomes that we considered on a higher level as we designed and tested the prototypes.

- Visitor will acquire knowledge about daily life in the 18th century
- Visitor will understand objects and how they were used
- Visitor will realize objects can tell interesting stories of the past
- Visitor will discover similarities and differences between the past and present day
- Visitors will have an enjoyable experience of untouchable objects

These are the high-level aims of for the entire prototyping process. The project team also defined specific aims and objectives for each iteration of the prototype. These aims and objectives can be found in sections 5.1 and 0.

Visitor Recruitment

For each version of the prototype, the project team conducted visitor research. This involved testing the prototype with visitors, performing qualitative observational studies, and asking the visitors a series of qualitative interview questions.

The project team recruited visitors from within the Making the Modern World gallery. The team was careful to recruit people in places beyond the Technology in Everyday Life display case (where the team was conducting the prototype testing). Recruiting beside the case might have introduced bias into the data by selecting people who were already inclined to look at the objects in the case.

When selecting visitors, the project team took care to stay within the defined target audiences. The team tried to be somewhat representative with the selection of test subjects, and tried to get an even mix of gender and family size. However, the team also recognized the need to reduce bias when selecting families. Therefore, as soon as the project team had decided the demographics of the next group to be recruited (for example, a family group with female children), the project team attempted to recruit the very next group to enter the gallery with those demographics. This introduced a certain amount of chance into the visitor selection process, which served to reduce some bias. The project team members concede that they sometimes had difficulty estimating the ages of certain visitors in the museum. The project team avoided groups in which the ages of children or independent adults were unclear, and therefore may have inadvertently introduced a small amount of bias in the data.

The visitor recruitment process can take a long time, and the project team sometimes had difficulties recruiting test subjects. One difficulty was that independent adults in the correct age range (19-35) who speak English and who are willing to participate were relatively rare at the museum during the time that team conducted the prototype testing. Although there was no trouble recruiting family groups during the mid-term school Easter holidays, after the holidays were over there were significantly fewer family groups with children in the required age range (at least one child 11+). During the weeks when school was in session, there were many school groups (easily identified by their green stickers), but few families. Another challenge was that the project team generally had more difficulty recruiting visitors when testing in the late afternoon because there are fewer visitors in the museum at this time, and the visitors who are in the museum generally are tired from being in the museum all day and are thus unwilling to participate. However, the project team was tenacious, and eventually collected all necessary prototype testing data.

Visitor Group Interaction and Responses

Testing the prototypes within the context of groups (either family groups or groups of independent adults) allowed the project team to observe the social interactions between the group members. In most cases, only one or two of the members from the group physically interacted with the prototype, but other members of the group would sometimes watch and offer their opinions about the prototype. The observations that the project team collected about the interactions between those members of the family using the prototype, as well as the interactions between those who used the prototype and those who did not use it, provide valuable insight about the way the interpretive technology affects social interactions. Moreover, during the interview question session, many of the members in the group would often contribute their thoughts to the discussion. Even if only a single person answered the questions, it generally reflected the collective thoughts of the group.

The Science Museum aims to promote learning between groups and within groups (i.e. inter-group interactions, intra-group interactions, and inter-generational interactions). Data about the behavior of visitor groups with regard to the new interpretive technology is therefore extremely valuable to the museum.

4 Boston Museum of Science Exhibit Interpretation

Deciding which technology would be best suited for the London Science Museum's James Watt and Making the Modern World exhibit and determining how to develop the storyline proved crucial to the development of the project. The IQP team turned to the Boston Museum of Science, which is famous for its interactive exhibits, to learn more about choosing a technology and prototyping it. A member of the team met with three museum representatives: Suzanne Berryman (a Program Manager of Interpretation), Edward Rodley (an Exhibit Developer in Content Development), and Daniel Noren (Program Manager in Cahners ComputerPlace). A short summary of the IQP intent and progress was given to the curators in a form of a PowerPoint presentation. The team had originally planned to gather information in a form of a formal interview and specific questions were handed out to the interviewees for reference; however, the interview soon turned into a general discussion of the topics covered by these original questions. The intent of the meeting was to find out about successful implementations of technology at the Boston MoS, the curators' experiences with developing storylines and prototypes, and, finally, their take on interpretation of older objects. The member of the IQP team led the conversation with additional inquiries about areas of interest. .

4.1 Augmented Reality

The Boston Museum of Science curators answered a lot of the team's questions regarding designing and prototyping successful exhibits. In particular, they had discussed at length the use of Augmented Reality in "Building Communities Augmented Reality Interactive" at the Star Wars display. The exhibit was at the time in another museum in Australia and could not be viewed in person. However, Edward Rodley, explained how Augmented Reality was developed and even showed some of the cardboard cards that were used as part of interaction. The discussion about a successful implementation of AR helped the team understand what kind of exhibits the technology would best be suited for and resulted in the decision against prototyping AR at the London Science Museum.

Figure 7: A visitor at the Boston MoS AR exhibit[5]

The Star Wars exhibition consists of several black and white cards with symbols, a table, camera, and a video screen. The symbols represent different natural resources or objects, such as a forest or a power generator. They have a double function of allowing visitors to distinguish between the cards and presenting a particular pattern of light and dark to the computer, which has been programmed to recognize it. Each pattern corresponds to a virtual model of a structure. Visitors place cards on a table-the physical landscape-and a computer superimposes a building on a site in virtual reality and real time. The exhibit allows visitors to combine computer graphics with the ease of use of a real object they can hold. It's designed to teach people about trade-offs in resource usage. All of the objects in this virtual reality interact to show exactly how those trade-offs work. For example: when a user places a power generator somewhere on the map, the area in its circumference lights up. If a user wants to give the community a lot of space to live in and thus excludes a trash dumping area, everything soon covers with filth.

When asked about the types of exhibits that AR would be most suitable for, the exhibit developer, Edward Rodely, talked at length about the following points:

- The technology should be used in order to make exhibit interaction more intuitive. In the case of the Star Wars exhibit moving physical cards around on the table is much more intuitive than navigating a 3-D space using controls on a screen. Users learn the technology very quickly,

[5] http://hungryspoon.com/IMG_1502.jpg

meaning that most of them will be able to figure out how to navigate the exhibit without a problem.

- When used for a single object, as opposed to several objects interacting with each other, AR should serve the following functions: fill in the missing pieces of the object or show the functionality of the object. In case of a broken vase, AR may be used to show the object as a whole, filling in the empty spaces with digital drawings to recreate the original. When showing a steam engine or a tool the AR may be used to show their functionalities by recreating motion in 3-D space.

- AR can actually distract visitors from the artifact. When Leonardo Da Vinci's sketchbook was shown at the American Museum of Natural History, users paid more attention to the virtual representation of the pages, than the original behind the glass case. In the end, the museum's study found that visitors learned almost nothing about the contents of the notebook.

The lesson to be learned from these points is that AR technology works well in places where it can add value to the already displayed object. However, it should not be used for the purpose of simply reproducing the actual object in 3-D space if doing so produces little educational value. From talking to the Boston MoS representatives, it can be judged that this applies to most forms of technology in their exhibits. However, an example in the same museum shows how a technology may be used differently. Daniel Noren of the Cahners ComputerPlace talked about a three year project of implementing a hologram tour guide. Although the exhibit employs human tour guides at the moment and all of the information that will be related by the hologram is already implemented in one form or another in the exhibit's displays, a hologram will be used to attract visitors to ask questions and also simply spend more time at this particular exhibit. Ultimately, the underlying goals of using a particular technology determine what kind of value it should deliver.

4.2 Exhibit Design Process

The team asked the curators at the Boston Science Museum about their experiences with creating exhibits from scratch. The IQP team posed a series of questions, including how the curators chose a particular technology for an exhibit and how they further determined the success of a prototype. Edward Rodely explained that the idea for a particular technology can be sparked at random. "It may be something you see on the news or hear about from other museums." What happens usually is that someone has an idea and the whole exhibit is developed from there. The idea and technology seem to go hand-in-hand. An existing idea may linger without being developed for a long time before it finds a corresponding technology. The exhibit designers, in fact, may spend a long time searching for an appropriate tool. In other cases, developers have a pool of both different technologies and ideas that are just waiting to be matched up. What may be seen from the experiences of the Boston MoS is that the idea always comes first, but the specific goals of the project make it fairly clear what type of technology should be used.

Once the goal for an exhibit is established, the brainstorming session begins. There is a whole department for Storytelling at the Boston Science Museum. Designers and "storytellers" come together to find the best way to represent the information in an exhibit. The big idea scope is gradually narrowed down to a storyline. There is usually a limited number of options, given that the creators have thought out exactly what they want to say to the visitor and how they want to say it. The storyline is a natural outcome of their brainstorming. Prototyping and user testing start when exhibit creators display a mock-up of their idea and facilitate the interaction of the audience with the display. This takes the most time and effort during the entire exhibit design. At first the creators explain the purpose of the exhibit and try to interest the visitor. "If you can't spark an interest or get people to understand what's going on even with a person standing next to them and telling them what to do, then the exhibit is not worth developing," says Edward Rodely. Given that the visitors are intrigued, the exhibit creators try to get the display to stand on its own, so that the visitor can navigate without any outside help. In cases where the visitors are still having trouble navigating the exhibit and there seems to be no way to improve it relatively soon, the development hits a plateau and the project, after eventually running out of time and money, is shut down. The more successful prototypes end up in the exhibit rooms as stand-alone displays that draw many visitors. (Berryman, 2009).

The complete responses to the interview questions can be found in "Appendix C: Interview at the Boston Museum of Science."

5 Prototype Alpha

Prototype Alpha was the first iteration of prototype testing for the iPod multimedia guide. The goal of this first prototype was to test the *usability* of the iPod guide. Although the project team was still in the early stages of designing content for the guide, the team wanted to begin to assess the techniques used to present it. The team needed to collect visitor data as soon as possible in order to identify any major barriers with the user interface and the structure of the content so that the team would have time to adapt the design of the content for subsequent iterations of the prototype.

Prototype Alpha consisted of a Microsoft PowerPoint presentation with each slide designed to be a mock-up of an iPod touch screen. Each slide had buttons which were hyperlinked to other slides. The user could thus navigate through the slides by clicking on the buttons using the mouse, similar to how the user would navigate through the screens by tapping on the screen of the iPod Touch. Figure 8 presents a few of the many screens from this PowerPoint Presentation. For the complete set of screen images, please refer to "Appendix D: Prototype Alpha Content."

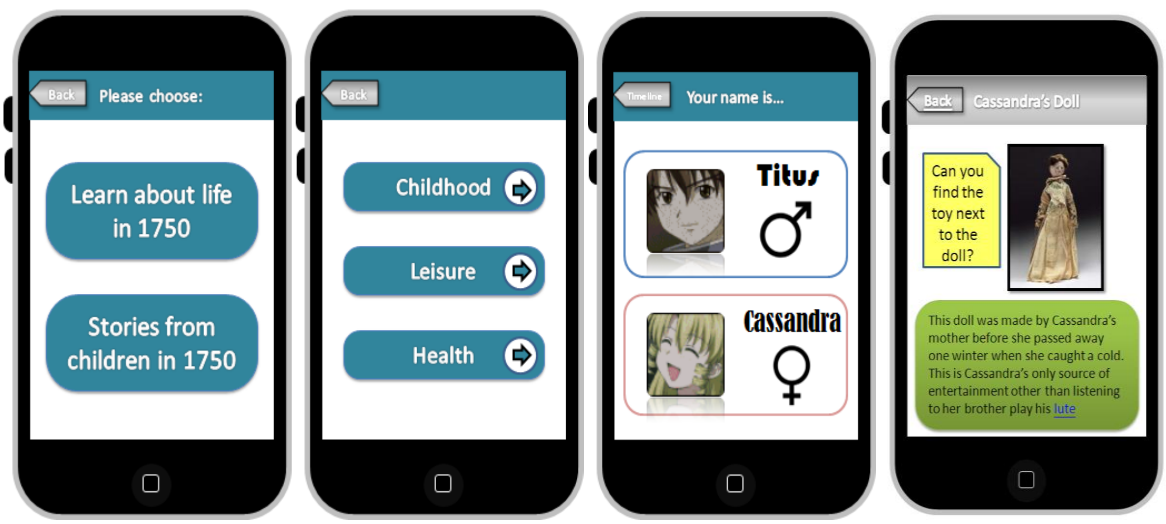

Figure 8: Sample Screens from Prototype Alpha

This chapter explains how the project team designed, implemented, and tested Prototype Alpha. This chapter also presents the key findings from the testing. Many of these findings influenced design choices for the second iteration of the prototype.

