Chapter 10
Augmenting the Experience of a Museum Visit with a Geo-Located AR App for an Associated Archaeological Site

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Abstract The experience and learning effect of visiting a museum associated with an archaeological site located nearby can be augmented by a location-based app designed to explore the site. In this chapter, we describe the design of such an app for a relatively small archaeological site called Thetford Priory in England. The design and development of the app was a multidisciplinary and inter-sectoral effort. A survey was conducted with 164 children aged 10–11 years old from five different schools to evaluate the usability and user experience of the app and the learning effect of deploying it. Results of the survey indicated that the enjoyability, ease-of-use, and understandability of the app were generally high, and that the users tended to download the app and recommend it to others. Overall, the main implication we can infer from the research study is that new mobile and interaction technology, when carefully designed, can be a powerful tool in enhancing and disseminating the value of cultural heritage and in utilising the complementarity of museums and their associated sites nearby.

10.1 Introduction

In Europe, popular archaeological sites such as Pompei in Italy, Delphi in Greece, and Stonehenge in the UK are widely visited and well-researched. In contrast, much less attention and research effort has been drawn to a number of relatively smaller but important archaeological sites, which could have elicited higher appreciation as cultural heritage and attracted a higher number of visitors if they were better known. More important, they would have better been exploited for educational purposes (Wishart and Triggs 2010). The potential benefit of improving the popularity of these sites is that they can not only stimulate local economies but also encourage community-building and identity-building in both rural and urban areas. To realise such a potential, one obvious recommendation is to enhance the accessibility and

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A. Vermeeren et al. (eds.), *Museum Experience Design*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-319-58550-5_10

appeal of these sites. Nonetheless, the challenge is that typically for small archaeological sites, the data and artefacts are not available or presented in forms that are meaningful to general audience.

In recent decades, we have witnessed major developments in the techniques of archaeological survey, the use of geographic information systems (GIS), 3D scanning and modelling, and theoretical work on place and space have all expanded our understanding of how people, sites, artefacts and landscapes fit together. Astonishingly, the potential of exploiting the emerging technical and theoretical knowledge to augment visitors' experience in an ancient landscape and environment of an archaeological site with their experience in a (typically co-located) museum dedicated to the site has been under-explored. This can be attributed to the fact that visitors are usually engaged with archaeological material on a site (with no artefacts) or in a museum (with no site). Developing mobile digital apps with the use of augmented reality (AR) to narrate histories vividly is regarded as a promising approach to enhance the meaningfulness, accessibility and enjoyability of visiting such sites, especially for a non-specialist public audience. Furthermore, like all other mobile educational tools, such apps should be grounded in strong pedagogical frameworks to foster learning. In our project *Representing Reformation* (RR) funded by the Arts and Humanities Research Council (AHRC) in the UK, we developed such a mobile app to explore a relatively small archaeological site known as Thetford Priory in England. In the following, we first briefly describe the motivation and historical background underpinning the project and the app. Then we depict the design of the app in detail, followed by a report on the evaluation results of a survey that aimed to evaluate the usability, user experience and learning effect of the app.

10.2 Motivation and Historical Background

Representing Reformation (RR)[1] is an interdisciplinary science and heritage project exploring the multifaceted lives of the Howard Dukes of Norfolk—the most prominent noble family during the era of Reformation. The three-year project studied the Howard Tombs, two of which were originally planned to stand in Thetford Priory, Norfolk, England, but were moved to 60 km away in Framlingham after the priory's dissolution by Henry VIII. The surviving remains of Thetford Priory include the lower walls of the church and cloister, along with the shell of the priors' lodging and, reached by a pathway from the main site, an almost complete 14th century gatehouse. The ruin is of high educational value for the intriguing history of reformation dated 400 years ago. Specifically, the project RR aimed to deliver to the public an AR-based iOS app that contextualises the research findings

[1] http://representingreformation.net/.

Fig. 10.1 Framlingham Parish Church (left) where the tombs were re-erected after they had been moved away from Thetford Priory (right) (photos source: Wikipedia; Creative Commons: CC BY-SA 3.0)

in situ of the priory. The app can be used as an educational resource by schools to engage students and by the local museum 'Ancient House of Thetford Life'[2] to attract more visitors (Fig. 10.1).

10.3 Design of the Mobile App

The design and development of the app were driven by the meticulous collaborative efforts of a multidisciplinary team consisting of historians, archaeologists, museum experts, curators, game designers, human-computer interaction experts, pedagogical experts and space research experts, who provided their expertise in 3D scanning and modelling. Technically, the app was implemented by a professional game company, *Enigma Interactive,*[3] which worked closely with the academic partners, who provided the content and resources.

