**Digital R&D Fund
for the Arts**

Bristol Museums: iBeacons & Visitor Engagement

Research & Development Report

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Executive Summary

The Hidden Museum project was centred on the development and testing of a tailor-made mobile application for use in Bristol Museum & Art Gallery. The application took the form of a game played by groups on hand-held devices. Its defining technological aspect is that it relies on iBeacons (small Bluetooth devices) to both locate and help users navigate the museum building.

People's lives across the UK are increasingly being shaped by the use of mobile technologies: the project aimed to capitalise on this by utilising those with which museum visitors were likely to be most comfortable i.e. those commonly used for communication and game playing purposes. The project combined the development of digital technology with museum content and academic research. Three organisations played a collaborative role in this process: Aardman Animations, Bristol Museums, Galleries & Archives and the University of Bristol.

There were two simple objectives:

1   To provide a means to encourage visitor exploration of all the museum spaces in a fun and engaging way so as to deepen the experience and to promote new audiences. It had already been identified that many visitors, especially family groups, lingered in the areas of the museum nearest to the entrance and did not tend to explore exhibits across all of the museum's three floors.

2   To use mobile technology as the mechanism to promote this exploration, so as to add value through shared group experiences and to modify visitor behaviours.

The headline finding from the research was that the majority of the groups who used the Hidden Museum application visited parts of the museum that they had not been to before or would not normally have chosen to. In addition, many users commented that the experience of doing this was of value and was achieved in a fun and effective way because of the application. The research results also highlighted the range of other impacts the application had on visitor behaviour as well potential tensions that surface when digital technology is integrated into museums.

Background

The aim of the Hidden Museum project was to explore whether or not a combination of iBeacons and mobile digital technology could provide visitors with a new engagement opportunity to help them to interact more effectively with museum spaces and objects.

Previous research (Dillon & Prosser 2003, Hawkey 2004, Coenen et al 2013, Ancafora et al 2014) challenged museums to think about the use of digital technologies in new ways, whilst an Arts Council England report (2014) had highlighted an absence of evidence around the use of these technologies by arts and cultural organisations. However the same report referenced a correlation between higher levels of well-being and engagement with the arts, and that structured engagement "improves the cognitive abilities of children and young people" (ibid). Unfortunately Bristol Museum & Art Gallery's audience analysis demonstrated that family and community focussed groups who might benefit from this were less-engaged and disproportionately represented.

With regard to mobile device penetration, a six-month research project at the museum in 2013 showed a 500% increase in mobile and tablet visits compared to the previous year. Deloitte's fourth annual edition of the UK Mobile Consumer survey in 2014 also showed:

> "More than 2 in 3 UK adults – about 35 million people – now have a smartphone. This is eight percentage points higher than in 2013, with the biggest rise in penetration among 55 year-olds. At the same time smartphone capability and utility has increased."[1]

Bridging the gap between visitor habits and their expectations as well as building the digital capability of the museum service became important drivers. If the integration of digital technology had the potential to transform and enhance the visitor experience, the end goal for the project was to provide it as another option on the menu of engagement opportunities.

[1] http://www.deloitte.co.uk/mobileuk/assets/pdf/Deloitte_Mobile_Consumer_2014.pdf

Discovery Pen (PenFriend) in use at Bristol
Museum & Art Gallery

Bristol Museums, Galleries & Archives has already developed innovative digital practices which enable its visitors to make the most of its resources. In 2011, for example, its 'PenFriend' project received a Jodi Mattes Trust Award for Accessible Digital Culture and contributed to the development of a cost-effective audio commentary system now being used across the UK. General observations made by museum staff were that many applications for hand-held devices appeared to promote more visitor interaction with the devices themselves rather than with each other, museums or their collections. This meant that the interaction was often passive and sometimes socially isolating. The challenge, therefore, was to produce an application that focussed on promoting effective visitor interaction but not on the actual device itself.

Group attention being diverted by a mobile
device at Bristol Zoo

This was a distinctly different kind of proposition for the technology partner: much of Aardman's previous work was invariably about keeping the user's attention on a screen and the application content. Jake Manion, Creative Director at Aardman Animations said:

> "It was a huge psychological jump for us because the idea of shifting attention away from the device was completely at odds with the way we usually work."

A key requirement for the application was for it to have the capacity to drive users to the more rarely visited galleries on upper floors, this behaviour being partly down to geography and partly down to content. The ground floor galleries provide the easiest and most obvious starting points but also include popular themed displays including Egypt, local wildlife and dinosaurs. iBeacons were thought to be capable of providing the digital technology solution that would enable this spatial navigational element to work.
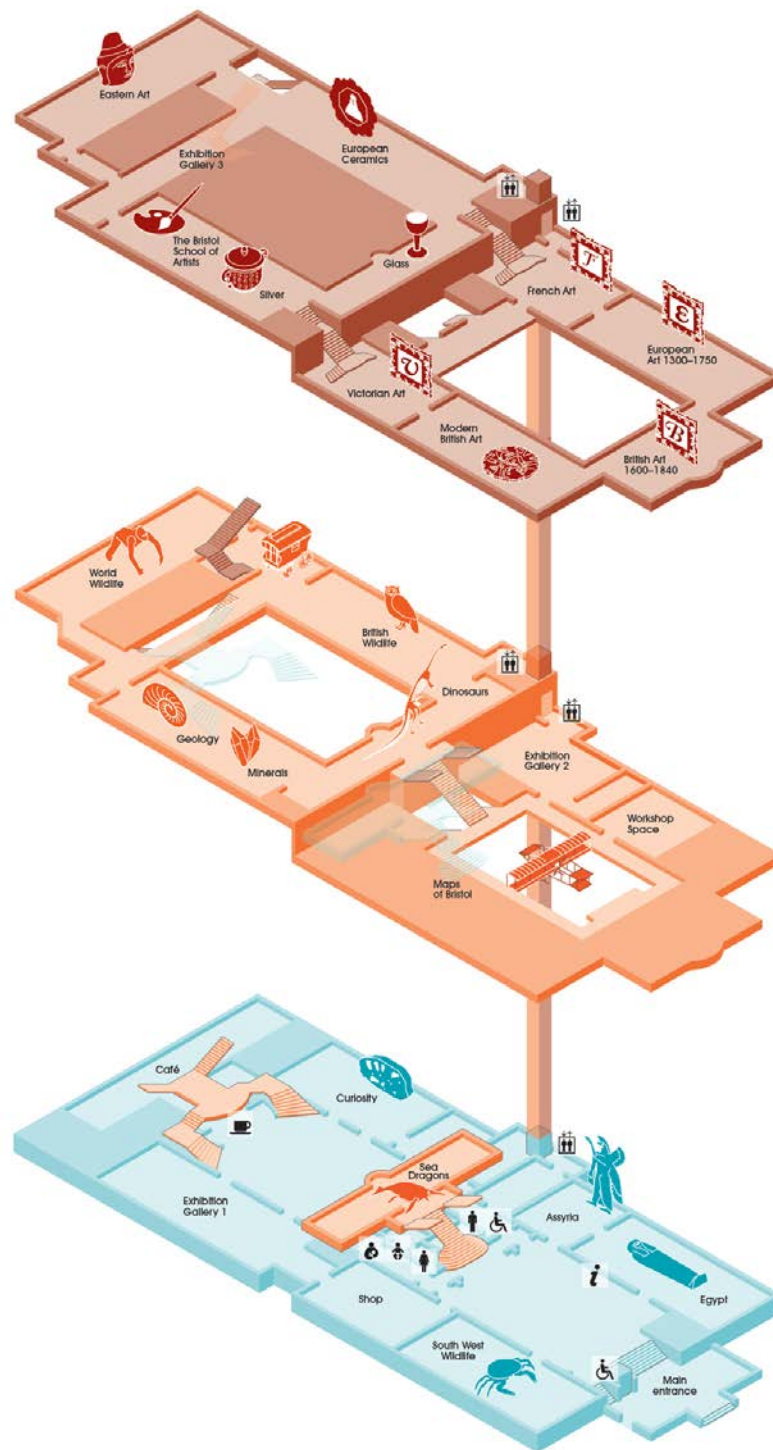
Schematic floor plan of Bristol Museum &
Art Gallery

iBeacons use a Bluetooth signal to detect the location and proximity of a mobile device. At the outset of the project in 2014, potential uses for iBeacons were still largely being explored but they were being successfully used in retail settings[2] . For example, a single iBeacon being placed at the entrance of a shop which detects the presence of a new customer; the iBeacon is then able to send a promotional message to the customer's device. The possibility of using iBeacons to enable people to navigate spaces in a similar way to GPS technology seemed to be far less well investigated and so this also presented a challenge for the technology partner in terms of the level of new research required to inform development.

Kontakt Smart Beacon like those used for
the project (http://kontakt.io/)

The Hidden Museum project set out to push the use of digital technology and the museum visitor experience to new boundaries: in doing so it also explored the future of the relationship between digital technology and museums. By focusing on the development of an application for smart phones and tablets, the project harnessed the kinds of technologies and digital literacy that are already abundant in contemporary society. The project was driven by a desire to acknowledge and utilise the interests and skills of museum visitors as a means to maximise their engagement with the museum and its objects, and to spark their desire to continue visiting and engaging with the museum.

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[2] See http://9to5mac.com/2014/06/16/ibeacons-in-retail-stores-blowing-up-app-usage-ad-engagement/ and http://blog.surveyanalytics.com/2014/08/top-5-infographics-of-week-ibeacon.html

The Partners

Bristol Museums, Galleries and Archives service is the largest museum service in the south west. It operates seven cultural venues of which Bristol Museum & Art Gallery and M Shed are its flagship sites. It cares for over 1.75 million objects of national and international importance and its venues, which are free to enter, collectively welcome over one million visitors per year.[3]

Aardman Animations is an award-winning British animation studio based in Bristol and is probably best known for films made using stop-motion clay animation techniques. However it also has a team dedicated to creating engaging interactive websites and games to both entertain and educate family audiences across the globe on mobile and tablet devices.[4]

The University of Bristol Graduate School of Education has achieved international prominence and distinction in developing the professional and academic skills of educationists both in the United Kingdom and around the world. It runs doctoral, masters' and teacher education programmes and its academic staff have extensive experience in technology based research projects connected to the arts.[5]

Bristol Museum (left) alongside University of Bristol Wills Memorial Tower.

[3] www.bristolmuseums.org.uk
[4] http://www.aardman.com/
[5] http://www.bristol.ac.uk/education/

The Project

The Hidden Museum application is a location-aware system for hand-held devices designed to inspire playful exploration and human interaction. Using over 120 iBeacons placed strategically around Bristol Museum & Art Gallery, the application helps small groups of visitors navigate spaces by generating customised paths based on personal preferences. The user experience was carefully designed so that visitors expend their time and energy engaging with the real museum exhibits around them rather than staring at the closed environment of their mobile screens. As visitors use the system they reveal elements of the museum they would not normally see, such as seldom-visited galleries, collections not currently on display and behind-the-scenes stories, all of which can be taken home digitally and enjoyed away from the site.

Metrics gathered by the application itself as well as feedback collected during user testing were designed to answer the project's two main research questions:

- To what extent does the application encourage visitors to explore and drive explorations more widely

- To what extent does the application encourage interaction with artefacts and hidden objects, promote discussion, and offer potential learning experiences within participant groups

The gaming experience is divided into three stages:

1   Game set up: choosing personalisation settings, themes, times, characters etc. (see badges below).

2   Playing the game: being directed to a particular gallery space and then playing a game appropriate to the space and theme (randomly generated) and collecting photo memories

3   Collecting rewards: the completion of a game unlocks extra information and images of objects and places that are not available in galleries or shared on other platforms.

The series of images which follow depict a typical user journey from player set up to the completion of one game (screens a- s).

Step 1 – Game set up for players (a-h)

a.

FIRST, PICK A THEME

◄ BACK

EXTRA - ORDINARY   0/12

OOOPS   0/10

DECEPTION   0/11

DEBATE   0/0

Explore the museum's most extraordinary stuff!

LET'S GO ►

b.

◄ BACK

NOW, HOW LONG DO YOU WANT TO EXPLORE FOR?

NOT VERY LONG

AN HOUR OR SO

MORE THAN AN HOUR

WE'VE GOT AGES!

ON WE GO ►

c.

◄ BACK

NEARLY THERE, HOW MANY PEOPLE IN YOUR GROUP?

1   2
3   4
5   6

NEXT ►

d.

Step 1 – Game set up for players (continued)

◄ BACK

i

PLAYER 1

Who wants to be player 1? Take the device and let's get you set up!

THAT'S ME ▶

e.

◄ BACK

PLAYER 1
HOW OLD ARE YOU?

15 or under

16-24

25-34

~~25-44~~

OK, NEXT ▶

f.

◄ BACK

PLAYER 2
PICK YOUR BADGE

DONE! ▶

g.