5.1 Prototype Alpha Aims and Objectives

Although the main goals of Prototype Alpha were to test the general usability of the guide, the project team also decided to begin testing techniques for engaging the visitor and establishing context, such as the use of a story mode, or the use of a hierarchy of themes to organize the objects. The project team defined the following set aims and objectives specific to Prototype Alpha:

- Usability
  - Did visitors understand what they could do on each page, or were further instructions needed? At each decision point, did the user know what to do next?
  - Was the structure of the entire prototype well-presented? Was it easy to navigate between sections and through linear parts? Were visitors easily able to access further information on topics that interested them?
  - What was the learning curve? Which types of visitors were most comfortable with the technology and format?
- Motivation
  - Did the guide motivate the user to look more closely at the objects in the case?
  - Did the story mode engage the visitor?
  - Did the organization of objects using a hierarchy of themes help visitor to better understand the objects?
  - Did the timeline help the visitor to understand object's place in history?

In order to design Prototype Alpha in a reasonable amount of time, the project team needed to limit the number of things that the Prototype Alpha would actually test. Subsequent iterations of the prototype allowed the project team to test other aspects of the iPod Multimedia Guide. The following is a partial list of some of the things that Prototype Alpha was **not** capable of testing:

- Learning
  - Because of the lack of adequately informative content in the guide, visitor learning could not be tested. However, the testing was conducted in such a way as to determine whether or not the visitors *wanted* to learn.

- Social interaction
  - The prototype was not similar enough to a real iPod to test the social behaviors that would normally develop. For example, an entire family can gather around a laptop screen, but the screen on an iPod is too small for many people to view at once.
- Mobility
  - Prototype Alpha was located in a fixed position on a trolley in front of the Technology in Everyday Life, 1750-1820 display case. Thus, the prototype could not test the ability of the visitor to navigate throughout the entire Making the Modern World gallery and to see the connections between the objects throughout the gallery.
- Wayfinding and Object Location
  - This version of the prototype had no features that would allow the visitor to quickly determine where the objects were located within the display case.
- Multimedia content
  - Prototype Alpha had only text and pictures, no audio content, and an extremely limited amount of video content (i.e., just one short animation of the Scarificator).

5.2 Content Design

A major part of the prototype design process was developing the content for the prototype. The project team was responsible for creating all aspects of the content, from selecting the objects to include in the prototype, to researching stories and interesting facts about the objects and the time period, to deciding how to organize and present the objects, to finally implementing the content in the guide. We created all of the content on our own because the audience research department wanted to see what new perspectives 'outsiders' would bring to the problem. In addition, it was necessary to create content on our own because even the curators of the exhibits did not have many interesting stories about the objects in the Making the Modern World: Technology in Everyday Life 1750-1820 display case. We constantly referred back to the visitor needs throughout the content design process. As we know from the literature in the Background section and from our discussions with the audience research department, visitors need to see context and relevance to learn and make meaning. In order to engage the visitor, we used techniques such as creating stories of about real people and creating parallels between the 18th century and today. Burch (2009, p.9) refers to such techniques as "routes to engagement" and states that a few of the "effective routes in to potentially difficult and dull content include personal relevance, moral and ethical dimensions, and social-cultural impacts." Working with Dr.

Burch, Dr. Teixeira, and other members of the audience research department, we identified these techniques and other techniques to help the visitor to engage with the objects featured in the guide.

We first selected about ten objects to interpret from the Technology in Everyday Life 1750-1820 display case. There are a staggering number of seemingly unrelated objects in the case, so we selected themes related to daily life and we selected objects to fit into these themes. Due to time constraints, we did not have time to add all ten selected objects to Prototype Alpha (we later included more of the objects from this list in Prototype Beta). We next performed some basic research about the objects and the time period, using the Science Museum's Making the Modern World website and Wikipedia. Since the purpose of prototyping was to assess the structure and presentation of the information, the content did not need to be elaborate or even entirely historically correct. (In fact, most visitors to the museum are non-specialist; therefore, relatively limited information about the objects satisfies most visitors.) There simply needed to be enough information to keep the visitor engaged and thereby test the guide.

We created two modes of presenting the content (theme and story mode), and tested the reception of each.

Theme mode

The theme mode used a hierarchical structure of themes to organize the objects. We selected the objects according to three main themes related to daily life in the 18th century: leisure, childhood, and health. We used these themes to draw parallels between 18th century life and the present day, highlighting similarities and differences, in order to help the visitor establish context about the time period. The use of themes gave the visitor the necessary structure and order to begin to make sense of the objects in the case and in the time period. This mode provided a mechanism for "filtering" the objects and presenting only a few of the most compelling objects so that the visitors could learn without becoming overwhelmed in the short amount of time that they have to spend in the gallery. As discussed in Chapter 2, there is a delicate balance between structured and free-choice learning. However, without some structure, the visitor could get lost in a sea of monochromatic, unrecognizable objects.

Story mode

This mode presented a story from the viewpoint of a fictional child living in the 18th century. The mode consisted of a linear sequence of screens with images and text containing dialog between the fictional characters in the guide. At certain points in the story, the visitor had the opportunity to take a detour from the sequence to find out more about objects mentioned in the story. After the visitor is done viewing the object pages in the guide (and presumably also the corresponding real objects in the display case), the guide resumes the story mode and continues the story.

As previously mentioned, stories can be an effective tool to engage visitors, especially stories that involve about real people. The story mode is designed with the intent that the visitor will form an empathic connection with the characters in the story, and thus become more motivated to look more closely at the objects. (We later discovered through visitor testing that the pictures of cartoon characters in Prototype Alpha were not compelling enough; visitors wanted to see photographs of real people instead.)

In the story mode of the guide, the user is presented with the choice of selecting to hear the story of either Titus or Cassandra. The concept of creating parallel storylines for two characters was inspired by an interactive activity on the PDA guide at the Tate Modern. We visited the Tate Gallery on 25 March 2009 and saw that the PDA guide had a few interactivities as part of the tour. For one of the paintings, the guide presented two viewpoints and encouraged pairs of visitors to have each person listen to a different viewpoint and then discuss. We hypothesized that this technique may effectively promote engagement and social interaction between visitors, so we designed a similar activity for our guide. Our intention was to have two people in a visitor group each select different characters. After each person finished going through the respective stories, the two visitors could share their thoughts about the daily lives of the characters in the stories. Unfortunately, we ran out of time to develop a story for the character Cassandra, so we were unable to test if our idea is effective. We suggest this as an area for future study.

Techniques for Engagement

The visitor learning outcomes that we defined for the prototype (Prototyping Aims) aim to give the visitor a better appreciation of what daily life was like in the 18th century. In order to accomplish this, it is necessary to give the visitor the appropriate context for the time period. The welcome screen at the beginning of the guide gives the user a general orientation to the time period by comparing it with present day; the screen states that there was “No electricity, No internet, and No Tesco Express” in the 18th century. We also created a timeline in the prototype in order to present the visitor with a few interesting facts about the time period. Our source of inspiration for the timeline was a timeline that curator Ben Russell created for the James Watt Workshop front-end evaluation. The Watt Workshop timeline contained a liberal use of pictures and a minimal use of text, and the evaluation found that visitors responded positively to it. Due to time constraints, we were not able to pursue the timeline idea as deeply as we wanted, but we believe it is something that deserves future investigation.

Other techniques that we explored in the prototype in attempt to engage visitors included:

Simple format for object pages. These pages contain minimal text and often ask thought provoking questions to encourage the visitor to think. The inspiration for this format of object interpretation came from the highly effective object cards that curator Ben Russell designed for the James Watt Workshop Front-end Evaluation.

Explaining how something works. We were curious to test if explaining how an object really worked is an effective means of engaging visitors. We also wanted to determine if a video showing a 3-D animated model of the objects was an effective way to communicate this. We therefore created an animation showing a view of the moving parts within a scarificator. The scarificator in the display case has an interesting name, but no information on the label. Without this interpretation, visitors are unable to understand the purpose of such a small, square metal box and would likely walk right past it.

Asking questions to encourage "detective work". According to the James Watt Workshop curator Ben Russell, visitors love the opportunity to do "detective work" (personal communication, 20 March 2009). We designed the guide to ask a few somewhat open-ended questions about the objects in the case, hoping that this would prompt the user to think more about the objects. We also included a few simpler questions that asked the user if they could find the objects in the case, hoping that this type of "I spy" activity would encourage the user to look more closely at the real objects, rather than only at the guide itself.

Please refer to "Appendix D: Prototype Alpha Content" for images of all of the screens in Prototype Alpha, as well as a description of how the screens were hyperlinked together.

5.3 Visitor Testing

The project team conducted prototype testing in the Making the Modern World Gallery in front of the Technology in Everyday Life display case. The team set up a trolley in front of the center of the display case and set up a laptop on the case, as shown in Figure 9. For a map of this gallery, please refer to "Appendix G: Map of the Making the Modern World Gallery."

Figure 9: Prototyping in front of the Technology in Everyday Life 1750-1820 case

The project team conducted the prototype testing using the accompanied visit model, in which the team allowed the visitor to interact with the prototype unaided and offered limited guidance if the visitor encountered problems. The project team first recruited a visitor group for testing (please see "Target Audiences" for more information about recruitment procedures) and then brought the group over to the laptop in front of the Technology in Everyday Life display case. The team then asked the visitors to indicate their choices by pointing at the screen. A member of the project team used the mouse to register the user's decisions on the computer. The initial pilot testing quickly ruled out the visitor using the mouse since mouse clicks on blank areas of the screen caused the PowerPoint to progress where it should theoretically have done nothing on a real iPod Touch. There were also the benefits of having the visitor mimic interaction with a touch interface and it permitted the project team to ask questions between screens.

The project team encouraged the visitor to share his or her thoughts about each screen aloud and posed questions to elicit more information as necessary. The team took notes on an observation sheet about the route the visitor took through the prototype and their reactions along each step of the way. Please refer to "Appendix E: Prototype Alpha Questionnaire" for the prototype observation sheet (first page of the questionnaire sheet), which contains key behaviors to look for, questions to ask the visitor as they interact with the prototype, and space to jot down observations. The team placed a small reference number in the lower right-hand corner of each of the screens. This allowed the team to easily refer to specific screens when recording the corresponding visitor behaviors on the observation sheet.

Since the project team was interested in testing the usability of the guide, the team allowed the visitors to navigate through the prototype freely, without interference and without forcing the visitors to follow any particular route. If the user became confused or stuck, the team noted the problem on the observation sheet and then helped the visitor to move to the next part.

The project team allowed the visitor group to use the guide until the visitors decided that they were finished. The team did not force the visitor group to explore all available paths on the device due to time constraints. In addition, the team wanted to test the users' motivation and ability to navigate to things that interested them.

The project team then asked the group a set of open-ended questions aimed to obtain the visitor's impressions of the guide and to identify any obstacles and barriers that the visitors encountered while using the guide. The questionnaire also included a few questions to determine the visitor's overall experience and comfort with technology, particularly mobile devices. The project team had designed the questionnaire to test the aims and objectives of Prototype Alpha. The team improved the questionnaire under the guidance of the audience research group, drawing upon the experience and expertise of Dr. Teresa Teixeira, audience researcher at the Science Museum. The project team also performed several rounds of pilot testing in order to further refine the questionnaire, as well as to resolve any bugs and issues with the PowerPoint presentation. The final version of the questionnaire that the team used in the Prototype Alpha testing is provided in "Appendix E: Prototype Alpha Questionnaire."

5.4 Data Collection and Analysis

The project team collected data from testing Prototype Alpha with a total of eight family groups and six independent adult groups. The team had intended to collect a total of eight independent adult groups, rather than six, but there were very few willing, English-speaking, independent adults within the 19-35 age range in the Making the Modern World gallery on the testing days, and the team ran out of time to perform the final two independent adult interviews. However, six independent adult groups were sufficient to identify the major usability issues with the prototype.

The team entered the qualitative observations and responses to the qualitative questions in a large table in order to easily identify trends and common visitor responses. Analyzing the qualitative data, the team created identified common barriers to learning throughout the visitor responses and examined which aspects of the guide's structure worked well and which did not work well. Please refer to the "Findings" section (0) below for a summary of the key findings.

