The enthusiast, the interested, the sceptic & the cynic: understanding user experience & perceived value in location-based cultural heritage games through qualitative and sentiment analysis

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We discuss the user study of a mobile cultural heritage game, designed to stimulate reflection about a city's history. Aided by location-aware technology, the game fosters the serendipitous discovery of Points-Of-Interest, historical images and stories, whilst players wander the city. This exploration differs from the typical pre-calculated path recommendations used by other location-based applications. It triggers reflection about the city's past that is as unique as its visitors. Ours is one of the first studies to attempt an understanding of the effects of *serendipitous* urban discovery and *historic reflection-triggering technologies* on user experience. We combined field trials with controlled experiments, analysing perceptions of the experience and value using responses expressed in open-ended questionnaire items. Using thematic coding and sentiment analysis, we observed types of emotional responses, indicating four potential profiles of their likelihood towards future technology adoption. *Enthusiastic* and *Interested* users appreciated the freedom of movement choice that created an autonomous experience that fostered a sense of personal accomplishment. The interface interactions of the game, designed to stimulate reflection, supported a feeling of connectedness to others. In contrast, *Cynical* and *Sceptical* users were less tolerant of perceived technological issues, and required more perfection in functionality and design. These users are less likely to be the early adopters of serendipitous location-based apps. The game was developed as part of a large cultural informatics project, but unlike typical evaluations, we conducted this study midway through the project and not at its end. This approach (1) gave the team the possibility to take stock, pause and reflect and (2) provided insight on future design improvements for increasing the perceived value of serendipitous urban discovery applications. Our results contribute towards a grounded understanding of user experience, and help progress the development of cultural heritage applications that incorporate elements of reflection and/or place-based exploration into their functionalities. [1]

CCS Concepts: • **Human-centered computing~User studies**; *Empirical studies in ubiquitous and mobile computing*; Geographic visualization • **Applied computing**~*Arts and humanitie*s

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1 INTRODUCTION

We cannot dispute the pervasive nature of mobile devices, such as smartphones. Firmly embedded into our everyday life, these devices shape our lived experience. The breadth of their influence is diverse. They affect, for example: how we communicate with each other, the modes in which we discover unfamiliar places or even how we learn and acquire new knowledge. The ubiquity of mobile technology represents an opportunity for the domain of cultural heritage - opening a world of possibilities to develop new applications that support a hybrid reality where the documentation, interpretation and visualisation of digital cultural resources combined with physical places. Along with these new potentialities come many challenges. Such challenges are associated to understanding how and if these new forms of accessing the digital and physical cultural resources can be useful, usable and offer real value to citizens.

Within mobile technology, location-based services are now standard. These services provide new and imaginative ways of creating new location-aware cultural heritage resources, often through the interface of a map. Indeed, maps in any form, paper or digital, have long been a means of recording and communicating information about locations, place, society and culture. Throughout history, the very act of graphically marking a place on a map bestows the place with a sense of importance, indicating that those cities, towns and villages demarcated in it have a value to society. This act reflects the interest of both the cartographer and the people for whom the map was created. In this paper, we evaluate a location-based cultural heritage game, which in a way shifts the tradition of map-making from the typical paper or digital form to the smartphone device, providing citizens with new playful forms of consuming and producing content associated to cultural heritage and history.

The location-based cultural heritage game that is the topic of this paper was developed as one of the pilot applications of a wider European cultural informatics project titled CrossCult[2]. Taking place outside the confines of a building, the game brings players into the city. Through an interactive mapping interface, it uses playfulness and serendipitous urban discovery to stimulate reflection on historical topics and aims to trigger reinterpretation of the city and its history as players walk the city. It does so by incorporating location information, historical images and stories, as well as encouraging the players to participate with their own stories and historic memories. This results in a new blended reality environment, where cultural heritage landmarks and places of social and cultural interest are paired with historic digital resources and stories, creating a unique mix between the present and the past, between how the city is and how it used to be. The game, being the enabler of this blended reality, thus becomes a mediator between the city and society and invites citizens to interact with and reflect not only on the parts of the public space that are visible, but also on those that are hidden or absent from public consciousness as well. By incorporating known and less known cultural heritage resources (city stories, archives and multimedia) into a geo-located game, we attempt to increase the cultural value of both the place and the public's historic memories, through the simple act of representing them on a map and encouraging people to experience the city differently.

[2] For more information: www.crosscult.eu

The underlying premise of our work is that the act of telling a story in situ places a cultural significance not only on the location but also on the content made available at that location. It enables the location-based cultural heritage game to become a form of societal commodity, a shared medium for creating, preserving and enriching cultural heritage capital (even if only temporarily)[19]. By experiencing such a game, players participate in the act of the re-telling of the city, increasing its cultural value through their participation and helping to shape a shared public consciousness. With these expectations set, the challenge then becomes how to evaluate the game app. Is it indeed useful? Will it offer perceived value to the citizens who engage with it? To unpick this, we need to consider many different dimensions ranging from technology adoption, user perceptions and attitudes, and user sentiment expressions regarding the app. The result, we hope, will lead to an improved understanding of the strengths and weaknesses of the methods used to design for and evaluate the likely use and perceived value of cultural heritage location-based mobile applications.

The app at the centre of the discussion was built following paper prototyping activities described in a previous work [32]. It then underwent subsequent iterative development cycles, during which we conducted two preliminary field experiments and two user evaluation experiments. The preliminary experiments tested the feasibility of the app and resulted in significant feature changes until the development of a stable version. This stable version was used for an initial set of evaluation experiments. The present study has two aims. Firstly, to understand the users perceptions and initial impressions of their experience, which helps unravel the perceived value and motivations that players have towards the adoption of cultural heritage mobile apps. Secondly, to understand the different emotional viewpoints of the participants, and explore this using sentiment analysis. The results help unravel a typology of four distinct types of users of our cultural applications, with different predispositions and different likelihoods of becoming lead users and early technology adopters.

2 RELATED WORK

2.1 Location-based games, cultural heritage and technology adoption

Interest in location-based gaming has been steadily increasing since the rise of the smartphone, which is now widespread, but emerged relatively recently following the release of the first iPhones in the late 2000s. Driven by the now ubiquitous Global Positioning System (GPS)-enabled smartphone technology, recent developments in location-based gaming have sparked considerable public interest. They are designed to be scalable and to be played anywhere where data has been made available. These mobile technologies have opened up a world of emerging possibilities that are (re)shaping our day-to-day experiences. They are now firmly rooted in our everyday experiences and encounters. They blend the physical space of the places that we inhabit and experience as residents and/or visitors with the virtual space of the digital realm to such an extent that they can alter and challenge our expected norms, values and behaviours.

When one thinks of location-based games, those that combine the physical location with the virtual game space, the first games that come to mind are Pokemon Go, Ingress or the long-running hide-and-seek treasure hunting game of Geocaching. The first two are hybrid games. They are pervasive and turn the physical space into either board game [34] or transform any city, town or village in the world into a playground [54]. These games do not require users to follow any dedicated paths in the sense of a traditional linear route through a city but rather they facilitate more serendipitous discovery as users choose to "hunt" for different objects or monsters in their local neighbourhood. These games have millions of players and attract the attention of researchers interested in a variety of factors. Firstly, an issue of interest is the relationship of player to play and their need to consider issues such as territoriality and notions of boundaries or place attachment [34,51,52]. Secondly, there are studies that consider the formation of communities of players, the user experience and user motivations [17,24,31,37,48,49]. Thirdly, there are research studies which have investigated issues relating to the hidden surveillance of players, whereby concerns have been raised about the passive tracking of positions and movement in the city, and the ethics of the uses of the resulting generated data, as well as the potentiality of geostalking [39]. There are also studies on positive health impacts such as these games' propensity to encourage sociability, social support [67] and physical activity [3], as well

as the negative health impacts of such place-based games caused by their distracting nature [33] and their impact on public safety and possible exposure to health-harming air-borne pollutants and/or insect-borne diseases [50].

For every app that has achieved mass success there are many more "niche" apps that have been designed by academics for specific research purposes, many of which include an element of crowdsourcing. These include games designed for studying the relationships between players and their connection between the physical space and the virtual space through the notions of territoriality [52], location, interactive story-telling [29] and personal story-creation [56]. They also crowdsource urban data as a way of informing planning decisions [9], as a medium for civic engagement [37], civic participation [21] and to encourage social inclusion [13]: or for the exploration of cultural heritage such as battlefields [53] or for discovery of historical novels [15]. Other games have been designed for pragmatic tasks using play as a support for navigation [10] and urban planning [54]. Consequently, there has been an upsurge of interest in geo-located games for cultural heritage, although these are more likely to be based indoors. For example, within museums, the use of game environments are a playful tool for narrative storytelling [59] or for personal exhibition creation [18] and memory making [16]. Outdoor geo-located games foster context-aware learning [47,61] and knowledge acquisition about historical sites [5] and events [38]. Games are also provided as a tool for linear tours that make use of storytelling [40], as well as for crowdsourcing 3D data for the reconstruction of historical sites using treasure hunts [22]. Despite the great potential for geo-located games that support learning and reflection, there are relatively few in mainstream use [26], and their potential has yet to be realised. Cultural heritage mobile applications that promote reflection are rare and those that exist are designed around specific path recommendations in the city and fail to maximise on the flexibility offered from serendipitous exploration.