◄ BACK

YOU'RE ALL SET UP!

PLAYER 3
AGE 25-34

START
EXPLORING ▶

h.

Step 2 – Playing the game (i-p)

EXTRA - ORDINARY

GO!

EXPLORE TO FIND GAME 1 IN...

EGYPT

ON THE GROUND FLOOR

(We'll know when you're there!)

❓
FEELING LOST?

OPEN MAP

i.

EXTRA - ORDINARY

FIRST FLOOR

GROUND FLOOR

Map disappearing in: 0.23

ℹ FIND:
EGYPT
ground floor
Map not working? ↻

j.

EXTRA - ORDINARY

FOUND!

EGYPT

PLAY A GAME ▶

k.

EXTRA - ORDINARY

GAME 1 - FIND IT!

ℹ

How to play:

We'll show you a picture. QUICK!
MEMORISE IT!
Then, explore the room to FIND IT!
before the time runs out.

⏰ YOU HAVE 2 MINUTES!

START GAME ▶

l.

Step 2 – Playing the game (continued)

EXTRA - ORDINARY

MEMORISE THIS:

Disappearing in:
⏰ 0:03

m.

EXTRA - ORDINARY

⏰

1:56

Find the object you memorised before the time runs out.

FOUND IT! ▶

n.

EXTRA - ORDINARY

≡

FIND IT!
DID YOU FIND IT!

This cool cat has been gift-wrapped for the gods!

NEXT ▶

o.

EXTRA - ORDINARY

TAKE A PHOTO OF IT

📷

p.

Step 3 – Collecting rewards and revealing secrets (q–s)

EXTRA - ORDINARY

CONGRATULATIONS!

You've unlocked a reward!

Shooting Stars

FIND OUT MORE ▶

MOVE ON ▶

q.

◀ BACK

EXTRA - ORDINARY : SECRETS
Shooting Stars

Shooting stars are created when pieces of rocky or metallic space debris (meteoroids) begin to burn up, creating a lightshow as they zoom through the Earth's atmosphere. They travel at amazing speeds of between 25,000 and 160,000 miles per hour

r.

EXTRA - ORDINARY

WELL DONE!
You've conquered the EXTRA - ORDINARY tour!

DATE: 28/10/15
THEME: EXTRA - ORDINARY
ROOM: Front Hall
GAME: Cat Mummy

DATE: 28/10/15
THEME: EXTRA - ORDINARY
ROOM: Front Hall

s.

How the project began

> "Physical location is no longer the defining factor when we refer to users of our services. In order to effectively use our spaces and reach wider audiences, digital activity needs to be at the very core of Bristol Museums, Galleries & Archives Service."

BMGA Digital Principles

A key driver starting Hidden Mueseum for Bristol Museums, Galleries & Archives (BMGA) was its desire to build digital capacity; it also provided an exciting opportunity for each of the three partners from very different fields to work together. BMGA's long-term research aspirations included the desire to understand the potential use of sensors and as an ACE funded Major Partner Museum there was an identified need to reach wider audiences. Fundamentally the project was designed to do something different and fun, to meet these aspirations, whilst adding to the digital research base for arts organisations.

Working and communicating in the partnership

Early on in the development of the project it was clear that there was a high level of commitment and investment in the working partnership. This was facilitated by the geographic proximity of the partners to each other and the organisation of project work and communications through Basecamp and Trello.

Aardman introduced the partners to agile project management: work packages were divided into 2 or 3 week sprints and managed using Trello. Good communication between the partners was key to the project's success and since all three organisations were located within Bristol city centre this enabled regular face-to-face meetings to take place at the beginning and end of every sprint. Online communication and file-sharing was facilitated using Basecamp and which also enabled material to be shared with the wider work group, management and funders. Meeting spaces were provided by all three partners as part of the process and office space supplied at Bristol Museum & Art Gallery for Aardman's developer whilst researching, testing and debugging the prototype application.

Aardman's developers troubleshooting in the museum

BMGA also provided a platform for online project updates via its 'labs blog': a place where anybody from the project team or their wider work group could highlight progress on, or learning from, the Hidden Museum as an emerging digital and technology project. A total of 21 blog pieces were submitted over a 6 month period.[6]

Risk management

A risk register was compiled at the beginning of the project but nevertheless the project was impacted by unforeseen events beyond the control of the immediate project team. Several individual team members experienced life-changing situations either at home or in the workplace that meant they were absent from the project or found it difficult to focus. The ebb and flow of the work programme affected the group dynamic across its lifetime since different partners were either working in close quarters with each other or on the side lines waiting for elements to be delivered or the prototype to be ready for testing. Many of these issues were mitigated by the excellent interpersonal and professionally supportive relationships that existed between the partner team members and the shared commitment they had towards creating something together that each could be proud of.

[6] http://www.labs.bristolmuseums.org.uk/category/hidden-museum/page/3/

Some members of the Hidden Museum
Team and friend!

The risks regarding the research element of the project were mainly around data collection and delivery of findings pertinent to the questions and fieldwork set out in the bid, as well as keeping this all on schedule. A perceived risk for the research partner was that tensions might arise from an inability to adequately articulate the value of their expertise to the overall project however this did not materialise due to the mutual respect the partners had for each other.

As an agile project, risks were discussed as soon as they manifested and decisions on how to handle them were made together as a team.

However two major technical risks did materialise. The first arose during the development period when the team had to decide whether it was more important to get the application 'app store ready' in the scheduled time that remained or to make it as good as it could be for the purposes of answering the research questions. Opting for the latter resulted in only having an advanced prototype application ready for the end of the project but allowed for the research to be completed as planned.

The second arose during the research phase when technical issues needed to be addressed over a weekend session when no technical support system had been identified. The risk was managed by making the technical team members informally available 'on-call'. In hindsight had the research period been longer it would have been sensible to arrange paid technical support for the testing period.

Roles and responsibilities

Each partner had a particular role to play in the project but as time progressed everyone began to contribute to all aspects of the work required. Aardman's technical team took the lead on the application development, which was realised in two-week sprints and measured against milestone deadlines: these sprints involved the development of 'user narratives', the structure of content, functionality and visual appearance.
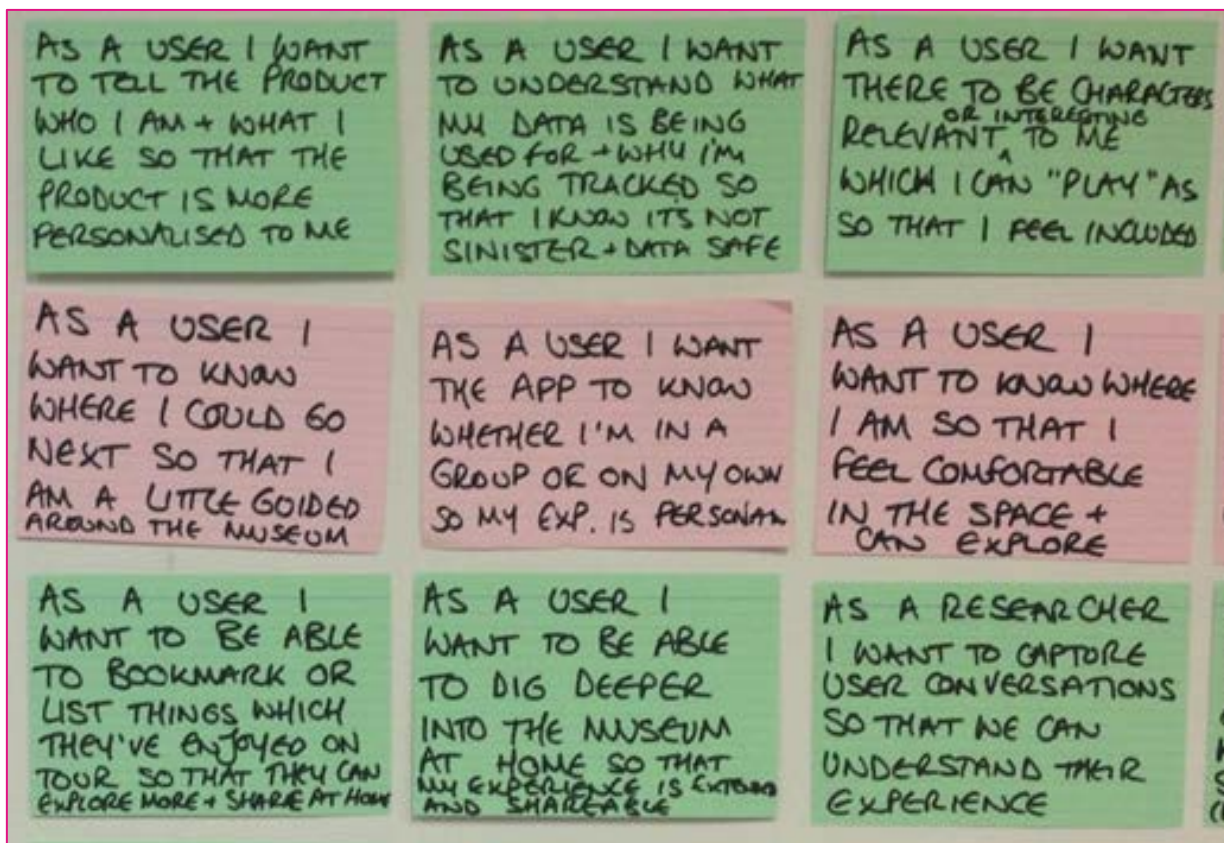
A selection of 'user stories' compiled in
advance of technical development

Lorna Probert held overall responsibility for Aardman as Head of Digital Production whilst Laura Chilcott was responsible for managing the production and delivery of its technical aspects as Senior Digital Producer. The application's structure and graphic design, narrative, copy and quality of content were the responsibility of Jake Manion in his capacity as Creative Director. Other members of the Aardman team included:

- Sarah Matthews (Designer) who undertook all graphic design and character illustration for the project

- Mark Burvill (Technical Director) who held overall responsibility for the technical output of the project

- Al Lam (Lead Developer) who undertook the technical development of the application

- Kasper Rosenthal (Junior Developer) who undertook technical research into iBeacons and supported the development of early versions of the mini-games

- Nate Ballantyne(QA Manager) who undertook quality assurance testing of the application
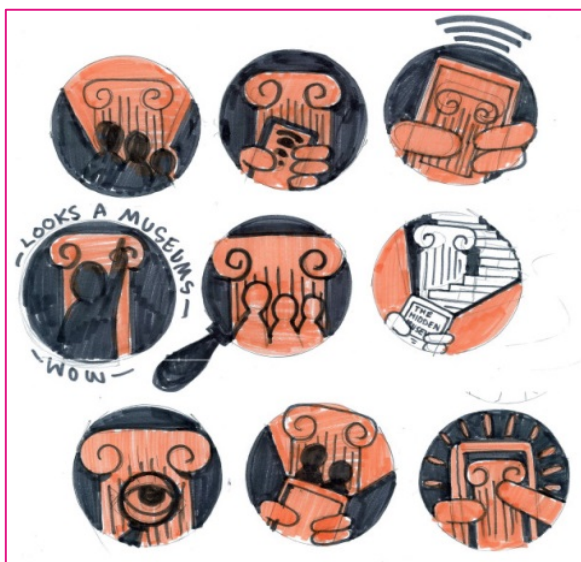
Early ideas for the project logo (left) and final logo (right) developed by Sarah Matthews.

These postcard designs by Sarah Matthews were used to promote the user testing sessions and are illustrated with the characters players adopt to represent themselves as part of the game.