The qualitative observations and responses are the most important types of data that the team obtained through the prototype testing process. However, the team also briefly looked at the quantitative data in order to identify any major trends in the visitor demographics. The team entered the quantitative responses (such as the ownership rates of electronic devices and demographic data) into a spreadsheet and graphed the data for easy viewing.

Figure 10 shows that mobile phones were the most common type of mobile device that visitors owned; at least one person from each of the fourteen visitor groups that the team interviewed owned a mobile phone. More than half of the visitor groups owned some sort of personal music player (either an iPod or some other type of mp3 player).

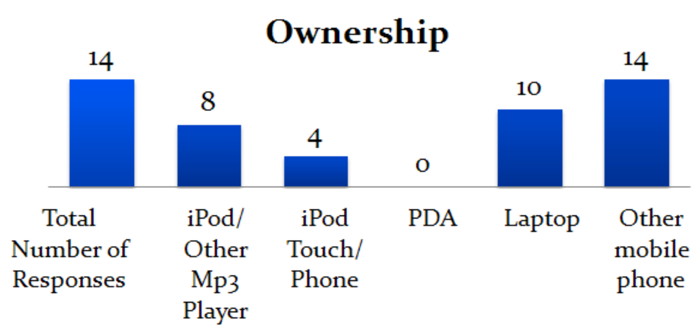

Figure 10: Numbers of visitor groups with various types of technology

Figure 11 shows the relative numbers of males and females who participated in the visitor testing. Out of the eight family groups and six independent adult groups, a total of twenty-one people participated in the visitor testing. Even though the project team wanted to divide the testing somewhat evenly by gender, the graph shows that two thirds of the visitors involved in the testing were male and one third of was female. In part, this is due to the availability of people for testing in the gallery on those days. For example, there were many solitary, independent adult males in the gallery that the team recruited for testing.

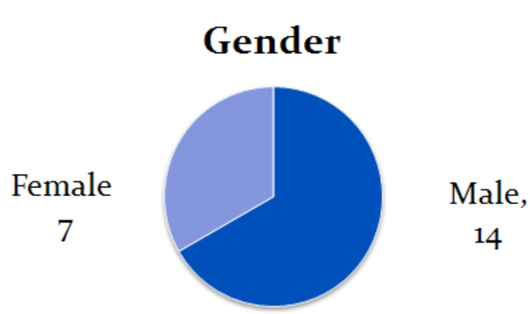

Figure 11: Gender split of all participants of prototype Alpha testing

Figure 12 presents the distribution of ages of all the visitors that participated in the testing. The graph indicates that many of the participants were children. The chart also shows that most of the independent adults that participated in the testing were from the younger end of the 19-35 age range; of the visitors who participated, only one of the visitors was in the age range 26-35, while six were within the range 19-25.

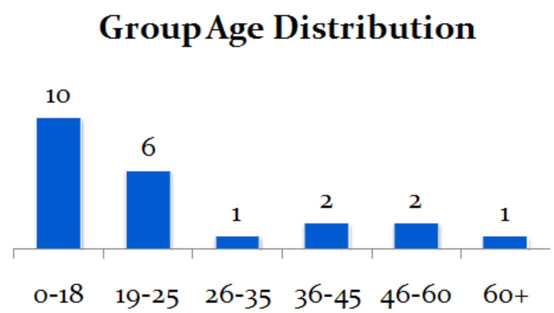

Figure 12: Distribution of ages out of all the people who participated in the testing

Figure 13 shows the age distribution of the users who actually controlled the interaction with the prototype (i.e., pointing to the screen and indicating where they would like to go next). This data indicates that the adults in family groups let the children interact with the screen. The independent adults also appear as a substantial portion of the chart because independent adults represent a substantial amount of the total interaction with the prototype. Notice that there are fifteen data points on this graph, but only fourteen visitor groups; this is the case because there was a visitor group in which two people spent equal amounts of time interacting with the prototype.

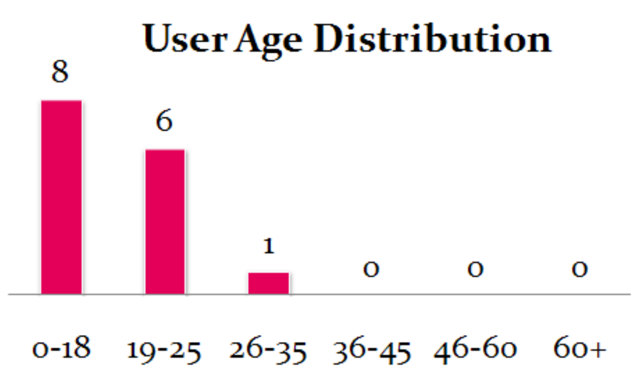

Figure 13: Distribution of ages of the individuals who actually controlled the interaction

5.5 Findings

In general, most visitors were positive about the idea of having such an iPod guide, but the content and presentation needed much further development. The following is a list of findings from the Prototype Alpha visitor testing:

Free-choice learning

Many visitors liked the fact that this guide offered the ability to present more information about the objects in an interactive way and gave the freedom and flexibility to skip to the things that interested them at their own pace.

> *"[The guide] takes you through… easy to use, and skip through to the parts you're interested in…"* – Male, age 15, part of a family group

Visitors also felt that the guide would be helpful to classify objects and pick out the important ones. Several groups (3 of the 14) stated that the guide was useful because it drew their interest to just a few objects out of the overwhelming number of objects in the case.

> *"[The guide] would help to classify objects. There's [sic] many objects in case… difficult to get it all… the computer points out specific ones…"* – Male, age 20, independent adult
>
> "*Case is so full of stuff, to have something to draw attention to just one object makes it easier to look at*" – Female, age 23, independent adult group

Content

More visitors decided to pursue the "Learn about life in 1750" option first, rather than selecting the "Stories from children in 1750" option first. Reasons for selecting the "Life in 1750" choice first included: curiosity about life in 1750, belief that it contained more content, and ordering of the choice. On the other hand, independent adults who chose the "Stories from children" replied that they wanted to learn more about childhood. Children in family groups who chose the same option wanted to learn about what lives of children in 1750 might have been like. Many visitors saw value in the idea of having stories. Visitors felt that stories were a good medium to convey information and made the objects more "real" by connecting them with people. Of the visitors that tried the story mode, several visitors commented that the cartoon characters should be replaced with photographs of real people. One independent adult male commented that "the characters weren't interesting." A father from a family group commented that the storyline was not engaging enough and that the stories should be more compelling. Those who learned about the scarificator through the scenario mode before testing the story mode were able to understand the joke in the story mode. Those who did not see the scarificator first did not understand the joke. This suggests that the content must be carefully planned so that it makes sense to the visitor without relying on the visitor to select things in a certain order.

Guide-to-Object Relationship

All of the visitor groups realized that the guide was intended to give more information about objects in the case. However, 5 of the 14 groups commented that the connection between the guide and the case could be improved. Three of the 14 groups commented that it was important to be able to see the real objects in the display case.

Visitors had problems locating objects shown in the guide in the glass display case. The team found that spatial orientation of the objects in the picture had to be the same if not similar to those in the display case. For example, visitors had difficulties associating the doll that was upright in the picture with the doll that was lying down in the case. Furthermore, when asked to "find the object," some visitors tried to find the object in the picture on the screen, rather than in the case. This suggests that care must be taken when designing instructions. This finding corroborates Gammon (1999)—visitors take things very literally. One visitor suggested a solution of having a map or a picture of the display case might help to locate the objects within in the case. At least 4 of the 14 groups wanted a feature that would allow them to enter the number of an object that they were interested in and then bring them directly to a page with information about that object. The visitors felt that this would make it easier to learn about specific objects in the case. A few visitor groups commented that such feature was something they were already familiar and comfortable with from taking traditional audio guides at other museums.

Navigation through screens in the guide

Nearly all visitor groups found the guide simple and easy to use, aside from a few issues such as navigation during the story mode or on the timeline.

Four of the fourteen visitor groups (about 30% of the groups) found the "Go" button on the timeline confusing. Visitors expected to click on the dates or arrows of the timeline, and did not understand what the "Go" button would do. Most visitors felt that events on a timeline should ideally be clickable in order to get more information about them. At the same time, it was not always apparent that clicking on the dots on the timeline screen would produce this result. The placement of timeline within the story mode confused visitors. It was not apparent to visitors that the timeline was intended to provide background information about the time period in which the character lived.

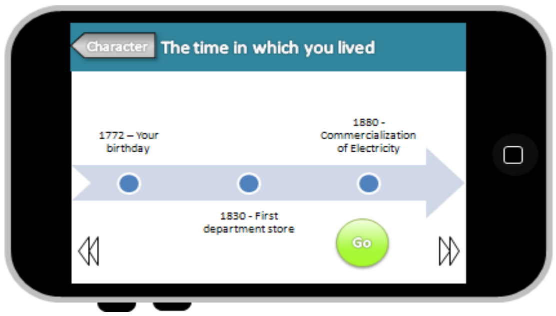

Figure 14: Timeline Screen

The “Welcome” screen needed to be modified. Several visitors commented about the taglines “No Internet”, “No Electricity”, or “No Tesco Express” back in the 1700’s, but many were confused about the purpose of this page. This was supposed to be a splash screen that would only be on for several seconds, but stayed up until the visitors clicked though. This caused several visitors to click on these headings.

Navigation in the story mode was not clear to the visitors. Again, some visitors were confused about the purpose of the “go” button. Other visitors wanted to jump to the menu when in the middle of the story sequence. A couple visitors even tried clicking on the speech bubbles.

Motivation

Visitors skipped over certain categories and item pages because they assumed that the content on those pages would not have been interesting or because they did not have a clear idea about what content those pages would contain. For example, 2/14 groups explicitly stated that the reason they skipped the “doll” page was that they thought it would be “boring.” Several other visitor groups stated they were not interested in learning about categories such as “Childhood” or objects such as the chair.

Most visitors choose the character (Titus/Cassandra) that was of their gender. Others chose the gender of the person with them (wife, daughter). Several visitors were confused about which cartoon character was male and which was female.

Group Interaction

In all 8 of the tests with the family groups, the parents allowed their children to be the ones who controlled the guide. However, the parents continued to be quite involved. Most of the parents helped their younger children to understand the content.

Visitor Perceptions

Visitor responses indicated that most visitors believed that the guide was suitable for them (i.e., for people of their age range or technical ability). 7 out of the 8 family groups believed that the guide was suitable for at least one of the members in their group. 5 of the 6 independent adult groups felt the guide was intended for themselves.

The next section of the report discusses how the project team took these findings into consideration in the design of Prototype Beta.

6 Prototype Beta

This chapter describes how the project team took the results of the Prototype Alpha testing and developed the next iteration of the prototype, Prototype Beta. In addition to explaining Prototype Beta's major features and design decisions, this chapter also describes the methods that the team used to test prototype Beta with visitors. A separate chapter, "Conclusions and Recommendations", has been dedicated to presenting the findings of Prototype Beta and the overall project conclusions and recommendations.

6.1 Overview of Prototype Beta

Prototype Beta consists of a set of web pages which are optimized to be viewed on an iPod Touch. The pages include content ranging from text about the history of an object, to videos showing the inner workings of the piece. The content can be accessed through any one of three modes:

- **Themes**: This mode asks the visitor what he or she would most like to learn about. With topics phrased in the form of questions, theme mode effectively piques visitor curiosity. (See Figure 15)
- **Story** – Follow a young boy named Edward through an average day in 1750, and learn about the objects he interacts with.
- **Object Look-up** – Using maps, panoramic images, and item number inputs/lists, this mode allows visitors to quickly find the specific items they are interested in. (See Figure 16)

Figure 16: A panoramic image from Prototype Beta's Object Look-up Mode

Figure 15: A screen from Prototype Beta's Theme Mode

In addition, the content of the guide includes documentary-type videos, in which an Explainer – a member of the Science Museum's troupe of expert tour guides – discusses the items in the guide, as well as adding a touch of wit and personality (see Figure 17). The content of the guide is further enhanced through selections of music, art, and cartography, which helps reveal more about the object's story, and put everything to perspective for the viewer. Finally, the guide includes a preliminary introduction to the iPod Touch, labeled "How to Use this Guide." It covers a few elements of iPod usage, including volume control, zooming in and out and screen rotation.

Figure 17: An example of an Explainer Video

6.2 Aims and Objectives

Because Prototype Beta is an actual iPod Touch-based guide, the team was able to test many features that can only be evaluated in this form. Some of the specific aims that the group tested include:

- Engagement – As the goal of the guide is to encourage the visitor to look 'more closely' at the objects, it is important to discover whether or not the guide acts as a supplement or a replacement for the artifacts. One way to test this is to note whether the visitors use physically move to the objects they are exploring in the guide.