There are many reasons for the current interest in location-based gaming apps. They offer more immersive environments [17,30] and provide an enhanced lens through which to focus the user experience. The city itself is constantly being transformed as a result of social and spatial processes over time [42] so it seems logical to use this lived space as part of the game. Furthermore, geo-located games take advantage of the multisensory nature of being in the city [45] offering clues that can be heard, touched, observed or emotionally felt [1] and the act of walking through a city provides a form of motivation for the players [49] as well as builds upon the notion of the wandering thought. Interactions within such games foster collaboration and self-efficacy [63] and are fun. Additionally, the city is said to encourage an embodied experience [69] providing a more authentic and inclusive environment, over that of the constructed environment offered by the classroom or a traditional museum. This we expect would mean that reflecting on historical topics and content whilst traversing the city using geo-located technology will offer a more situated experience [25,60] which results in a thoughtful form of play and discovery.

2.2 Geo-located cultural heritage games and technology adoption

The pivotal development behind the creation of location-based apps, be it in the fields of cultural heritage or urban planning or with commercial products such as Pokemon Go and Ingress, was the mass adoption of GPS within smartphone technology and the availability of WiFi and affordable data plans. It was not until GPS become ubiquitous and reliable within the smartphone that geo-located gaming emerged in the mainstream and became widely adopted [65]. Nevertheless, niche location-based cultural heritage apps still face well-known challenges that must be met before they cross into the mainstream. In terms of adoption of products and market diffusion, these technologies, with the exception of a few, are currently at the early stage in the 1962 model proposed by Rogers [57]. Adoption of cultural heritage technology is also influenced by this curve and its chasm, as are location-based games (where it is only recently that we observe successful games that crossed the "chasm"). Today, the majority of these cultural heritage and history apps/ technologies, with the exception of a few, face the challenge to bridge the "chasm" that exists in Rogers' framework and, that was identified by Geoffrey [46] (Fig. 1).
In this paper, we consider how a deeper understanding of the emotional aspects of the user responses gathered as part of the evaluation could offer a more nuanced approach to understanding perceived value of such tools and hint towards the potentiality of their technology adoption. By undertaking a sentiment analysis and combining this with the overall score for their attitude, we explore the patterns in our participants' responses. We investigate if this can help us identify where experiment participants fit into the technology adoption curve and thus develop improvements that encourage the early adopters and early majority. We do this to contextualise responses to the app experience and to understand it more fully from the perspective of the players.

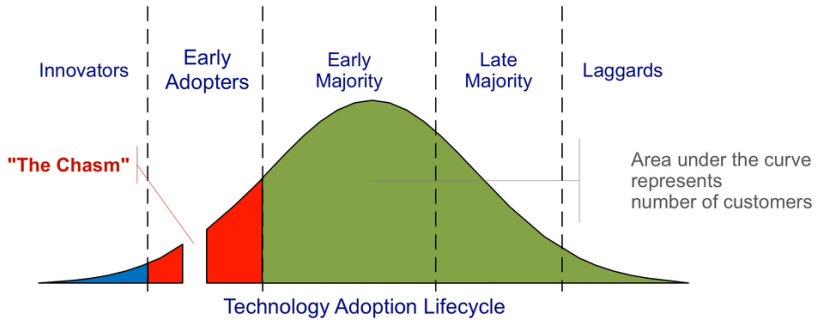

Fig. 1. The technology adoption curve that also influences the acceptance of cultural heritage applications (source: Craig Chelius, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=5938404)

3 SITUATED CROWDSOURCED/CITIZEN-CONTRIBUTED REFLECTIONS: GAME FUNCTIONALITY AND MECHANICS

The game app and its mechanics are designed iteratively, motivated by the desire to foster new, location-based, embodied experiences for users for the lived city. As users discover places and content in the city, they are encouraged to explore perspectives and interpretations associated with topics in European history while reflecting on their own understanding and personal perceptions. These user-generated reflections and interpretations will, we hope, contribute to a shared collective memory and serve as a source for public history on the topic.

3.1 Citizen-Contributed Situated Reflections

To evaluate our ideas for stimulating reflective history, we started with a basic user scenario that outlined the app from the perspective of the user experience. We imagined multiple user interactions that could encourage contributions and indicate people's thoughts on the topic and the places. These interactions included (1) tagging a thought, (2) rating a point of interest, (3) answering a question on the topic that draws upon personal experience and (4) contributing a personal story. With this initial scenario drafted, we turned the experience into a board game to explore its strengths and weaknesses. This prototype took the form of a paper map-based board game to simulate being in the city which mimicked how players could interact with historical multimedia objects and stories which were recorded in a postcard booklet. With this booklet, we simulated interactions for all of the four features that we expect to stimulate reflection. This study was described in detail in a previous article [34], the results of which led to the refinement and development of the game mechanics, as well as the first evaluation of the content and the mechanisms for reflection.

3.2 Pilot 4 – Core Game Play Mechanics

The use of the board game to co-design requirements ensured the identification and description of the core game design-concepts of goals, loops, incentives and rewards. Gameplay is formally defined as a set of one or more causally-linked challenges in a simulated environment [58]. These concepts defined the elements of a game, which act as descriptors of the intended gameplay experience. We started by defining how the game should be accomplished through the game loop — the primary set of actions that players must learn in order to become skilled [44]. In the app, the core gameplay loop consists of

the app detecting the user's location and showing relevant or nearby points-of-interest (POIs) (Fig. 2, left). The user can then choose to walk towards any POI, following indications of distance, and when inside its range (geofence), they can then interact with (game) content appearing on the mobile device (Fig. 3). After the interaction, the user receives appropriate rewards and can decide to move towards any of the other POIs (serendipitous discovery) (Fig. 4).

Table 1: Original Core Game play for Pilot 4 of CrossCult

Game type	Core game	Game play loop	Incentives & rewards
Location-based treasure hunt game	Explore the city and reflect on the topic of migration and more, linking with other cities, histories and eras	Receive guidelines to next location, walk to location, find hidden object, read about object at location, interact with and contribute to object, receive reward	Score, achievement system (badges and achievements), levels and travel diary,

3.3 Description of App and Game Play

As users walk through the city they encounter points-of-interest (POIs) composed of navigational clues that direct players to locations where they can activate stories. POIs are marked on the map as yellow or purple circles – yellow for official CrossCult POIs and purple for player-added stories, (Fig. 2). If the player has previously discovered a story attached to a POI, these change colour to a teal blue or green. The symbol size of each POI (size of the circle) indicates its activation radius; this is a form of geofence around the point to help the user discover the clue and activate the story more easily. This geofence manages uncertainty that arises from GPS error [12]. As soon as the user's physical location (blue dot) is located within the yellow or purple circle, the distance indication on the navigational clue changes to a "Discover this story" indication, and the user can read the story that accompanies the POI. When the user selects the option to receive POI notifications (from the app menu/preferences), but has not yet opened the POI clue, if they are within the POI's radius, they receive a notification. This is in the form of haptic feedback: the phone will vibrate to indicate that he or she is passing through a clue and can discover a story.

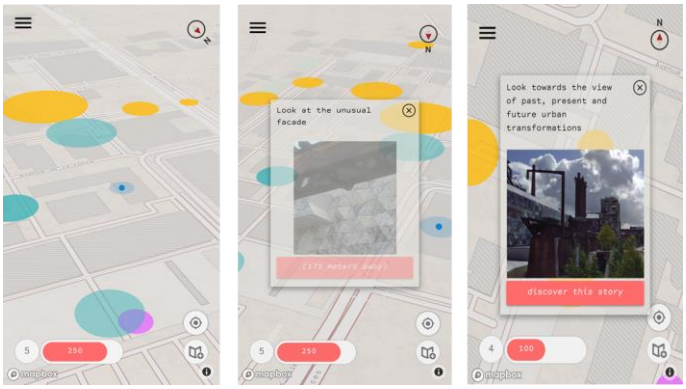

Fig. 2. (Left) Map showing Points-of-Interest, (POI), (middle) navigational clues telling the player where to look at to identify the POI in the physical space, and (right) discovering stories once the player's GPS location falls inside the geofenced area of the POI.

Navigational clues (Fig. 2, middle and right) comprise a title, which is a hint of where to look or a short fact that links the location to the pinned story, and an image of the location with an indicator that tells you how far away you are from it. The images show either a close-up of a building or feature (akin to a puzzle piece – designed to make you look more closely) or a more distant view of the location. In Figure 2 (middle) you see an example of a navigational clue showing a close up of the windows of the new library building on the Belval Campus in Luxembourg and the textual clue indicates that the user should look at the unusual façade of the library building. These navigational clues are designed to bring the player and the city closer together, so on discovering the story, the user learns how the façade is symbolic of the dusty windows of the building from its days of steel production. The clue was designed to trigger a reaction in the player. Currently in the app, each navigation clue has one story attached to it but we have designed the content management system and the data model so that in the future we can manage and visualise multiple stories attached to a POI.

