The development of a theoretical framework for designing smart and ubiquitous learning environments for outdoor cultural heritage

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Abstract

The work presented in this thesis focuses on exploring the potential of the use and development of mobile location-based services at outdoor cultural heritage sites. This PhD research investigated how people use mobile and wearable technologies for learning purposes with respect to cultural heritage sites. A user-centred design approach was adopted in this thesis using the socio-cognitive engineering methodology. Three empirical studies (field studies) were conducted with the aim of capturing users' requirements adopting mixed methods. The studies were conducted sequentially using focus group, questionnaire and interview techniques; the focus group and questionnaire were conducted with potential end-users (learners), and the interviews were conducted with officials of cultural heritage and potential end-users. The studies with end-users were carried out to investigate their habits, behaviours and attitudes when using mobile and wearable technologies at outdoors cultural heritage sites. The official staff were interviewed to extract their opinions regarding using such services at their sites as well as find out what technologies they actually used to present information to their visitors. The results of the field studies led to the development of a theoretical framework, FoSLE, supported by the learning theories. FoSLE is introduced for designing smart and ubiquitous learning environments based on mobile and wearable technologies for outdoor cultural heritage sites. The framework was further analysed to pull out general requirements (GRs) (high-level requirements – more abstract) to be adopted in developing new technology-supported artefacts. Four scenarios were developed based on the identified requirements to depict the context of use as well as to draw out a list of low-level requirements (LRs), i.e. detailed requirements. The LRs informed the design of a proof-of-concept, a smart and ubiquitous learning environment based on mobile and wearable technologies, SmartC. SmartC was evaluated in the field in two cycles using experts of human-computer interaction and potential end-users (learners). A combination of observation and interview techniques were used in the evaluation studies alongside the cognitive walkthrough method in the expert study and a usability questionnaire in the user study. The results of the evaluation studies revealed that SmartC is user-friendly and suitable for learning. The results of the evaluation studies contributed to the enhancement of the list of LRs, which consequently led to devise a list of design recommendations. The list of the design recommendations was designed to assist researchers and designers in designing and developing smart and ubiquitous learning environments based on mobile and wearable technologies. This PhD research introduces two main contributions to add to the academic knowledge, which are:

1. FoSLE: a theoretical framework for smart and ubiquitous learning environments utilising mobile location-based services and wearable computing.
2. A list of design recommendations for designing smart and ubiquitous learning environments utilising mobile location-based services and wearable computing.

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AR	Augmented reality
FoSLE	Framework for smart and ubiquitous learning environments
GPS	Global position system
GRs	General requirements
HCI	Human-computer interaction
LBS	location-based services
LRs	Low-level requirements
NFC	Near field communication
RFID	Radio-frequency identification
SCE	Socio-cognitive engineering
S-ULE	Smart and ubiquitous learning environment
TEL	technology enhanced learning
UCD	User-centred design
ULE	Ubiquitous learning environment
U-learning	Ubiquitous learning
VR	Virtual reality

Dedication

I dedicate this work to the memory of my beloved father, Sinan Abbas Al-Khafaji. Your love always lives in my heart.

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Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

Signature Alaa Alkhafaji

Date 6th June 2018

Chapter one

1. Introduction

The field of learning technologies has seen a rapid development in recent years with the emerging of mobile and wearable technologies. In recent years mobile technology has begun to feature profoundly in our everyday lives. The majority of people own a smartphone or tablet PC and use them for many different purposes (i.e. shopping, financial transaction, and learning) (Baloch, Abdulrhaman, & Ihad, 2012; Crabtree, Nathan, & Roberts, 2003; Traxler, 2010). Consequently has led to introduce ubiquitous computing, which is embedding computers invisibly into our daily life (Weiser, 1993). Ubiquitous computing offers technology that interweaves into our lives and the surrounded environment in an unobtrusive way (Dourish, 2004), which could be an excellent solution for enhancing learning experiences. Thus, learning has become ubiquitous with harnessing mobile and wearable technologies (Hwang, 2008; 2011), which support learning in both formal and informal contexts (Pachler, Bachmair, Cook, & Kress, 2010; Rau, Gao, & Wu, 2008).

Ubiquitous learning (u-learning) promises to free people from the boundaries of time and place, providing opportunities for people to learn regardless of where they physically are using mobile and wearable technologies (Sharples, 2000). Continuously, researchers and educational practitioners are seeking ways to make the learning process smart (Hwang, 2014). U-learning offers the foundation for the concept of "smart learning environment" as it gives people the opportunity to learn within different contexts, which enables them to learn while they are doing their daily activities (Brown et al., 2010; Kukulska-Hulme & Traxler, 2005; Scott & Benlamri, 2010).

The smart learning environment concept refers to the acquisition of information about the learners and their surroundings/environment intelligently to enhance people' experience (Chianese, Piccialli, & Valente, 2015). Hwang (2014, p. 2) points out that "a smart learning system can be perceived as a technology-enhanced learning system that is capable of advising learners to learn in the real-world with access to the digital world resources". Consequently, that would enhance the learning experience as learning takes place through experiencing life

in the real-world while carrying out the daily routines (Cohen, 1993), which could be considered as part of the informal learning process (Eraut, 2004; Marsick & Watkins, 2001). Informal learning is a type of learning where learners are in charge of their learning instead of being content consumers (Skule, 2004). Informal learning is defined as "[t]his type of learning is never organised. Rather than being guided by rigid curriculum, it is often thought of as experiential and spontaneous" (Ainsworth & Eaton, 2010, p. 14).

Informal learning occurs in every field, including cultural heritage. Cultural heritage refers to the inheritance of cultural traditions from one generation to another (Nuryanti, 1996; Timothy & Boyd, 2003), which is categorised as tangible and intangible. Intangible refers to traditions of verbal expressions, dance, music and habits, while tangible refers to physical artefacts produced, maintained and transmitted intergenerationally such as: cities, remains, buildings, landscape, rivers, and monuments in a society[1]. Tangible cultural heritage is considered in this thesis, which aims in particular to explore the potential of mobile location-based services with respect to cultural heritage contexts. It is important to clarify, wherever the term "cultural heritage" appears in this thesis it refers to tangible cultural heritage.

This PhD research explored the potential of applying smart learning into an informal learning context with respect to cultural heritage. So as to support people learn about the surrounding cultural heritage based on location and while doing their daily activities without the intervention of users – intelligently, which refers to learning on-the-move.

The rest of this chapter is organised as follows: Section 1.1 discusses the motivation, section 1.2 discusses the significance of this research. Section 1.3 discusses the aim, objectives and research questions. Section 1.4 gives a brief overview regarding the research methodology adopted in this research. Section 1.5 highlights the contribution of this research and Section 1.6 outlines the structure of this thesis.

1.1. Motivation – Interpretation of outdoors cultural heritage sites

Outdoors settings of cultural heritage sites form a significant part of towns and cities' culture and landmarks; if people would listen to them, they could tell great stories about the cities they are located in.

[1] http://resources.riches-project.eu/glossary/tangible-and-intangible-cultural-heritage/

A city like Portsmouth with a great history, which is a naval base city and also the home town of some famous writers in English history, has many cultural heritage sites around the city. Many outdoors memorial monuments, historical buildings and statues are distributed all over the city. Some statues of famous people who contributed to the English history over time such as Queen Victoria and Charles Dickens are located in the main square in the city, where people pass through when moving around doing their daily routines. Additionally, there are several monuments along the beach that serve as a commemorative for events that have happened back in time and/or for people who participated in those events. The commemoratives, from our point of view, are not very well interpreted and visitors might not have a chance to know more about events that happened there. Monuments have labels attached with a brief description, and at some places there is only a board with some photos and a brief description to explain the history of the seafront that witnessed events back in time (see Figure 1.1).

Figure 1.1: outdoors memorials monuments along the seafront in Portsmouth

Visitors need to get very close to attractions in order to read information that is rather brief and does not provide an adequate level of information to help them envisage what has happened back in time. Additionally, visitors often come to the seafront to have a nice walk with a group of friends or family, and they might not be able to leave the group and stop for a few minutes to read the attached labels. Moreover, there are no audio descriptions, which cause people with

sight problems to have no access to the stories behind these attractions at the time of a visit. In order to give visitors and locals of this great city an opportunity to learn its history in an interesting and engaging way, every effort should be employed to promote its history and culture to residents and tourists to make them realise the importance of their beloved city, especially the young generations. The present quiet and lovely city was a place of wars for over many decades[2]; the peaceful and green Southsea common was a place where a huge army was waiting for battle one day back in time, while at the present is a place for leisure where people come to relax after a busy week.