There were two key members of BMGA staff directly involved with project delivery; Zak Mensah (Head of Transformation) and Gail Boyle (Senior Curator). Zak was the Hidden Museum Project Lead. He was responsible for brokering the initial relationship between the partners, scoping the project from the outset, driving the submission of the bid and once funding was secured ensuring the successful delivery of the project as planned. Zak was the first-point of contact with the Digital R&D Fund for the Arts and had managerial responsibility for the budget. He also played an important role in the creative process that led to the initial design of the application and made sure that it adhered to BMGA's digital principles which encompass:

- Users at the heart

- Evaluation

- Digital services

- Digital skills

- Experimentation

- Collaboration (Partnerships)

- Sustainability

- Open practices

Gail's role was to inform the user journey from a museum perspective. It was her task to liaise with the other project partners who had no direct knowledge of the collections or experience of delivering 'museum-style' interpretation. It was also important for her to share organisational knowledge of public visiting habits, their desires, wants and needs, as well as inside information on the intricacies of an Edwardian building. Gail played a full role in the creative design process and shared insights gained from work she had previously undertaken on a number of software based museum inter-actives. She was responsible for the collation and creation of all the museum assets required to populate the app with relevant content: this involved the provision of digital datasets, images and text.
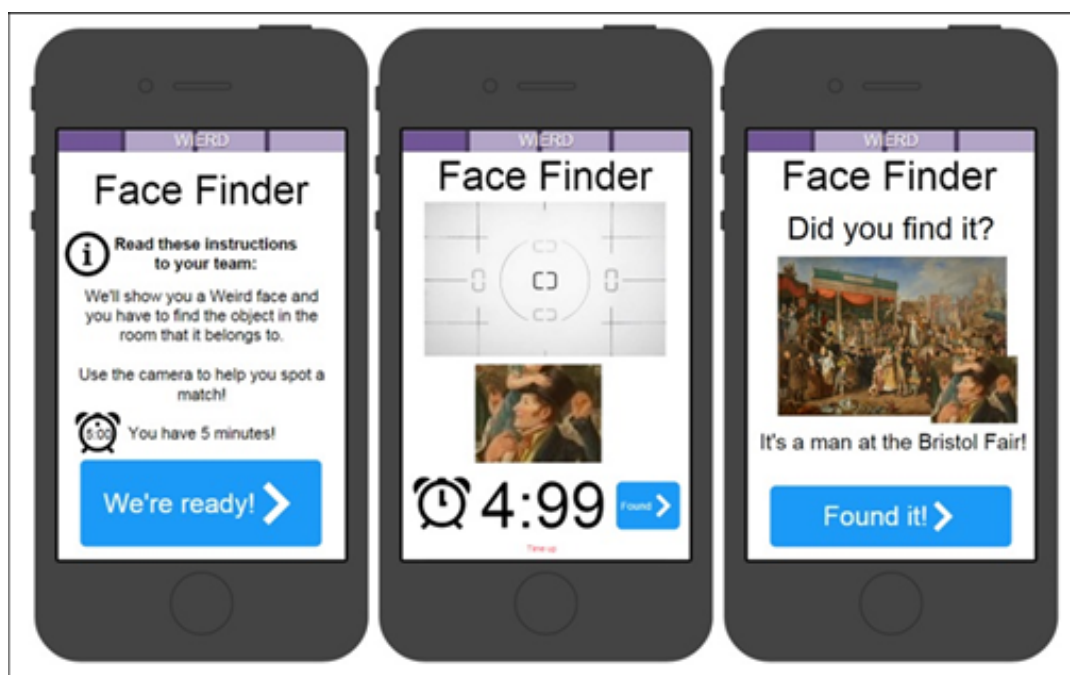
*Wireframes completed with text and
images as part of content development
process*

Both Gail and Zak acted as ambassadors for the project, sharing knowledge of the project and its progress within BMGA, promoting it to the public through all forms of media and external museum stakeholders.

As the academic research partner, the University of Bristol's role was to frame the project's research questions and to ensure that it was designed in such a way that it was possible to deliver, then collect and analyse the data required to answer those questions. As lead academic Dr Frances Giampapa played an integral role in the development process and ensured that the results of preliminary testing forced the team to think, pause and re-do as a necessary part of the iterative work process. Dr Giampapa was also responsible in collaboration with Dr Darren Roberts for the user testing research design, who also delivered the final user testing stage and subsequent analysis of the results.

Key steps and processes

As an experimental research project, the team recognised that it was important to take a flexible approach to the development process and so chose to use agile methodologies, specifically 'Scrum', a methodology

framework for teams developing a product. (See Appendix 1 for the outline project development plan.)
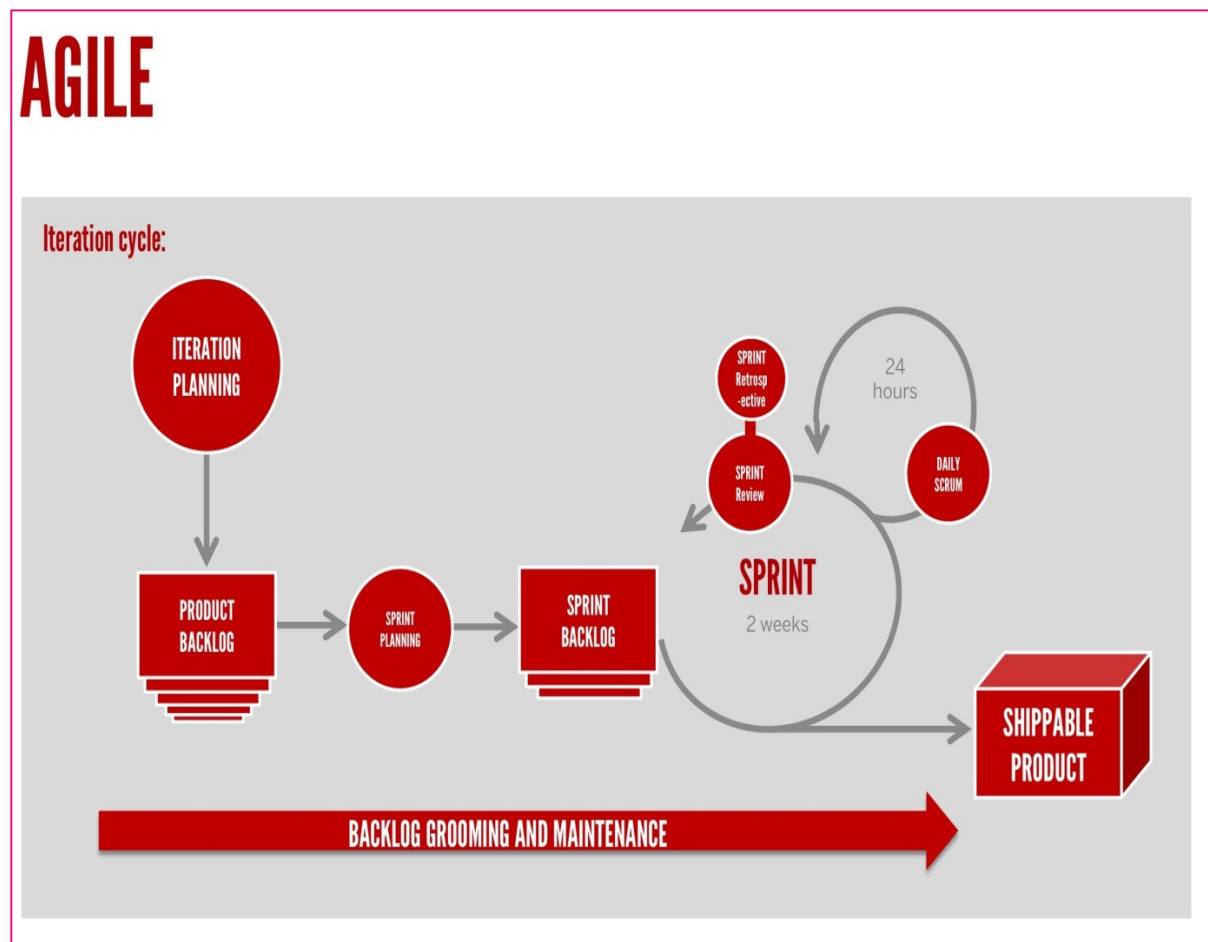
Schematic diagram to show agile iteration cycle

The first two iterations were 'scoping' iterations, with no real code or designs being created: these were used to set up a structure for the project, to undertake initial technical research, mood-boarding and the creation of concept designs for the look and feel of the application. The following iterations contained a vertical slice of planning, game design, graphic design and technical code at each stage, with testing and reviewing happening at the end of each to inform the plan for the next two weeks.

Style 'mood board' produced for initial user testing

This was an invaluable way of working as it meant that all project members were involved in all the decisions to be made. In particular it allowed for changes in direction to be more easily made from a technical and design perspective at the start of each new iteration period.

Nearly all of the technical development was carried out at Aardman's studios, but towards the end of the project it was more appropriate for developers to work at the museum to be able to troubleshoot issues more quickly. This pattern was mirrored by the user testing activity since early testing was carried out at Aardman's studios during the scoping and technical research iterations, but all subsequent user testing was carried out at the museum.

This testing was a key part of the refinement process and took place at the end of each production iteration, be it small and informal with team members, or wider reaching with the general public. The full project was carried out over a 12 month period (August 2014 – June 2015), but the technical production took place over 7 of these months (August 2014 – March 2015). There were 9 iterations during these months with some

production breaks and some additional days of bug fixing and amends at the end of the production period.

Kasper, Al and Laura (left to right) testing
the prototype app at Aardman

User testing and research

A series of informal and formal user testing sessions were carried out during the course of the application development programme: these were planned to inform and refine the overall product design, functionality and user experience as well as to elicit answers to the research questions that were integral to the project. The outline project development schedule determined at what points testing would take place (see Appendix 1). Several staff members and volunteers who took part in this process documented their thoughts on the museum blog. [7]

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[7] http://www.labs.bristolmuseums.org.uk/category/hidden-museum/page/2/

Around the half-way point in the project (November 2014), the team ran a user testing day as part of the 'Kids in Museums' programme.[8] The aim was to test and collect feedback on a prototype version of the Hidden Museum application with 26 primary school children (9-10 years old). In addition, both the technology partner and the academic partner were to provide critical feedback in the form of a report about the design and general nature of the application based on this testing.


Testing underway as part of 'Kids in Museums' takeover day

At the time of testing, the prototype application consisted of two main elements; an 'on-screen' compass to direct users to particular spaces within the museum and a series of six haptic feedback games that required the users to move the device in particular ways. The report notes 'the kids liked the games a lot', however, 'they were far more interested in playing the games on the devices than they were in the museum artefacts'. In summary the main finding of the testing day was that whilst the prototype was fun and engaging, it was clearly not delivering on the main project objectives. A number of key recommendations were developed in light of this which made

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[8] http://kidsinmuseums.org.uk/

fundamental differences to the subsequent development of the application. Changes made to improve the user experience are explored in detail below.

Making difficult decisions in light of the user testing paid dividends because it gave focus to the project. As much as it nulled work that had already been done, it provided a crucial evidence base for understanding how the app could address the two research questions.
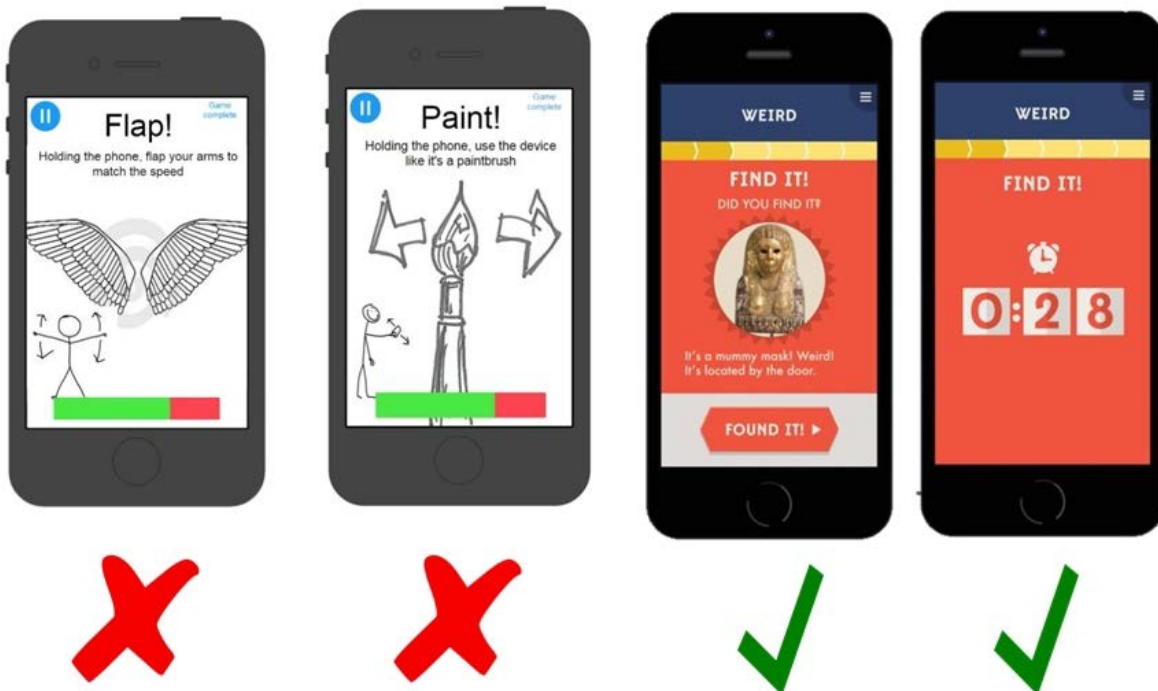
Testing showed that games that involved
haptic feedback (left) did not deliver
project objectives

The final phase of the project involved testing the Hidden Museum application with members of the public in Bristol Museum. The focus of this testing was to focus on user feedback rather than the technical functionality of the application. Feedback was collected from users about their experiences and the results analysed with the aim of answering the project's two main research questions.

The initial plan was for visitors to test the application by downloading it to their own devices but this was not possible as it was not 'app store ready'. User testing was therefore undertaken using a number of pre-loaded iPads

provided by the museum: the decision to do this had an impact on the research element's design and delivery.