When users click on "Discover this story", the screen changes and the map is replaced by the POI's story (Fig. 3). The story relates to the physical location (in the city) either where the player is currently standing, through a direct connection to the location or because the location is used as a metaphor because it is associated with the topic of the story. For this reason, the image included on this screen is either directly related to the location or provides a visual context for the story. Underneath the historical photo/image the user can find a short self-contained story about one aspect of the reflection topic (thread) that he or she has chosen to follow.

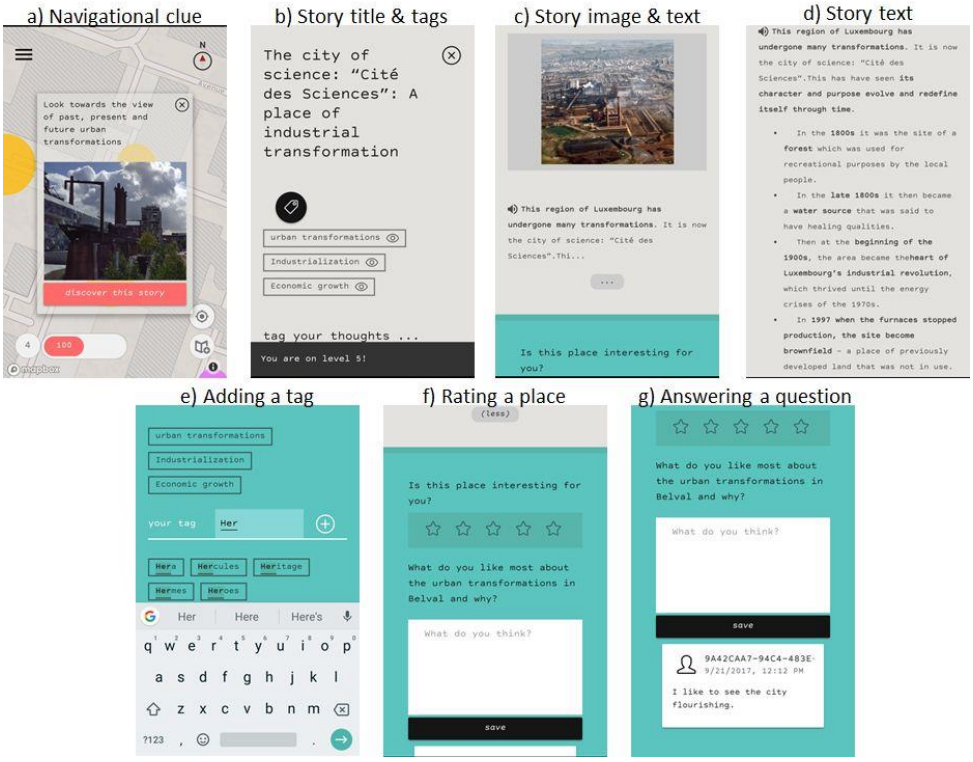

Fig. 3. Reflecting on a digital cultural heritage story by discovery (a) reading (b, c d), listening (d), tagging (e), rating (f) and answering a question (g)

The stories were written as a trigger to stimulate thinking. For usability reasons, the story text is by default minimised and can be expanded, it has been styled using markdown to improve on-screen readability. For players that do not wish to read the text, there is text-to-speech capability. By combining the location, navigational clue, story title and historical image with the story, we hope to trigger a process of personal reflection. *This reflection helps strengthen the players' mental connections between the city, its history and the topic of reflection referenced.*

To foster this process of reflection further we ask the user to complete three activities: (1) to rate their perception of the place; (2) to answer a reflective question; (3) to tag their thoughts. The aim of the question is to provoke the user into thinking about either the story they just read or use that to encourage an expression of a viewpoint stimulated by the mental connections made after discovering the content. Comments on reflective questions are marked as pending until they have been through the moderation process. The moderation process involves the use of a companion app that asks either the crowd (via CrowdFlower) or an expert to accept or reject the comments based on whether they contain hate speech or not. To tag content, players click on the tag symbol found near the story's title. This opens a new screen, where the user can type any tag they wish. They also receive tag suggestions based on what they type; these suggestions are retrieved from the knowledge base of controlled terminology that was created for Pilot 4.

A set of incentives and rewards were defined as part of the original core game play (see section 3.2). As players interact with the game by discovering stories or reflecting on content, they earn points and progress through a series of levels. We also implemented a secondary reward system known as achievements. The need for this came about from the request of users during the board game to have extra missions that they could complete as they discover content. In gaming, achievement systems provide additional goals for players that help players to reach particular milestones [70] whereby on completion of an achievement, players are awarded badges. The achievements were designed to encourage and motivate reflection interactions (tagging, rating a place and answering a question). In gaming theory such systems have a number of purposes such as extending the life of game motivating players and increasing the sense of playfulness [70]. We reward users for various tasks and missions associated with contributing their reflections. For example, there is a *speaker* badge awarded when you publish your first story or a *commentator* badge when you answer your first question. The purpose of these achievements is to aid external motivation.

After accumulating a certain number of points and reaching a particular level (2) the players are able to unlock functionality enabling them to add their own personal story (designed as a progressive reveal), they can add content associated with their local knowledge to the game that was triggered by their own thoughts of their experience (reflections). All stories discovered and contributed whilst playing the game in the city can be reviewed later. Using the menu, players can view their journey and continue reflecting upon the stories they have encountered ("My Journey") and contributed ("My Stories") and view their achievements ("Achievements"). This means that they can carry on thinking about the content or see who has commented on stories they have discovered without being *in situ* (Fig. 4).

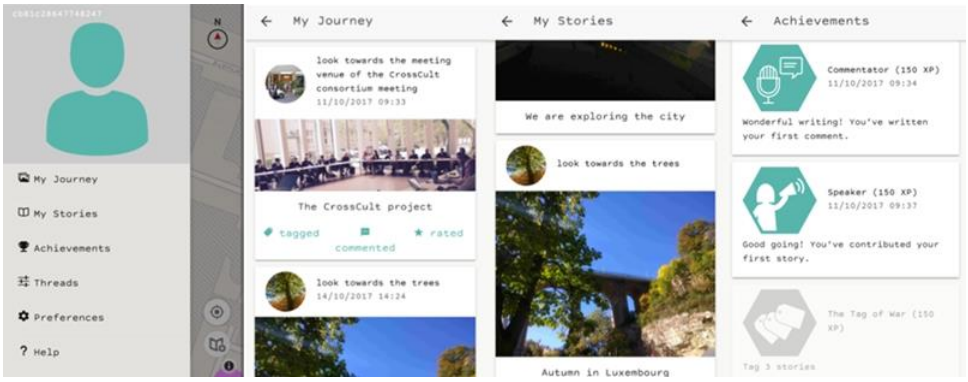

Fig. 4. Menu, My Journey, My Stories, My Achievements

4 METHODOLOGY: IN-THE-FIELD PRELIMINARY EXPERIMENTS AND CONTROLLED USER STUDY

The study had two aims: (1) to understand users' perceptions and initial impressions of their experience with a view to unravelling use, perceived value and players' motivations towards the app, and (2) to understand the different emotional viewpoints of the participants with regards to their perceived value of the app. Therefore, we used a mixed methods approach combining field trials with controlled experiments to gather data analysed qualitatively using a thematic approach and quantitatively using sentiment analysis scores. This study applies common methodological practices in user study research to the domain of cultural heritage, where user research is less developed. In this paper we consider the strengths and weaknesses of this approach by reflecting upon our results and experience in undertaking this study. We carried out four experiments over a two-month period between late September and mid-November 2017, which took place in Luxembourg. We chose this period for practical reasons. We had to undertake our experiments before the weather turned inclement. The purpose of the first two experiments was to take the app into an external location and observe how users experienced it and interacted with it. Data collected (or lack of it) during these early experiments provided vital insights into development priorities and ensured we focused any improvements on actual user needs. These experiments are discussed in subsequent paragraphs. The third and fourth experiments were based on a more established and stable version of the app. They constitute the essence of this user study, which evaluates user perceptions of their experience i.e. the response to their visit in the city. These latter experiments were performed on two distinct player groups: stakeholders and students. Neither group at the time of the experiments had any direct association to the project, but resulting from their participation, one group of students used the tools to curate their own experience about the history of mental health. Another stakeholder joined the project's living lab and became active contributors to the co-design of the app and its ecosystem.

Experiments 1 and 2 are not included in the detailed evaluation discussion in the findings section of this paper because significant changes were made to the design and features of the app both between the experiments and subsequently. Experiments 3 and 4 were usability experiments that followed the same protocol and were conducted on the same version of the app; they were therefore more controlled and comparable to each other. The results of the two field experiments are described individually to set the scene for the user study comprising of experiments 3 and 4. Our primary content was written for Luxembourg City and the Maltese capital Valletta, with stories related to the broad topic of migration. However, we also developed content on architecture, cultural heritage and urban change for the town of Belval, in southern Luxembourg, (Fig. 6). The University of Luxembourg is situated here and for the purposes of evaluating the user experience (UX), usefulness and usability we chose a site nearby for the convenience of participants. Three of the four experiments were conducted in Belval.