The seafront is not the only outdoor setting that has memorial monuments; another such place is Victoria Park. Victoria Park is a place where families come to enjoy the nature as well as bring their kids to a playground in the park. The park also contains a few commemorative attractions that hide historical stories behind them, which need to be told. It would be really helpful for families to receive historical information related to these attractions while supervising their kids. People in such cities need to know how they ended up having what they have, which would promote the sense of pride and belonging.

Portsmouth is just an example, other cities in the UK and many others around the world have witnessed great history over decades, which needs to be interpreted properly to make their citizens proud of their culture and help them realise the values their culture holds as well as encourage more visitors to visit. With the rapid pace of life there is a lack of time for people to learn about history themselves. Given how important their history is, technology could play a significant role and facilitate receiving information in a smart way that helps people to gain knowledge while moving around even when they are doing leisure activities. The next section gives an overview of how significant this research is.

1.2. Significance of this research

Learning interweaves with people's daily routines and cannot be distinguished separately as it occurs while experiencing life (Kolb, 1981; Schunk, 1996). People get motivated to learn in different contexts and spaces while they are moving, either through work or leisure activities. Mobile learning has emerged to support learning throughout a lifetime in both forms, formal and informal (Pachler et al., 2010). Informal learning is a type of learning where learners are

[2] http://www.localhistories.org/portsmouth.html

in charge of their own learning instead of being content consumers. Informal learning is defined by Livingstone as "any activity involving the pursuit of understanding, knowledge or skill which occurs without the presence of externally imposed curricular criteria" (Livingstone, 2001, p. 4). As informal learning occurs in different places and contexts, and at different times while people are doing their daily routines, thus, employing mobile technologies may help people learn informally regardless of time and place (Sharples, 2000).

Experiencing and engaging in aspects of cultural heritage may form a significant facet of the informal learning process. Since cultural heritage reflects the identity of societies (González, 2008), it could be important for people to know more about their history and learn how historical stories relates to heritage sites. This may help people to appreciate their history, which could further promote the sense of loyalty and engagement (UNESCO, 2013). Additionally, visiting historical sites reinforces the revival of the glorious past that the communities have had during a particular age, which helps people to derive a power from that history and to be proud of belonging to their community (Caton & Santos, 2007). Learning about historical stories and events that have taken place in a certain space not only attaches people to their roots (Poria, Reichel, & Biran, 2006), but also evokes their emotion and identity towards societies that they belong to (Poria, Butler, & Airey, 2004). Consequently, that may inspire them to give more to serve their communities and, contribute to community advancement. Visiting cultural heritage sites that have witnessed significant historical events in a particular time in the past would reinforce maintaining a link between the present and the past which would help stimulate the perpetuation of culture (Du Cros, 2001). Additionally, it would help visitors grasp the significance of these sites:

> "*In social studies courses, teachers may arrange students to visit ancient assets or temples surrounding their schools to help them realize the value of their local culture*" (Hwang & Chang, 2016, p. 1217) .

> "*In the process of the learning, the students had a chance to gain in-depth understandings of the learning content since they could physically observe the objects mentioned by the teacher in class, and the experience strengthened their impressions of and feelings about the local culture*" (Shih, Chuang, & Hwang, 2010, p. 58).

Thus, it is significant to introduce a new learning technology that supports people to learn from cultural heritage sites in real-time while they are on-the-move. Consequently this may have a

significant impact on society, giving learners the opportunity to learn about events that have taken place in the past using modern technology, such as mobile location-based services. Mobile location-based services (LBS) could be a helpful instrument to be used at cultural heritage sites for learning purposes. That could support people learn on-the-move while wondering around at sites, which would save their time and effort looking for information. The outcome would be a greater understanding and appreciation of the history which may contribute to the sites' conservation, consequently, would contributes to the country's income.

According to the review conducted as part of this PhD research (details in the next Chapter), there is a lack of services that meet the needs that outdoors cultural heritage requires in order to offer a pleasurable, informative and effective experience for visitors. Some aspects that could be essential for making the experience informative, pleasurable and effective, are: a) supporting informal learning at outdoors cultural heritage sites; b) supporting visitors/learners to learn on-the-move; c) considering visitors' requirements. These aspects would increase visitors' engagement, which is an essential element in such a context, as visitors perceive visiting sites as a form of entertainment. That in turn would enhance the experience and consequently learning from sites. Given that, this research introduces a theoretical framework for designing smart and ubiquitous learning environments for outdoors cultural heritage sites utilising mobile and wearable technologies. The framework was formulated based on users' requirements that were gathered throughout this PhD research. The framework considers using LBS to provide a smart and ubiquitous learning tool that supports informal learning on-the-move at outdoor cultural heritage sites that meets visitors/learners requirements.

1.3. Aim, objectives and research questions

This PhD aims to contribute to knowledge by exploring and developing the potential of mobile location-based learning services for cultural heritage. This research has investigated how people may use mobile technology for learning purposes, and also how ubiquitous learning environments could be developed based on mobile and wearable technologies to support informal learning in cultural heritage contexts. The starting point of this research is triggered by several questions, which led to achieve a number of contributions; the objectives and questions are given below.

Objectives of this research

This research aims to achieve a number of objectives, which include:

1) To develop a task model in the form of a theoretical framework for smart and ubiquitous learning environments utilising mobile location-based services to be used at outdoor cultural heritage sites (See Section 1.4 for more details about the task model).
2) To develop a smart and ubiquitous learning environment utilising mobile and wearable technologies as a proof of concept based on the task model.
3) To develop a list of design recommendations for designers who are designing smart and ubiquitous learning environments in the cultural heritage domain.

Research questions

Several research questions were answered throughout the process of this research, which include:

1) How do people use mobile and wearable technologies for learning in the cultural heritage context?
2) What are the essential elements for developing a smart and ubiquitous learning environment utilising mobile location-based learning services for cultural heritage sites that meet the user's needs?
3) What are the requirements for developing smart and ubiquitous learning environments to support people to learn from cultural heritage sites?
4) How can the requirements be used to guide the development of a learning environment for outdoors cultural heritage settings?
5) What are the recommendations that could be inferred from this research for researchers and designers who are interested in the design of ubiquitous learning environments based on mobile and wearable technologies in the cultural heritage domain?

1.4. Research methodology outline

This research adopted the socio-cognitive engineering (SCE) methodology to help address the research questions, which consequently led to several contributions this research added to the academic knowledge. SCE stresses a two-stage process: (1) the analysis stage which involves field studies and investigating learning theories; (2) the design stage involves conceptualisation of the design concept through scenario-based design and implementation. The first stage involves formulating a theoretical framework (task model) based on the findings of the field studies and the investigation of learning theories that acted as strength evidence. The second stage involves building a mobile application prototype based on the framework resulted from

the first stage. This methodology and how it was used in this research are described in detail in Chapter 3.

A sequential mixed methods approach was adopted to carry out the field studies. Three field studies were conducted separately with the aim of gathering user requirements for developing ubiquitous learning environments utilising mobile location-based services and wearable computing. Focus group, survey and interview techniques were used in the field studies. This research employed statistical and thematic analysis (Braun & Clarke 2006) methods to analyse the quantitative and qualitative data, respectively. The findings of the field studies helped in shaping a theoretical framework for designing such services. More details about the methodology are given in Chapter 3. This methodology helped to achieve a number of contributions to knowledge, which are given below.

1.5. Contribution to knowledge

Since learning is one of the main elements that supports society's advancement, it is important to provide an effective tool to help people in carrying out new learning experiences while they are doing daily activities. Ubiquitous learning utilising mobile location-based services and wearable technologies provides a good foundation for offering a smart learning environment. This technology could support people learn whenever and wherever they need regardless of time and place in a smart way while they are on-the-move – learning on-the-move. Learning on-the move refers to acquiring information through ubiquitous devices while people are moving, automatically and intelligently without any intervention of users based on the context. The value of learning on-the-move is to support people receive information they are interested in on-the-move, which helps in saving their time and efforts searching for information, which in this PhD research the information was historical stories behind cultural heritage sites.