Users may access help for further information. The access is displayed as an overlay on the map of the priory (Fig. 10.2). The six Interest Points (red dots with '?' and the green dot with '?') are displayed in their appropriate locations on the map. Selecting 'Where to next …' suggests the next Interest Point to visit. The next Interest Point will flash prompting users to either walk to the Interest Point or select it directly on the map. 'Where to next …' will lead users around the Priory on a predefined route. If the user has already visited the next predefined Interest Point, this will be skipped and the user will be prompted to visit the next point. Once a user has accessed or visited an Interest Point on the map, the point will be displayed as visited. Users may still access or revisit the point if required.

[2] http://www.museums.norfolk.gov.uk/Visit_us/Ancient_House/index.htm.

[3] https://www.enigma-interactive.co.uk/work/university-of-leicester-thetford-priory-tablet-app.

Six different QR codes are generated to represent the six Interest Points on the map. On selecting to scan a QR code, the application will change to camera/scanning mode allowing users to scan QR codes. The scanning interface will also let users exit scanning mode. On successfully scanning a QR code, the appropriate Interest Point will highlight on the map, prompting users to select the Interest Point.

10.3.1 Basic Concepts

The mobile app enables geo-located AR of the artefacts found at the dissolved Thetford Priory site to tell stories about their relevance to the Howards and the findings of this project. There is a narrative to the physical exploration of the site clustered by themes on the funerals and tomb monuments of the Howard family with Second and Third Duke being most prominent characters. Six Interest Points (A–F) are:

A. Dukes of Norfolk were powerful and important
B. Second Duke had a spectacular funeral at Thetford Priory
C. Second Duke's tomb at Thetford Priory
D. Tombs were covered in meaningful things
E. Second Duke's body was moved to Lambeth
F. Clues to the Third Duke's tomb were found at the Priory

Using GPS location, the app can test whether the user is onsite or offsite. If onsite, the user can explore and access Interest Points by walking to them or by selecting the Points directly on the interactive map. If offsite, GPS navigation is disabled and users can access the Interest Points by selecting them directly on the map or scanning a QR code. The main app navigation is represented as an illustrated map of the Thetford Priory site (Fig. 10.2 with the five numbered dots and related notes).

The six Interest Points (IPs, A–F) feature formatted text areas, imagery and video (Table 10.1). Each content area is designed to display the supplied content in the most appropriate format. After visiting all six IPs, the 'Conclusion Screen' will be presented to prompt users to find the location of the Third Duke's tomb (NB: a historical puzzle is yet to be resolved). This screen is also used to provide key points the user has been given whilst using the app. If the user is onsite, the current location of the device will be displayed on the map. Users will be taken into the camera mode with the 3D render of the tomb being displayed over the device's camera display. Users may rotate the image around the horizontal axis to position the tomb. If offsite, the user will have to identify the location of the tomb by selecting a point on the map; selecting will add a location marker onto the map, users may change this location by selecting another point. On selecting a location, the '*I think the tomb was here…*' button will be displayed. Clicking it will lead to the conclusion videos.