The testing took place in two parts: a two-day pilot to trial the logistics required to carry out the research followed by a month of user testing.

*Members of the Hidden Museum Team
waiting to greet participants in the
museum*

For both elements of the testing activity, a desk was set up in the front hall of the museum and iPads were distributed to users who had either registered to take part online prior to their visit or on-the-day whilst visiting the museum. Dr Roberts interviewed the user groups when they returned to the desk to hand back the iPad.

The logistical components required for the pilot testing were as follows:

- Recruitment of users

- User-registration via Eventbrite (online events registration and ticketing portal)

- Location of the Hidden Museum desk in the museum

- Arranging resources such as chairs, tables, cables etc.

- iPad charging

- Gaining consent from users to take part in research

- Security measures to protect the iPads (including taking proof of ID)

- Instructing research volunteer assistants

- Collecting and sending statistical data from iPads for each user testing event

- Conducting observations of user testing around the museum

- Conducting interviews with users following testing

- Using audio devices to record interviews

Staff from all three partners played a role in organising and running the pilot to allow for a quick response should any problems arise. After reflecting on lessons learned from the pilot days, 14 user testing days were completed over a period of one month according to a pre-prepared User Testing Research Design protocol. (Appendix 3)

The testing took place over a variety of weekdays and weekends, with few logistical problems although issues did arise which were documented on the project blog.[9] A substantial dataset was collected over a relatively short period of time but due to a lack of staff resource it proved impossible to collect the observational data that had been planned. This was in part also due to the time constraints placed on the research assistant and volunteers by the administration of the iPads and the variable length of time users could choose to play the game. The interview data was deemed to be of greater

[9] http://www.labs.bristolmuseums.org.uk/project-insight-half-way-point-in-the-user-testing/

value by the research partner because it provided a more direct insight into user's experiences, was easier to collate for analysis and more readily communicable to audiences. An aspiration to conduct further observations of users still exists.

Hidden Museum desk; handing out an iPad
to a participant

Resources

The projected budget breakdown for the project was as follows:

Breakdown of Items	Total Cost (£)	Unit Cost (£)	Justification of Costs
12 days Frances	3,184	265.33	
8 days RA 1	1,393	174.13	Research Assistant1 will be involved mainly with the handling of the statistical data from the app, its analysis and reporting
19 days RA 2	3,307	174.13	
2 days Kirsten Cater	582	291	Research Assistant 2 will be involved in the design of qualitative instruments (e.g., interview questions and observation tools), will carry out the data collection and analysis of the qualitative data, as well as being involved in the reporting process. This will be done in consultation with the research co-investigator.
2 days Prof Keri Facer	944	472	Research project Principal Investigator
Travel & subsistence	75	75	Act as educational consultant feeding into the research development and outcomes of the project
Printing costs	515	515	Used during research of the project
Indirect costs	8,448	8448	FEC cost
Estate costs	1,552	1552	FEC cost

Breakdown of Items	Total Cost (£)	Unit Cost (£)	Justification of Costs
Digital manager - Zak Mensah	9,766	157.46	2 months' time for project managing from initial kick-off, development and evaluation. Time also includes working alongside partners and museum staff to provide design reviews and provide museum digital expertise
Senior curator -Gail Boyle	9,766	157.46	2 months' time to cover shaping the interpretation, advising on exhibition design and providing curatorial support
Inclusion Officer - Paul Sullivan	630	157.46	Approx. 4 days to help understand key inclusion issues and work with the prototypes
Senior Museum marketing officer	314.92	157.46	Approx. 2 days Marketing time to organise the design and delivery of marketing activity
Travel	75		
(NB Sprints are two week development periods)			
Paper prototype Sprint x 2	8,495	4247.47	The first two sprints of the project will each involve planning, research, mood boards, creating paper prototypes of the app we are proposing, user testing with real people at the museum location, and documenting our findings.
			Each prototype sprint contains at least 5 days of Creative direction, 2 days of a designer's time, and 3 days production time, plus associated costs.

Breakdown of Items	Total Cost (£)	Unit Cost (£)	Justification of Costs
Development Sprint x 7	70,973	10138.99	The latter seven sprints of this project will each involve the full development cycle of user experience design, visual design, technical development, QA, user testing, and marketing + PR
			Each development sprint contains at least 3 days visual design, 8 days app development, 1 day web development, 1 day quality assurance, three days of a Creative Director, three days of a Producer and one day of our Technical Director
Physical objects	2,000	2,000	Purchase of iBeacons, lights, props and any other physical requirements of game mechanic
5k Promotional Postcard	188	188	Onsite marketing item to raise awareness of the project and give instructions about where to get signed up
Posters	80	80	Onsite marketing item to raise awareness of the project and give instructions about where to get signed up
Café Poster	150	150	Onsite marketing item to raise awareness of the project and give instructions about where to get signed up
Roller banner	110	110	Onsite marketing item to raise awareness of the project and give instructions about where to get signed up
A frames , till, gallery doors	1085	1085	Onsite marketing item to raise awareness of the project and give instructions about where to get

Breakdown of Items	Total Cost (£)	Unit Cost (£)	Justification of Costs
			signed up
Vitrine vinyls	192	192	Onsite marketing item to raise awareness of the project and give instructions about where to get signed up
Total	**123823.61**		

Breakdown of spend per partner	Total Cost (£)
Arts Partner	22281.81
Technology Partner	81466.8
Research Partner	20075
Total	123823.61

Commentary on the resources

In regard to resources for all three partners the estimated staff time and associated budget was insufficient to deliver the project within the original timescale and parameters that had been set. Both the academic and arts partners continued to work on the project well beyond the time which had been allotted and absorbed the staff cost of doing so, but this was more difficult for the technology partner because of their commercial imperatives.

The Arts partner has subsequently invested a further £5,000 in order to ensure the application was made viable for download on iPad via the appstore. Continuing work on the project was also made possible by the fact that the project's research assistant, Dr Darren Roberts successfully applied for a fulltime permanent post at Bristol Museum & Art Gallery, and is now working as a User Researcher on the organisational audience development

programme. The project could also not have been achieved without the use of a number of volunteers who helped to administer the research days.

Overall there were no major deviations from the budget although the money allocated for two research assistants was used to employ a single assistant with a higher range of research skills who undertook the whole of the number of days the research was planned for. The main error in the budget forecast was not to have accounted for the travel that was required for representatives to attend learning workshops.

The technology partner did spend beyond the full budget that had been allowed for their work on this project. Proportionally the allocations of budgets were as per the original budget breakdown with the lion's share being spent on the 7x production sprints, and the rest being split between the iBeacon hardware (physical objects) and the scoping sprints.

The physical object cost was as also per the predicted value. However, all sprint costs were inflated from the predicted value, and this was largely due to the amount of documentation which had to be produced for the funders at each stage. Whilst some budget had been allocated per sprint for such documentation, there was an underestimation of the level of documentation that was required and so consequently there was a small overspend in this area.

Results

The research has indicated that:

- The application encourages visitors to explore parts of the museum that they would not normally enter,

- Their experiences of visitors going into those sections were of value and achieved in a fun and effective way

- The application was also able to encourage visitors to interact with objects, collections and stories.

In answering the original research proposition the personal testimonies collected during post-visit interviews, provide the best evidence for the extent to which this happened and the added value that the application has afforded to the quality of the visits.

One of the museum's many staircases leading to relatively unvisited galleries upstairs

To what extent did the application encourage visitors to explore and drive explorations more widely?

"It [the application] definitely kept the focus, it kept us moving round. It was more fun than just walking round the museum. I quite liked the fact that it just picked out bits that we might not normally have found or seen."

The majority of the participant groups who used the Hidden Museum application went to parts of the museum that they had not been to before or that they said they would not have 'normally' chosen to go to during their visit. The quantitative data collected by the app during user testing showed that at least 90% of visitors went to the upper galleries on the second floor of the museum. In addition users commented that the experience of going to those parts of the museum was of value and was achieved in a fun and effective way.

"There's some parts that I didn't know…I think it was the Eastern Arts, we haven't been up there before. We've mostly stayed on the first floor and the main lobby part, we haven't gone right up there."

Wider exploration of the museum appears to be restricted by factors other than the building's geography since some of the galleries are seen to have less 'natural' appeal to family visitors with young children:

Parent: "I think, previous feedback [from the children], it's been 'it's a bit boring up there', when you get into the silverware it's not quite as [silent pause]… like the animals and natural history."

The novelty of the route and the element of discovery that the application promoted was a particular recurring theme in the feedback provided by children:

"I think it was better because there was an area that I'd never visited before and because of the App I now know where it is. It had paintings."

Silverware on display at Bristol Museum &
Art Gallery

Several adults who had already visited the museum many times before also made comments about how their spatial awareness of what was available had changed:

> "I didn't realise there were that many floors. It really shows you how the big place is and you get to see the places that you wouldn't normally... you explore more than you world generally do; which is good because I was unaware of certain rooms."

The application provided a simple but
effective method of way finding for each
location

User feedback confirmed therefore that the application was able to actively alter the route that visitors took around the museum and to promote its wider exploration. Since it transformed the way visitors navigated the spaces it therefore also had the potential to encourage engagement with objects (as well as their associated interpretation) that were new to them.

To what extent does the application encourage interaction with the artefacts and hidden objects, promote discussion, and offer potential learning experiences within participant groups?

"So, I went in places that I haven't been in before because I'm not interested in what's there, or I thought I wasn't interested in what was there. It gave me a better, sort of, understanding of where everything is. Because I've been here before, but I can never remember where anything is, so that's quite useful."

The application appears to cut across, undo, and challenge visitor assumptions about what the museum is for and their place within it. In particular, users repeatedly commented on how they did things, saw things and found interest in things that were outside of their norm. It also produced combinations of spaces, people and practices that the visitors themselves would not have produced: its ability to disrupt their usual visiting habits was welcomed:

"it was good to actually go and explore areas that I wouldn't think I'd be interested in, but then it's actually interesting to kind of learn facts and look at the objects."

An exhibit typical of those that parents assume will be of more interest to their children

Parental assumptions about what their children would be interested in were also challenged by the use of the application, and their feedback suggests that it provided family groups with new opportunities for both learning and discussion:

> "It made it a lot more fun, for the kids especially. They're not always that engaged with the whole museum stuff - anything to do with dinosaurs, but maybe not other things."

Interest that parents expressed in particular exhibits may have resulted in part from their children's own behaviour, but nevertheless the application appears to have acted as a platform which made the least appealing parts of the museum less risky places to go in terms of the potential for disinterest. It also clearly provided opportunities for learning to take place:

> "With the rewards they were learning more about things that we wouldn't necessarily be talking about – things that we wouldn't be discussing normally. The kids wouldn't normally be interested in ceramics [laugh], and they were really interested in the pictures. I'd never been up to the ceramic room, right at the top."
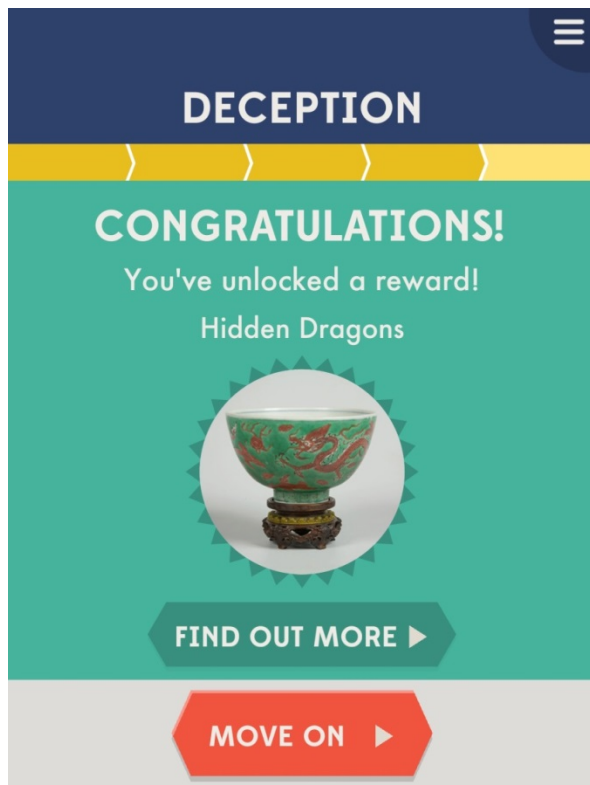
Screen shot of rewards page within the Hidden Museum application

Finding the 'hidden' museum

Providing users with a mechanism that invited them to visit particular places clearly affected their overall spatial engagement with the museum but the research also showed that the activities it provided enabled them to connect more deeply with the objects within them. Importantly it provided an antidote to particular forms of museum visiting behaviour that act as potential barriers to engagement:

> "You get museum fatigue quite easily, I think…. Just because there's so much, it becomes a bit like I'm not doing it justice."