Given the importance of learning on-the-move, introducing a framework and a set of design recommendations for developing smart and ubiquitous learning environments in general, and with respect to cultural heritage sites in particular, would assist designers in designing such services. That, in turn, would have a significant impact on societies as providing new modern technologies would encourage people to visit heritage sites and learn about their history. For example, technologies could enhance people participations and attendances that may contributes to better economy. In addition, it would raise the awareness of cultural heritage places, and consequently, would encourage authorities to preserve sites to help maintain this

channel of income as well as sustain the culture. Additionally, learning about history may promote the sense of responsibility towards the society, and engender contribution to its progression. This PhD research adds contribution to knowledge in this respect, which is discussed below.

There are several important areas where this research makes a unique and original contribution to academic knowledge. A major contribution of this research is the development of a task model (framework) for developing smart and ubiquitous learning environments based on mobile and wearable technologies. The task model – framework – is for designing informal learning environments to be used in the cultural heritage context. The "task model" concept has been introduced by Sharples in his methodology "Socio-Cognitive Engineering methodology" (Sharples et al., 2002) which was adopted in this research (more details in Chapter 3). Empirical studies were conducted in the field to capture user requirements to inform the design of the task model.

The task model was further analysed to devise a list of general requirements to inform the design of a new technology-supported artefact. Furthermore, a list of design recommendations was set out for researchers and designers who are designing and developing ubiquitous learning environments to support informal learning in the cultural heritage domain.

Figure 1.2 illustrates the major contribution of this research, which include:

- The collection of empirical data in the form of user requirements through three field studies
- A task model for developing ubiquitous learning environments utilising mobile location-based services and wearable computing for outdoor cultural heritage contexts.
- A set of general requirements to be adopted for developing technology-supported artefacts for such environments.
- A proof-of-concept in the form of a native android mobile application.
- A list of design recommendations for researchers and designers who are interested in designing smart and ubiquitous learning environment based on mobile and wearable technologies with respect to cultural heritage contexts

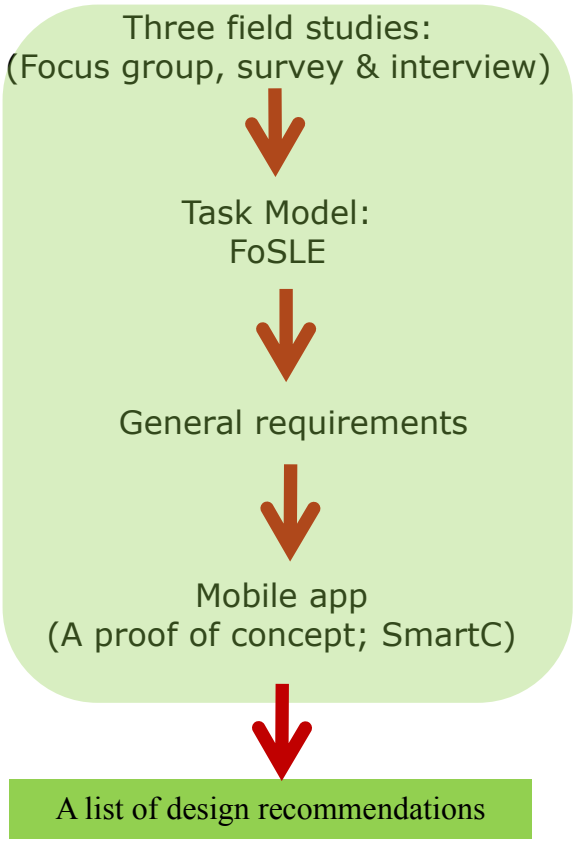


Figure 1.2: illustration of the steps of the major contributions

1.6. Structure of the thesis

This PhD thesis is organised as follows:

Chapter 2: discusses the learning theories and the existing models, frameworks, guidelines and technologies that support informal learning with respect to cultural heritage context.

Chapter 3: outlines the research methodology used in this research with the adopted methods and techniques.

Chapter 4: presents the focus group study that was carried out as a first step to gather preliminary data within the series of field studies to gather user requirements (Alkhafaji, Fallahkhair, & Cocea, 2015)

Chapter 5: presents the questionnaire survey study that was carried out a second step to gather user requirements incorporating quantitative method (Alkhafaji, Fallahkhair, Cocea, & Crellin, 2016).

Chapter 6: presents the interview study that was carried out to gather in-depth user requirements incorporating qualitative method.

Chapter 7: discusses the results of the three field studies presented in chapters 4, 5 & 6, and pulls them together to shape a theoretical framework.

Chapter 8: presents a theoretical framework for developing ubiquitous learning environments, FoSLE, which was developed based on the findings of the field studies (Chapters 4, 5 and 6) and supported by the learning theories presented in Chapter 2 (Alkhafaji, Fallahkhair, Cocea, & Crellin, 2017).

Chapter 9: reports a set of general requirements to guide the design of new technology-supported artefacts, which was pulled out from the framework identified in Chapter 8.

Chapter 10: presents the SmartC prototype, which was developed as a proof-of-concept based on the general requirements identified in Chapter 9.

Chapter 11: presents evaluation studies that were carried out to assess the SmartC app in terms of usability, usefulness and acceptance (Alkhafaji, Cocea, Crellin, & Fallahkhair, 2017).

Chapter 12: presents a list of design recommendations for developing smart and ubiquitous learning environments developed based on the requirements from Chapter 9 and the findings of the evaluation studies presented in Chapter 11.

Chapter 13: concludes this thesis with a summary of how the research questions were answered and summarises the findings, outlines the contribution and sets out directions for further research.

Chapter two

2. Informal learning, cultural heritage, and the applied services and technologies

Chapter 1 set up the research scope, questions and objectives of this research. The present chapter discusses previous research related to the topic of this thesis, which can be grouped under three main topics: learning, cultural heritage, and technologies that support learning from cultural heritage.

This chapter is structured as follows: Section 2.1 discusses the perception of learning; section 2.2 gives an overview of informal learning and the related learning theories; Section 2.3 discusses the previous models, frameworks and guidelines; Section 2.4 gives an overview of pervasive, ubiquitous and ambient intelligence computing – models and frameworks; Section 2.5 discusses technologies applied to cultural heritage; Section 2.6 discusses the previous ubiquitous learning services that act as guides for visitors; Section 2.7 presents examples of technologies that are currently applied at the cultural heritage sites (on-site technologies) and highlights their limitations; Section 2.8 concludes the chapter.

2.1. Perception of learning

Learning is defined by (Schunk) as " … an enduring change in [behaviour], or in the capacity to behave in a given fashion, which results from practice or other forms of experience" (Schunk, 1996, p. 3). People differ in how they are perceiving learning; Saljo (1979) has conducted an empirical study in the form of interview to understand how people perceive learning. The author categorised learning into different categories based on the results: (1) a quantitative increase in knowledge; (2) memorising; (3) the acquisition of facts, methods, and the like, which can be retained and used when necessary; (4) the abstraction of meaning; (5) an interpretative process aimed at understanding reality (Richardson & Wolfe, 2001; Schmeck, 1988). On this basis, it could be inferred that learning occurs while people are experiencing their life and practicing different types of activities.

Tough (1979) reports that some individuals undertake one or two major learning efforts a year, while others undertake 15 to 20. The author points out that people mainly undertake a learning project to gain new knowledge and skills that could improve people's life, such as change one's habits or completing tasks related to one's job, home, or family. Furthermore, the author stresses that adults get motivated to learn by curiosity, interest and enjoyment. The author use the term "self-planned learning" which means self-directed learning in his book "The adult's learning projects". He conducted a series of empirical studies in the form of interviews to understand how people learn. He stated some points regarding why self-planned learning is so popular:

1) The learner may believe that he would actually lose time in the long run by turning to someone else.

2) He may be confident that planning the learning episodes for the particular knowledge and skill he desires will be easy, and that the content will be readily available.

3) The learner may not be able to see past the next two or three learning episodes. He may not be sure how much longer he will continue the learning project; and may think that the direction or subject will change soon. Consequently, he does not want to commit himself for a long period of time to a particular object, person, or group. He does not want to give up the possibility of shifting the subject matter significantly or frequently.

4) Using oneself as a planner avoids any difficulty in locating, selecting, and using the planner.

5) The learner may be reluctant to let others direct its learning project in case their procedure produce in him some inappropriate beliefs, attitude, habits, or techniques.