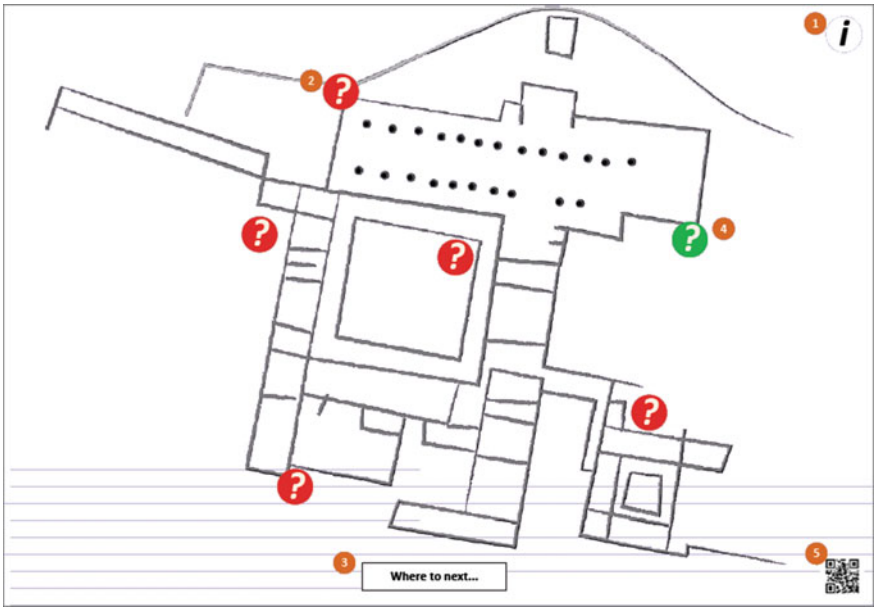

Fig. 10.2 The main navigation map as an illustrated map of Thetford Priory

10.3.2 Pedagogical Design

The field of mobile learning (or 'mlearning') has grown over the last decade in several related fields, including HCI and technology-enhanced learning (TEL) (Vavoula and Sharples 2009), from small-scale case studies to larger international initiatives, commercial projects and institutional programmes. The emergence of location-based technologies, countrywide Internet access and increasingly powerful multimedia capture and display has brought new opportunities to enhance learning in settings outside the classroom (Brown 2010). Specifically, the following areas of research and practice where mobile technologies feature have been identified (Sharples and Kukuluska-Hulme 2010): handhelds in the classroom, mixed reality learning, personal informal learning, distance and online education, learning across contexts and between informal and formal settings. An interesting implication is the use of mobile technology for field and school trips with a particular emphasis on the pedagogical gains that can be made through the use of location-based technologies to bridge formal and semi-formal (outside the classroom) settings.

Our app employs an inquiry-based design (Healey 2005) that attempts to mimic the research process of the project. It can facilitate the realisation of our aim to encourage user-led investigation of the site while communicating some of the project's findings and the type of work researchers in academia conduct. Specifically, we identify which media are required for different Interest Points (A–F),

Table 10.1 Six Interest Points (IPs) with Generic Learning Outcomes and associated attributes

IP	Media required	Learning styles served	Generic Learning Outcomes (GLO)	Relevance & personal meaning
A	Photo of terracotta roundel and Hampton Court roundel; Voiceover for 'Dukes are important'	**Dynamic learner**: there is a logical induction here; seeing one element as the clue to something bigger **Analytical learner**: using source material to compare to something else you know	**KU** (know that the roundel was part of the priory, and that it is similar to that in Hampton Court, and how that might indicate style and wealth) **ABP** (reflect on how and why a family 400 years ago behaved the way they did – decided to self-fashion themselves in a particular way)	How we use material things to project our own style and image today
B	Video of actors discussing 2nd Duke's funeral Picture of funeral from that time	**Imaginative learner**: constructing a picture of what happened, and empathising with what it would have been like to be at the funeral **Common sense learners**: how funerals worked, what happened, and who did what	**KU** (understand what a Tudor funeral was like) **AV** (empathise what it was like to be at a Ducal funeral; and respect how Tudor people mourned their dead)	The rules of our own (and other) public festivals and events Today's ceremonies around life and death
C	3D reconstruction of 2nd Duke's tomb 2D image of 2nd Duke's tomb 3D scans of fragments from 2nd Duke's tomb	**Imaginative learner**: seeking meaning from the empty vault, and imagining the presence of the tomb **Analytical learner**: knowing what experts think the heraldry on the tomb means, and the significance of where the fragments were found	**KU** (know that the tomb was here and looked a particular way) **EIC** (be surprised by the presence, scale and placement of the tomb) **S** (be able to perceive the augmented space of the priory)	Our spatial awareness and literacy
D	2D snapshot of 3rd Duke's scanned tomb Pop-up videos describing sections of 3rd Duke's tomb	**Analytical learner**: asking what these symbols mean; learning by thinking through the ideas around symbols and signs on the tombs; learning from expert views on the symbols and signs	**KU** (make some sense of the symbols on the tomb) **S** (know how to read some symbols and heraldry) **AV** (be sensitive to what Tudor people did with their tombs to commemorate and communicate things)	How we read and communicate through non-textual signs and symbols Why and how we mark a death – through (for instance) memorialisation, eulogy or obituary

(continued)

Table 10.1 (continued)

IP	Media required	Learning styles served	Generic Learning Outcomes (GLO)	Relevance & personal meaning
E	Photo of where 2nd Duke's body is in Lambeth and of Lambeth parish church Plaque with relevant information in Lambeth	**Dynamic learner**: seeking solution to the mystery of the missing body; processing the information offered and seeking to test theories of where the body might be **Imaginative learner**: asking why a body would be moved	**EIC** (think innovatively about what may have happened to the 2nd Duke's body) **AV** (acknowledge why the body was moved)	The role of sacred places in the respect for the dead How evidence can be lost over the passage of time The change in the built landscape around us (the lost priory, the Lambeth café …)
F	Animation Rotatable 3D construction of 3rd Duke's tomb Image of a dig at the priory	**Dynamic learner**: seeking and reflecting upon the possibilities presented by the fragments; responding to the idea of different hypotheses; engaging with the idea that the extant tombs can become something else **Common sense leaner**: seeking a solution to the problem of the fragments; seeing the tombs and the fragments as a problem-solving activity; engaging with the practical application of laser technology to history	**KU** (know and follow the project's 'working hypothesis' around the tombs, and how the team came to it) **EIC** (be inspired by the project's approach; and able to identify the innovative thoughts around Heritage Science) **AV** (empathise with how the Howards had as a family to respond to the Dissolution)	The impact of politics and religion on our lives, our families our self-identity How research works, how different academic disciplines are different How technology affects how we see the past.