- Style, Layout, and Structure – Does the layout and structure of the guide – both our design and the iPod standard – lead to easy, seamless navigation of the content? Does the overall structure of the guide promote learning and interest?

- Depth of Information – How much information do visitors want? Compared to that, is there to much/too little information in the guide? Is the information too easy or too difficult for the average visitor?

In addition, because the guide is on its final platform (the iPod Touch), the group can determine what impact the technology has on the engagement of the guide. This allows us to make conclusive recommendations to the museum, without having to take into account the fact that the prototype is not the "real thing."

6.3 Methodology

In testing Prototype Beta, our methodology was very similar to what it was whilst testing Alpha. Our target audience was identical, and our observation model was nearly so, with a few exceptions, which are outlined in the following section:

Observation model

The team continued to use the model of accompanied visits, which worked well in testing Prototype Alpha. We did, however, adapt the model slightly to better correspond with the evolved prototype. For example, when testing Prototype Alpha, the team took an 'over-the-shoulder' approach to observations, meaning that we could observe the visitors' actions on the screen of the device. This time around, however, observations were conducted from a distance. In contrast with the Alpha prototype, we were less concerned about the usability of the device, and more focused on the visitors' interaction with their environment. To emphasize this, our observation sheets included a map of the Making the Modern World gallery (see Figure 18). This map, combined with our written observations, gave us a better understanding of the visitor's mindset as they use the guide.

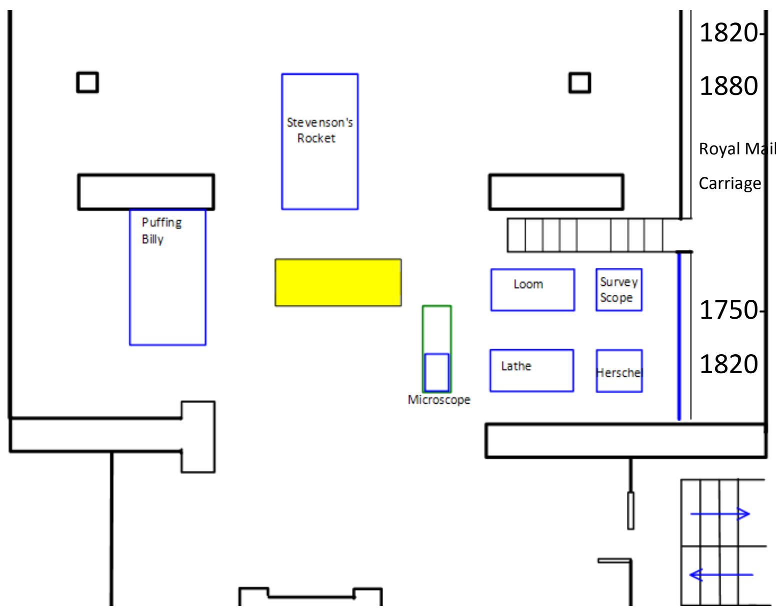

Figure 18: Map used to track visitor movement

In addition, the observation sheets include notes to the testers about behaviors and actions to look for, as well as demographic information, such as group type, age, gender, an iPod ownership and familiarity. The last demographic is collected so that data on ease of use can be interpreted more accurately. Please see "Appendix F: Prototype Beta Questionnaire" for the complete observation sheet.

Questionnaire

Some of the data we would have lost in the adapted observation model is reclaimed in the questionnaire, which was more thorough than in the previous testing cycle. For example, instead of noting every aspect of visitor behavior on the observation sheets, the first inquiry on the questionnaire was "How did you use the iPod Guide?" This question not only informed the team of the visitor's actions, but also highlights those experiences which the user felt were more important. Many of the subsequent questions asked the visitor what he/she liked most and least about certain aspects of the guide, such as mode, object, and overall experience. Other questions gauged the visitor's opinion of the style land layout of the content in the guide, probing into the individual types (i.e. video, text, images, etc).

One of the questions – "Who do you think an iPod guide like this is best suited for?" – is particularly subtle since it asks the visitors whether or not they like the guide, without any biasing pressure. If the visitor says that the guide is best suited for a person like themselves (such as in age or technology level), then they liked the prototype. However, if the visitor believes that the guide is better left for "the younger generation" or "the more tech-savvy crowd," then we will know that there were some barriers to use during the test. Please see "Appendix F: Prototype Beta Questionnaire" for the complete questionnaire.

Data Collection

Fifteen interviews were conducted for Prototype Beta. In total, twenty-seven visitors used the guide. The observations and responses to the questionnaires were coded to answer a number of important questions. This coding provided insight into the guide's impact on social interaction and visitor engagement, as well as their feelings towards most aspects of the guide.

The figures below summarize the demographic profile of the visitors that tested Prototype Beta. Prototype Beta was tested with eight family groups and seven independent adult groups (Figure 20). The latter group included six couples and one individual.

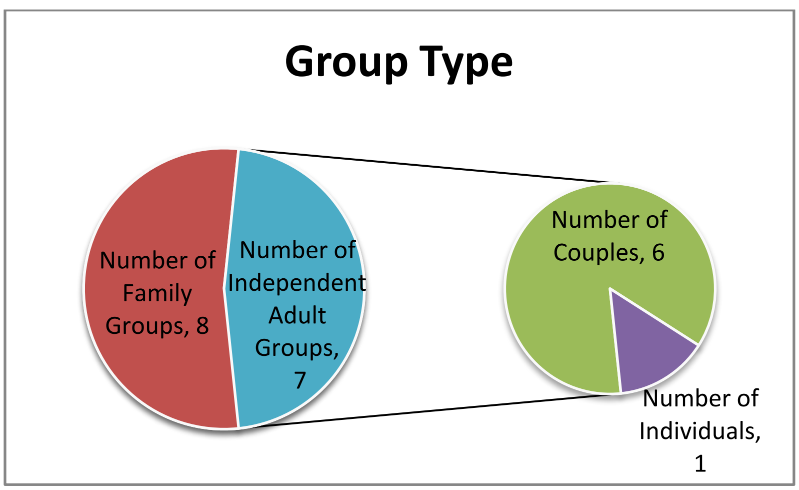

Figure 19: Chart outlining breakdown of group types during prototype testing

Figure 20 shows the distribution of ages of all the user of Prototype Beta. The mode age was between 11 and 18 years, which accounts for the children tested as part of family groups. The next most common age was 19-25, which includes most independent adults surveyed. The remaining ages include a few independent adults, but consist mostly of parents and other kin from family groups.

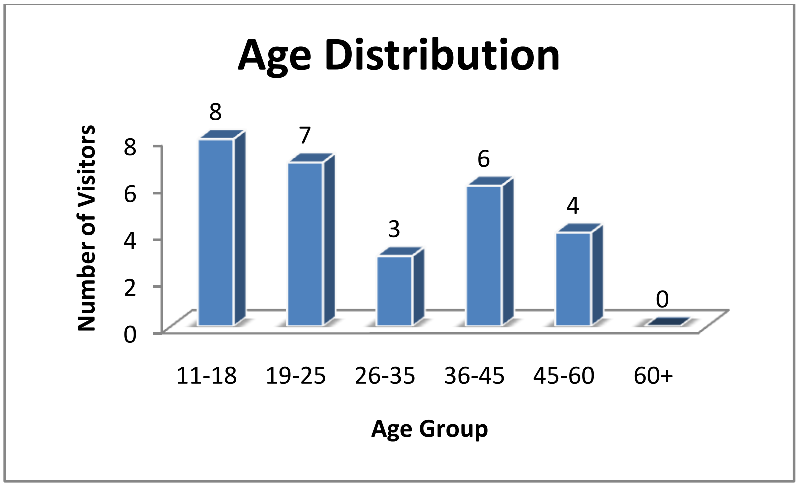

Figure 20: Age distribution among Prototype Beta testers

Figure 21 demonstrates a significant gender bias in the prototype testing. There is a two-to-one ratio of males to females in the data. Most of the females tested were part of couples, with another few being mothers or elder relatives in family groups, as almost no female children of the correct age for our target audience could be found.

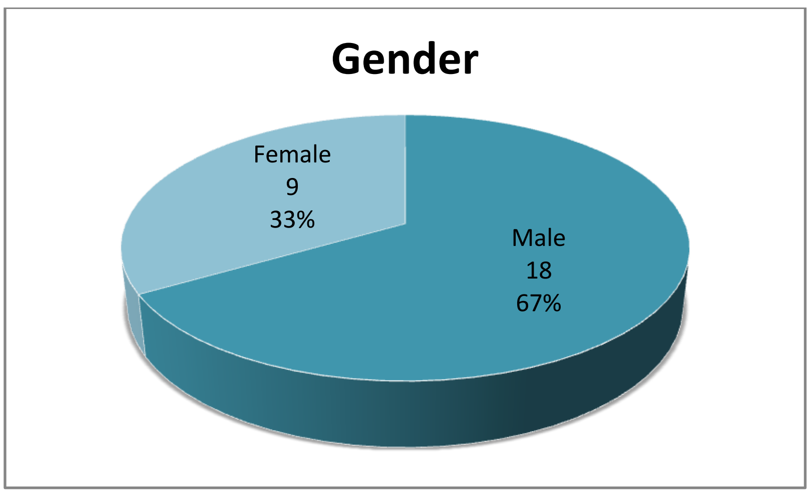

Figure 21: Gender Bias in Prototype Beta testing

Finally, Figure 22 displays data taken pertaining to ownership and familiarity of the devices in question: the iPod Touch and iPhone. While around two-thirds of visitors surveyed were familiar with the devices, only about one-fifth owned them.

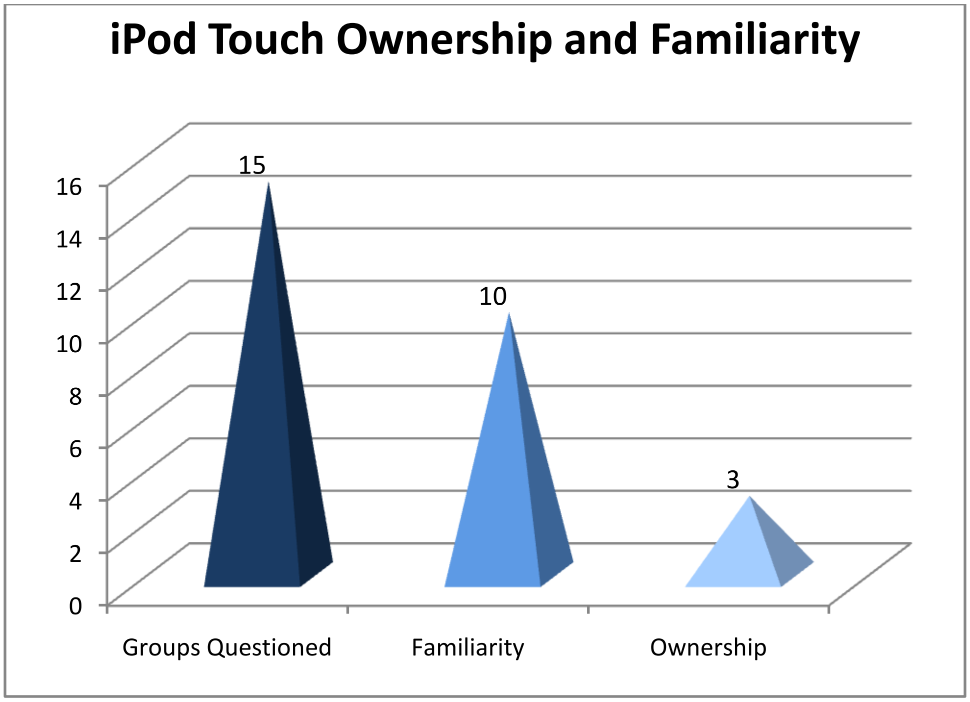

Figure 22: iPod Touch Ownership and Familiarity

7 Conclusions and Recommendations

The on-gallery testing conducted with Prototype Beta yielded a number of interesting – and sometimes surprising – results. After analyzing these results the project team formulated a number of conclusions and created a set of recommendations to the museum as to its future course of action.