6) The learner may be highly skilled at locating printed materials, and quickly selecting and grasping their relevant ideas.

7) The learner often has greater insight than anyone else into his own capacities, preferred methods, goals, needs, pace, and emotional block to learning.

8) The learner may expect to discover, invent, or synthesise the knowledge and skill because no one else has done so. The desired knowledge and skill may be unique: no one else is trying to obtain it.

9) In order to deal with a certain problem, the learner may want to gather a variety of possible solutions from several sources before selecting the best solution.

10) The learner may be especially likely to choose self-planning if he is self-reliant, independent, and autonomous.

He may expect to feel especially proud or pleased if he successfully plans his own learning, or may hope to impress others (Tough, 1979, p. 93).

2.2. Informal learning and learning theories

The literature related to informal, non-formal and incidental learning has been reviewed by some researchers to unravel the dependencies of theories to the practice of learning (Fallahkhair, 2009; Vavoula, 2003). This section aims to review the theories more specifically to understand situated and contextual aspects of learning.

The "informal learning" concept has been increasingly used in adult education (Eraut, 2004). It is a concept that refers to learning when it occurs out of the formal education context in which learners take the active role and are being in-charge of their learning. It could be considered the complimentary partner to experiential learning (Eraut, 2004). Kolb defines learning as " …the process whereby knowledge is created through the transformation of experience" (Kolb, 1984, p. 38). Individuals learn when experiencing life and through a trial and error process, which often happens incidentally and spontaneously (Dewey, 1938).

The learning from experience notion was originally developed by the theorist John Dewey in his book *Experience and Education* (Dewey, 1938). Dewey's theory has served as a foundation stone for informal learning that was developed by Malcolm Knowles in 1950, in his publication *Informal Adult Education* (Smith, 2002). Learning could be an outcome not only a process, as we might see a changing in an individual's behaviour as a result of what he/she has learnt (Richardson & Wolfe, 2001). Learning also happens during social life, when individuals are interacting with the community, as social learning involves supporting learning via observing others' behaviours, attitudes and cognitive processes (Bandura, 1977; Vygotsky, 1978). In other words, learning occurs by engaging with the community while doing formal or informal activities. In the same vein, collaborative learning is an approach of learning that involves learning by sharing experiences between learners, which also could be considered as social

learning (Bruffee, 1984). Learning occurs at any time and place, as there is no restriction for acquiring information and enhancing knowledge, which supports situated learning.

Lave and Wenger (1991) argue that situated learning is the acquisition of knowledge through a community of practice where social interaction in context is the main component of the learning process. Conversation tends to enhance memory and consequently enhance learning as the discussed information is meant to stay longer in an individual's memory (Sharples, 2005a). Pask (1976) defines conversational learning as "conversational systems which allow mental activities to be described in terms of dialogue and behaviour" (Pask, 1976, p. 128). Conversation helps construct knowledge between learners, which in turn enhances their knowledge (Pask, 1975). Thus, interacting and socialising with the community would enhance informal learning as people could reinforce their knowledge by sharing their experience with each other's (Vygotsky, 1978).

Marsick and Watkins (2001) differentiate informal learning by contrasting it with the formal learning process, which is a highly-structured system and always takes place inside a classroom, whereas informal learning can occur outside the classroom and does not need a well-structured process. Informal learning is defined as "[t]his type of learning is never organised. Rather than being guided by rigid curriculum, it is often thought of as experiential and spontaneous" (Ainsworth & Eaton, 2010, p. 14). Another definition by Livingstone is "any activity involving the pursuit of understanding, knowledge or skill which occurs without the presence of externally imposed curricular criteria" (Livingstone, 2001, p. 4). Informal learning would support people to be self-directed and make the learning process learner-centred rather than instructor-centred or content-centred (Caffarella, 1993; Schugurensky, 2000).

Researchers classify informal learning differently; Mocker and Spear (1982) identified four situations of learning, which are: formal, non-formal, informal and self-directed learning. They distinguished between self-directed learning and informal learning. According to them, in formal learning learners have little control over the objectives or means of learning; in non-formal learning learners control the objectives but not the means of learning; in informal learning learners control the means, but not the objectives of learning; and in self-directed learning learners control both the objectives and means of learning.

Schugurensky (2000) argues that informal learning involves three forms: self-directed, incidental and socialisation. Self-directed learning happens intentionally when the learner

intends to learn a specific skill without attending an organised course for instance, such as learning a second language and learning how to cook. In this type of learning the learner sets his goal and chooses the means to achieve the goal without being fully organised. Incidental learning occurs when the learner does something incidentally then realises afterwards he/she has learnt something new, for instance when someone gets lost, and after finding their way, he/she has learnt how to get to that particular place. Social learning occurs spontaneously without any awareness of conscious learning, for instance when a group of friends play a sport regularly and after a period of time they get the skills of playing this sport without realising.

Ainsworth and Eaton (2010) classify learning as formal, non-formal and informal learning without mentioning what forms could be included in informal learning. The authors define informal learning as never pre-organised and spontaneous, which might include self-directed learning. In contrast, the authors do not consider taking a training course out of formal education system as informal learning but they consider it as non-formal learning, which is a type of learning that could occur outside the classroom but still be organised in some way. Similarly, Eraut (2004) does not consider training as informal learning, he points out that informal learning happens incidentally and spontaneously. On the other hand, he claims that mentoring comes in the middle between informal and formal, which could be considered as a type of informal learning, while coaching could be a type of formal learning.

Conversely, Marsick and Watkins (2001) argue that informal learning involves mentoring, coaching and networking, which might mean that the authors consider taking a training course, such as learning a sport, as a type of informal learning (Conlon, 2004; Marsick & Watkins, 1990, 2001). Livingstone (2001) discusses forms of learning in terms of who has more control of the learning process, which ranges from dominant teacher control, through other forms that involve teachers/trainers/mentors, to dominant learner control. He points out that education involves four types of learning based on the presence/absence of an instructor: formal education, non-formal education/ further education, informal education/ informal training and self-directed/ collective informal learning. The author characterised all other forms of learning that do not rely directly on instructors as self-directed or collective informal learning. It could be assumed that the author then included informal education/ informal training, and self-directed and collective informal learning under the category of "informal learning". Thus, it could be concluded that he considers training courses as informal learning.

This research tends to agree with Marsick and Watkins, and Livingstone in considering training courses as a type of informal learning – informal training courses. In addition, this research agrees with Schugurensky in classifying informal learning as self-directed, incidental and socialisation. On this basis self-directed learning could be classified into two forms: 1) with the absence of an instructor (fully-self-directed); 2) with the presence of an instructor but the process is learner-centred and not instructor-centred (e.g. learning to drive, learning a sport). Accordingly, informal learning could be partly organised with or without an instructor. in which the learners are being in charge of their learning rather than being content consumers, whilst non-formal learning refers to learning courses that are more organised, but outside the formal education system, where adults voluntary attend institutional and organised courses or workshops, which most of times lead to a certificate (Schugurensky, 2000). It could be also referred to activities that are related to the educational system but outside the classrooms such as field trips.

2.3. Previous learning models and frameworks, and design guidelines

This section presents an overview of the existing models and frameworks that support learning, and also guidelines for designing apps that support learning at cultural heritage sites. Finally, a summary is given to outline the main limitations of previous studies, which provide a rationale for conducting this research.

2.3.1. Models and frameworks that support learning

Learning is always inspiring researchers to explore it further and introduce models and frameworks to assist practitioners and other researchers in the field of learning. A number of models and frameworks have been introduced to support learning in the aforementioned forms: formal, non-formal and informal in different contexts. Table 2.1 illustrates the models and frameworks that were introduced for informal learning accompanied by the field they were proposed for, the applied theories or methods, if they are proposed for developing new technologies and if the studies considered user requirements (user-centred design). It is important to note that the term "technology" refers to "The application of scientific knowledge for practical purposes" as defined by Oxford Dictionaries. The following abbreviations were used.