The application's capacity to create a different type of visitor experience that was less daunting and more engaging was evident in many of the users' comments:

> "I think I felt a little bit more connected to it [the museum], I suppose because you had something else….. I tend to kind of just

coast about in a museum, and then maybe do that and then see something and then hone in on it. So that helps not do that."

The activities provided by the application also helped to promote a sense of adventure and a greater awareness of museum content that helped visitors feel more satisfied with the way they had spent their time:

"It's a different experience altogether, because I just feel like I'm more involved in it, if that makes sense?.... I can get distracted quite easily but I was quite engaged with the App the whole way, the whole time... I feel like it's been quite an adventure. I think that's the good thing about it, it really kind of makes you look around and become aware of everything, see things you wouldn't normally see. I feel like I've maximised the time I would have in the museum."

The research results show therefore that in some cases the museum becomes 'hidden' to visitors because of a lack of directed engagement and the visiting behaviours that result from this. Importantly the use of a variety of games appears to have encouraged users to look at objects in different ways so that more was revealed to them than ever before:

"I thought the good part was actually it really got everybody to really look at things. When it says oh, 'this is a picture of something find it.' It really, really got us to look at things. It's a good memory thing as well, to remember what it looks like. That's one of the best ones I think."

Screen shot of three different game options
within the Hidden Museum application

The application often acted as a catalyst for engagement that would grow, deepen, and multiply: interest in one thing would spark interest in another

and in turn create new ways of thinking about the objects that were encountered:

> "There were really good bits where we actually stopped and talked about a macaw where we probably wouldn't have done."

> "When you're wandering around and trying to find the thing, you just come across another thing and then you talk about it"

> "I did like the themes about finding things on a different level, like the fake things or the broken things. That, you wouldn't normally go around thinking 'is that fake? Or is that?...'"

Hyacinth Macaw in the World Wildlife Gallery

The activities such as 'find it' and themes in the application such as 'deception' were repeatedly highlighted by the testers as providing a fun way of focussing on the objects whilst the games in general provided them with an overall sense of purpose:

> "I think it made it a quite an interesting way of visiting the museum because we were being taken to different areas but with a purpose in mind."

Surprising encounters – the social museum

A central tenet of the project was to design an application that would encourage an increase in museum-focused social interaction between individuals and groups. One user in particular explained how the application transformed what for them was a usually non-social and isolated activity:

> "… just standing there looking at something, reading about it; you get involved with other people in your group and it becomes a topic to talk about. We discussed quite a few things that came up on the App which was quite nice because you kind of elaborate and talk about it, and then she gives me her thoughts and I give her my thoughts, and you're like, 'oh, I didn't know that'. It's quite interesting… Our conversations were more relevant to the museum, rather than just talking about what we're having for dinner and stuff like that."

The gaming aspect of the application helped to change behaviour within groups as well as make it a more enjoyable shared experience and the competitive element was especially attractive:

> "It was nice how it made it interactive between the group, so you're not just interacting with the iPad and the App, but between each other there's kind of competition which is good, I liked that."

Using the application also appears to have had a significantly positive effect on the level interaction between adults and children in family groups. Children repeatedly commented that it made the family more communicative and that this was something they enjoyed:

> Child 1: "There's a bit more team work involved than just having a look around the museum."

> Interviewer: "Do you think it changed the experience of being in the museum?"

> Child 2: "Yeah, it was really fun because sometimes when we come to the museum, when mum and dad want to look around, me and *sibling's name* are just lagging behind, but that [the App] was really fun because that kept us going around together."

The design of one particular game, 'Ask an Expert', was aimed at increasing the level of social interaction between users and museum staff. The game itself presented logistical problems since members of staff weren't always available and this in turn led to some negative feedback:

"The only thing that didn't work, in a sense, was being asked to go and ask staff stuff and there weren't any there."

Despite this when museum staff members were present, the feedback suggested this was one of the most valuable and rewarding aspects of the Hidden Museum experience:

"I went to the eastern art room, which was one of the prompts and then the game to do was to ask a member of staff something which I did …. and we just carried on a conversation and we got talking about other things in there, so that became a bit more interesting."

Screen shot of Ask Experts game within the
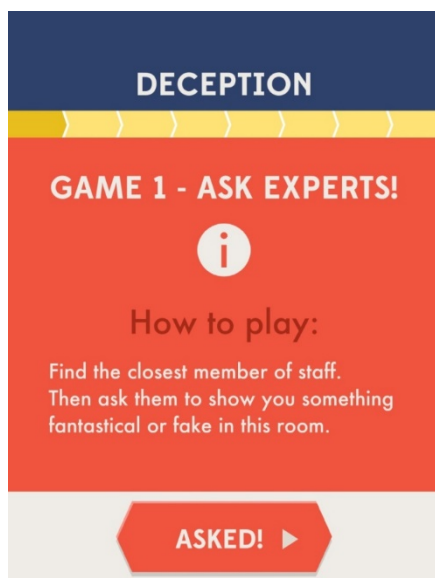
Hidden Museum app

The Hidden Museum application was therefore highly capable of creating multiple opportunities for museum visitors to experience more of the museum spatially, socially and with deeper levels of engagement. It became obvious that as visitors explored more rooms and became aware of more of the objects around them they also became more vocal, excited and eager to share their thoughts and feelings with others. This also enabled the museum to be experienced as a place that is about relationships as well as the sharing of knowledge.

Digital Technology & Making Meaning in Museums

The vast majority of interviewees were asked about how they felt regarding the place of digital technology in museums and whether or not they thought digital integration was a 'good thing'. Unsurprisingly, given the ubiquity of digital technology in contemporary life, the feedback was unanimously in favour of it. Many respondents showed considerable familiarity with digital technology and there was a general level of expectation about its integration. Anecdotal evidence was recorded about young children instinctively trying to swipe various non-digital screens in front of displays and how the lack of this provision had discouraged them from paying any more attention to the objects in front of them. The same expectations were repeated by both children and parents within the Hidden Museum user groups:

> Parent: "With the App, I guess, they [the children] won't say, 'oh, I'm bored now', because if nothing else they're running around with technology and they don't realise that actually they're taking in the things as well."

> I: "Do you think you learnt more because you had the App there?" [Directed at children]

> Children: "Yeah!" [CHILDREN]

> Child: "It just made me a bit more interested in what it had to say about certain things.

Recognising and meeting the expectations of young people with regard to the presence of digital technologies and how they use them to try to make sense of the world is key to ensuring that they can make sense of museums. In short it is no longer simply the case that it would just be exciting and fun to integrate digital technology into the museum experience, it is an essential part of ensuring that museums remain relevant to young people.

Museum staff members, who also played a part in testing the application, made comments about digital technology and its place in the museum:

"…we have to engage with it and we have to be at the forefront of doing stuff otherwise we always be catching up, we need to be pushing boundaries. I think anybody under thirty now, it's part of their lives, so you can't ignore it, you have to engage with it….we've always tried to manipulate people's visits... but this is that with knobs on."

Gail Boyle testing the application

This issue is not without tension since the visitor's desire for digital technology was sometimes mismatched with perceptions of the museum as traditional and reserved spaces. Digital applications are often viewed as progressive and about youth and playfulness, and also about modernisation. In contrast to this, Hidden Museum interviewees indicated that museums are perceived as educational spaces, traditional, mature and slower paced. This sometimes led to users to be in a quandary about what to think or how to behave: should they have indulged in the fun and childish behaviours that

the application encourages, or have maintained the reserved behaviours which seem more appropriate to the museum?

The difficulty that emerges for the museum from this is how to integrate digital technology in the face of entrenched perceptions, imaginations, and expectations about whom and what it is for.

Quantitative Analysis

The application was developed with the capacity to gather elements of quantitative data with which to support or challenge the qualitative and observational findings. However the decision to administer the research element using a number of pre-loaded iPads not only impacted on the delivery of the observational research but also the time available with which to complete the analysis of the statistical data the application provided. Information was gathered relating to:
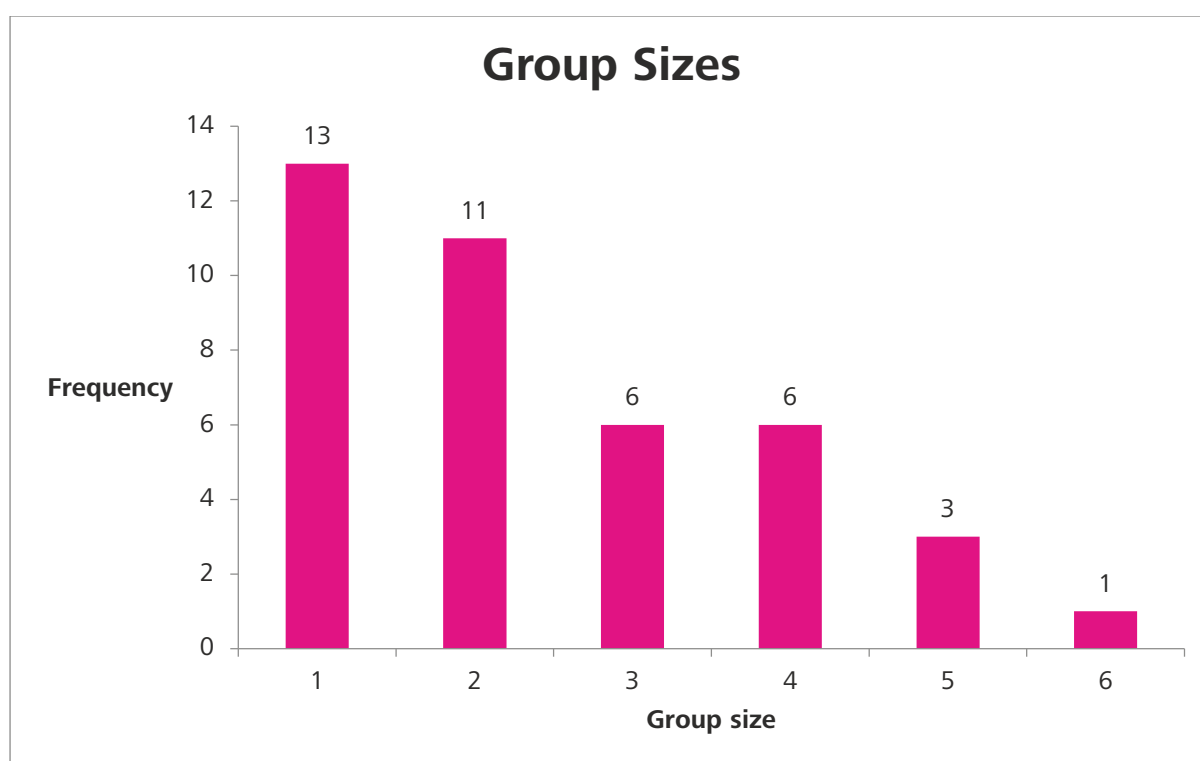
- The length of real time taken up using the application