which learning styles to be served, and what learning outcomes to be expected, and what relevance and personal meaning to be implied (see Law et al. 2013 for details). For our project RR, we embrace the Generic Learning Outcomes (GLO) framework. The GLOs are underpinned by a broad definition of learning which identifies benefits that people gain from interacting with museums, libraries and archives[4]:

[4]http://www.inspiringlearningforall.gov.uk/toolstemplates/genericlearning/.

- Knowledge and Understanding (KU)
- Skills (S)
- Attitudes and Values (AV)
- Enjoyment, Inspiration & Creativity (EIC)
- Activity, Behaviour & Progression (ABP)

10.3.3 Challenges and Beta Version Prototype

As described above, the design of the app was first focused on the creation of the bespoke map (Fig. 10.2) and then on the integration of the GPS location finding functionality, which was used to inform onsite users where they were (the blue dot in Fig. 10.3) and to trigger off the next Interest Point (the six points A–F explained above) by making it blink. When visitors were close to an Interest Point, pictures, expert videos and interactive 3D renders of some of the important objects found by archaeologists would become accessible (Fig. 10.4).

The alpha version of the app was thoroughly tested in the field by the project's partners. The main challenge was the precision of the GPS location finding in the archaeological site, which is relatively small to allow accurate estimation.

Fig. 10.3 The mobile app used onsite in the Priory; the blue dot indicates the position of the user (the beta version)

Fig. 10.4 The mobile app showed the pictures, videos and other educational resources

10.4 Evaluation

Evaluation is an integral part of the developmental lifecycle of any interactive system, given the importance of interplay between user experience evaluation and system redesign (Law and Abrahao 2014). As the app developed for the project RR was aimed to be a mobile learning tool, a specific evaluation framework should be employed, which is described subsequently.

10.4.1 Evaluation Framework for Mobile Learning App

The evaluation strategy is informed by the six challenges of evaluating mobile learning (Sharples and Kukuluska-Hulme 2010; Vavoula and Sharples 2009; Vavoula et al. 2009) and the three-level framework proposed to addresses these challenges (Vavoula et al. 2009). The challenges include: capturing and analysing learning in context and across contexts (school, local visitors, museum and priory site), measuring the processes and outcomes of mobile learning activities (learner-led inquiry), privacy issues (visitors using their own technology), the usability of the technology which is not personal (project supplied iPads), assessing in/formality of the learning setting (visitors and school field trips), and considering how well this fits into the wider organisational and socio-cultural context (the local museum, community and schools).

The three-level framework aiming to address these challenges is relevant to our mobile app (Vavoula and Sharples 2009). The micro-level assesses usability issues; a meso-level examines the learning experience including the breakthroughs and breakdowns that occur in the process. Finally, the macro-level considers how well the technology is integrated into the existing socio-cultural context, in this case the local museum, which facilitates visitors and educational field trips. This final level especially helps assess the impact of the application on the local community. A variety of mainly qualitative methods need to be used at different stages, including focus groups, semi-structured interviews and ethnographic observation of the application in use, Google Analytics, user feedback reviews and questionnaires. Within the lifetime and resources of the project, we were only able to evaluate the micro-level—usability and user experience issues of the app, and the preliminary meso-level in terms of learning.

10.4.2 Methods

10.4.2.1 Instrument

As mentioned, the museum Ancient House of Thetford Life is linked to the archaeological site Thetford Priory. The museum is often visited by school children to learn about the British history of the Reformation era. It also attracts tourists, scholars, amateur historians and archaeologists and the like. Typically, after visiting the museum, visitors walk to Thetford Priory. The evaluation of the app was incorporated into this typical journey. To facilitate data collection, we opted for a paper-based questionnaire. However, for a handful of cases, upon the consent of the visitors, the 'shadowing' technique (Hagen et al. 2005) was employed; results of these cases are not reported in this chapter. To avoid overwhelming the visitors with a long questionnaire and to minimise the time they needed to spend in filling it out, especially for school trips, the questionnaire was made to be short and highly accessible (Fig. 10.5).