For new technology	NT
Model/framework	M/F
Field/Context	F/C
Theories/methods applied	T/M
User-centred design	UCD
X	Indicates the study supports what is being said in the title of the column

Table 2.1: illustrating models/framework that support informal learning

Author(s)	NT	M/F	F/C	T/M	UCD
Marsick and Watkins (2001)		Informal and incidental learning model	Informal learning in workplace	Dewey's work/ a previous study	
Lytras, Pouloudi, and Poulymenakou (2002)	X	A Framework for Technology Convergence in Learning and Working	Learning in business context	Evaluation of existing projects	
Vavoula (2003)	X	FoLL: a framework of lifelong learning	Lifelong learning	Diary and interviews	X
Bagnasco, Chirico, Parodi, and Scapolla (2003)	X	A virtual learning community / Online classroom	e-training environment in workplace/ just-in-time	Does not mention, seems to be based on previous studies	
Koper et al. (2005)		A design model for lifelong learning Networks	Informal learning	Theory-based	
Li, Zheng, Ogata, and Yano (2005)	X	A conceptual framework of computer-supported Ubiquitous learning environment (ULE)	ULE is for integrating schools, communities, and families.	Theory-based	
Zhang, Jin, and Lin (2005)	X	A Framework of Social Interaction Support for Ubiquitous Learning	A social interaction community	Theory-based	
Taylor, Sharples, O'Malley, Vavoula, and Waycott (2006)	X	Task Model for Mobile Learning	Mobile learning	Two field studies	X
Nino et al. (2007)	X	Context-Aware Model for Ubiquitous Learning Environment	Ubiquitous Learning	Previous studies	
Paganelli, Bianchi, and Giuli (2007)	X	A context distribution and reasoning model	Tourism	object-oriented and ontology-based modelling	

Gan and Zhu (2007)		A Framework for Knowledge Building and Collective Wisdom	Virtual learning communities	Theory-based	
De Jong, Specht, and Koper (2008)		Reference model (content, context, purpose, information flow and pedagogical model)	Learning, mobile social software	Previous studies	
Savio and Braiterman (2007)	X	A context model for designing mobile application	Mobile interaction design	Theory-based	
Saccol et al. (2009)	X	A framework for the design of ubiquitous learning applications	Ubiquitous learning/ learning in general	Literature/ previous studies	
Fallahkhair (2009)	X	A pedagogical framework for informal language learning services via interactive television	Informal language learning	Based on the review of previous models and focus group studies	X
Chatti, Jarke, and Specht (2010)	X	3P learning model for TEL	Informal, lifelong learning	Does not mention, seems to be based on literature	
Barbosa, Hahn, Barbosa, and Saccol (2011)	X	A ubiquitous learning model focused on learner interaction (LOCAL)	Ubiquitous learning	A previous study (Saccol et al., 2009)	
FitzGerald (2012)		Creating user-generated content for location based learning: an authoring framework	Informal learning Outdoors settings	Literature-based	
Park, Yoon, and Kwon (2012)		Task Model and Task Ontology for Intelligent Tourist Information Service	Tourism	Case study	X
Candello (2012)	X	Framework for content presentation in outdoor settings	Tourism/Informal learning Outdoor cultural heritage	Observations, interviews and questionnaire	X
Sha, Looi, Chen, and Zhang (2012)		A conceptual framework for understanding the nature of mobile learning	Mobile learning/ self-regulated	Literature-based	
Yin, Song, Tabata, Ogata, and Hwang (2013)		Conceptual framework	Scaffolding participatory simulation for mobile learning	Theory-based	
Saeed, Saher, Shahzad, and Ammer (2014)		Framework for interactive mobile application (usability framework)	Mobile application in general, smartphone	Observations and interviews Evaluation/ usability test	X

Hwang (2014)	X	Framework for smart learning environments	Real-world and online contexts (non-formal)	Literature-based	
Koren and Klamma (2015)		A framework for dealing with physical artefacts using wearable computing	Informal learning	Previous projects	

Table 2.1 outlined previous studies that support informal learning; some of them were closer to the field of cultural heritage such as tourism (Paganelli et al., 2007; Park et al., 2012), however they are not for designing new technologies. One study only was particularly for outdoors cultural heritage (Candello, 2009), and it is focused on content presentation at cultural heritage sites. Candello (2009) considered user requirements in designing the framework, but she did not consider learning on-the-move aspect at sites, nor utilising wearable computing, which could be helpful for learning from sites while walking from an attraction to another at outdoors sites. Some of the presented models were introduced to support designing new technologies (Barbosa et al., 2011; Fallahkhair, 2009; Hwang, 2014; Nino et al., 2007; Saccol et al., 2009; Taylor et al., 2006; Vavoula, 2003; Zhang et al., 2005), however, only three of them, FoLL, Taylor et al. and Fallahkhair's models have considered user requirements in designing the model, which would be an essential element in enhancing learners' engagement by providing an adaptive learning environment based on learners' preferences, that consequently would enhance the learning experience.

FoLL is introduced to support learners organise their learning over a long period of time, which is not particularly to support learners in taking new learning experiences; moreover, it does not support a context-aware feature, which would be an important feature for supporting people learn on-the-move. Taylor et al. (2006) have developed a task model for designing a mobile learning environment, however, they did not consider cultural heritage contexts.

Studies such as in (Barbosa et al., 2011; Saccol et al., 2009; Zhang et al., 2005) have proposed models and frameworks for ubiquitous learning to support interaction between learners. Supporting learners to interact with each other is an important element within the learning process, as it helps them learn collaboratively, but it is not the only element involved in designing new learning services. The services might consider other aspects such as: (a) various learning types, e.g. individual learning, as not always learners like to learn collaboratively, there are some times when learners need to concentrate on learning on their own (Cohen, 1991); (b) designing the content that learners consume to learn; and (c) designing the interfaces that

the learners deal with to access content and services. Some other models considered the contents (FitzGerald, 2012; Park et al., 2012), and others considered the interaction design (Saeed et al., 2014; Savio & Braiterman, 2007). That means each individual model is not sufficient to introduce relatively adequate services without being integrated with the others. The framework developed as the result of the PhD research in this thesis, i.e. FoSLE, aims to integrate all the aforementioned aspects to pull out a framework that could be sufficient for designing new learning environments for outdoors cultural heritage that are smart and ubiquitous.

Li et al. (2005) have developed a conceptual model for ubiquitous learning environments (ULE) to offer a space for schools, families and communities to integrate and collaborate with each other for a better educational quality. This model is particularly for supporting formal learning where schools, communities and homes integrate to support the educational process. Additionally, it supports all the integrated dimensions (schools, families and communities) to smoothly use and share spaces and resources whenever and wherever they need.

Nino et al. (2007) have proposed a context-aware model in a ubiquitous learning environment based on a project called GlobalEdu as cited in (Barbosa, Geyer, & Barbosa, 2005). This model supports adapting content based on learners' current location, but it does not support learning on-the-move where learners receive instant information intelligently regarding the surroundings while moving, whereas FoSLE aims to support learning on-the-move to help learners learn while doing their daily routines.

Hwang (2014) presented a framework to address the design and development considerations of smart learning environments to support both online and real-world learning activities. This framework is for designing learning environments that helps students learn in different contexts, including leisure activities context. It aims to provide a learning environment that helps students to gain knowledge at the right time and place taking into account students' preferences. It acts as a friend who advices students to do the right thing at the right time. This framework is alike FoSLE in terms of providing the right information at the right time, but it is for different contexts, as FoSLE is for outdoors cultural heritage sites, which has different requirements for a learning environment, as outlined below.

An important aspect about the cultural heritage context is the necessity of enhancing visitors' engagement to take this experience, as well as enhance the interpretation of sites. Interpretation

is not only about presenting factual information, but more importantly about evoking the emotional and intellectual connection between visitors and attractions (Casella & Coelho, 2013). That in turn, would promote the sense of loyalty and belonging to the community, as well as increase awareness of cultural heritage places, which consequently would encourage the conservation of sites. In addition, due to the fact that visitors need to go back home or return to other activities after the visit, investing the time smartly during the visits is crucial. Given that, technologies for cultural heritage contexts need some other aspects to be considered, which were not considered in the mentioned models, such as: (a) the content that learners consume to perceive history; and (b) interaction with the contexts, which could involve some important aspects, such as: activities that learners perform to take learning opportunity, resources and tools that mediated the performance, information format, and, the interface design that learners use to access services and activities. More importantly, visiting outdoors cultural heritage sites involves a lot of movements between artefacts and attractions in order to acquire information, which could be supported by including learning on-the-move aspects with such learning services.