4.1 Preliminary experiments for evaluating feasibility and fine-tuning game mechanics

The first experiment took place during the University Welcome Day held in the middle of September 2017. The weather was overcast but not raining and temperature was between 10 and 15 degrees Celsius. The students were given a short introduction to the project during the Welcome Day presentation, and those that were interested were invited to come and find our stand. Students downloaded the app using a link/QR code provided by the project team and were given a short overview on how to use the app, then asked to try it out and come back and complete our questionnaire. Many students showed an interest in the project (there were around 40 Android app downloads) but the number of downloads did not convert to players. We observed four issues. Firstly, only three users found more than one point of interest; secondly, users could not activate stories; and thirdly there were technical issues with Wi-Fi saturation due to the volume of students on campus at the time; and fourthly, one user stated that the stories were difficult to read. This last issue was addressed subsequently by activating common markdown language in the web interface used to write and publish content for the app. Stories could be styled using quotes and fonts, while previously they were in plain text.

4.1.1 Revising the game mechanics and interaction design of navigational clues

The first issue represented a major usability and UX issue: if users were not able to activate content (i.e. stories) then essentially the app was failing at the first hurdle. Only three users found more than one story and were motivated and engaged, determined to try hard to understand what they had to do. The majority of users found just one story and did so only because a point of interest was located very near to the stand where we were running the experiment. We located it there so that we could explain the principles of the interaction, but without our support they failed to activate more content, and stopped using the app. We had placed restrictions on interaction based on the scale of the map. They could only view a navigational clue at a certain zoom level on the map (see Fig. 5, top row). If they were at the inappropriate zoom map scale, they received a message that they had to zoom into the map until the "My location" button turns blue. There was a rationale for implementing this restriction on access to the content associated to the game play. We initially thought players had to explore the city serendipitously, so they could only see clues in their immediate local neighbourhood where they were standing. Thus, the discovery of locations required some effort and movement. This experiment revealed the flaws in our original concept. The interaction was too complex and prevented people from activating and engaging with any story. Most importantly, it revealed a cognitive mismatch between how users expected the functionality of the map to work and how we had conceptualised and implemented the game play. Players expected to be able to zoom in and out to any scale following expectations set by everyday norms acquired from tools such as Google Maps. This highlights the importance of following interaction mapping "norms" – even in playful geo-located applications. We redesigned the interaction based on this knowledge of common map interactions and the evidence from the evaluation that people did not want to feel that finding POIs required considerable effort and they wanted to know where more POIs were located. If a player tapped on a POI, the clue window opened for users and told them how far away they were from the story, thus giving feedback on the effort required to get to the location. If this window was open, the distance to the POI was dynamically calculated and updated as users approached it or moved further away (Fig. 5,bottom row).

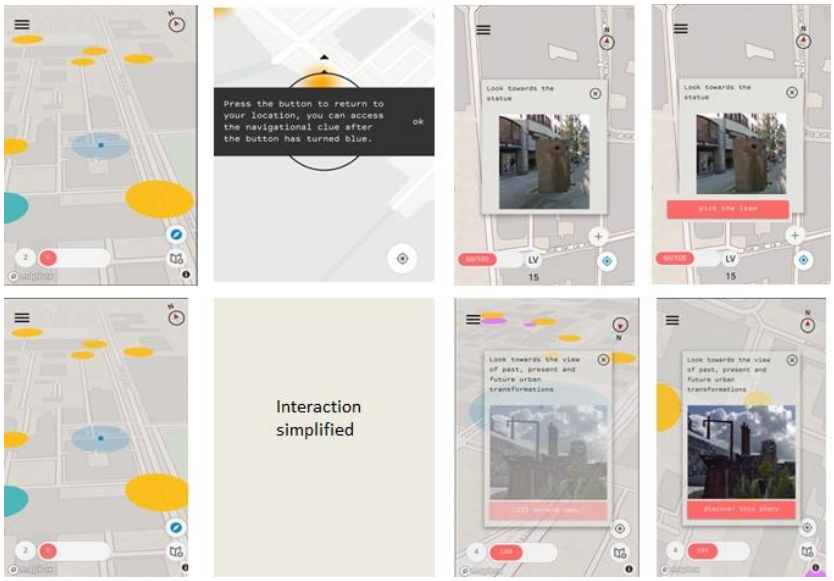

Fig. 5. Screens showing workflow for activating a clue and discovering a story: Before the preliminary experiments (top row) and after (bottom row).

4.1.2 Revising the mechanics of content delivery

The second experiment, unlike the others, was situated in Luxembourg City during the Luxembourg Institute of Science and Technology (LIST) after-work get-together event. It took place in late September on a beautiful autumnal evening with sunshine, blue skies and quite balmy temperatures. The event had limited participation; of the staff present only 12 downloaded the app and from those 12, we gathered four trajectories (paths through the city). In this social context, players chose to use the app in small groups – perhaps this is indicative of how people might use it in the future. The new design for activating stories worked as the users discovered more than one story. Participants were interacting with the content stories and providing their own reflections. Discussions with participants following the experiment revealed a number of things. To engage fully with the experience, users must be interested in discovering and reading the hidden stories and must take the time to consider the stories. In other words, they need to be in the right frame of mind before beginning to play the game otherwise they will not have meaningful interactions. It was also evident that some players (one in particular) just did not like reading texts on their smartphone. This was despite the fact that none of the texts exceeded 200 words. After talking to this participant, it became apparent that he perceived himself to be a visual learner. This motivated us to activate an automatic text-to-speech service within the app offering many potential benefits. This helps make the app more inclusive for people with sight impairments, more suitable for participants who prefer to use auditory methods for learning, and it means that people can immerse themselves more in the physical environment. We chose an automated service for converting text to speech, as it is much more scalable then creating individual recordings of each story.

4.2 Controlled user study: protocol and data collection method

To evaluate the app in more detail we will discuss the third and fourth rounds of experiments, which were controlled in so far as is possible with participants out in the real environment. It was necessary to conduct these further experiments to understand in more detail the experience of the users when interacting with a stable beta version of the app. These systematically followed the same experiment protocol and the same version of the app. At the beginning, all players were collectively given a short introduction that briefly described the app and its interface. Players were told that the game would guide them to discover pointsof interest located in the city and that they would be able to activate stories at these locations. This session took around 15 minutes, they then either installed the app on their own Android phone or used one of the Android test phones available. The test phones came with the app preinstalled but the app not opened, because on first use of the app users had to accept the terms and conditions and give consent for experimentation. They were reminded that they could withdraw from the experiment at any time or could request modifications or deletion of their data, and that they were free to contact us via email. On first use of the app, players were shown a few help screens and notified that their location was being tracked.

Fig. 6. The Belval campus: picture of the user study location (left), next to the location's POIs in the app (right)

In pairs, players were asked to play with the app for 30 minutes. Both experiments took place in Belval in southern Luxembourg (Fig. 6). On their return they were asked to individually complete either the short version or an extended version of a paper-based post-test questionnaire. This included a mix of Likert scale and open-ended questions and was divided into the following sections: demographics and habits, impressions of the app (would they recommend it, what did they like most and least), overall user experience and perceptions of ease of learning. The questionnaire was inspired by the Use questionnaire [41] and the User Acceptance of Technology (UTAUT) framework [68]. The extended survey included questions designed to evaluate the features and the potential learning outcomes based on the user experience written specifically for the app. We used the Android version of the app because at the time we had a very unstable version of the iPhone app with known technical bugs that required fixing, and due to the winter weather in Luxembourg, it was imperative to test outdoors beforehand. We did not give an award or incentive to users taking part in the evaluation. To complement the questionnaire data, we also had access to the log files of the apps that record all the interactions that users made with the app and their contributed reflections. This can be combined with digital traces of users in the neighbourhood to build a rich picture of how they interacted and engaged with the app (this analysis is not part of this paper).

4.2.1 Description of the participants

Combining the results for experiments 3 and 4 and after cleaning the data, we had a total of 30 valid questionnaires with 19 respondents identifying as male, 9 as female and 2 preferring not to say. This gender bias is consistent with previous experiments involving location-based games. Two thirds of the respondents were aged between 20 and 34, 23% were aged between 35 and 54 with the remaining being 55 and over. There was an even distribution between Luxembourg natives and non-natives; almost half of all players were not Luxembourg nationals (this is in line with population statistics for the country). All the players had higher education qualifications: 30% had a Bachelor's degree or equivalent whilst 60% had a Master's degree. The remaining had a PhD. With respect to their habits, two thirds of participants had used only free apps on their mobile phone, and 64% of these played games on their phone in a typical day. Just over 40% of participants did not play games on their phone. Since the game involves a map, we also asked people to rate their map-reading ability on a scale of 1 to 5, where 1 represented very weak and 5 represented very strong. The responses stated that the majority of participants, 18 in all, rated themselves as having either strong or very strong map-reading abilities. None of the 30 participants were part of the project or had been involved in the project in anyway prior to the experiment.