10.4.2.2 Participants

Altogether 164 school children aged 10–11 years old (Grade 6 when they study the related British history at school) were involved in the evaluation of the app. They came from five different schools in the vicinity of Thetford and took part in the study as part of their excursion of visiting the museum and the archaeological site. The five schools are designated as S1, S2, S3, S4 and S5. Overall, the participants were gender balanced: 50% female and 50% were male. 46% of the participants chose the option 'most days' with respect to the question on Computer Usage, 26% indicated that they used computer every day whereas 10% showed that they hardly ever used computer (Table 10.2).

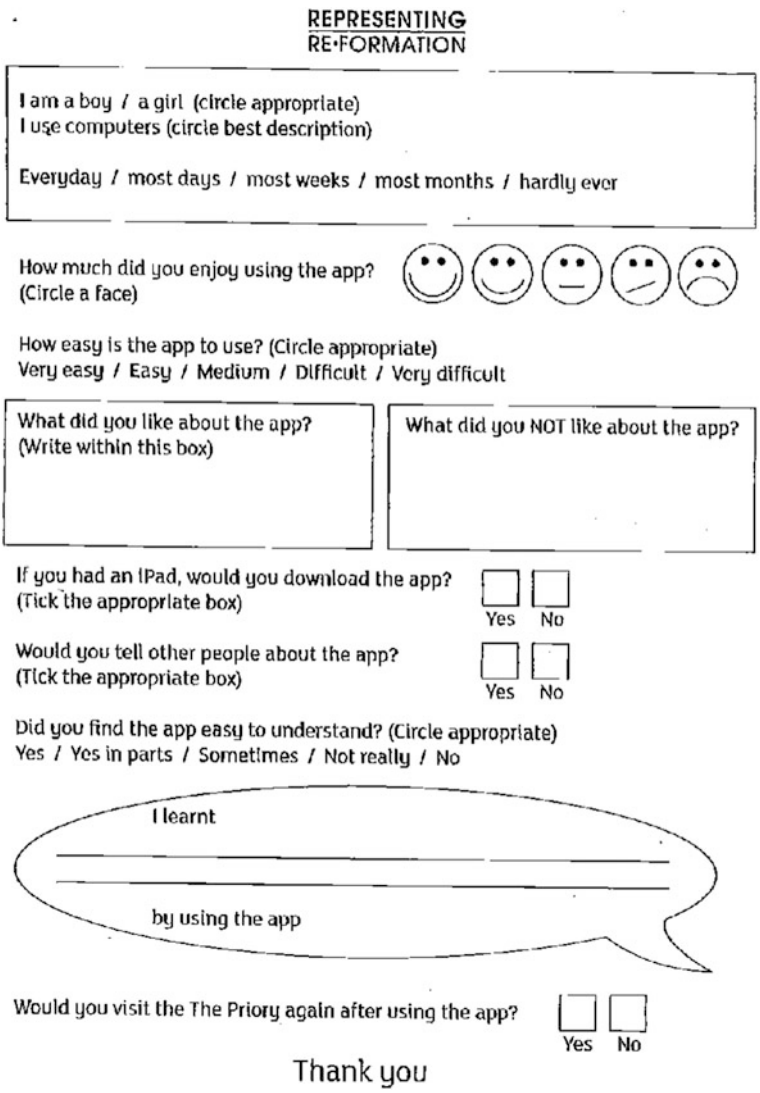

Fig. 10.5 The evaluation questionnaire for the mobile app

Table 10.2 General demographic data of the participants

School	Total number of children	Gender		Computer usage*				
		Girl	Boy	Everyday	Most days	Most weeks	Most months	Hardly ever
S1	28	17	11	5	19	1	0	2
S2	21	11	10	4	9	5	0	1
S3	50	19	31	10	16	11	1	8
S4	19	9	10	4	11	2	0	2
S5	46	26	20	18	16	8	0	3
Total	**164**	**82**	**82**	**41**	**71**	**27**	**1**	**16**

*Computer usage: Eight children did not respond to this item

10.5 Results and Discussion

Quantitative and qualitative data have been analysed and their respective findings are reported subsequently. The former data focus on five aspects of which three address the participants' perceptions of the quality of the app and two address their behavioural intentions, whereas the latter data focus on specific features of the app that the participants liked and disliked, as well as on what they learned from deploying the app.

10.5.1 Quantitative Findings

In evaluating the five aspects, we explored whether the three variables, namely gender, computer usage and school—had any influence on the findings.