Besides the aforementioned models and frameworks that were introduced for informal/non-formal learning, some others were introduced for formal learning such as : (Chung & Paredes, 2015; Peng, Su, Chou, & Tsai, 2009; Rau, 2017; Scanlon, Anastopoulou, Kerawalla, & Mulholland, 2011; Wang, Han, & Yang, 2015; Yau & Joy, 2009). Although, formal and informal learning might have some similarities in terms of supporting learning, formal learning occurs most of times in settled environments such as school or home, unlike informal that might occur at any time and in any place while people are moving doing their daily routines. Additionally, formal learning has a rigid curriculum that needs to be followed to achieve certain objectives, which therefore requires different needs for developing new technologies – thus they were not included in the Table 2.1.

As the aforementioned studies introduced models/frameworks for designing new learning technologies, here we briefly report some services that were developed for learning and not dedicated for introducing a framework. Yang (2006) built a ubiquitous learning environment for enhancing collaborative learning amongst students; Hwang, Yang, Tsai, and Yang (2009) utilised context-aware features to develop a ubiquitous learning environment for a field trip. Utilising inquiry-based mobile learning, Shih et al. (2010) developed a mobile learning environment to enhance social science learning effectiveness; Kim, Song, and Yoon (2011)

developed smart learning services for delivering smart content based on users behaviour through a cloud computing environment. Kwok, Cheng, Ho-Shing Ip, and Kong (2011) developed a smart ambient media for effective learning. Yao (2017) developed a user-friendly ubiquitous learning system to assist students in learning English by providing personalised content based on location and regardless of time and place. These studies, however, are not particularly for enhancing informal learning at outdoor cultural heritage sites while moving. The next section gives an overview of guidelines for designing mobile and ubiquitous learning services.

2.3.2. Guidelines for designing mobile and ubiquitous learning services

This section presents an overview on the existing guidelines for designing and implementing mobile and ubiquitous learning services and highlights their limitations.

Vavoula, Lefrere, O'Malley, Sharples, and Taylor (2004) have suggested a set of high-level design guidelines for learning, teaching and tutoring. The guidelines were set out based on previous empirical studies and previous mobile learning projects. The guidelines include the following aspects: costs, usability-systems design, choice of technology, roles, equipment management, support for teachers, admin, collaboration, services/applications, and security/privacy.

Grasso and Roselli (2005) proposed principles to act as guidelines for designing courses and content for mobile learning. Previous studies were used to formulate these principles, which include: (a) user analysis; (b) designing a usable interface; (c) implementation of the application; (d) usability. These guidelines, however, are mainly for designing courses for teaching purposes to be used on mobile devices.

Seong (2006) proposed a set of guidelines for the interface design of mobile learning portals. The guidelines were grounded on a usability theoretical framework, possible constraints, and unique properties of mobile computing. The set of guidelines was categorised under three categories, which are: user analysis, interaction and user interfaces. The guidelines act as a guidance to design a friendly usable mobile user interface for better outcomes of teaching and learning.

Candello (2009) proposed a list of detailed design recommendations for designing a mobile multimedia guide in the context of outdoors cultural heritage settings. The set of

recommendations were set out based on empirical field studies to observe tourist behaviour when using mobile devices with the aim of capturing issues with interaction with the devices. The recommendations were designed to assist designers who are interested in designing and developing such guides.

Uosaki, Ogata, Li, Hou, and Mouri (2013) introduced a set of practiced-guidelines to assist implementing a ubiquitous seamless learning environment featuring the Capturing and Reminding of Learning Log system (SCROLL). SCROLL helps users to share and remind themselves of ubiquitous learning experiences**.** The guidelines were designed to assist instructors and teachers, who are interested in using SCROLL between two different scenarios, inside and outside class.

Binsaleh and Binsaleh (2013) introduced a set of guidelines for implementing mobile learning in the conflict area of the four southernmost provinces of Thailand. The guidelines assist teachers and practitioners in setting a mobile learning environment in school. These guidelines (G) are: G1: Guidelines for M-learning curriculum, G2: Guideline for M-learning teaching plan, G3: Guidelines for M-learning content identification, G4: Guidelines for M-learning evaluation, G5: Guideline for perceptions and roles, G6: Guidelines for M-learning usability design, G7: Guidelines for additional services/applications, G8: Guidelines for choice of technology and infrastructure establishment, and G9: Guidelines for equipment management.

Winter (2016) suggested 10 high-level design aspects for designing ubiquitous annotation in particular social object labels (SOLs) in a museum context. SOLs use small interactive displays providing up-to-date information before, during and after interaction to support users' in-situ engagement with digital annotations of physical objects and places. The recommendations are: openness, plasticity, interrogability, ease of engagement, interaction modality, user control, content moderation, information design, conspicuousness and robustness.

Saleem et al. (2017) studied the challenges in developing immersive and wearable technologies and consequently he identified a set of issues to act as guidelines for designing such technologies. The issues are categorised as: (a) design and development; (b) social; and (c) security. The challenges are rather technical and could be used in several contexts such as: social networks, healthcare, and banking. However, they are not about learning, nor for outdoor cultural heritage.

From the guidelines presented so far, two guidelines were suggested for cultural heritage contexts, which are Candello's and Winter's guidelines. The remainder were proposed for different contexts and different learning scenarios, which are not necessarily for designing technology, but rather to implement the learning environment by mediating technology. Candello's one is mainly for interaction design, and more specifically interface design and content presentation. Winter's one is for museums settings, which are different from the outdoors settings as there is no weather effect and also artefacts are close to each other, unlike in outdoor settings. Therefore, it is clear that there are no specific guidelines for designing smart and ubiquitous learning environments utilising LBS and wearable computing to support visitors learn at outdoors cultural heritage sites on the move.

2.3.3. Discussion

Based on the review presented above, it is clear that there is a lack of models, frameworks and guidelines that could support aspects that are considered as essential elements in designing informal learning services for outdoors cultural heritage sites. These aspects include: interaction design, designing a content object and also support different types of learning designs and processes. In addition, none of the aforementioned models support learning on-the-move, where learners receive instant information regarding the surroundings based on location. Supporting learning on-the-move is considered an important type of learning in the current time, which helps learners keep up with the rapid pace of life. This aspect would be a great support for informal learning at outdoors cultural heritage sites as it involves a lot of movements for acquiring information. Learning in a cultural heritage context has different needs in terms of content, activities and interaction to make it efficient and pleasurable as learners see it as a form of entertainment and not necessarily learning. Visitors visit individually and in groups with friends or family, and also they visit at different times of the day. In addition, there is often a time constraint as visitors need to go home or elsewhere after the visit, which emphasises the need to invest the visit's time efficiently and effectively by experiencing the site smartly.

Only one of the discussed studies was designed for outdoors cultural heritage context, which is Candello (2009). The scope of her research was on content presentation for outdoor settings of cultural heritage. From the point of view of the application area, i.e. outdoor cultural heritage, this is the closest to the work of this PhD research. This research, however,

investigates the design of new technologies for outdoor cultural heritage from a holistic point of view, aiming to capture all the relevant elements including content.

Therefore, there is a need to introduce learning tools – models, frameworks or/ and guidelines – that could inform the design of informal learning services to support visitors to learn on-the-move at outdoor cultural heritage sites. The next section gives an overview of models and frameworks that were proposed for the field of pervasive, ubiquitous and ambient intelligence computing in general.

2.4. Pervasive and ubiquitous computing, and ambient intelligence

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." (Weiser, 1991, p. 94). Pervasive or ubiquitous computing refers to invisibly embedding computers into the surrounded environment to enhance the users' quality of life (Weiser, 1993) – context-aware technologies. Context is defined by Dey and Abowd (1999, p. 3) as "… any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." Contexts include the interaction between learners and the environments (Hwang, 2014). Context-aware systems gather information about the users and the surroundings by sensing, detecting, monitoring and tracking their behaviour (Dey & Abowd, 1999; Economides, 2009). Thus, context-aware applications are considered smart and intelligent, which is also true for the environment they are used for – these are referred to as smart environments or ambient intelligence. Ambient intelligence is defined as "a digital environment that supports people in their daily lives by assisting them in a sensible way." (Augusto, 2009, p. 3).

While the previous section discussed frameworks/models that were introduced to support learning in different contexts, this section gives an overview of models and frameworks for pervasive and ubiquitous computing, and ambient intelligence.