5 FINDINGS

Using a process of axial, open and selective coding of the open-ended questions, we were able to gain a deeper understanding of the players' experiences and perceptions of the app. We were particularly interested in the qualitative coding of themes linked to acceptance of the technology as described by players' experience. Also of interest were the form and patterns of the user responses themselves, as this helped us to see whether any recognisable user types emerged from the experience.

5.1 General user perceptions and attitudes

When asked to describe the app, the most frequently used word was *discover* –used by 7 of the 30 respondents and in connection with words such as fun, explore, history, city and interest. Participants described the app as giving them the opportunity to, "*walk around and discover with some fun, entertainment and learning*" (P13, 26.10.17) or "*a fun way to explore the city/area with a little "spice*" " (P11, 7.11.17). In answering this question only two participants used the term history, with one stating it was a "*funny way to discovery history and geography*" (P03, 7.11.17). Note that to a native English speaker the use of "funny" would be taken negatively here (i.e. weird) whereas for a non-native speaker they often confuse "fun" and "funny", so "funny" was presumably intended to be positive. This suggests that one of the key motivations for using the app in these responses was associated with the discovery and exploration of places and information.

5.1.1 Surprising locations beyond the everyday

Analysis of the remaining questions revealed further insights into the discovery process of this app. When creating the content for the stories and selecting the locations we tried to make sure that the POIs were distributed throughout the built environment so as to avoid too much reliance on obvious locations or well-known cultural heritage sites. Since the cities that we were working with are reasonably small, this was not always possible, so we tried to balance obvious cultural heritage locations with surprising stories and then to play with metaphors that we could find in the built environment to symbolise an aspect of the story. Some players were **motivated by this use of non-traditional and surprising locations and stories**, with one participant stating "*... since tourist guides usually refer to the old parts of the cities. I didn't think there would be so much to tell about the place!*" (P07, 7.11.17).

Table 2: Open-ended questions that form part of the post-experiment questionnaire

Question	Justification	Total number of responses
Using one sentence, how would you describe the app to a friend?	To discover what participants understood the app to be following one session of gameplay	30
Would you recommend the app to a friend? and Why (Not)	To understand if participants saw any value in the game	28
What did you like most about the App and why?	Understand the positive features that stood out to participants	27
What did you dislike most about the App and why?	Understand the negative features that stood out to participants	24

In this context, the location of the stories (contributed either by a CrossCult curator or by a participant) seemed to provide a system of **social recommendation** going beyond traditional guides to highlight to participants where they could find potentially interesting and **unexpected places** and stories. The use of the stories and locations together with navigational clues provided a different way of experiencing the city. The clues sometimes showed detailed features of part of a building or a wider landscape, both of which required users to pay more attention to their surroundings. Even if participants were familiar with the area where the experiments were located, the app encouraged them to consider **the urban landscape more deeply and to look beyond the everyday.** This effect of the app is backed up by the responses to the reflection-based questions that are posed in the game. The questions were designed to support the process of experiencing the city and history from a different perspective and to encourage users to stop and reflect on things that they walk past every day but seldom pay attention to. "*I was very surprised, because I have never seen them before. I am just passing to get to the university. The story behind is very interesting."* Here we note a participant who had a new encounter with a place they thought they knew well. The content of the app challenged them to reconsider a local environment to which they had previously given only a cursory glance. These observations are consistent with research that has been carried out on motivations for participation in geocaching [49]. The POIs in the app created a novelty value that motivated some players and provided a sense of usefulness, particularly as they are able to be "*learning completely new stories about familiar places*" (P10, 7.11.17).

5.1.2 Motivation and situated story-telling

The **situatedness** that is embedded in the experience of encountering and revealing stories according to a person's location had an added value for participants; it enabled them to "*learn interesting things about the place where you are at the moment*" (P10, 7.11.17), highlighting the significance of the **geolocated stories.** The geo-located aspect of the stories is not a new idea; it is used, for example, in guided walking tours where you hear stories about a particular point in time relevant to the places you encounter as you walk in an ordered manner through a city. However, the ability to develop apps that make use of emerging technologies and geo-located services now within a user's mobile device, combined with low-cost data and Wi-Fi services often available in many cities, creates real potential for the development of location-based storytelling grounded in the city. The process of being able to access available historical information (stories and resources) instantly based on where you are standing at a particular point in time resonated with the players. "*It gives all the historical information that I usually must read before coming to a place or bring some docs with me to the place. Now everything is in your phone*" (P30, 26.10.17). This reveals the usefulness of located information for information acquisition which can have the effect of leading to the construction of local knowledge [27].

In previous studies of location-based technologies/games, the motivational factors influencing player engagement are not just about the simplicity of the process of discovering content according to your time and location; they are also about the act of finding a location and the challenge this represents [24,49]. Players in traditional geocaching games do not always want easy–to-find locations, but rather are motivated by the challenge of looking for and locating a particular geocache that is hard to find. In traditional geocaching games it is said that the best locations are those that are difficult to find and hard to reach, where participants can linger and become more immersed [31,49]. In our results, it was not evident that players were motivated by the thrill and challenge of finding an obscure, hard-to-reach location, since the more remote POIs were not visited (although this could be a limit of the experiment timeframe). Players were more focused on the act of revealing the story content than the challenge of finding the locations. One user found the process of using the map and the navigational clues to get to a point in the city quite frustrating and said that what they disliked most was the "*need to be located in [an] exact spot before information became available*" (P02, 26.10.17). After discussing with this player following the experiment, she said that the Belval campus has quite large open spaces so she could see the buildings and location from afar, they did not see why the game could not be set up so users could activate the content from afar without actually going to the exact location. This implies the user was less interested in the game and its challenge of finding exact locations and instead was focused on activating content and reading stories. In this instance, winning points was not sufficient motivation to encourage people to walk to the exact location. This implies that the motivating factor in our app is primarily the content and not the act of playing the game itself.

5.1.3 Cognitive mismatches between clues and their geofences

This challenge of finding locations was also a point of frustration for some users because of how the activation radius was implemented. The activation radius demarcates a zone around the centre of the point of interest (POI): it is a geofence that can vary in size and is set by the content curator in the administrative interface. It was designed to manage the fluctuating accuracy of the GPS signal which can occur because of urban canyons, high buildings and narrow streets. During early testing (prior to any of the four experiments) we noticed that in certain locations the GPS signal would bounce around so that sometimes users were able to activate content, but a few minutes later the signal (and therefore access to the content) would disappear. This represents a well-documented limitation and a general point of frustration with GPS [16,23,43,53]. The resulting error and uncertainty creates a seam within the geo-located game that needs to be managed by either removing, hiding, revealing or exploiting it. Otherwise these game seams can negatively impact upon the user experience [11]. We chose to manage the seam by creating an activation radius, which was designed to account for this jitter in positioning and minimise the frustrations that we observed during early testing. The seam was managed by using the activation radius to hide the GPS positioning uncertainty from the user. So when a player enters the zone of the activation (the geofence of the navigational clue), the short text and a picture becomes opaque where previously it was transparent and the distance to clue notification becomes a button that can be selected to activate the story (Fig. 5). If users leave the zone they are no longer able to view the content. Users generally found this facility useful, but for a few it led to a **cognitive mismatch between clues and their geofence**. It gave the impression that "*real views did not necessarily match pictures*" (P23, 26.10.17). Thus, for a few players

a mismatch was evident between where people were standing to activate content and the static nature of the clue picture. Therefore, there should be a balance between hiding the seam by increasing the geofence around the POI by varying the size of the activation radius to provide a seamless gameplay while still ensuring that the activation zone remains meaningful. In a feature iteration of the app, we will evaluate what happens if the cartography does not visually show the geofence to the user.