10.5.1.1 Enjoyability

It was measured with a 5-point visual analogue scale (VAS) (Funke and Reips 2012) with the leftmost anchor being most positive and rightmost anchor most negative. In converting the VAS into numeric values with 1 being most positive and 5 being most negative, the average rating was 1.97 (N = 164, SD = 0.88). It implies that the app was generally perceived as rather enjoyable.

- *Gender*: No significant difference in perceived enjoyability of the app between girls (M = 2.04, SD = 0.84) and boys (M = 1.98, SD = 0.93) was detected.
- *Computer usage*: The bivariate correlation between Computer Usage and Enjoyability was very low ($r = 0.04$, $p > 0.05$), indicating that the two variables were independent. The extent to which the participants enjoyed the app was not influenced by how much they had used computing technology before.

- *School*: There were statistically significant differences in perceived enjoyability of the app among the five schools ($F_{4,159} = 2.97$, $p < .05$) (Table 10.3). Results of post hoc Bonferroni test showed that the difference between S1 and S3, which had the highest and lowest average ratings of enjoyability, was highly significant ($t = 3.13$, $df = 76$, $p < .01$).

10.5.1.2 Ease of Use

A 5-point textual scale was used to evaluate this aspect with 'very easy' being the leftmost anchor and 'very difficult' the rightmost anchor. Eleven participants did not respond to this question. In converting the five scale points into corresponding values 1–5, the average rating of ease-of-use is 2.08 (N = 153, SD = 0.95), implying that the participants found it rather easy to use the app.

- *Gender*: No significant difference in perceived Ease of Use of the app between girls (M = 1.96, SD = 0.98) and boys (M = 2.2, SD = 1.00) was detected.
- *Computer usage*: The bivariate correlation between Computer Usage and perceived Ease of Use was positively significant ($r = .182$, $p < .05$). It was a logical finding. The extent to which the participants found the app easy/difficult to use depended much on their previous experience in deploying computing technology.
- *School*: There were statistically significant differences in perceived Ease of Use of the app among the five schools ($F_{4,148} = 3.4$, $p < .05$) (Table 10.4). Results of post hoc Bonferroni test showed that the difference between S3 and S5, which had the highest and lowest average ratings of Ease-of-Use, was highly significant ($t = 3.32$, $df = 86$, $p < .001$).

10.5.1.3 Understandability

While Ease of Use focuses on the tool, Understandability addresses the content delivered in the app. Eight participants did not respond to this item. A 5-point textual scale was used to evaluate this aspect with 'Yes' being the leftmost anchor and 'No' the rightmost anchor, whereas 'Yes in parts', 'Sometimes' and 'Not really' were in between. In converting the five scale points into corresponding values 1–5, the average rating of Understandability is 1.93 (N = 156, SD = 1.04), implying that the participants found parts of the app easy to understand (Sect. 10.5.2).

- *Gender*: No significant difference in perceived ease of use of the app between girls (M = 1.87, SD = 0.98) and boys (M = 199, SD = 1.1) was detected.
- *Computer Usage*: The bivariate correlation between Computer Usage and Understandability was not significant ($r = .158$, $p = .053$). The extent to which the participants found the content understandable seemed independent of their earlier experience in deploying computing technology.

Table 10.3 Results of the influence of the variable School on perceived enjoyability of the app

School (S)	N	Mean	SD	Min	Max
S1	28	2.25	0.645	1	3
S2	21	2.19	0.680	1	3
S3	50	1.66	0.872	1	5
S4	19	1.89	0.994	1	4
S5	46	2.09	0.962	1	4
Total	**164**	**1.98**	**0.879**	**1**	**5**

Table 10.4 Results of the influence of the variable School on perceived Ease-of-Use of the app

School (S)	N	Mean	SD	Min	Max
S1	27	2.04	0.759	1	3
S2	19	2.26	0.933	1	4
S3	44	1.68	0.883	1	5
S4	19	2.21	0.918	1	4
S5	44	2.36	1.036	1	5
Total	**153**	**2.08**	**0.950**	**1**	**5**

Table 10.5 Results of the influence of the variable School on Understandability of the app

School (S)	N	Mean	SD	Min	Max
S1	27	1.81	0.962	1	4
S2	21	2.24	1.044	1	5
S3	45	1.62	0.716	1	3
S4	19	1.74	0.933	1	4
S5	44	2.25	1.296	1	5
Total	**156**	**1.93**	**1.042**	**1**	**5**

- *School*: There were statistically significant differences in perceived Understandability of the app among the five schools ($F_{4,151} = 2.86$, $p < .05$) (Table 10.5). Results of post hoc Bonferroni test showed that the difference between S3 and S5, which had the highest and lowest average ratings of understandability, was highly significant ($t = 2.84$, $df = 87$, $p < .01$).