7.1 General Conclusions

1. **The iPod Touch guide improved the visitors' depth of engagement with the gallery.** Through both comments and observations, the team concluded that most visitors looked at objects they would have otherwise missed entirely. One 21-year-old female said *"If it wasn't for [the guide] we never would have noticed any of these things."* Many visitors engaged with the objects for a longer period with the guide.
2. **Every demographic found the technology easy to learn and use**. Parents, children, and middle-aged adults alike found that the device was very intuitive and had a "quick learning curve." One mother noted that "it was quite easy to use, to get the hang of, even for oldies like me!" This sentiment was especially prevalent among those users who first explored the "How to Use this Guide" page, which gave a quick overview of the features of the iPod Touch. Since this page did not include the most basic functions (such as scrolling a page or clicking with one's finger) there was typically a few seconds of confusion for those who had never before come into contact with an iPod Touch.

   Recommendation: Augment the "How to use this guide" page to make it accessible to even the most novice visitors.
3. **A web-based platform is an efficient means of delivering and maintaining content.** Given the option of transmitting the guide over the internet (or the museum's intranet) or keeping a self-contained application on each device, the web-based option is much more sensible. From the museum's perspective, it is easier to update the guide, and it would allow guests to easily access the guide on their own devices. This would require the installation of a wireless infrastructure in the gallery.

   Recommendations:

   a. **Continue developing the guide as a set of web pages.**
   b. **Install a wireless access point in the appropriate locations.** If the guide is to be used in the James Watt Workshop exhibition, the project team advises the museum to consider

the placement and installation of these devices while the gallery is still in its planning stages.

7.2 Social Behavior

1. **The iPod Touch guide worked well in pair groups.** Of the 11 multi-person groups who used the earbuds, nine shared them amongst themselves. Sharing earbuds allows two people to engage in the guide, and yet still communicate with one another because one ear remains ‘open’. We observed that visitors discussed the objects and collectively decided on which objects to view next. Furthermore, the high quality iPod Touch screen allowed multiple people to view the content at the same time. The findings showed that visitors wanted to share the experience with the guide. We observed, however, groups of three or more had difficulty sharing the device at the same time. With groups of this size, the group members who were not using the iPod Touch guide wandered away.

   Recommendation: The project team recommends that the Science Museum conducts further evaluation of the social interactions between and among visitors sharing headphones. For example, avenues of further pursuit may include experimentation with different types of headphone configurations (e.g., multiple headphones with a splitter, wireless earpieces).
2. **The average usage time of the guide was about 25 minutes**. The Science Museum’s past evaluations of the gallery showed that the average dwell time in Making the Modern World was seven minutes. The visitor’s increased time in the gallery implies that visitors engaged more deeply with the objects.
3. **Visitors enjoyed being able to move at their own pace.** Visitors commented on the flexibility of the guide and how it allowed them to spend more time looking at objects that interested them.
4. **Most users thought that the guide was suited for them.** When asked “Who do you think this guide is best suited for?” nearly three-quarters of visitors responded with a bracket that included themselves, usually in age, technology familiarity, or interest level.

7.3 Content

1. **Some visitors would prefer an option for more content.** About half of the visitors expressed their interest for something like a "Learn More" button for each object in the guide that would provide additional resources.

   Recommendation: Add a 'learn more' link to each item page for the next prototype. Test such a layered content mechanism to determine its usefulness and feasibility.
2. **Users engaged with both 'iconic' and 'everyday' objects**. This shows that the iPod guide is capable of making even 'dull' objects engaging. The guide encourages visitor engagement with otherwise unattractive and inconspicuous objects.
3. **Many visitors wanted more information on how objects worked**. Visitors mentioned the need for diagrams and/or explanatory videos for the more complex objects, such as the telescopes and steam engines. They also wanted to see the objects in action, if possible. The moving, three-dimensional computer model of the scarificator is one option..

   Recommendation: Develop additional supporting material on the function and mechanics of the objects in the guide. This especially applies to complex mechanical objects. Three dimensional computer models with audio serve the purpose well.
4. **Many children preferred story mode**. Of the eight children (ages 11 through 14) interviewed, four stated that the story mode was their favorite out of the three modes. They commented that seeing what life would have been like for them 200 years ago was intriguing. Most adults found story mode "too easy," but assumed it would be "great for young kids."

   Recommendation: **Continue to develop and test the story mode.** Consider adding branches to the story.
5. **Navigation within the guide was difficult at times.** Due to time constraints, the project team had limited time to pretest the guide, and overlooked some of the inconsistencies of in-guide navigation. Not every page had a dedicated 'Back' or 'Home' button, and visitors became confused at times.

   Recommendation: Ensure that the navigation controls ('Back,' 'Home,' 'Next,' etc) are consistent – in style, location, and function – throughout the guide.

7.4 Navigational Aids

1. **The navigational aids in the guide are not developed enough.** The gallery map is not detailed or intuitive enough to provide easy navigation of the space. About half of all visitors found themselves lost at some point (although this is still most visitors' favorite mode). Some visitors moved towards objects that were *similar* to objects in the guide, but were not, in fact, the correct objects. (For example, the two team engines Puffing Billy and Stephenson's Rocket). Once they realized their mistake, it was very difficult for the visitors to find their location and reorient themselves. In addition, there is currently no way to pinpoint the locations of objects or cases one is interested in seeing.

   Recommendations:

   a. **Include the entire gallery in the map**, no matter how much of the space is actually covered by the guide. This will allow visitors to better orient themselves spatially.
   b. **Add easily recognizable landmarks**. Initial orientation is very important, and adequate landmarks would help this. These landmarks should be large features of the museum or gallery – such as the lifts or WC.

2. **Visitors relied upon the 'find me' button for to locating objects.** In the first two interviews before this feature was added to the prototype, guests had difficulty finding the objects that the guide was showing them (and asked the testers for help on several occasions). After this feature was implemented, visitors used this feature extensively.

   Recommendation: The Science Museum should investigate this feature to promote the relationship between the object in the guide and the object in the case.

Figure 23: Item finder image of 1750-1820 case

7.5 Multimedia

1. **Visitor responded positively to the video content.** Visitors enjoyed the quick overview, which highlighted the importance of the object or period. In addition, visitors felt that the videos added a "personal touch" to the tour, and that they were "witty and fun." One guest noted that "the videos fit the tone of the museum. They're fun, laid-back, and humorous."

2. **The videos enhanced, but did not replace, looking at the actual objects.** Nearly all visitors sought out and looked at the actual displays when watching the videos. Some visitors looked back and forth between the video and case when appropriate, while others simply listened to the explainer speak, and looked closely at the objects the entire time. However, we cannot draw any conclusions about replacing the video with audio-only because video may provide important orientation aids and the personal touch of being able to see the speaker. Visitors were especially engaged by content which asked them to imagine life in the given period, or form an opinion.

   Recommendation: Continue creating video content that encourages the visitor to look at and learn about the objects. Develop interesting and engaging questions for the speaker to ask in the videos. Also find interesting physical features of the objects that the speaker can point out in the video, which the user can search for in real life.

7.6 Future Work

This project represents the Science Museum's first endeavor in testing a mobile multimedia guide system. Although this project began to explore many challenges of such a guide, many possibilities for this technology are still left untested. In moving forward, we recommend that the museum research and test some the following ideas:

1. **Consider the option of a multilingual guide**. Multilingual guides would increase accessibility to the many non-English speakers who visit the museum. Visitors mentioned that, when they visited foreign countries, they were especially grateful for English-language audio tours
2. **Consider adding a search feature**, so that visitors can search for the objects by name. This will require extensive testing, as visitors may not know the names of the objects (regardless of the presence of labels)

3. **Look into QR (Quick-Response) tag support for iPhone**. This technology was mentioned by two separate visitors as a feature they would like to see implemented in the guide. As an addition to the item finder mode, it would make object location fool-proof and instantaneous.
4. **Consider implementing location-based content** so that visitors may find out where they are in the gallery. This feature may also be used to drive location-specific content. For example, a video will start to play if the visitor comes within 6 feet of the object. (A similar application is in effect at Culloden Battlefield in Scotland).
5. **How can the museum make the existence of the guide known to visitors?** As the museum has learned from the mobile tour in the “Dan Dare and the Birth of Hi-Tech Britain” gallery, the most amazing, innovative guide is meaningless if the visitor does know or care that it exists.
6. **Is the guide still as successful when more objects are added?** It is possible that there is a threshold to how many objects can be included in the guide before learning and engagement turn to confusion and frustration, and the structure of the theme and story modes breaks down. Further testing is required to make an informed decision on how much content should be in the guide.

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Appendix A: The London Science Museum

The London Science Museum

The British museums are world renowned for their collections of artifacts and serve as major tourist attractions for visitors from all over the world. Our sponsor, the Science Museum in South Kensington, London, welcomes about 2.5 million visitors per year and holds one of the world's most significant collections illustrating the history and contemporary practice of science, technology, medicine and industry. The museum's collection comprises over 300,000 artifacts, including over 700 human remains. The collection is so large that the museum only has space to display about 7 percent of it at any time. (London Science Museum).

The history of the Science Museum can be traced back to the mid-1800s. In 1851, London hosted The Great Exhibition, which was a World's Fair that showcased technology and the arts. Prince Albert believed that the wealth generated by the Exhibition should be used to found museums, which resulted in the establishment of the South Kensington Museum in 1857 (Azhari, Briand, O'Conner, and Titone, 2006, p.3-4). Over the years, there was a growing need to construct new buildings to house the museum's expanding collections. In 1909, the South Kensington Museum split up its collections: The "Art Collections" became part of the Victoria and Albert Museum, and the "Science and Engineering Collections" officially became the known as the Science Museum (London Science Museum).

The Science Museum is part of the National Museum of Science and Industry (NMSI), which is an organization consisting of four museums: the Science Museum, the National Railway Museum, the National Media Museum, and the Science Museum Swindon (NMSI, 2008). The NMSI summarizes its core mission in the following statement:

> "…We inspire and engage our audiences through a combination of expert knowledge of the collections, cutting-edge interpretative techniques, and understanding of diverse audience needs… We engage people in a dialogue to create meanings from the past, present, and future of human ingenuity."
>
> (NMSI, *Three-year Funding Agreement between NMSI and DCMS*, 2008, p.2)

Throughout its history, the Science Museum has striven to better educate and serve its visitors. A major development was the creation of a "Children's Gallery" in 1931. According to the Science Museum, the exhibits were designed to teach children about science and technology, and many were hands-on, such as an exhibit consisting of pulleys and blocks that demonstrated physical principles (London Science Museum, "Science Museum History"). While the museum's exhibits and programs have changed substantially over time, the essence of the mission to inspire and engage audiences in an exploration of science remains constant. For example, the Science Museum invests a great deal of effort in improving content for its popular, interactive exhibit named “Launch Pad.” The Science Museum also works to promote learning outside of the museum itself through the development of outreach programs. These programs help to educate children in classrooms throughout the United Kingdom (London Science Museum).

The Science Museum is an extremely popular tourist attraction and draws millions of visitors annually; in the year 2007, the Science Museum reported approximately 2,714,000 visitors (ALVA, 2007). Of those visitors, about 1.3 million visited as a family. 300,000 were school children on field trips. This number of visitors with school groups is greater than any other attraction in the United Kingdom, and is greater than that of the Natural History Museum and the British Museum combined, proving that the Science Museum is predominantly a children’s attraction. For more demographics, please refer to Table 1.

Table 1: London Science Museum demographics[6]

- An average of 2.5 million visitors each year
- Over 85 million visitors since 1960
- 1.3 million visitors (53%) in family groups
- Over 300,000 in school groups
- Over 6000 school and college groups visit the Museum each year.
- 68% of visitors come in groups with children (family or educational)
- 36% of visitors are 16 or under
- 34% of visitors are aged 19 to 35 years
- 600,000 (25%) foreign visitors yearly
- 45% of Londoners have visited the Museum in the last 5 years.
- Science Museum visitor-base has a 50:50 gender split.

Some of the museum’s most popular exhibits have been “The Science of Spying,” “Inside the Spitfire,” and “Listening Post,” which displays random samples of text from thousands of chat rooms in real time. “Listening Post”, along with many others, was a key reason the museum won the Gold Visitor Attraction of the Year award at the 2008 Visit London Awards. For a list of some of the many accolades, see Table 2.