- The size of the team

- The number of games played

- The choice of theme

- The length of time each group wanted to play for
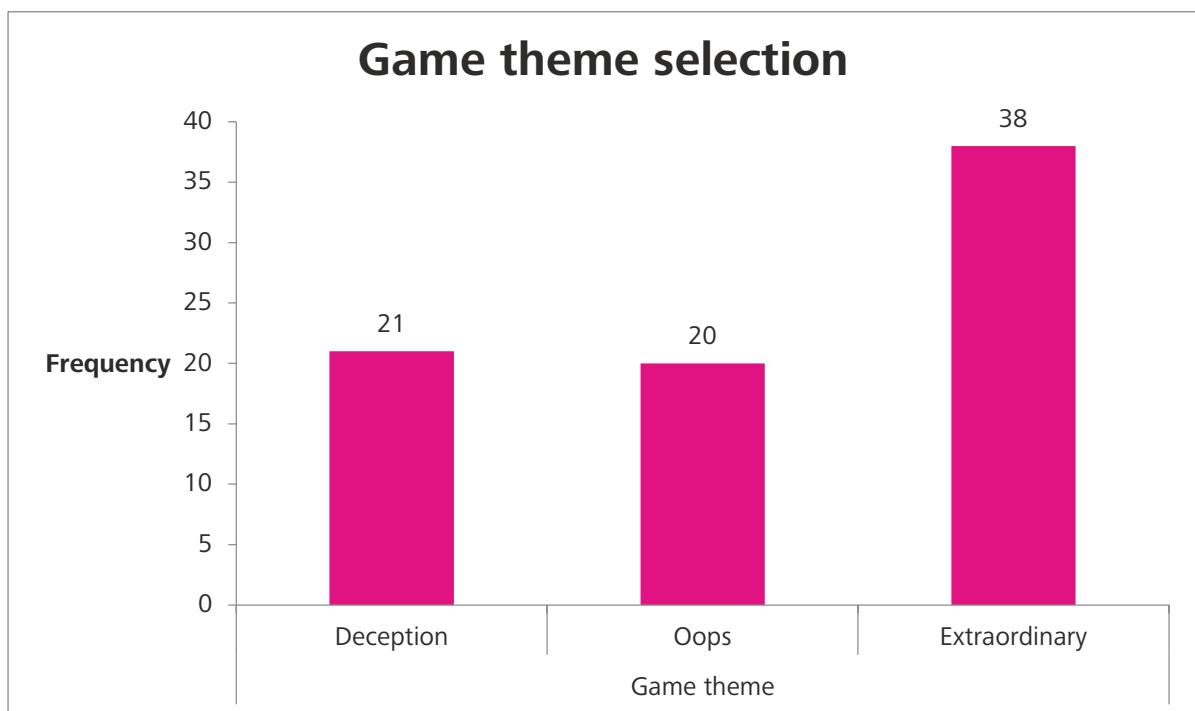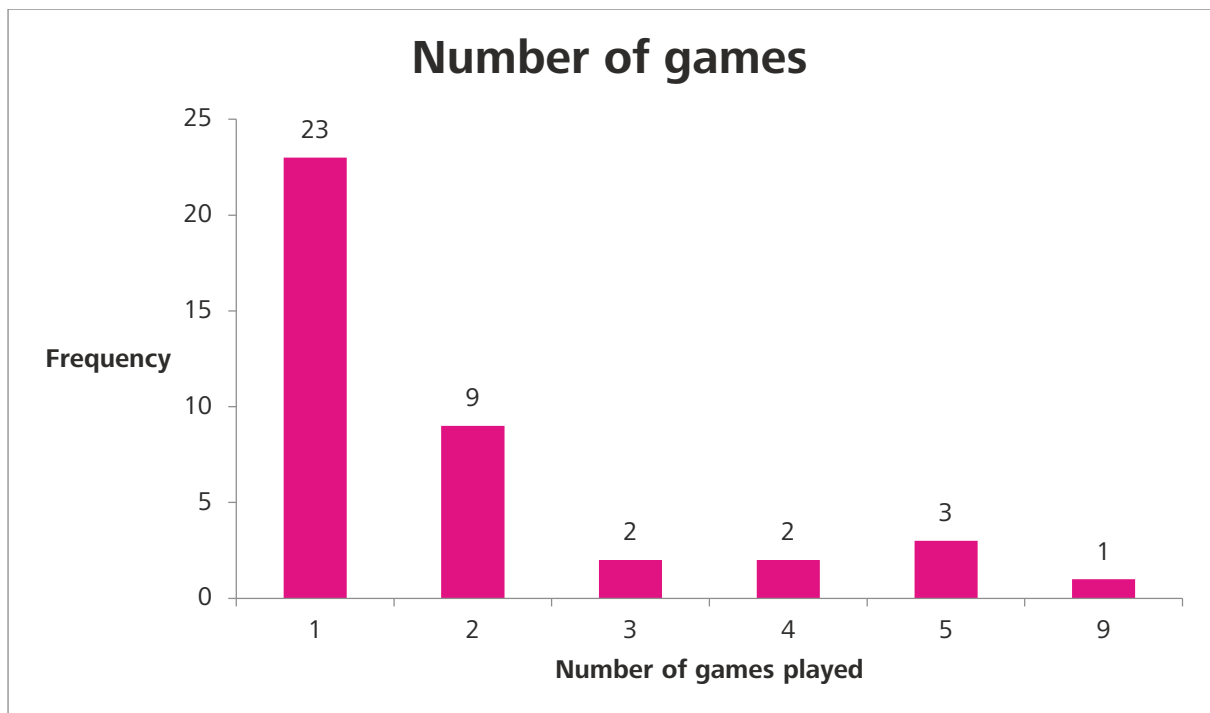
- The age range of each group

A huge amount of digital data was gathered and exported as comma-separated values in tabular format. A typical dataset relating to one group visit consists of approximately 80,000 individual values that must first be converted into easily readable data before any meaningful results can be observed. At the time of writing, 40 full datasets have been produced as readable data, which represent 42% of the total overall dataset. It is worth noting here that it is possible that the results relating to size of and nature of the groups testing the application may have been biased by the method of recruitment and are not therefore derived from a completely random sample of the museum's general visitor profile. Within the sample that has been analysed, 18 of the 40 groups were visiting with 1 or more children under the age of 16. The results must also be seen as a reflection of the length and
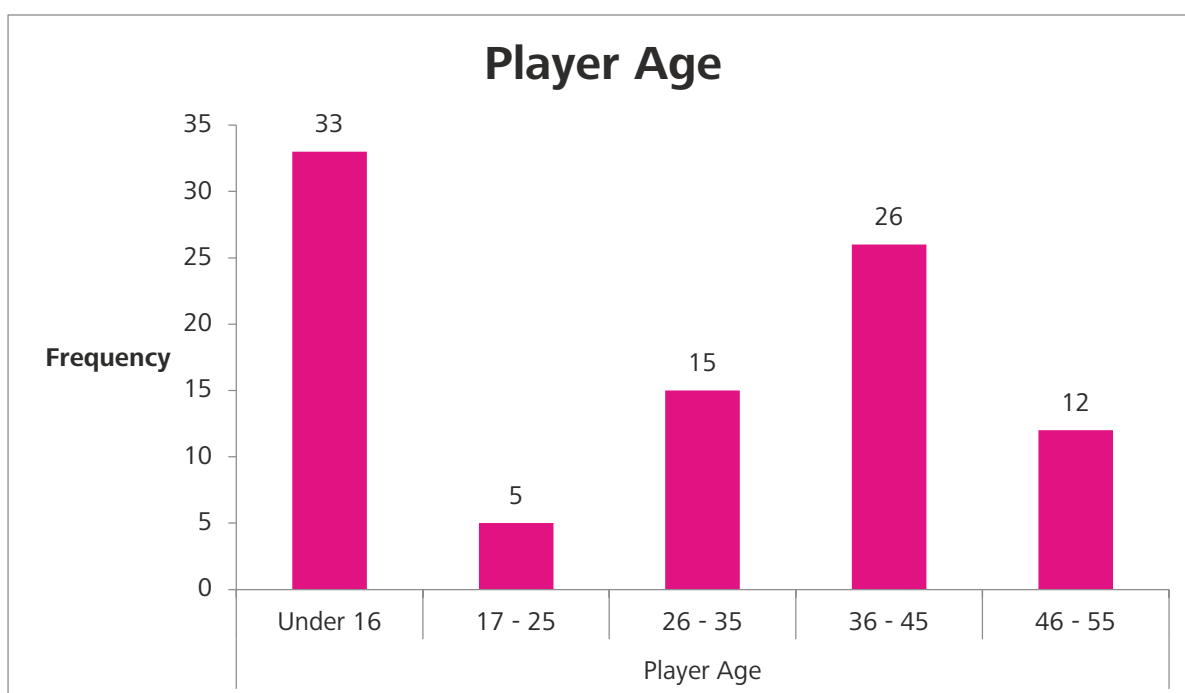
nature of their interaction with the application itself rather than of their overall visit.

The results may be expressed as follows:

Average time taken playing	01:08:07
Average team size	3
Average number of games	2

Group Sizes

Number of games

Game theme selection

Game length selection

Game length	Frequency
30 minutes	50
1 hour	23
2 hours	3
3 hours	3

Player Age

Player Age	Frequency
Under 16	33
17 - 25	5
26 - 35	15
36 - 45	26
46 - 55	12
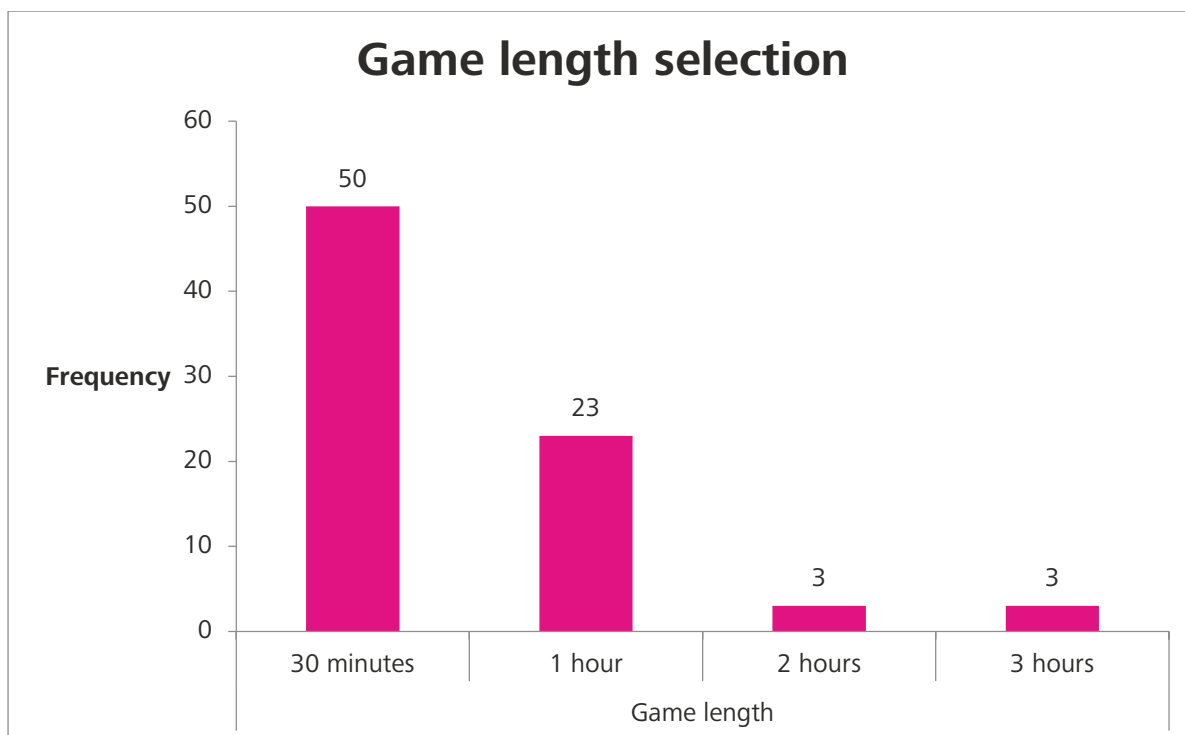
Observations

The most popular theme that users chose to play was "Extraordinary" – it was chosen almost twice as many times as the other two themed games. Since no images were attached to the choice of theme this might suggest that visitors had a greater interest in exploring or being directed to the very

unusual or remarkable aspects of the galleries. It is also possible, however that the words "Oops" and "Deception" were less understood as the names for themes or that "Extraordinary" was simply the first choice on the list.

It is impossible to know from the data that was gathered whether or not the time spent playing the games represented the whole of the museum visit for each group since this would have required an exit survey to have been undertaken on the same day as each of the research days. Many of the groups that tested the application also booked a particular time slot to begin their testing but it is unknown as to what point during their visit to the museum that they played the game and what impact this may have had on the choices they made over how much time they chose to play. It is worth noting that some of the groups that chose the shortest period of time to play then chose the same period again for up to four consecutive times which would suggest they enjoyed the experience and wanted to play more.

Data supplied by the Audience Agency's Audience Finder for 2014-15 shows that the typical dwell time in Bristol Museum & Art Gallery for about 45% of its visitors lies between 60 and 119 minutes and that less than 20% visit for under an hour. The objectives of the project however were to increase footfall in particular areas of the building as well to improve levels of engagement for visitors rather than affect their overall dwell time. However although the method of triangulation used by the application in conjunction with the iBeacons was able to successfully direct visitors to particular areas of the building, the system was conversely not capable of providing accurate recording of the movements of people using the same system nor the time they spent in a particular place. This is because the values captured by the device may relate to spatial data provided by the iBeacons in adjacent rooms or floors.

Insights

A number of valuable insights were gained during the course of the project's development and delivery, many of which were manifested in detail on the museum blog.[10] The main areas of insight involve:

- the nature of the working relationship between three very different types of organisation and how this related to the practicalities of delivering the project

- learning to understand the requirements of the application from an audience perspective and the subsequent development of new thinking and practice

- understanding the capabilities of the digital hardware and how to best use it in the context of the application

- the value of the research process, the results achieved and what this means for the future

The Partnership

The project required three very different types of organisation to work together and each had their own 'in-house' processes and methods of working that the others needed to be able to accommodate or assimilate. In practice it became apparent that the technology partner was more capable of directing staff resource and time specifically to delivering the project, which is understandable since this is a key aspect to its ability to succeed in the commercial world.