10.5.1.4 Download

The question was phrased as a hypothetical situation whether the participants intended to download the app if they had the iPad and the app was available. Out of 156 participants who responded to this question, 126 checked 'Yes' (81%). This indicated quite a high acceptance rate. Results of Chi-square tests showed that none

of the three variables—Gender (75% for Girls vs. 81% for Boys), Computer Usage (the highest of 85% for 'Everyday' versus the lowest of 70% for 'Most days'), and School (the highest of 84% in case of S4 versus the lowest of 67% of S2)—played a significant role in influencing the tendency to download the app.

10.5.1.5 Tell Others

The majority (80%) of the participants responded that they would tell others about the app. Whether they would share the positive or negative experience with the others could not be inferred from their answers. Results of Chi-Square test showed that Computer Usage played a significant role in influencing the tendency of the participants to tell others about the app (χ^2 (3) = 10.68, p < .05). Those who hardly ever used computers had the lowest tendency to do so (50%) as compared with those who used computers 'Most weeks' who had the highest tendency (89%) (cf. 83% and 82% for 'Everyday' and 'Most days', respectively). The former observation is intuitive as those inactive computer users might not be interested in sharing the app. Conversely, results of Chi-Square tests indicated that neither Gender nor School played a significant role in influencing the tendency of the participants to tell others about the app. Furthermore, there was a highly statistically significant association between 'Download' and 'Tell others' (χ^2 (1) = 8.66, $p < .01$). It suggests those who intend to download the app are also very likely to tell others about the app.

In summary, the app was positively perceived by the participants in terms of its Enjoyability, Ease-of-Use, and Understandability. The participants' perceptions of good usability (Ease of Use, Understandability) and positive user experience (Enjoyability) were correlated significantly with their behavioural tendencies to download (reuse) the app and to tell others about it (Table 10.6).

In summary, all statistical tests conducted indicate that gender did not play a significant role in these variables. This can be considered as encouraging observations because both genders have comparable attitudes and behaviours with respect to the use of computing technology. In contrast, Computer Usage played a significant role in Ease of Use and Tell Others, but not in the other variables. Similarly, School played a significant role in the participants' attitudes towards the app but not in their behavioural intention. As no objective data have been collected about five different schools (e.g. quality of teaching, socioeconomic status of children's family), we do not want to speculate the plausible causes for the observed significant differences.

Table 10.6 Correlations between quality perceptions and behavioural tendencies (**p <.001)

Pearson correlation r	Enjoyability	Ease of use	Understandability
Download	0.326**	0.273**	0.288**
Tell others	0.240**	0.220**	0.273**

10.5.2 Qualitative Findings

Three open-ended questions aimed to identify what the participants liked and disliked about the app, and what they have learned from using it.

10.5.2.1 Likes of the App

Nine participants did not respond to this item and one response is illegible, leaving 154 valid responses to be analysed. We coded the responses into three categories, namely content-related, technology-related and general feedback. Some responses fall into more than one category, for example, '*clear labelling, different mediums of information, the interactive bits of GPS*'. Table 10.7 displays the distribution with examples. Apparently, the technology-related comments suggest that the location-based app was successful in engaging the participants.

10.5.2.2 Dislikes of the App

Interestingly, the number of blank responses was much higher, 35 as compared with 9 in the case of Likes, two responses were illegible. Another interesting observation is that 23 participants responded to this item with the word 'nothing'. For the remaining responses, we categorised them as either content-related, technology-related, or both. Table 10.8 shows the related results.

Table 10.7 Categories and examples of qualitative responses on the Likes of the app

Category	Frequency	Examples
Content-related	75 (49%)	'I really liked the actors, the funeral music, and moving the grave'; 'it showed old history about the churches'; 'I thought it was really good because you could learn facts about it while visiting' 'I liked the videos and the awesome information' 'that the people told really boring things interestingly'
Technology-related	67 (44%)	'it can detect where you are' 'the app brought the priory to life' 'The walk around GPS' 'sat nav blue dot' 'the way it's a virtual map'
General feedback	18 (7%)	'everything' 'I guessed I like it a lot' 'it was fun' 'I liked the style of it' 'it was good'

Table 10.8 Categories and examples of qualitative responses on Dislikes of the app