5.1.4 Need for navigational directions or not

The emphasis on content discovery and the content itself was an important aspect of the app, particularly following the criticism levelled at location-based games in the literature back in 2006, which claimed that they placed undue importance on the navigation processes at the expense of content [29]. With this in mind, from the very beginning we focused on the content and stories, and designed the app to support free movement through the city and specifically chose not to implement navigational features. We did not intend to reproduce the functionality of a more traditional topographic reference map with directional support akin to Google Maps. This is why we implemented a notification system: if the app is installed on the device and running in the background then the phone delivers haptic feedback in the form of a notification to indicate to users that they are passing through a POI. This was intended to encourage more serendipitous discovery and minimise the time spent looking at the phone and the map. In reality, the majority of participants made use of the map on the phone to navigate to their selected POI, but this dependence on the map and the absence of direction seemed to lead to frustration. It also led to the perception that players had to look at their mobile phone too much, a criticism of many geo-located games (e.g. Pokemon). This reliance on the map also led two players to dislike the fact that there were "*no navigational direction instructions*" (P20, 26.10.17) and to remark that there was "*poor direction guidance*" (P23, 26.10.17). It is clear they felt the app **lacked navigational directions**. This is despite both of the participants recording their map reading ability as very strong (scoring it a maximum of 5). The map used in the game was a customised topographic map using Mapbox where we applied a cartography that gave the street map a historical look and feel. Another respondent shed more light on this issue: the Belval campus where we conducted our experiments is rather unique; it is a former industrial site that was at the heart of the steel and industrial revolution from the late 1800s until the 1960s and it comprises wide streets and open spaces that can be difficult to navigate. This was expressed by participant P07 (7.11.17), who articulated this difficulty by stating that "*in a place like Belval campus where we don't have many street names, navigating and finding the right direction can be fairly problematic*. *But that is only in Belval".* It is plausible that this issue was exacerbated by the design of the map, which, because it is part of a game, did not show any building names which would ordinarily help people to position themselves more accurately in the built environment. That said, in the better known and the most successful location based games, navigational directions are not provided, so this response could also indicate that the playfulness of the app is not sufficient for people to become immersed in the game. For a future iteration, the map will be tweaked: the streets will be widened to give them more visual dominance and the map styled more playfully. Future tests will investigate if lack of navigational directions was only problematic in Belval or extends more generally to other towns and cities.

5.1.5 Serendipity, autonomy, personalisation and social function

In line with other studies [13], we observed a number of **needs and personal motivations** for participants using the app. Playing the Pilot 4 game gave users a sense of **autonomy** which is not so typical in traditional methods used to discover the history of a city (such as guided tours). The freedom of being able to walk through the city without following a predefined linear path or formal route encouraged autonomy in participants: "*I create my own way, I have the information I want but at the same time I discover new things*" (P22, 26.10.17). This autonomy offered by the unguided discovery seemed to foster a more **personal experience**. Although the app has a few personalisation features *per se* – you can switch sounds and notifications on and off and select either curated CrossCult stories or stories authored by players – these are relatively standard and there are currently no real ways of customising the types of content received. However, the serendipitous approach seemed to allow **free movement** and the placing of stories on POIs facilitated an urban discovery process that evokes a feeling of personal customisation and social recommendation. This sense of freedom and customisation was articulated by one participant

who, when asked to describe what they liked most about the app, wrote "*related to my position, nice to see hot spots all around so I know that I can follow my taste*" (P02, 26.10.17). This comes back to the open choice of where to go and the self-contained nature of the story composition that led participants to feel that the app was open to their preference to go anywhere.

The app was designed for asynchronous play: participants are not expected to play and interact with each other at the same time or indeed be in the same location. This meant that for more participants more interested in social experiences, whilst they appreciated the autonomy and self-guiding nature of the app, they found it somewhat unsocial "*I can't really have a social experience with the people around me. You have to be alone to actually use and enjoy it*" (P16, 26.10.17). This contradicts the more enthusiastic and interested participants who immersed themselves in the experience and noted that reflecting on the stories was one of the features that they liked the most in the app. This is because the responses to the reflective questions gave them the feeling that they were "*engaging in a conversation or dialogue*" (P10, 7.11.17), and they found them "*equally interesting to the stories' text*" (P11, 7.11.17). Therefore, whilst the app does not support a social network, the fact that it incorporates reflective questions that elicit a more personal response gave some participants the impression that it serves a **social function**. A few players felt a sense of **connectedness** to others **rooted** in the participant experience of reading other people's comments.

5.1.6 Accomplishment and knowledge acquisition

Players appeared to develop a **sense of accomplishment** from the process of discovering new places, reading interesting stories and sharing their thoughts. A number of players considered the app to support the process of **new information and knowledge acquisition**. For enthusiastic participants, it helped them **to acquire information** because "*it gives information which we did not know*" (P24, 26.10.17). Therefore, it offered some participants an added value as an educational experience by engaging learning processes. This educational aspect of learning something new and surprising appeared to motivate a number of the participants. Although the app was not designed explicitly as a learning tool, there is evidence from the responses that value could be derived from its adoption as an "*Educational, fun experience*" (P19, 26.10.17). Motivation came from the stimulation afforded by either learning about new places or learning new stories "*about familiar places*" (P10, 7.11.17). The process of being *in situ*/moving through the built environment whilst exploring your surroundings through markers of cultural heritage provided an immersive experience for these participants. This process for accessing relevant stories on historical topics might unlock new opportunities of **situated learning** within pedagogical practices. For sceptical players, the stories lacked sufficient depth for research, but the app was never intended to support this type of activity.

5.1.7 Playfulness and game play

So far in this process we were aware that the focus of the app design had not prioritised playfulness. This was because we had chosen to focus first on the content and its discovery as well as the interactions and features that we designed to trigger reflection. What is interesting in the user responses is the lack of the use of the word game or play. Only one participant used the term across all the free text responses, when asked to describe the app in one sentence, stating that it was an "*App to discover the campus Belval in a playful way*" (P.21.11.8.2017). The questionnaire also included two questions related to the game play and its design: (1) Using the app felt playful and (2) The design of the app was unfinished. Players had to agree or disagree with the statement using a Likert scale. The responses to these questions was not conclusive. Half of the participants either slightly agreed or slightly disagreed with both statements. Indicating that the playful elements of the game and its design need improvement, as they were currently not obvious.

5.2 Sentiment analysis and indicative types of user responses: A lens for understanding participants experience and perceived value

The qualitative analysis of the open-ended questions affords some insight into the perceived value of the app by participants, but what it does not do is capture the emotional responses or indicate if there are any potential patterns evident in the user responses of our participants. Technology and marketing research has shown that users of apps who express more strongly positive emotional reactions to the user experience are more likely to be indicative of usage intention and therefore help us to predict who could become a real user of such an app [4,35]. We believe sentiment analysis offers one such possibility

to evaluate the emotional responses of participants by providing a further layer of understanding of the responses towards the Pilot 4 experience. Using a mix of sentiment and qualitative analysis we explored how participants perceived the value of the application and try to determine if there were any similarities in the response patterns. We did this because we thought that by identifying patterns in the participant response we would be better placed to: (1) understand and prioritise the next development steps and (2) understand the perceptions of value that the users felt the app provided. We took inspiration from Armelesu and Jones [6] who analysed linguistic patterns in the responses of Think Aloud experiments on different types of web interfaces to identify three types of responses that users felt towards the interfaces varying from the sceptic, the enthusiast and the immersed user.

We started with a sentiment analysis of the responses. We used the TheySay[3] online demo tool that uses natural language processing to explore different sentiment dimensions that are expressed in the test. We were able to determine a likelihood that the response was positive (i.e. they responded favourably), negative (i.e. participant responses were unfavourable towards the app) or neutral (i.e. little emotion was expressed). The tool also indicates the types of emotions that people expressed indicative of a range of psychological dimensions, such as happiness, fear, like or dislike.

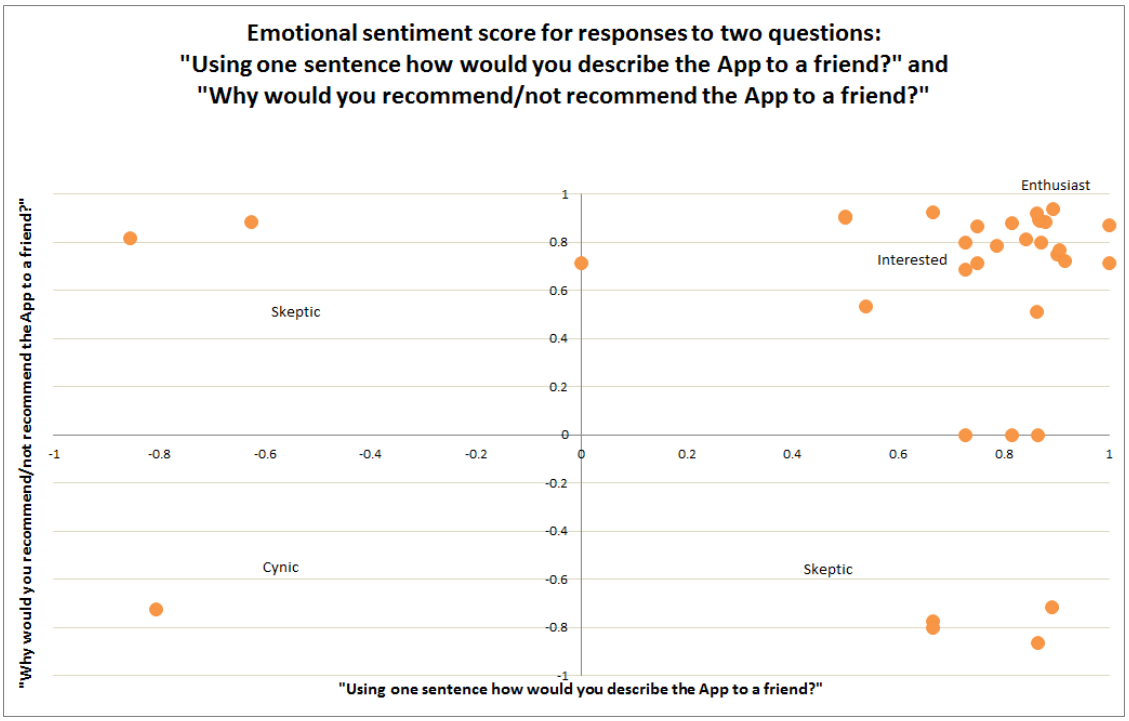

Fig. 7. Plot of emotional response scores for answers to questions on how users would *describe the app to a friend* and *why they would recommend /not recommend the app to a friend*?