Team members from the arts and research partner organisations were less able to commit to working on a single project to the exclusion of all others. Museum staff, for example, are typically required to work on multiple concurrent projects, to be reactive to public demand and affected by the need to respond to many externally driven agendas. Similarly university staff are timetabled by teaching commitments and the ebb and flow of the academic year. Although establishing excellent mechanisms for communication and information sharing was the key to facilitating project development, taking the time to understand how each partner operated in

[10] http://www.labs.bristolmuseums.org.uk/category/hidden-museum/

its own domain was vital to its success. The use of Trello and Basecamp as well working in Agile sprints clearly had a significant impact on project delivery but also on working practices. As a result of project 12 members of museum staff have been SCRUM certified and management is looking at how this might be adopted across the service.

Working together over a long period of time takes focus.

The long lead into the project, beginning with the bidding process, added to the pressure on the team to maintain focus before funding was even secured: the reporting requirements added an extra pressure at a time when the partners' focus was primarily on delivering the mechanics of the application and its outcomes. All partners clearly understood that ongoing recording and reporting was an integral part of the brief but under-estimated the time that it required: the team collated huge amounts of documentary information but this still needed to be synthesised for reporting. With hindsight the partners were good at sharing information with each other but should have been more astute about the format of what was produced and how it could be modified to meet reporting requirements more efficiently.

Negotiating the development journey was relatively straightforward as each partner was prepared to be open and honest with each other, willing to make compromises and not to hold on too tightly to pre-conceived ideas. However the flexibility to develop the idea for the project could not have been achieved if the project bid itself had been too prescriptive. Simple aims matched with simple outcomes allowed for creative and productive thinking that resulted in elegant solutions. The research results suggest that the application is doing what the team hoped it would but nevertheless there are still some issues that need to be resolved regarding its future development, general maintenance and delivery.

User Experience (UX)

The term User Experience broadly refers to how a product meets the needs of its users. In digital terms this usually refers to the on-screen experience, whereas the Hidden Museum is an on-screen tool that enables an off-screen experience: this is a rare dimension for digital specialists to be working in. Users of the Hidden Museum had two primary needs:

- On-screen: To understand what the tool is, how to use it, and to enjoy its content.

- Off-screen: To navigate the physical museum, and to comprehend and enjoy the activities.

These two needs are intertwined, as neither can be met without the other and in some cases they are barely separable.

A static prototype of the application's screen flow was created (using the tool www.proto.io) with which to test the team's initial assumptions. Although static prototypes work in a device and feel like an application, they only enable users to flick through screens rather than anything happening automatically. Whilst this informed some narrative elements, it failed to provide any real insights into navigation around the physical museum, or any issues with the activities the application provided: almost all of the most useful insights came from testing a later functional version with real users around the museum.

Physical navigation

The biggest UX challenge was ensuring users were looking up and around, and talking to one another rather than being transfixed by the device in front of them.

The interface was originally designed so that all the application's technical capability was hidden from the user; all that could be seen whilst moving around simple graphic compass for navigation purposes, but even this proved to be far too captivating. During user testing people continued to stare at the screen and consequently tripped up over bags or walked into walls because they weren't looking where they were going. It took two more iterative stages of development before users began to look up instead of at the screen: the final and most successful iteration recognised that users only needed to be given the name of their next destination gallery and floor number since they would naturally use the museum's existing signage and information to help them get there. Players were still able to access an interactive map through an "I'm lost!" function but this feature was pitched as a last resort.

Playing games

Hidden Museum activities take the form of games to be played at a specific destination which enable visitors to engage with museum content. As with the development of the navigation UX, the approach to these activities changed considerably once it had been tested by real users.

The initial thinking was to make the most of the mobile device's capabilities, for example, by using the gyroscope, accelerometer, screen and speaker, to encourage group engagement. The activities were designed to be fun, content-light games that just encouraged users to spend a little more time around the chosen exhibits. Many involved movement, for example, a wing-flapping game where individuals held the device and 'flapped' their arms at a particular speed to match a bird's wing beat. The screen was programmed to turn green when the flapping was correct, and red when incorrect. The rest of the team helped by shouting 'faster' and 'slower' as only they could see the screen properly.

User testing proved, however, that although these games were fun and exciting, very little attention was being paid to the exhibits themselves.

Participants stood in front of the exhibits for longer but were simply staring at the device waiting for it to respond. The solution was to make the games far-less reliant on the screen. If the navigation element of the application became about assisting teams into the desired rooms, the games became about teams finding objects in the rooms and discussing these against the clock. If players stared at the screen during these games, it meant they wouldn't be able to play them.

Outcomes

The earlier assumptions can be tested the better since no matter how well considered decisions may be sometimes it's just not clear what is an assumption and what is really based on experience. Developing a functioning prototype and testing it in the real space should be prioritised in order to test it out with as many users as possible during the development process. Focussing the team's earliest efforts on the application's underlying technology meant that some of the more assumption-based UX decisions were overlooked until later. Fortunately UX changes are one of the more flexible elements of digital projects, so meaningful changes could be made in response to the results of testing.

With both the physical navigation and the activities, it was clear that people liked staring at devices, particularly when it was doing something novel like responding visually to their exact movements. The only way to stop users engaging with the device's special technology to the detriment of the project goals was to hide it until it was is absolutely necessary even if this meant hiding 99% of the team's ground-breaking work. Being drawn in to trying to utilise the mobile device's own technical capabilities may appear to have been a distraction that cost time but did help the team to crystallise its thinking as soon as the testing results were known.

The provision of museum content appropriate to the application was aided by the existence of a well-developed museum collections management system (CMS). Once the team had resolved how the application might best link objects with people, activities and spaces it became obvious that although the CMS contained lots of data this was almost always in need of modification and in many cases it was necessary to produce new images and bespoke text. Whilst the CMS undoubtedly helped the team to reduce the time required to produce datasets and to identify more playful connections, in reality it was the analysis of the feedback report from the 'Kid In Museums' testing day that proved to be decisive in the approach that was finally adopted.

Testing with real people throughout the development process led to some fundamental changes in thinking that created a much better outcome for the user. Implementing these changes, however, also meant the team being brave enough to discard work they had spent many hours on developing. In order to do this it was essential to focus first and foremost on what was best in order to achieve the project outcomes and always from the user perspective.

iBeacons

The basic technology required for the Hidden Museum project was:

- a large number of iBeacons strategically placed around all three floors of the museum

- a hand held device capable of using triangulation to calculate where it is in the museum by receiving signals from the iBeacons and which is also able to use its own compass to know which way it's pointing.

The application uses these tools to help visitors navigate a randomly generated tour of the museum by leading them from room to room, floor to floor and producing an activity when they reach each destination.

Brands, placement and security

The suitability of a wide-range of iBeacons was assessed (see Appendix 3 for a list of suppliers). The primary reasons for choosing to use those manufactured by Kontakt were that they are visually discreet, easy to configure, have easily replaceable batteries and could be supplied in volume at a reasonable price. The triangulation method required a large number of iBeacons to be placed throughout the museum building in precise locations to create an effective 3D grid of signals. They needed to be out of reach and ideally invisible to both the public and staff to avoid them being accidentally moved, tampered-with or stolen.

Software

The navigation system was implemented in Unity 3D which is primarily a game engine and where Aardman's core mobile experience lies. Unity 3D is popular and satisfies the cross-platform requirements of real world implementations as well as having a super-low barrier-to-entry with developers and very little reliance on proprietary tech.

Kasper at Aardman doing battle with triangulation!

It is possible for the mobile device to work out its precise position by triangulation using the perceived distance from all 'visible' iBeacons. Some exceptionally advanced mathematics was required to achieve this and so the

developers eventually decided to use Unity's built-in physics engine to do the work for them: this involved using Spring Joints from each iBeacon to automatically position the device on a virtual map, (based on perceived distances from each iBeacon in range) and allowing Unity to perform the calculations.

Reliability

For a triangulation system to work effortlessly the distance data needs to be accurate and updated frequently. However testing showed that iBeacon distance readings tended to be fairly inaccurate, with meaningful variance, even in the best conditions (up to 3 metres out), and much worse in poor conditions (physical interference such as pillars or people, and electrical interference such as laptops or mobile devices). Accuracy does tend to increase the closer the iBeacons are to the device.

Frequency of updates also proved to be an issue since users moved around the museum space surprisingly quickly. Since the system was only able to read signals approximately once per second, a lot of smoothing of the positioning data was required to avoid flip-outs every time an update occurred.

The compass

The compass was 100% reliant on the accuracy of the device's hardware and software, which isn't necessarily the case with smart phones and tablets. Even in the best conditions digital compasses are likely to be anywhere up to 20% inaccurate and in poor conditions (such as an indoor space with lots of electrical interference and organic, metal or stone structures).[11] Testing showed readings to be out by up to 90 degrees which is not ideal for leading users around a space accurately.

Three-dimensional placement

Since iBeacons work on distance it followed that the height at which they were placed also made a difference. The team's assumption was that this wouldn't cause much of an issue so long as it was consistent. Unfortunately this did not take into consideration how powerfully the signals could penetrate through floors and ceilings or travel across open atriums and balconies. Bristol Museum & Art Gallery is a complicated building, with a variety of galleries of all shapes and sizes arranged over six levels across

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[11]   http://www.techhive.com/article/2055380/six-iphones-tested-and-they-cant-agree-on-true-north.html

three defined floors, which are interconnected by a series of corridors and stairwells. This meant that it was difficult to find a consistent position in which to place the iBeacons and there were many opportunities for the mobile device to pick up signals from the floors above and below it. With a standard GPS system this would be like expecting it to show a user what side of a multi-storey car park they were in as well as the level they were on. Whilst iBeacon triangulation is vastly easier to use in environments that can be mapped in two dimensions one of the outcomes of the development work was to produce a system that showed it was possible in three.

Handling shortcomings

The solution for many of the technical challenges was to simplify and adapt the user experience even though the underlying technology remained largely the same. Many of the changes required the team to accept the huge variance in the quality, accuracy and timeliness of the data the navigation system was is based on and to soften the blow as much as possible so that the user experience was least affected:

- Inaccuracies and signal latency of iBeacons led to the user experience being focussed on the room they were in rather than pin-point positioning within that room.

- Compass inaccuracies lead to the user occasionally having to find their bearings when stationary rather being led around step by step.

- Three dimensional inaccuracies led to the creation of navigation logic that only recognised movement between adjacent rooms. In practice, this meant that if the triangulation data suggested the device had changed floor it was only recognised if the user has just left an appropriate stairwell or lift area.

Summary

Each of these solutions had significant emergent benefits to the overall user experience and whilst iBeacons may not provide the perfect navigation system, the project proved that they can be used successfully indoors and out by taking full account of their limitations.

From a museum perspective iBeacon technology enabled visitors to navigate its spaces and engage with objects and each other in new and innovative ways but it has also presented it with simple challenges such as the prospect

of changing 100+ batteries positioned in difficult places to reach. The more complex challenges surround the resourcing of future iterations of the application.

Research

Within the university world there is an increasing push to engage in cross-sector, partnership-based and collaborative research projects. From the outset of the project, however, it appeared as if the research/academic partner had a comparatively less defined role than the other two partners. The Museum was the host partner with a problem to be solved and Aardman was the digital technology solution provider: the research element didn't seem to necessarily fit into the neat problem/solution duo. The individuals who were to provide this expertise had also predominantly worked in universities and academia: they considered themselves to have limited insight into the working culture of the other project partners and that they in turn would have a relatively limited knowledge of how social science disciplines conduct research.

One of the museum service's aspirations, however, is to move beyond the traditional museum model (collect, care and display) and to enable its audience to become more participatory in the way that it is delivered. It now invites its audiences to 'discover, challenge and contribute' which provides a good metaphor for the way the Hidden Museum team dynamic evolved: in order to innovate, each partner had to be open to learning with and from each other, to trust in each other's area of expertise and to be guided by them and the fresh perspectives they brought. In short, challenging each other's assumptions was embraced and seen as a productive part of a collaborative creative process rather than a potential source of friction. This inevitably meant that the research element fitted seamlessly into the overall process: the academic partners were well-placed to be able to scrutinise emerging issues and search for oversights or cleavages that might have caused problems further down the line.

The foreground element for research within the Hidden Museum project was to conduct the final user testing of the application and to collect and analyse feedback from the users. In reality, the development of the application was as much shaped by the research that took place along the way as by the technological capabilities of the hardware.

An observational report produced by Dr Keri Facer as part of a 'Kids in Museums' day, which trialled some of the early game designs, proved a seminal point in the team's intellectual approach to producing the types of game which met the needs of the project rather than one which just made use of the technology available.

 Aardman's Laura Chilcott said:

> "The research goal of the project really helped shape our user stories by choosing those that would best answer the research questions, rather than getting carried away by the technical wizardry at our fingertips, or the huge breadth of content at the Museum. And the R&D focus liberated us all to genuinely respond to user testing results – a rare privilege when working commercially."