Saha and Mukherjee (2003) point out that the essential elements for building pervasive computing fall into four broad areas: devices, networking, middleware and applications. The authors explain the elements as follows: (1) Devices include: (a) traditional input and output

devices; (b) wireless mobile devices; and (c) smart devices e.g. intelligent appliances/ devices embedded with sensors; (2) Devices and machines of everyday life will be connected to a pervasive network; (3) In order to provide services to end-users through the pervasive devices, middleware is required to interface the service between the network and the applications running on the devices; (4) as pervasive computing is more environment-centric, the applications guide the middleware and the networking issues to a large extent (Saha & Mukherjee, 2003). Figure 2.1 illustrates the four broad areas.

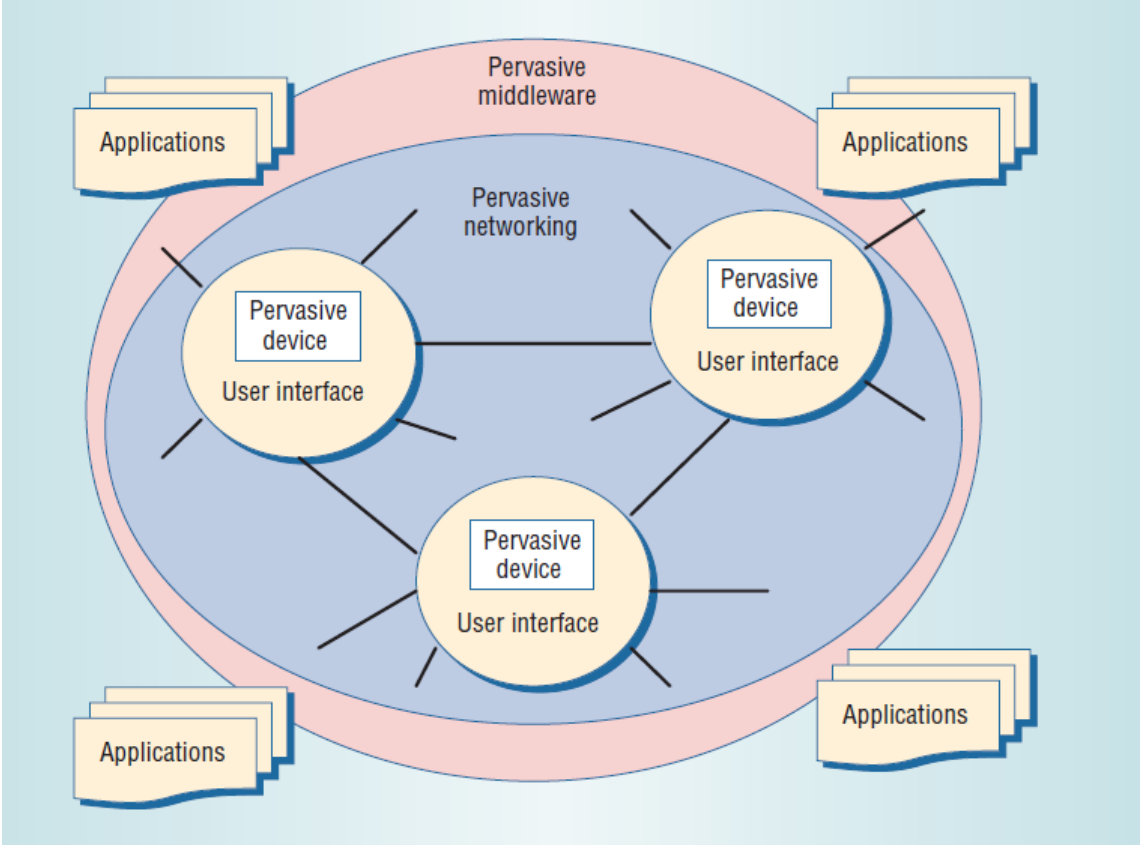


Figure 2.1: the pervasive computing model (Saha & Mukherjee, 2003)

A number of frameworks/models were introduced for context-aware pervasive computing applications for context adaptation, such as: a framework for facilitating prototyping of context-aware applications (Biegel & Cahill, 2004; Henricksen & Indulska, 2004; Ranganathan, Chetan, Al-Muhtadi, Campbell, & Mickunas, 2005), for context provision (Knappmeyer, Baker, Liaquat, & Tönjes, 2009), and for modelling context information (Held, Buchholz, & Schill, 2002; Henricksen, Indulska, & Rakotonirainy, 2002). In addition, Satoh (2005) proposed a location model for managing location-based and personalised services in indoor settings. Roman and Campbell (2002) proposed an application framework to provide an

adaptation mechanism for the existence application to be used on ubiquitous devices in order to provide contextual information to users regarding the surroundings. In the same vein, Hallsteinsen et al. (2012) introduced a framework for software development that is sensitive to contexts, which works on ubiquitous devices. It provides an adaptation mechanism in terms of the interaction design based on the environment. Zhou, Yu, Riekki, and Kärkkäinen (2007) proposed a framework for ambient intelligence that consider user's emotion for providing an adaptation mechanism for such services. Saleemi, Rodríguez, Lilius, and Porres (2011) proposed a framework for developing context-aware applications for smart spaces.

Although the aforementioned studies proposed models/ framework in the field of pervasive, ubiquitous and ambient intelligence computing, most of them are technical and typically provide a technical architecture to assist in designing such services. These could assist developers in a variety of fields in identifying different ways of collecting and using contextual information from the environment. This PhD research aims to introduce a theoretical framework for designing smart and ubiquitous learning environments for enhancing informal learning at outdoor cultural heritage sites, in which the contextual information is likely to play an important role. The focus, however, is to provide a comprehensive framework with the focus on three aspects: (a) supporting informal learning, (b) supporting learning on-the-move, and (c) for outdoor cultural heritage. Thus, the work in this thesis complements the previous work in the area of pervasive, ubiquitous and ambient intelligence computing, by providing guidelines for a particular purpose, while leaving the choice of how the context-aware aspects are implemented to the developers (e.g. through the use of models from pervasive, ubiquitous and ambient intelligence computing). The next section provides an overview of technologies applied in the field of cultural heritage.

2.5. Cultural heritage and technology

The cultural heritage concept refers to passing cultural traditions and physical artefacts from the past generation to the present (Timothy & Boyd, 2003). Nuryanti (1996) points out that it is considered as cultural tradition of society, as it carried the historical values from the past. Cultural heritage, therefore, reflects the identity of societies (González, 2008) and it is considered the gateway people use to discover history. Given that, it could be important for people to learn more about the historical information that relates to heritage sites. This may help people to appreciate their history, which could further promote a sense of loyalty and engagement (UNESCO, 2013). Visiting historical sites reinforces the revival of the glorious

past that the communities have had during a particular age, which helps people to derive a power from that history and to be proud of belonging to that community (Caton & Santos, 2007). Learning about historical stories and events that have taken place in a certain space not only attaches people to their roots (Poria et al., 2006), but also evokes their emotion and identity towards societies that they belong to (Poria et al., 2004), which may inspire them to give more to serve their communities and contribute to their advancement. Visiting cultural heritage sites that have witnessed significant historical events in a particular time in the past might reinforce maintaining a link between the present and past which would help stimulate the perpetuation of culture (Du Cros, 2001). In addition, it offers an opportunity to portray the past in the present (Nuryanti, 1996).

Cultural heritage forms a significant part of the tourism industry as it contributes to a country's income (Silberberg, 1995; K. Taylor, 2004). Visiting sites for some people is to be educated or to enjoy themselves, and for others to feel the place and be emotionally connected with it (Chang, Hou, Pan, Sung, & Chang, 2015; Poria, Butler, & Airey, 2003). Promoting heritage tourism would be powerful by evoking visitors' emotions and offering the sensation of sites (Prentice, 2001). Experience is defined by the Oxford English dictionary as "something felt or learnt by personal contact" (Beeho & Prentice, 1997). That therefore emphasises how important is to enhance the visitors' experience at sites by helping them feel places and hold the sensation of these places. That would help the experience stays for a long time in learners' memory, which consequently enhances learning from these sites, as heritage tourism is considered a form of informal learning. In addition, it helps raise awareness of heritage places as it encourages more visitors to visit.