[3] https://apidemo.theysay.io/

Each of the dimensions and their subtypes are assigned a score from 0-1, for example, the statement "*Nice way to become more familiar with the neighbourhood*" is assigned a positive sentiment score of 0.867, which indicates happiness and liking and does not express speculation, intent or risk. A neutral statement is given a score of 1.

We processed the two open-ended items on the questionnaire using TheySay (Table 2). We chose the question "*Using one sentence, how would you describe the app to a friend?"* and "*Why would you recommend /not recommend the app to a friend?*" These were chosen because the responses best indicate the value perceived value. The sentiment scores for each of the responses to the questions were plotted on a graph (Fig. 7). To do this, we transformed the scores into a continuum where negative emotions were multiplied by -1, and -1 was subtracted from neutral scores. This meant we could plot the scores on a graph from -1 (strongly negative) to +1 (strongly positive) with 0 being the neutral mid-point for each of the responses (Fig. 7). The experience of using the app covered a full range of emotions, from strongly positive to strongly negative including responses that took a more neutral viewpoint. We observed four patterns of emotional responses, which we propose to describe as the sceptic, the cynic, the interested and the enthusiast. To understand the detailed characteristics that underlie these responses we then investigated the linguistic patterns to provide a richer interpretation.

Table 3: Identifying patterns in emotional response and attitude towards the app experience

User response	Response Criteria	Description	Total responders
Cynic	2 negative responses	Negative sentiment expressed in both responses	(1)
Sceptic	1 positive, 1 negative	Mixed sentiment with one negative response and one positive response	(6)
		or one positive and one neutral response or one	(3)
Interested	2 positive and ranking of 3 or 4	Positive sentiment expressed in response to both questions and a ranking of the app that focus around the average range of 3.5.	(15)
Enthusiast	2 highly positive (<=0.7) and a ranking of 5	Strongly positive sentiment expressed in both question responses and the maximising ranking of 5	(5)

5.2.1 The cynical response: unconvinced and less likely to adopt cultural heritage games

Alongside the sceptical responses we also observed one user whose responses were highly *cynical* in nature, expressing more pessimistic responses that emphatically rejected the app and clearly stated that they would not recommend it to a friend. They were personally unconvinced of the added-value of the app. This responder found neither the geolocation of the stories nor the gaming elements of the app to be advantageous. They were not motivated or interested in the location-specific nature of the stories: "*I didn't like the fact that I had to be on the spot to achieve the story*" (P28, 26.10.17), features that other participants responded to very positively. They were closed to the entire experience, stating that "it feels redundant…I am not sure it's an added value" (P28, 26.10.17).

5.2.2 The sceptical response: open to apps' usefulness but perfectionist for functionality

The *sceptical* user responses employed expressions that combined the use of the first person (I and my) with words that articulated uncertainty or indicated that the app was seen as requiring more work. They used terms such as "unfinished", "work in progress" or "needs improvement", "potential", "buggy". In total, the responses of 9 users (3 male and 6 female) were aligned with this perspective. Of these responses, 7 of the 9 in a typical day spent at least 30 minutes playing games on their phone. For these sceptical participants, the responses to the experience were closely tied to their understanding of the maturity

of the app (they were told they were beta-testing). The issues that they encountered were connected to the limitations of GPS or the lack of navigational capabilities that they believed would be useful. They often used negative words such as *not*: "*it is not yet complete*" (P02, 26.10.17) and "sort of *bugging… not moving on the map as I walked*" (P04, 7.11.17). Note that the bugging they refer to was a result of the limitations of the GPS, which took a while to find locations when the participants started the experiment (because they went from indoors to outdoors). Sceptical users were of the view that ease of use and user experience and satisfaction were lacking. They nevertheless retained an open attitude towards accepting the app with respect to their perceptions of its usefulness. These participants, when responding to one of the post-test questions, stated that they slightly enjoyed using the app. This suggests that they were optimistic about it and possibly open to accepting it in the future since they saw some potential in it. Indeed, one of the sceptical respondents even noted that it had "*tons of potential*" (P01, 7.11.17).

5.2.3 The interested responder: mixed responses and a little distant

We observed two more open and positive categories of user responses to our questionnaire, which we have labelled the *interested* and the *enthusiast*. Participants that were categorised as interested had user responses that while positive, took a more distant viewpoint than the enthusiastic participant (who mainly expressed themselves using the first person). The interested type of user either talked about their experience using the second person (you or we) e.g., "*it gives information that we did not know*" (P24, 26.10.17) or attached no pronoun at all to their sentences. The result is the creation of distance of response between their experience and perceptions of the app. This category contained by far the most participants, a total of 15 of the 30 respondents. The majority of these participants were male (11). Of the total number of participants, nine did not spend any time in a typical day playing games on their phone. Interested users ranked the app with either 3 or 4 stars and all stated that they would recommend the app to a friend. In describing the app, they used adjectives such as simple, useful, helpful and educational – indicating that from their experience of using it they felt that there was an underlying value to its use.

5.2.4 The enthusiastic response: strongly in favour and motivated

For the enthusiastic responses, participants were more likely to describe their experience using the first person (I and my), and tended to use superlatives (wonderful, nice and good) or adverbs and adjectives that expressed enthusiasm such as "a good way", "an interesting app", "very handy" or "fun". Five participants articulated enthusiastic user responses to the app in the post-test questionnaire. They were asked to give the app a ranking based on 1 to 5 stars (5 being the highest score). They awarded the app with either 4 stars (4 participants) or 5 stars (1 participant). There was also consensus about their general thoughts on whether they enjoyed the app, with all participants stating they agreed or strongly agreed that they enjoyed using it. Enthusiastic responses were all from male participants. The enthusiastic respondents saw intrinsic value in the linking together of points-of-interest in the city, cultural heritage and history to encourage reflection, meaning that they perceived the app to be personally useful. They saw value in the surprising information, the app as a form of geo-located social recommender and as source of situational learning.

5.2.5 Benefits and limitations of understanding emotional aspects of the user responses as part of the evaluation process

The relationship between emotion and technology adoption is well-established. It has long been proven that use of technology is an intentional behaviour, driven by a conscious decision to act [28]. Indeed, there are many models for evaluating technology adoption and acceptance, including in the domain of informal learning [66], such as the theory of diffusion [57], the technology acceptance model [20] or the unified theory of acceptance of technology [36,68] which consider aspects of cognition, emotion and context that encourage technology use. The decisions that lead to the act of using a technology are driven by two aspects: firstly, people's perceptions of ease of use and the usability of the technology and secondly, their emotional responses to the use of the technology [28]. People become attached to certain devices and technologies because they have been perceived to deliver an emotionally fulfilling experience [2].

Therefore, by looking at the user responses from the perspective of emotion and the perceived value, we are better able to contextualise them. We observed some distinct patterns in the sentiment scores of the responses to the question. Formed as a result of direct experience with the app. The responses indicated the presence of four forms of user responses to our app

(further evaluation of the app should, we hope, provide further evidence to support these findings). The different forms of response describe the user experience expressed only in our evaluation results. This could be indicative of the participants' future intention to use such an app or the likelihood that they may at least download one like it. The results help us gain better insight about the features of the app people placed value on in our evaluation cohort of 30 people. For example, research has shown that people's attitudes are more likely to influence adoption and acceptance behaviour when they are formed as a result of direct experience, or/and where a positive experience indicates greater likelihood of adoption [8]. For our participants who had a strongly positive attitude towards the evaluation experience and described the experience from a personal perspective, we suggest that they might represent early adopters or even innovators of this type of cultural heritage app. In our experiments, *Enthusiastic* users had an open attitude towards the app despite it still being in beta development; their comments indicated that they found it easy to use and sensed it had personal value to them. In future, it would be useful to encourage these participants to become lead users of the app, benefiting in turn from the experience/value this app could bring to them. For the more *Sceptical* participants, i.e. those who felt frustrated because they perceived the app as not being mature enough yet in terms of development and design, it is likely that their mixed emotional response had the effect of *derailing behaviour intentions* [28]. Their frustrations associated with GPS error that lead to seams in the gameplay interrupted their play, leading to a breaking point in their user experience [11,53,65]. Whilst the literature refers to game seams and issues resulting from GPS uncertainty, there are still no hard and fast rules for its amelioration. So understanding the attitudes our experimenters had towards these issues, indicates what should be prioritised accordingly. Without addressing these issues, it is most probable that these participants would form the late majority of users who want the uncertainty of a technology to be resolved before they are open to using it. Therefore, to move such participants into the arena of early adopters, we should consider in future, an enhanced approach to handling game seams resulting from GPS limitations. Responses summarised as *Interested* sat between the enthusiastic and the more sceptical participants. Their positive but distant replies also focused on the functional aspects of the app where they recognised its usefulness and described it as fun, useful and user friendly. They did not describe it from the perspective of being a game or had a strong sense that is was playful. Their distant viewpoint and low-to-moderate sentiment score indicates that they did not have such a strongly positive emotional response to the evaluation experience, which would influence their intention to use such an app. Therefore, for this group there should be more effort made on the game design to encourage a greater sense of its playfulness and foster motivation.