The same sense of liberation in letting the results do the talking was expressed by Gail Boyle at Bristol Museum:

> "Producing interpretive narratives for this particular application meant using different types of language, imagery and subject material than we might usually do in a museum setting - because I knew that the published application would be ultimately shaped by the research results it made it easier to take risks and to be governed by what people liked and didn't like, what worked and what didn't."

The practical delivery of the research phase within the public museum setting was not without its challenges: for example, it was hard to test an application that related to all the floors if one was closed due to staff shortages. Also although the team decided to use social media to generate interest, and an online registration process to help spread the weight of testing throughout the days and across all the programmed days, it was perhaps inevitable that visitors who had not booked would want to join in. Testers were subsequently recruited 'on the day' but were still required to provide ID and to fill-out the consent form in order to take part. The flexibility that had manifested itself across the rest of the project development process therefore also came to the fore during the research phase but without compromising the outcomes required by the research design. In fact in hindsight it would have been unlikely for so many users to have tested it in such a short period of time without recruiting from within the museum itself.

Since this project is part of an on-going process of building knowledge, the results will also feed into a much wider series of research areas. As well as particular knowledge about the capabilities (or otherwise) of the technology the application uses, there are broader themes that both the academics and museum partners are especially interested in exploring and becoming expert in. These include 'informal education', 'digital literacy' and 'cultural production' which clearly extend far beyond the use of the application itself. In the shorter term specific learning about the user experience and feedback regarding the digital interface will be incorporated into the 'app store ready' release.

Sharing the learning from the project and understanding that it will contribute to helping other institutions to develop their own digital capability is certainly a positive outcome. However each partner will also use the results in their own way to provide platforms from which to build more: doing the research was the means to achieve a particular project goal but will not necessarily be the end of the project itself.

Future

The Hidden Museum project has been successful in many ways, and each of the partners is eager to build on those successes and drive their ideas forward. One of the first steps will be to fine-tune the existing application based on user feedback and to release it for public download. This in turn will provide an opportunity for further research over an extended period of time and especially in light of how differently it might be received and experienced by visitors when they have to download it to their own devices. The majority of the resources were used to develop the application content, design and structure as well as to establish the iBeacon infrastructure: to fail to make the proceeds of this work available to a regular visiting audience would be deemed a major failure by all three partners. Options to make further finance available are currently being explored. This would also enable further exploration of observational data collection and analysis of quantitative data.

As well as launching the application in an app store, all three partners agree that a strategic plan is required to resource and add new layers of up-to-date content to ensure that repeat visitors would continue to be encouraged to use it. In addition to this, having a system whereby the museum could add new material to the application would present it with an unique opportunity to bring so much of what remains 'hidden' in its database and below stairs to the public. As well as providing a new means for visitors to engage with the museum, the application will also provide a new mechanism for curators to engage with both the artefacts, exhibitions and the visitors.

Bristol Museums, Archives and Art Galleries incorporates a number of other museum sites beyond Bristol Museum and Art Gallery. As such, there is a strong desire from the museum partner to further explore how the approach could be used in the other venues. Each museum site has its own issues regarding how visitors engage with them and given the insights gained from the Hidden Museum project, it is clear that digital technology could provide potential solutions with which to enhance visitor experiences and encourage greater engagement with objects.

The Hidden Museum project happened at a time when Bristol Museum and Art Gallery is actively trying to increase and strengthen both its digital and its

user research capacities: the Hidden Museum project has demonstrated is that this is only the beginning of its journey in both these areas.

It has also shown that creating partnerships with strong industry and research organisations is mutually beneficial. The relationships with Aardman and the University of Bristol are something the museum wants to maintain. Currently, all three partners are exploring the possibility of another bid application through the University of Bristol to continue research in the museum on digital technology. More generally, this adds clarity to the fact that collecting data on visitor patterns and behaviour is an area that the museum wants to continue exploring and this project helped as proof of concept.

The Hidden Museum project has ultimately been about experimenting with new technology in order to create a way for visitors to maximise their experience of the museum by enabling them to utilise mobile devices they have daily access to. Central to this is the idea that museum visits take shape as the result of a two-way relationship between the visitor and the museum. It is not about the museum prescribing how the museum should be experienced or about how visitors should behave. Nor is it about simply opening the doors of the museum and abandoning visitors. It is about creating a relationship with visitors which enables the museum to share resources and knowledge and which enables visitors to bring their own ideas and desires to the space which is the museum. This is part of a wider aspiration to make the museum a dynamic and multidimensional space which can be about many things at once including enjoyment; learning; family; socialising; questioning; or simply getting out of the rain or having a coffee.

What it means to be a museum is not fixed and the Hidden Museum project has provided valuable insights into the ways this can be pushed in new and exciting directions. This is why it is important for the Hidden Museum application to continue to be developed and also why it is important to continue to engage with digital R&D in the future. It will support making the spaces museums provide relevant in a way the visitors want the spaces to be relevant to themselves rather than the ways the organisation prescribes. In short it will give them a license to behave how they choose to.

Further Resources

Further project information

Information and guidance can be found via The Hidden Museum blog including a wide variety of documents regarding the development process, testing and insights:

http://www.labs.bristolmuseums.org.uk/category/hidden-museum/page/3/

Tools and guidance

Accessibility and 'assisted digital'

As well as creating the application in such a way that it met accessibility standards it was important to ensure that it was also delivered within legal and policy restraints such as Bristol City Council's Equality Plan and the Equality Act 2010. In addition to accessibility considerations, therefore, BMGA drew up an 'assisted digital action plan'.

The Government Service Design Manual has helpful guidance on what to consider with regard to 'assisted digital', which is defined as:

> "…support for people who can't use online government services on their own."[12]

Providing support for visitors using mobile applications in the museum context requires consideration of:

• Which users might need such assistance

• The organisational ability to provide such support

The purpose of offering assisted digital support is to ensure the museum provides a great experience for all and to ensure as many people as possible are able to benefit from being able to use the application.

Assistance can be provided by visitor assistants who are trained to support visitors with the application as well as being able to offer alternative forms of engagement activity within the galleries themselves.

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[12] https://www.gov.uk/service-manual

Assisted digital action plan

1.   Baseline support to be based on the percentage of general visitors who consider themselves to be disabled (this figure informed by the annual general visitor exit survey).

2.   Test the application and proposed assisted digital in-person support with the inclusion officer.

3.   Provide assisted digital support information to visitors ahead of visits.

4.   Ensure visitor assistants are aware of the assisted digital support that may be required and provide appropriate training

5.   Monitor the volume of assisted digital support activity including wait times.

6.   Record and monitor feedback by users and experts with the aim of achieving 'fairly or highly satisfied feedback' in accordance with standard surveys.

7.   Test, measure and iterate the application procedures for supporting assisted digital users during our Beta phase

8.   Ensure the support offer is sustainable and consider using volunteers for additional support

9.   Provide guidance that will support users to complete the tasks within the application independently

Further reading

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Glossary & Abbreviations

Agile   A project-management methodology which employs an iterative approach to development that typically breaks the process up into small work packages and allows for teams to respond to issues as they arise throughout the course of the project.

Basecamp   A web-based project- management tool developed by a company called Basecamp (formerly 37 Signals): see www.basecamp.com

BMGA   Bristol Museums, Galleries & Archives

CMS   Content Management System: a computer application that enables the creation, collation, sorting, editing and publishing of datasets

GPS   Global Positioning System: a method of pinpointing location using signals from a series of space satellites

Haptic   From the Greek *haptikos,* which means "pertaining to the sense of touch": this manifests itself in mobile devices in the form of vibration that can be felt in response to touch or a particular way the device is handled.

iBeacons   iBeacon is the name of a protocol standardised by Apple that enables mobile devices to receive and react to Bluetooth low energy signals: the term has become synonymous with the transmitters that emit the signals which can be used to determine the proximity of a mobile device and to trigger messages, actions and prompts within an application

SCRUM   a methodology framework for teams developing a product.

Spring joint	A spring joint constrains two bodies in such a way as to enable them to move like they were connected by a spring.
Sprint	A unit of development (iteration) which is part of an agile process that uses Scrum. Sprints are defined by a specified period of time and tasks to be achieved within a project.
Trello	A web-based project- management tool developed by Fog Creek Software (now Trello Inc.): see www.trello.com
Unity 3D	A cross-platform game engine developed by Unity Technologies: used to develop games for PC, consoles, mobile devices and websites.
UX	User experience: The overall way in which individuals interact, perceive and respond to the application.

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Appendix 1

The Hidden Museum - Outline Project Development Plan

Each two week sprint incorporated a planning session at its beginning where the remaining functionality was prioritised, the development cycle was reviewed and a product iteration was demonstrated to all partners so that the process is could be analysed and improved. Each development sprint contained the full project cycle: functionality was built to the highest priority as defined and agreed by the partners for that particular sprint.

Project Development Plan
Setup   • Contracts signed   • Kick off meeting   • Statement of Work agreed   • Release plan finalised   • User stories agreed
Project management   This ran parallel to all milestones. Initial set up included project management templates and an agreed partner communication plan. Specific project management input took place at the start and end of each sprint or research finding.
Museum interpretation development   Scoped to enable the application to deliver appropriate information, meaning and concepts in relation to the museum collections   • Accessibility essentials   • Marketing planning   • Initial research input
Sprint 1 (prototype)   • Preliminary content, team and technical research completed   • Prototype Game Design Document (feature map) version 1   • Mood boards created (overall look and feel)   • Paper prototype created   • Paper prototype and mood boards user testing session #1

Project Development Plan

Museum initial asset development

Exploration of what already existed, possible connections and the available datasets to inform the prototype

Sprint 2 (prototype)
- Further content, team and technical research completed
- Prototype Game Design Document V2
- Mood boards (character and user interface)
- Paper prototype amended
- Paper prototype and mood boards user testing session #2

Museum asset creation and delivery

Creation and completion of templates to populate wireframes, text writing and photography to agreed themes and structure

Sprints 3 - 9 (development)
- Planning (user experience, wireframes, technical architecture)
- Visual development (user interface, characters, branding, site design)
- Technical build (app build and deployment, server side architecture, iBeacons, screen based media, website build)
- Physical objects (planning, design, build)
- User testing (informal)
- Marketing + PR

Purchase of physical objects (e.g. iBeacons)
Digital Marketing onsite

Release 1
- Core functionality for user testing at Bristol Museum: to include iBeacon and location technology, personas, unlocking archive mechanism, app visual design, physical objects.
- Museum testing
- Accessibility review
- Start of data collection and analysis

Project Development Plan

Release 2
- Beta functionality for user testing at Bristol Museum: to include improved iBeacon and location technology and analytics, question + interaction to unlock archive mechanic, improved visual design, physical objects, website feature test
- Museum testing
- Accessibility review

Final release
- Full functionality for prototype launch
- Marketing delivery and review
- Further data collection, analysis and writing up

Museum project delivery – including marketing and training visitor assistants
- Data analysis and writing up
- Presentations/Publication of research findings

Appendix 2

Research Design

User Testing Research Design
Data collection and sample
- Estimated 15-20 research days (10:00am - 17:00pm)   - Research will take place on a mix of weekends and weekdays   - Estimated 3-4 hours of observation per research day (= 45-80 hours in total)   - Estimated total of 30-50 interviews with participants (10-20 minute interviews)   - Estimated participant sample of 5-10 groups per research day   - Estimated total participant sample of 75-200 groups   - Possible range of individual participants of 75-1200 (depending on the size of each participant group with a variation of 1-6 in each group)
Recruitment of research participants
- The primary means of recruitment will be based on invitations to existing organisational networks at the Museum, Aardman, and Bristol University   - A smaller group of participants may potentially be recruited from the general public on research days   - Research Participants will be able to register to take part in the research via a Hidden Museum 'Eventbrite' page   - The Eventbrite page will enable us to monitor how many participants to expect on each research day
Research risk management
- A key research risk is the security of the iPads that will be handed out to research participants   - We are not able to minimise the security risk entirely but measures are being taken   - Research participants will be required to register online prior taking part   - Research participants will be required to fill-out and sign a consent form   - The consent form will require that one member of the group is nominated as a leader who will provide full name and address   - The lead participant of will be required to provide photo ID to verify their name and address

Appendix 3

iBeacon suppliers & technology

Supplier	URL	Volume pricing	Price per 100 (ex VAT + Shipping)
Kontakt	http://kontakt.io/product/beacon/	Yes	$2200 (need to contact for discount)
BlueSense Networks	http://bluesensenetworks.com/product/bluebar-beacon/	Yes	£1499
Glimworm beacons	http://glimwormbeacons.com/buy/20-x-packages-of-4-glimworm-ibeacons-white-gloss-finish/	Yes	€1980
Sensorberg	http://www.sensorberg.com/en/	No	€89 per 3
Sticknfind	https://www.sticknfind.com/indoornavigation.aspx	No	$389 per 20
Estimote	http://estimote.com	No	$99 per 3
Gelo	http://www.getgelo.com/beacons/	No	$175 per 5