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[6] Quarterly visitor report 2006 (London Science Museum)

Table 2: Accolades[7]

- London Visitor Attraction of the Year Award (2001, 2002, 2008) - the first back-to-back winner.
- English Tourism Council Excellence in England Award - Visitor Attraction of the Year (2002).
- BAFTA Interactive Entertainment Award - Interactive Arts for the Wellcome Wing (2000).
- RIBA Award for Architecture - for the Wellcome Wing (2001).
- IPR Excellence Awards - Consumer Relationships (2003).
- Tomorrow's World Award - Raymond Baxter Award for Science Communication (2001).
- Winner of the Design Week Awards for Museum/Galleries/Visitor Attractions - The Energy gallery (2005).
- Loo of the Year Awards - Heritage Category Winners for the IMAX cinema toilets.

The NMSI is an "executive non-departmental public body" (Science Museum, 2008). The NMSI is not under direct government control, but it still overseen by the government, specifically the Department of Culture, Media, and Sport (DCMS), which also provides the NMSI with funding. The NMSI is run by a Board of Trustees and a director who report to the DCMS. The members of the Board of Trustees are appointed by the Prime Minister. (NSMI Annual Report, 2008). The current director of the NMSI is Professor Martin Earwicker, although he recently (as of 4 December 2008) announced that he will be stepping down as director in order to accept another position. (Science Museum Press Release, 2008). There is also a separate director for the Science Museum itself. The current Director of the Science Museum is Professor Chris Rapley (Science Museum Website).

The total income of the NMSI during the 2007-2008 period was £61.7m.(National Museum of Science & Industry, 2007-2008). Since admission the Science Museum is free (except for special exhibitions and IMAX shows), the Science Museum relies on other sources for funding. In addition to the sponsorship of the DCMS, the Museum also receives funding from donations, patrons and "Friends of the Science Museum", and Corporate Memberships. (Science Museum Website.)

In order to improve the experiences of its visitors, the Science Museum is looking to find ways of using current technology to improve the presentation of the museum's content. Mobile technology, including devices such as cell phones, PDAs, and personal entertainment players (e.g., iPods) are ubiquitous in today's society, and the Science Museum hopes to leverage these types of devices in order better engage and educate its visitors. Our IQP will explore and evaluate potential solutions through a

[7] Quarterly visitor report 2006 (London Science Museum)

combination of research and experimentation, thereby helping the Science Museum to further its goals outlined in its mission statement.

Audience Research and Advocacy

The project team worked for the audience research and advocacy department at the Science Museum. This group conducts research to obtain data about real visitors so that the museum will be able to better meet visitor needs. They acknowledge that “working in a museum has changed us. We are not visitors; we do not think or act like visitors. That’s why we need to do audience research” (Burch 2009, p.8). This project brings the audience research group new perspectives, which they need to challenge their ways of thinking so that they can improve. The project team will perform audience research to learn if the team’s new ideas on technology will truly benefit visitors.

The audience research group conducts three main types of evaluations as the museum designs, tests, and improves its exhibits: front-end evaluations, formative evaluations, and summative evaluations. Front-end evaluations are conducted at the very start of the exhibit design process and are intended to get an initial idea about visitor responses to the exhibit. Formative evaluations are conducted as the exhibit is developed and prototyped, with the intent of identifying problems in the early stages so that they can be corrected for the final exhibit. Summative evaluations are conducted after the exhibit is completed. Although it is too late to change the exhibit once the exhibit is completed, the summative evaluations are useful because the museum uses them to better design future exhibits.

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Appendix B: Qualitative Technology Comparison System

Technology / Criteria	Cost/Savings/ Cost to Visitor	Ease of Implementation/ Prototyping	Ease of Use/Convenience	Flexibility	Accessibility	Social Interaction	Durability
iPod Audio Tour	**Variable: Museums can either lend out their own iPods (high cost), or have visitors bring their own (some offer discounts for doing this)**	Easy: Only requires audio recordings and maybe music	High: CMNH Study: 89% thought iPod was easy to operate; those that did not were not constrained to any particular age group. Small, lightweight, easy to learn	Medium: Podcasts are linear, 1-track tours. Non-linear tours contain multiple files and can be confusing.	Low: Must be recorded in multiple languages. Obviously cannot be used for deaf people	Low: Cuts user of from other visitors. User may be more focused on device than on artwork	Poor: relatively fragile
Cell Phone/PDA Audio Tour	Low: One time cost to implement tour (unless reception must be upgraded); must consider roaming/pay-as-you-go charges	Easy: Certain companies develop and implement tours for museums	High: Tate Modern study: of visitors who preferred a mobile phone tour, 93.5% said it was because they felt 'comfortable and familiar with the device'	High: Tour can be taken in any order, and users have the option to hear more information if desired	Low: Must be recorded in multiple languages. Obviously cannot be used for deaf people	Low: Same as above. Also, visitors run the risk of tours being mistaken for conversation by security	Medium-high: varies from phone to phone
Cell Phone Text Message Bookmarking	**Unknown**	**Unknown**	Medium: Text messaging may be more complex than dialing (as above)	High: Knowledge base can be edited on pre-existing ObjectWiki and it's easy to link objects to database	Medium: Easier to translate text than speech. Accessible by the deaf.	High: Text messaging should not affect social interaction.	Medium-high: varies from phone to phone
iPod Video Tour	**Variable: Museums can either lend out their own iPods (high cost), or have visitors bring their own (some offer discounts for doing this)**	Medium: requires in-depth recording, editing, etc	High: CMNH study: 88% of visitors preferred video iPod tour over audio tour or text labels	Medium: Like Podcasts, either must be linear or multi-track. Also difficult to re-make if exhibit changes.	Medium: At least video portion can be enjoyed by all	Low: Cuts user of from other visitors. User may be more focused on device than on artwork	Poor: relatively fragile
Augmented Reality	High: Cost of devices plus cost of graphic designs and software *or* graphics and user-provided iPhones	Hard: Computer animations and speech must first be created, devices must be programmed to recognize objects	High: All functions are automatic and intuitive	Medium: Objects can be viewed from any angle, and huge amounts of information can be presented, but may not be feasible for many exhibits	Medium: At least video portion can be enjoyed by all	Low: In the video press release, users are seen walking around the museum with their screens held in front of them, engaged and oblivious to the world around them.	Medium: Includes delicate components, but enclosed in a case designed for museum use
Multi-Touch Surface	High: ~$10,000 (~£7,000) per unit	**Unknown**	High: Claim to fame is intuitive gestural interface (iPhone)	High: Each unit is customized to buyer's specifications, and some companies specialize in museums	High: Complies to ADA standards, part of customization can be multi-language interface	High: Surface promotes social interaction (horizontal layout, multi touch-point detection)	High: Made of thick tempered glass and aircraft-grade aluminum
QR Codes (Microsoft Tags)	Low: At this time anyone can make their own QR codes for free. Museum already has ObjectWiki database	Easy: QR codes can be generated very easily, and ObjectWiki already exists (would have to be expanded?)	High: Users only have to download small application to use QR codes.	Medium: If exhibit is changed, museum would have to move QR labels as well	Medium: Alternate-language pages would require separate tags	High: Users may spend more time interacting with their deice than with other visitors or the exhibits	Medium-high: varies from device to device

Technology	Criteria	Maintenance	Ownership Rate/ Popularity	Visitor Appeal/ Engagement	Information Density	User Volume	Information Retention/ Learning	Risk and Liability	Pros	Cons	Neutral/ Other
iPod Audio Tour		Impossible: Must be returned to apple after damage or battery death.	Medium: 20% (54% age 12-17, 30% age 19-34) [Americans as of June 30, 2006]	Low: No longer considered cutting-edge; passé	Low: Only that which can be narrated in 30-50 seconds (Max time a visitor wants to listen)	Low: 1 User per device	Medium: 30% retain info from audio tours, compared to 6% from text labels	**Variable: High if museum chooses to lend out, none if visitor-provided**	2	7	5
Cell Phone/PDA Audio Tour		Non-issue: No Maintenance for user-owned devices	Very high: 84% of adults in UK as of 2008	Low: Visitors will only use because of convenience, not interest.	Low: Only that which can be narrated in 30-50 seconds (Max time a visitor wants to listen)	Low: 1 User per device	Medium: 30% retain info from audio tours, compared to 6% from text labels	None	7	5	2
Cell Phone Text Message Bookmarking		Non-issue: No Maintenance for user-owned devices	Very high: 84% of adults in UK own cell phones as of 2008	Medium: Slightly more innovative than cell-based audio tour, could be more interesting	High: User is linked to huge knowledge base (ObjectWiki)	**Non-Issue**	Medium: Users are able to learn at their own pace	None	6	0	8
iPod Video Tour		Impossible: Must be returned to apple after damage or battery death.	Medium: Only small potion of iPods have video capacity	Medium: More appealing than audio alone	Medium: Text, images, audio, and video combined, but still on a small interface.	Low: 1 User per device	High: CMNH study: Visitors noted that that the added level of interpretation helps them to "better comprehend and relate to the exhibits ... thus providing a higher level of appreciation."	High, assuming museum lends: fragile, expensive, and easy to steal.	3	6	5
Augmented Reality		Low: Never have to tamper with exhibits.	**N/A**	High: Very exciting, engaging technology	High: Large amounts of both audio and visual information can be presented that may not be successful in any other form.	Low: 1 User per device, and most likely a limited number	High: users 'felt motivated to examine the artwork more closely.' Immersive learning	Medium: expensive and moderately fragile	3	4	7
Multi-Touch Surface		Low: Machines are fully automatic (turn themselves on/off daily)	**N/A**	High: Very exciting, engaging technology	High: Large amounts of both audio and visual information can be presented	High: as opposed to regular touch screens, multi-touch can detect touch points from multiple users	**Unknown**	Low: Safe and virtually unbreakable	10	1	3
QR Codes (Microsoft Tags)		Non-issue: No Maintenance for user-owned devices	Medium-High: Smart Phone and iPhone ownership rates quickly growing	Medium: Innovative technology which may quickly lose its allure	High: As much as a webpage can hold, including video, images, text, etc	Low: 1 User per device	High: CMNH study: Visitors noted that the added level interpretation helps them to "better comprehend and relate to the exhibits ... thus providing a higher level of appreciation."	None	7	2	5

Appendix C: Interview at the Boston Museum of Science

Interview questions for Suzanne Berryman and colleagues at the Boston Museum of Science

04/08/2009

Technology and Exhibit Interpretation

1. What are some of most successful exhibits at the Boston Science Museum that use some kind of technology for exhibit interpretation? (Examples of technologies: Audio/video tour, interactive kiosk, multi-touch surface, etc.)

   The museum has used Augmented Reality in their Star Wars exhibition. People would move pieces of cardboard around that represented different landscapes, people, and power sources. The objects would interact on the video screen. For example, if a user placed a power generator somewhere on the map, the area in its circumference would light up. This exhibit is supposed to teach people about the trade-offs of resource building as part of community building. If you want to give people a lot of space to live and thus exclude a trash dumping area, everything will soon be covered with filth.

   Additional Information: Building Communities Augmented Reality Interactive

   "Together, visitors build a spaceport, moisture farm community, and walled Jawa town. Placing cards on a table—the physical landscape—a computer superimposes a building on a site in virtual reality and real time. A VR explorer enables visitors using a head-mounted display to "fly" through the collaboratively built environment. "

(http://www.mos.org/starwars/doc/1858)

2. Could you describe the functionalities of these technologies in detail? How was any one of those technologies chosen for a particular exhibit?

   The idea for a particular technology can spark at random. It may be something you see on the news or hear about from other museums. It seems that the museum does not spend too much time brainstorming which technology to use. Somebody has an idea and the *whole exhibit is developed from there. The Star Wars exhibit's idea came from a New Zealand project that the exhibit developers have attended years ago. The AR technology seemed too complex and useless at the time. It was not until much later that the "interesting technology finally found a use." Somebody remembered AR when thinking of how to develop the "Building Communities" project.*

3. How do you measure the "success" of an exhibit? Do you analyze how much information visitors retain after leaving the exhibit?

    Some additional user testing is performed after the exhibit is displayed and this information is used to write a formal report about the successes for the exhibit. The main goal that the exhibit creators are trying to achieve is to convey an idea of the exhibit to the user. For example, the idea of the AR Star Wars exhibit is that there are trade-offs in building communities. The goal of the robot programming station in the Computer Room at the Boston Science Museum is to convey to children that they can program using a sequence of messages or tasks.

4. What factors do you keep in mind when designing new exhibits? Do they promote social interactions among visitors? Are they designed with families in mind?