It was helpful to understand the different forms of the initial user responses and the general sentiments that were expressed mid-way through the app's implementation. By doing so, we were better able to recognize the multi-faceted viewpoints of the experiment participants. The results offered a grounded understanding of the user experience, which serve to identify user requirements and their associated priorities. Furthermore, the results have helped the project team to bridge the gap between the social scientist and the computer scientist, as they offered detailed insights about the participants' responses, contributing to a richer team dialogue. We postulate that both evaluation of the perceptions of value and an understanding of the user through their forms of emotional response can be a useful part of the iterative development and user design toolkit for cultural heritage apps; this might help the niche apps reach a broader audience by supporting the crossing of the technology adoption chasm.

6 LIMITATIONS AND NEXT STEPS

The purpose of running these experiments midway through the project was to provide insights into user experience of the app and to provide us with an understanding of the types of responses to the experience that succinctly articulate the participants' viewpoints. It provided us with a gauge in which we could understand the app from the perspective of the player and not from the design, development and research team. The results of this user study have stimulated many ideas for future design development of the app, which we will take into consideration. We are currently working on improving the graphic design of the gaming elements that are part of the achievement system, to maximise the potential of the reward system by making it more playful and aesthetically pleasing. Interface designs that are fun, enjoyable and aesthetically pleasing increase user satisfaction with an experience more likely to elicit a positive emotional response [55]. Consequently, the badges used in the award system are being redesigned to incorporate more colour and to ensure visual impact [64]. Additionally, we are

integrating the concept of a character through the use of an avatar as they have been shown to foster intrinsic motivation by facilitating self-identification by building an emotional connection between player and the game [7,14]. As well as implementing a system to group stories into topics to enable users to filter POIs according to their topic preferences, enhancing the free-choice aspects of the app. To address the frustrations of the game seam that develops from the visualisation of the geofence on the map, we will l consider hiding it from the map display so that it is only active in the background..

This study is not without its limitations. The sample size of 30 participants is rather small and we are aware that there is a bias in our results which prevents us generalising at a population level or beyond to the general experience of location-based games for cultural heritage. Given that all our participants had higher education qualifications (> Bachelor), we cannot claim that our content is necessarily understandable by people that have lower educations qualifications. Future experiments will try and engage participants across a wider audience demographic spectrum and we will probe more deeply about their general behaviours towards technology adoption. We will also run more experiments to understand the viewpoints of the different user responses to enrich these preliminary findings, by extending our sample size of participants.

Reflecting on the sentiment analysis, we thought that it served a useful purpose to summarise the responses of the participants indicating favourable and less favourable impressions of the app. This perspective is an especially important in the exploration of future technology adoption as it provides an indication of the emotions and attitudes behind the words that the participants used to describe the app. We found this useful, even though the actual corpus of text extracted from the questionnaire responses used to develop these scores was rather small. There were no more than 1000 words in total across the 30 participants. This represents an average of 2 to 3 sentences per participant, which is more or less one sentence per question per responder.

For future evaluation studies using sentiment analysis, we would recommend including in the survey more open-ended questions or incorporating the use of sentence completion to probe about perceived value. This would help to develop a larger and more robust corpus for the sentiment analysis. The results from using this method in our study provide a useful starting point to indicate the potential value of the app but they are by no means conclusive. Such techniques are not yet reliable in detecting sarcasm or irony, which whilst not present in our current corpus, is something we should certainly be mindful of as a limitation. Furthermore, our findings only represent a snapshot of one point in time from one experience with the app when participants; mood of the day could have potential influence their emotional response. Finally, we found that sentiment analysis can be useful to counteract the tendency among a lot of researchers to impose a polarity on the analysis of the results (positive/negative), when in fact the scale of emotions expressed is more diversity as highlighted even by our small corpus (Fig.7). In order to to gather the required data for the study, we adapted standard user study questionnaires and then applied thematic and sentiment analysis to their open-ended items. These items proved valuable assets, offering multi-facetted perspectives and enabling us to delve into the participants' perceptions of the app. We found that the use of open-ended questions offered a rounded evaluation approach than that of analysing Likert scale questionnaire items as they provide more evidence about what people thought. We found that Likert-scale questions are a pragmatic solution when time and resources are tight as they require less effort to analyse but they do offer less depth and are prone to elicit superficial answers. In a forthcoming second evaluation at the end of the project, we will integrate an approach known as sentence completion into our post-test questionnaire to determine if such an approach can offer a parsimonious evaluation technique and inform us about the different aspects of the user experience and what people were thinking as they used the app.

Additionally, this evaluation analysed the interactions and whole experience of users focusing mainly on the perceived value and attitude of users. This approach provided many insights into the serendipitous discovery and location-awareness aspects of the app. However, the main goal of the app is to stimulate reflection and (re)interpretation on history, which is a very complex phenomenon to define and measure. For this reason, it will be tackled in a follow-up study, where we are developing a protocol to specifically investigate if the app succeeds in triggering reflection. To achieve this we will use two approaches. Firstly we experiment by adapting the Remind protocol, developed by Daniel Schmitt to understand the museum experience [62] and use of version of it to evaluate the traces of thoughts that are stimulated by the app experience during city-based exploration. We will also conduct experiments combing a think-aloud protocol with walking interviews followed by a short sentence completion questionnaire. This will enable us to compare the results with those acquired from the Remind

protocol and should offer evidence as to which one is more effective, given time and resources, at detecting traces of reflection in participants using location-based technology.

7 CONCLUSIONS

In this study, we combined iterative design with research field trials followed by controlled experiments, to carry out an in-depth, detailed analysis of a cultural heritage location-based mobile game app (Pilot 4) mid-way through its design and development cycle. **This app is one of the first to offer serendipitous urban discovery of cultural heritage content, and one of the first to create a blended reality historic environment in the city, where users not only interact with but also continuously shape and interpret the city and its history through their own reflections.** Our purpose in this analysis was to assess the potential use and value of the technology brought by this application as perceived by citizens and expressed through their sentiments. Our main finding was that there are four types of users in our study responses, the Enthusiast, the Interested, the Sceptic and the Cynic, who exhibit perceptions and likelihood adopting this cultural technology. A secondary purpose of our analysis was to reflect on our methods to determine if they are best suited for assessing the new technological affordances brought by the combination of mobile, location-aware and crowdsourcing technologies for cultural heritage applications.

We found that this form of evaluation was useful to undertake midway through the project. Indeed, all too often digital cultural heritage evaluations take place at the end of the development cycle where only a few project resources remain and there is little time is left to address any issues or to incorporate interesting ideas generated through co-design, which could help technology adoption. The use of midway evaluations such as the one adopted in this study, encourage the act of reflection by the researchers during the design and development phase of the project. This also provides a critical lens from the perspective of citizens with which to view the eventual cultural heritage product. The research field trials offered a test-bed for an earlier implementation of our co-designed ideas and app requirements. Conducting early evaluations in-the-wild as research trials attached to other events also enabled the core team to engage with external participants. From our experience, this helps to ensure a degree of distance between the experimenters and the participants, which is helpful in obtaining objective feedback. We were able to gather data (or testimonies) and observe objectively at an early phase of the project the breaking points in the user experience. In the end, our mid-way evaluation offered an improved understanding of how users perceive the potential value of a digital cultural heritage application. This is essential when designing apps that bring a novel technology such as a blended reality historic environment continuously shaped by the users. Such an evaluation creates a process of continuous improvement through reflection-driven understanding.

The thematic analysis of the questionnaire responses served to offer insights into the heterogeneity of the value that participants assigned to using the app and the strengths and weaknesses they reported from their experience, which are important characteristics of technology adoption. The values expressed by the user responses, in particular by the *Enthusiastic* and *Interested* players, point towards a number of design challenges and best practice considerations of which we should be mindful. These include: (1) the need to design mobile mapping interfaces in line with user expectations shaped according to existing experiences with mapping apps such as Google Maps, (2) the need to design for a social experience that fosters the creation of social bonds between players, (3) the need for designs to incorporate the desire of participants to play city-based games that offer a sense of accomplishment, (4) the importance of strengthening situated learning driven by serendipitous curiosity, and (5) the importance of maximising the interactions of players in and with the city. Our evaluation showed that consideration of these best practices should help progress the development of cultural heritage applications that incorporate elements of reflection and/or place-based exploration into their functionalities.

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