Category	Frequency	Examples
Content-related	47 (37%)	'The words were difficult to understand. The videos need to be more interesting. The facts were hard to understand. Maybe a kid version on the app might be nice' 'some of the videos sound were not loud enough and too long' (both) 'the information was not that child friendly' 'They seemed pretty dull talking. They should put more feeling into it'
Technology-related	61 (48%)	'I did not like when you had to press the button to scan because it took a long time to load' 'I think the word font could be bigger and that there should be a pop-up dictionary' 'the blue dot did not tell us where to go' 'it did not scan the barcode' 'it froze a couple of times, hard to restart'

10.5.2.3 Learning from the App

Out of 164 participants, 18 did not respond and seven responses were illegible, leaving 139 responses for further analysis. To analyse individual responses, we adopt the following steps:

(i) Checking their relevance;
(ii) In case of a relevant response, determining whether the learning mentioned is related to the content of the app, technology, or feedback;
(iii) For a content-based response, enumerating how many distinct concepts it covers and assigning one point for each concept.

There was only one case of irrelevance: '*there was a hospital near*'. Several cases are a combination of content-related, technology-related and general feedback, for instance, ('*a lot of history, fun*', '*how to track much more easily and about Thomas Howard*'). Eight cases are technology-related (e.g., 'better map reading') and five cases are general feedback (e.g. '*I liked the app very much*').

From the pedagogical perspective, we are more interested in the content-related responses. As shown in Table 10.9, eight participants scored zero point, either claiming that they did not learn anything (frequency: 4) or failing to specify explicitly what they have learnt (frequency: 4); 59 participants scored 1 point (i.e. named only 1 relevant concept pertaining to the app); two participants scored 5 points. The average score over 139 participants is 1.55 (SD = 1.06). As depicted in Fig. 10.6, the concepts mostly mentioned with the highest frequency of 23 are 'priory' and 'tomb', followed by 'Howard' (frequency: 17) and Henry VIII (frequency: 14).

Table 10.9 Distribution of the scores earned by the participants on what they have learnt

Scores	Frequency	Examples
0	8	'nothing', 'not really', 'a little bit', 'a lot of things'
1	59	'that there was a tomb', 'about stuff in the priory'; 'some monks lived here'
2	36	'there was a tomb under the church'; 'Duke of Norfolks body wasn't in the vault'
3	21	'I learnt that Thomas Howard was moved from his tomb'; 'about the ghosts that are here and the monks singing'; 'every king like king Henry VIII had a cool coat of arms'
4	3	'I learned that King Henry the VIII destroyed all the monasteries for money'; 'The Duke's body was layed out in the chapel for 1 month';
5	2	'About Henry's tomb and about the priory. Fitzer didn't have a gravestone', 'about Howard's interaction with the churches, the things Thetford, and the history of the Priory, their living'

Fig. 10.6 The relative frequencies of learnt concepts (generated with Tagcrowd)

10.5.3 Limitations

There are some limitations to the study. First, given some organisational constraints such as restricted time allotted for visiting both venues, we did not measure the participants' experience in the museum to understand how it could influence their perception and use of the app in the site, especially the two experiences happened close to each other temporally as well as geographically. Second, the background information of the participants could have been richer, for instance, we could have asked about the participants' interest in the subject matter. In cases where the participants were not interested in the historical topic concerned, their overall perception of the app might tend to be lower than those who were already enthusiastic about the topic. Third, due to the time and situational constraints, the questionnaire needed to be short and simple to encourage the participants to

complete it. While open-ended questions were included, the qualitative responses would have been richer with interviews where the participants could express their thoughts and feelings in a more elaborate manner.

10.6 Conclusion

Overall, the location-based app was empirically demonstrated to be effective in enabling its users to enjoy the experience of visiting the archaeological site and to acquire the related historical knowledge. Qualitative responses of the survey showed that the technical functions of Augmented Reality (AR), GPS-based navigation, and 3D visualisation are appealing features for children to explore cultural heritage in an engaging way. Nonetheless, the use of videos as a learning medium invited some mixed responses; some children appreciated them whereas some others found them lengthy and boring. Ideally, adaptive content taking users' learning needs, interest and preferences into account and presenting accordingly will be the optimal way of learning content delivery (e.g. Karran et al. 2015; Jailani et al. 2015). Future work can further tap into the power of gamification (Jailani et al. 2015; Mortara et al. 2014). All in all, the main implication we can infer from the research study is that new mobile and interaction technology, when carefully designed, can be a powerful tool in enhancing and disseminating the value of cultural heritage and in utilising the complementarity of museums and their associated archaeological sites nearby.

Acknowledgements The author would like to thank the support of the Arts and Humanities Research Council, UK, and for the project team members of the project *Representing Re-Formation*[5] for co-designing the mobile geo-based AR app and collecting the evaluation data. Thanks also go to participating school children for their kind co-operation and sharing their experiences and ideas.

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