    Exhibits are definitely family-oriented. However, there are specific galleries just for adults or for children. In one exhibit, the adults and children received audio guides with different types of information. The idea behind this was that each can get a piece of information and tell the other one about it. Both kids and adults can feel like "experts" this way. The idea did not work very well, though. Adults ended up listening to both tapes in order to get more information.

5. What are the stages of prototyping an exhibit? Do you perform user testing? How do you determine whether the technology should be fully implemented or whether you should to move on to find another technology?

    The user testing of an exhibit starts with exhibit creators standing next to the exhibit and explaining to the audience how to interact with the objects. This is the longest of the phases – the Formative Evaluation Phase. At first a person aids the interaction the visitor with the exhibit and then they try to get it to stand on its own- so that the visitor can navigate without any outside help. "If you can't spark an interest or get people to understand what's going on even with a person standing next to them and telling them what to do, then the exhibit is not worth developing." Also sometimes the development hits a plateau. At this point if the exhibit is not good enough and you can't get it better relatively soon, money and time will run out and the project will be shut down.

Interpretation of Older Objects

6. Some objects may appear old and unattractive to the visitors. They may be hidden behind a glass case or be out of reach for visitors. Are there any innovative ways in which you have figured out how to make more static, quasi-historical exhibits more exciting, interactive, and engaging?

   Museum of Natural History was able to host Leonardo Da Vinci's notebook for some time. The notebook contained his sketches and information about the flight of birds, astronomy, etc. The book was quite old and written in Italian. It was placed behind a class. Many interactive were developed to go along with it, including a video tour which translated and highlighted interesting information from the book. This was not very successful, because people spent five times as much at the video screen and in the end could not say anything more about their experience than that "they saw Da Vinci's sketchbook." Presenting historic objects does pose a challenge, but the creators must not divert the audience's attention from the exhibit itself too much with virtual depictions. After all, there would be no point in going to the museum if visitors could learn all there was to know about an object from computerized graphics.

Storytelling

7. How do you tell effective stories about the objects in the exhibit? For example, in case of an audio or video guide, what determines what voices will be used and whether the story will be presented through a simple narration or through fictional characters?

   There is a whole department dedicated just to that. Storytelling starts off with a high level idea. "What is the story that you want to tell?" You get ideas from various sources. Once the goals are specified, the best ways to represent them in an exhibit are developed. There is usually not a lot of options, given that the creators have thought out exactly what they want to say to the visitor and how they want to say it. The storyline is a natural outcome of their brainstorming.

Appendix D: Prototype Alpha Content

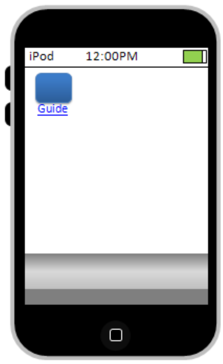
Prototype Alpha consists of a Microsoft PowerPoint presentation with hyperlinked slides. This appendix describes how the slides were linked, and also provides images of each of the slides in the presentation.

The following table (known as an *adjacency list* in graph theory) shows how the slides are linked to each other. (Note that “P” stands for previous slide; clicking the “back” button will take you to the slide you previously viewed. This notation is particularly relevant for the object pages because most object pages can be accessed through different paths when navigating through the guide.)

Current slide	Slides that are linked directly to current slide
1	2
2	2, 3
3	2, 4
4	2, 5, 9
5	2, 4, 7, 8, 18
6	2, P
7	2, 5, 17, 19
8	2, 5, 20
9	2, 4, 10, 21
10	2, 9, 21
11	2, 10, 12
12	2, 11, 13, 17
13	2, 12, 14
14	2, 13, 15
15	2, 14, 16, 18
16	2, 15, 17, 19,
17	2, 16
18	2, 21, [link to video], P
19	2, 20, P
20	2, P
21	2, P

The following table provides images of all of the screens (PowerPoint slides) in this prototype:

1



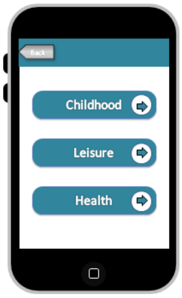
2


Technology in Everyday Life
1750-1820
No Internet
No Electricity
No Tesco Express
Go

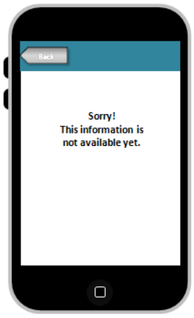
3


Back
Please choose:
Learn about life in 1750
Stories from children in 1750

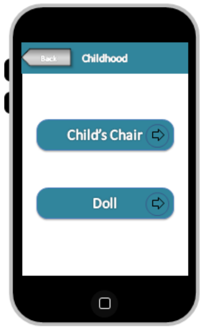
4


Back
Childhood
Leisure
Health

5


Back
Sorry!
This information is not available yet.

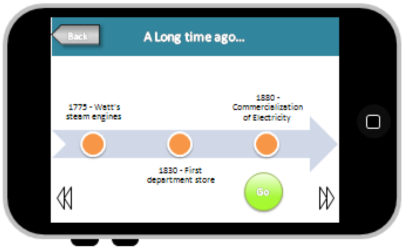
6


Back
Childhood
Child's Chair
Doll

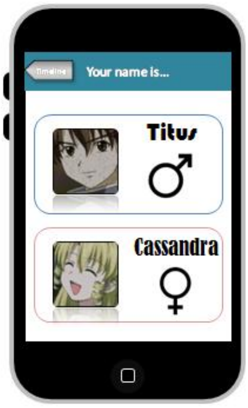
7


Back
Leisure
Lute

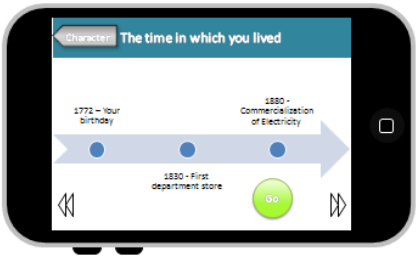
8


Back
A Long time ago...
1775 - Watt's steam engines
1880 - Commercialization of Electricity
1830 - First department store
Go

9


Timeline
Your name is...
Titus
Cassandra

10



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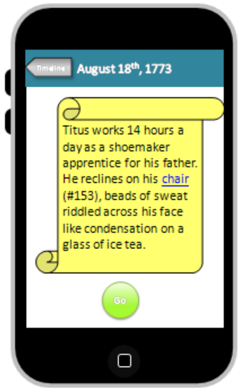

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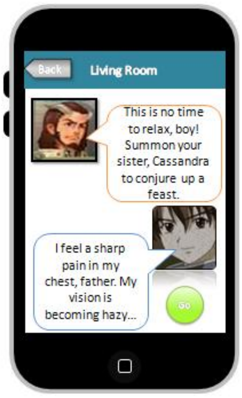

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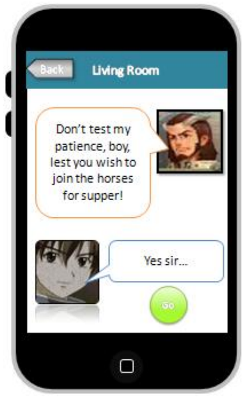

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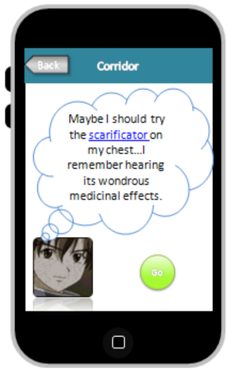
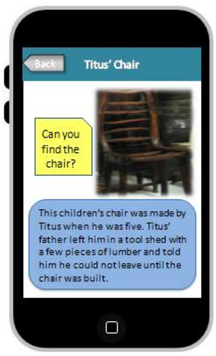


15

16



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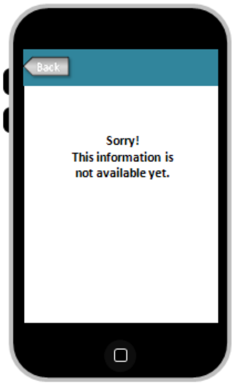


21

References:

- Sources of information about the objects and the time period:
  - Wikipedia. http://www.wikipedia.org
  - Making the Modern World Online. http://www.makingthemodernworld.org.uk/
- Sources for images used in the slides:
  - Photographs the project team personally took of the objects in the case
  - Making the Modern World Online. http://www.makingthemodernworld.org.uk/

Appendix E: Prototype Alpha Questionnaire

Questionnaire for iPod Guide Prototype Alpha

Hi, my name is ______, I work for the Science Museum, and we're developing some new interpretation for ***that*** *case (over there). Would you be willing to help us by trying out a prototype and then tell us what you think? It won't take more than 10 minutes.*

Thank you!

Now, this is a very ***rough model****, and the final product will be on an iPod, so don't worry about how it looks right now, we'd just like to find your* ***opinion of this prototype****. There are no right or wrong answers, and your comments will* ***be completely anonymous****. I didn't make any of this, so please be completely honest, I won't be offended by anything you say. Anything you tell us will help us improve this exhibit.*

I'll be taking some notes as you use this exhibit, just so that I remember what you did. Don't worry if you get stuck, I will help you along. Could I ask you to ***think out loud*** *as you go along? This is so that I understand what you're thinking and doing.*

Thank you!

"A real iPod lets you to click things on the screen with your finger. Could you point to things on the screen as if you were clicking on them? My assistant ____ will take care of managing the computer.

OBSERVATION SHEET

Date: Time: Duration: Age: Gender:

"That's very interesting, can you tell me a bit more about that?"

"What do you expect to find here?"

"What do you think you can do on this page?"

"What are you thinking about?"

"What are you looking for?"

"Could you tell me your thoughts out loud as you work your way through the screens?"

What **character** did you choose? Any reason in particular?

(*Be sure to trace route visitor takes through the state machine! You can use the numbers on the slides to indicate user journey.*)

Thank you. Now I'd like to ask you a few questions about what you just did.
What did you think about using this prototype? **Why?**

What did you like **most** about using it? **Why?**

What did you like **least** about using it? **Why?**

What did you find **difficult** or **confusing** about using it?
What could be **changed** to make it **less confusing**?

Was there anything **new** or **surprising** that you found out from using this guide?

What do you think people would **find useful** about this type of guide?
What do you think this guide is trying to **show you**?

Can you tell me about the **time period** in which the character (in the guide) lived?
What was **everyday life** like? What time period are the objects from?

When did you notice the **relationship** is between this **guide** and the **objects in the case**?

Who do you think this guide is **for**?
What kind of ages?
Can you tell me a little bit more about that?

Do you **use** or **own** any of the following devices (tick all that apply)?

- ☐ iPod/other MP3 Player
- ☐ Laptop
- ☐ iPod Touch/iPhone
- ☐ Mobile Phone
- ☐ PDA/Blackberry
- ☐ Other: ___________________________

Have you taken **museum tours** before?
If YES: What kind of tours (i.e. guided tour, audio tour, mobile phone)? **Where?**

If NO: Is there any particular reason why you haven't taken tours before?

Circle Age Group: 19-35 35-45 45-60 60+

Appendix F: Prototype Beta Questionnaire

Questionnaire for iPod Guide Prototype Beta

*Hi, **my name is _____**, I **work for the Science Museum**, and we're **developing some new interpretation** for **this gallery** using an **iPod Touch**. Would you be willing to **help us** by **trying out a prototype** and then **telling us what you think**? It **won't take more than 15 minutes**, and we'll give you **£15 as a thank you** for your time.*

Thank you!

*I'd like you to and try out the guide included on this iPod. Now, this is still a very **rough model**, so it **doesn't yet cover the whole gallery,** but **feel free to move to any display case** in the gallery. Take **as much or as little time** as you'd like. When you've finished, just let me know. At the end I'd like to **ask you a few questions**, so try to **remember what stands out** while using the iPod, either **positive** or **negative**. There are no right or wrong answers, and your comments will **be completely anonymous.***

Are you familiar with **how to use** an iPod Touch? Y / N | Do you **own** one? Y / N

*Then let me give you a **quick demonstration** [turning, playing/pausing video, volume, etc]*
Any questions? Then have fun!

OBSERVATION SHEET **Group Type:**

Date:	**Time:**	**Duration:**	**Age:**	**Gender:**

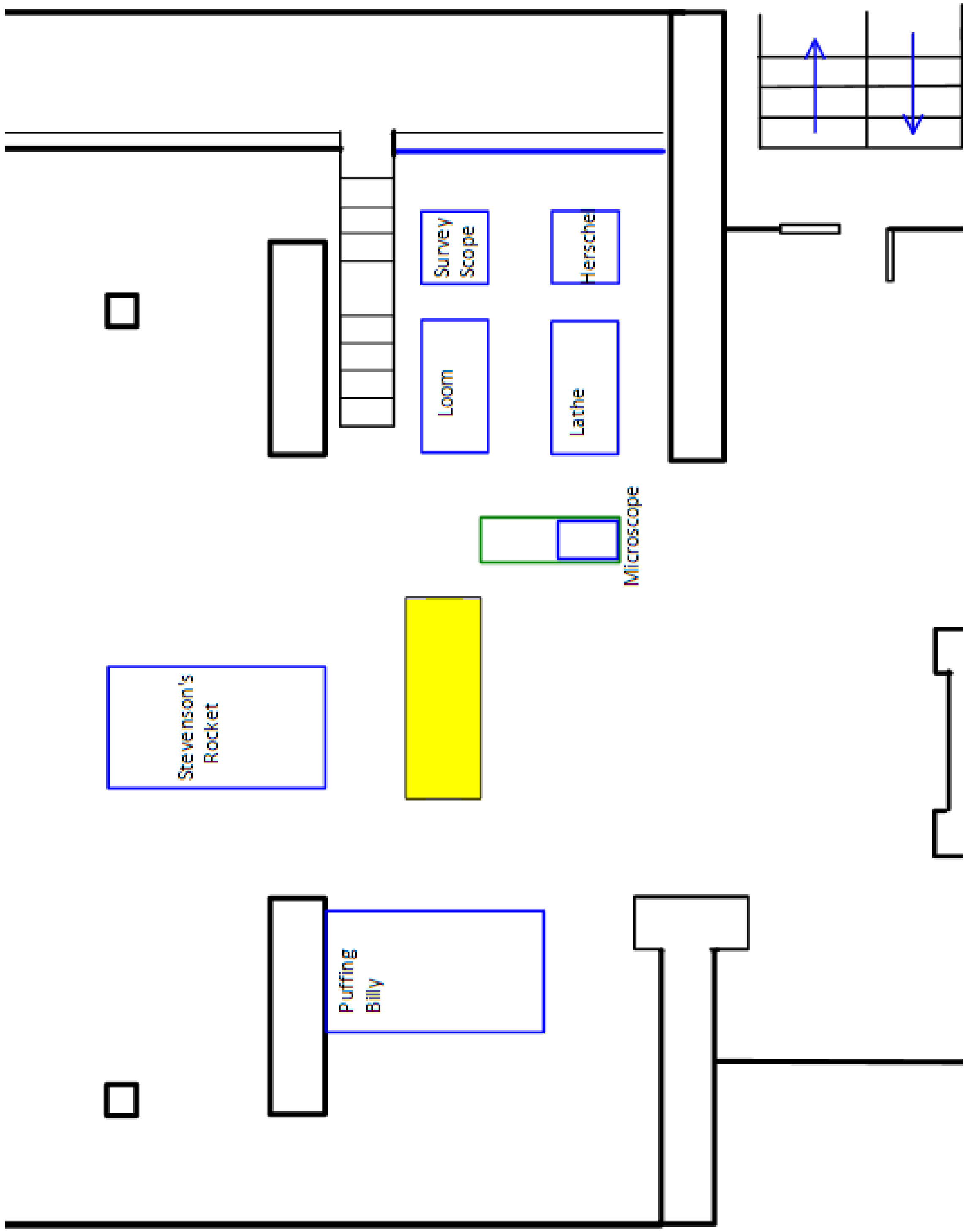
Do visitors move away from starting location?

Do other objects distract the visitors, or do they follow only the tour?

How do visitors react to obstacles (benches, people, etc)?

Do visitors appear more interested in the glass-case objects or the 'iconic' ones?

On the map, indicate routes that visitors take through the gallery:



Thank you. Now I'd like to ask you a few questions about what you just did.

Could you describe to me how you used the guide in the iPod?
Can you tell me what you did while you were using the iPod?

Did you try all three **modes**? [Y / N] Which did you **like the best? Why?**

What did you **think** about using this guide? **Why is that?**

What did you like **most** about using it? **Why?**

What did you like **least** about using it? **Why?**

What did you find **difficult** or **confusing** about using it?
What do you think could be **changed** to make it **less confusing**?

Would you be **interested** in **having an iPod guide** like this **when visiting the museum**? **Why?**

Of the **objects** you looked at **using the guide**, which one was your **favorite? Least favorite?** Why?

Which **other objects** would you like to **see included** in the guide? **Why?**

Did you **watch** any **video** in the guide? What did you **think** of the videos? **Why?**

What did you **think** of the **style of the content** in the guide?
What did you think of the **way things were explained** in the guide?
What did you think of the **text and images**?

What did you think of the **level of content**?
Too easy? Too difficult? Too little? Too much? Just right?

What **stands out** as particularly **interesting** to you from everything you saw or heard **in the guide**?

Who do you think an iPod guide like this is **best suited for**? (What **ages**? **Technology levels**? Etc)

Have you taken **museum tours** before? (docent-guided tour, audio tour, mobile phone)?

YES: **What kind** of tour was it? Where? What did you **like it about it? What did you dislike about it?**

How do you think the iPod guide differs from these tours?
(*People are answering this question:* How is the iPod Tour **better** than those tours?)

How is the iPod Tour **worse** than those tours?

NO: Is there any particular **reason** why you **haven't** taken tours before?

Would the iPod Tour **fix** that? **Why?**

In your opinion, how do you think we could make this iPod guide better for you?

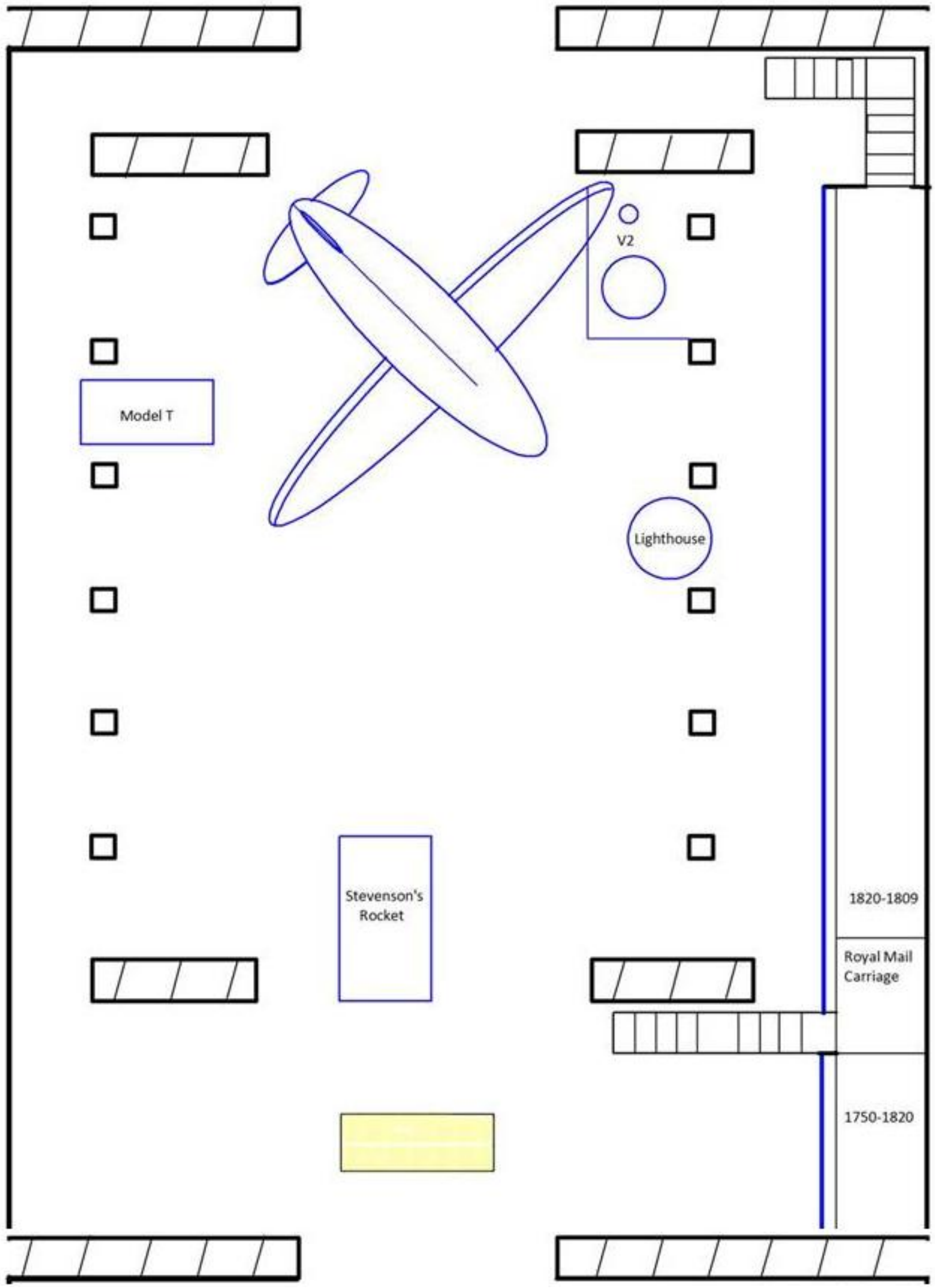
Is there anything else you'd like to add?

Age: Age Group: 19-35 35-45 45-60 60+

HONORARIUM[8] **MONEY** **THANK YOU!**

[8] For longer interviews, the Science Museum is in the practice of giving honorariums (small sums of money to interviewees as a thank-you for participation). The Prototype Beta testing required about 20 to 30 minutes of each visitor's time, so the audience research department authorized the distribution of honorariums. (Since the Prototype Alpha testing was shorter, only requiring about 10 to 15 minutes of each visitor's time, no honorariums were disbursed.)

Appendix G: Map of the Making the Modern World Gallery



Appendix H: The James Watt Workshop

The Science Museum collections contain many historical objects, and issues in interpreting myriad obscure, monochrome historical objects located behind glass are recurring challenges that exhibit designers face. For example, the James Watt Workshop also contains objects from the same time period which are not immediately recognizable or interesting to visitors. The lessons learned from the Making the Modern World exhibit can suggest pitfalls to avoid and areas of future study for the design of the James Watt Workshop exhibit.

Figure 24: The busts inside the James Watt Workshop

James Watt (1736-1819) was an enthusiastic inventor, an engineer, a businessman, and a visionary with a fertile imagination. Born as a son of a shipwright, Watt mixed mechanical work with mathematics and other disciplines since early age- "everything became science in his hands." (James Watt – Life and Work). Many of his most well-known accomplishments were improvements to the designs of steam engines, such as his innovation to use a separate condensation chamber, which greatly improved the efficiency and practicality of steam engines of the time. His engines were 'double-acting' with steam acting alternately on both side of the piston; Watt devised 'parallel motion' specifically for this type of engine. Watt made the rotative steam engine a power source for all industry. Watt and his partner Boulton built pumping engines across the country, which gained unprecedented success and even replaced every single Newcomen engine. (James Watt – Life and Work).

James Watt stands out as a major figure from this time because his work was pivotal in the development of the industrial revolution. The concept of using science and engineering to advance industry is one of the central themes of the Science Museum, and the museum has many objects related to steam engines and other similar innovations in its collections. Many people coming to the museum are already familiar with Watt's most popular inventions, but few know him as a human being. James Watt was not a 'people person' and he "once said that talking to strangers gave him a headache." The Science Museum's collections contain the objects from James Watt's workshop in the attic of his house, where he spent much of his time after he retired. The workshop contains two sculpture-reproducing machines, which was just one of the few inventions of Watt after his retirement. The workshop door is unusual- it has a special shelf on which food was left when Watt was too busy to be disturbed. This shelf and the workshop itself tell the visitors of Watt's reclusive nature. (James Watt – Life and Work).

After Watt died, the workshop was preserved, and eventually obtained by the London Science Museum. It has been closed to the public for the past ten years. The museum now wishes to reopen it, and prominently display it to the general audience, using new methods of interpretation. The exhibit itself is placed behind a glass barrier, and visitors are limited to viewing the display from this perspective – they cannot enter the workshop to see the artifacts up-close. Exploring new ways of recreating the detail and functionality of Watt's inventions is the fundamental aim of the project. The design for this exhibit is still in the very early stages, but the museum has high hopes that new interpretation technologies will eventually find application here. Therefore, several of the key findings from the Watt Workshop front-end evaluation will be considered in our prototypes.