The interpretation of sites is a key element in this learning process as it helps visitors of sites (learners) to travel through time to visit the past (Nuryanti, 1996); in other words it brings the past to the present world. Tilden (1957, p. 34) proposed six principles for interpretation:

1) Any interpretation that does not somehow relate to what is being displayed or described to something within the personality or experience of the visitor will be sterile.
2) Information, as such, is not Interpretation. Interpretation is revelation based upon information. But they are entirely different things. However all interpretation includes information.
3) Interpretation is an art, which combines many arts, whether the materials presented are scientific, historical or architectural. Any art is in some degree teachable.

4) The chief aim of Interpretation is not instruction, but provocation.
5) Interpretation should aim to present a whole rather than a part, and must address itself to the whole man rather than any phase.
6) Interpretation addressed to children (say up to the age of twelve) should not be a dilution of the presentation to adults, but should follow a fundamentally different approach. To be at its best it will require a separate program.

Enhancing the interpretation of sites would lead to a higher engagement of visitors with the experience, which would have a great impact on increasing attendance which would contribute to conserving sites.

The interpretation of sites has witnessed a significant revolution as visitors constantly look for some sort of guidance when visiting sites to help in understanding history better (Brito, 2012). Human guides used to be the only known means in this context until technology started to take over (Rabotić, 2010). Technology has been widely harnessed to enhance the experience of visitors at culture heritage. Different technologies are adopted to enhance visitors' engagement and consequently visitors' experience, which in turn, increases the sense of sites.

Technologies such as Virtual reality (VR) (De Paolis, Aloisio, Celentano, Oliva, & Vecchio, 2009; Gaitatzes, Christopoulos, & Roussou, 2001; Mavrogeorgi, Koutsoutos, Yannopoulos, Varvarigou, & Kambourakis, 2009), augmented reality (AR) (Casella & Coelho, 2013; Chang et al., 2015; Demiris, Vlahakis, & Ioannidis, 2006; Vlahakis et al., 2001), near field communication (NFC) (Angelaccio, Basili, Buttarazzi, & Liguori, 2012), radio-frequency identification (RFID) (Ghiani, Paternò, Santoro, & Spano, 2009; Hsi & Fait, 2005), infrared, Bluetooth and location-based services (LBS) using global position system (GPS) (Candello, 2012; Schmidt-Belz, Laamanen, Poslad, & Zipf, 2003; Van Aart, Wielinga, & Van Hage, 2010) have been used to enhance the experience of cultural heritage. Immersive technologies and context-aware systems have been increasingly utilised in the field of cultural heritage.

Immersive technologies, i.e. VR & AR, have been increasingly utilised in the cultural heritage field to help visitors experience life back in time, which helps them immerse in the experience. Immersive technologies enable users to explore the past and use their senses, such as touch, smell, sight and hearing. Virtual reality (VR) is defined by Coates (1992) as "…electronic simulations of environments experienced via head-mounted, eyed-google and wired clothing enabling the end user to interact in realistic three-dimensional situations" (Steuer, 1992, p. 74).

AR is defined by Azuma (2001) as "Combines real and virtual objects in a real environment; runs interactively, and in real time; and registers (aligns) real and virtual objects with each other." (Azuma et al., 2001, p. 34). AR helps to enhance the current world instead of replacing it (Fritz, Susperregui, & Linaza, 2005). From this stance, it seems to be a better choice for enhancing the interaction in outdoors cultural heritage settings as it would allow visitors to still gaze at attractions while seeing a virtual object in the real environment in real time, which would help visitors to feel the place (Chang et al., 2015), which in turn enhances the engagement.

The harnessing of ubiquitous computing, such as mobile and wearable devices, to enhance cultural heritage sites interpretation, offers a great opportunity for people to take a learning experience at sites whenever they want. Taking a learning opportunity in cultural heritage context would greatly benefit from context-awareness computing. Context-awareness computing is defined by Dey and Abowd (1999, p. 6) as "A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task". Technologies such as RFID, NFC, infrared, Bluetooth and GPS are considered context-aware computing, as they respond to changes in context to deliver information regarding the surroundings (Baldauf, Dustdar, & Rosenberg, 2007). RFID, NFC and Infrared require visitors to get their device close to attractions to be able to access the related information, which is not always possible especially if visitors are at a new place and do not know what is in their surroundings. Additionally, it could cause a long queue of visitors trying to retrieve information regarding the same attraction. Although Bluetooth does not require being close to attractions, it could be picked from only a short distance; it would be suitable for a small area. Location-based services using GPS would be a good option for outdoor settings especially for new visitors, by helping to deliver information regarding the surroundings based on current location from a long distance; it does not need visitors to attach extra hardware to their mobile device such as an RFID reader. Harnessing context-aware computing for enhancing visitors' experience would have a significant impact on promoting learning from cultural heritage sites, which was considered in this research. The next section provides an overview of ubiquitous and mobile computing for enhancing visitors' experience.

2.6. Ubiquitous and mobile computing for enhancing visitors' experience

Ubiquitous computing offers technology that interweaves into our lives and the surrounded environment in an unobtrusive way (Dourish, 2004). It offers features that allow people to be freed from the restriction of time and place, which would be an excellent choice for enhancing the experience at cultural heritage sites as the experience at sites involves a lot of changing in contexts and happens at different times. It is context-aware computing which allows visitors to receive information based on the context while they are moving. This section provides an overview regarding similar technologies that utilises LBS or/and AR technology.

2.6.1. Mobile guides for tourism in general

Ubiquitous and mobile computing has increasingly been utilised to enhance the visitors' experience not necessarily at cultural heritage sites, which could be considered as informal learning.

CyberGuide is a project which has been presented as a series of versions for indoor and outdoor settings. The outdoor version has employed LBS to identify the current location of users and also to record the route that they have followed during their trip. In addition, it enables users to discover nearby places (i.e. restaurants) (Abowd et al., 1997).

The GUIDE app was developed to provide a hand-held electronic context-aware guide for Lancaster city visitors. GUIDE provides a set of functions that enables visitors to access information, design their own tour, access interactive services and also sending and receiving text messages (Cheverst, Davies, Mitchell, & Friday, 2000).

The Crumpet app proposed by Poslad et al. (2001) was implemented as a multi-agent service. This app uses location-aware services and personalised user interaction to offer a preference adaptation that could be addressed by recording the history of users' visits (i.e. traditional church or historical building) that the users have visited during their tour.

In a similar field, Simcock, Hillenbrand, and Thomas (2003) have developed a tourist guide that is augmented with GPS. This project utilises context-aware computing, in particular, context sensitive features to investigate user feedback regarding the GPS guide. The system enables users to find out where they are in the real time and provide nearby places that they may need to find during their trip (e.g. public telephones and restaurants).

CEARUS was developed to support educational aspects in an outdoor setting. It used a pocket PC hand-held computer that was linked to a GPS receiver to present location-based multimedia content (Naismith, Ting, & Sharples, 2005).

InfoTour is a mobile application that was introduced by Paganelli, Parlanti, Francini, and Giuli (2009) for assisting visitors in interacting with the surrounding by offering a set of services for communicating and sharing knowledge such as offering a third-party communication for easing the search for aspects e.g. accommodations.

Although a number of studies have introduced apps and services for assisting visitors in exploring places utilising LBS – the aforementioned studies were not dedicated for enhancing the experience at outdoors cultural heritage sites in particularly. The next section provides an overview of studies that were conducted particularly for cultural heritage sites.

2.6.2. Mobile apps for cultural heritage sites

In addition to the projects mentioned in the previous section, a number of apps have been introduced with respect to cultural heritage sites.

Candello (2009) proposed a number of guidelines for mobile apps development for outdoor cultural heritage sites. These guidelines focus on viewing images, videos and also the interaction between a user and the system with a touch screen device. Additionally, she used LBS to show and describe directions for pedestrians to get to a particular site. She also examined the tourists' behaviour while using the app in an outdoor setting (i.e. to see if they can use the other features of the app when they are listening to the audio presentation).

Suh, Shin, Woo, Dow, and MacIntyre (2010) suggested a mobile-based guide for cultural heritage sites that was developed for tourists. The purpose of their system was to enable a group of users to share their experiences while they are on a trip. Audio eavesdropping was used to enable users to hear each other's conversations during the tour.

Van Aart et al. (2010) has studied the use of GPS in a cultural heritage setting. The authors used the user's physical location that is determined by the GPS receiver to retrieve historical information about the surrounding environment.

Chianese et al. (2015) have introduced a smart mobile multipurpose system for smart cultural heritage space, single smart space S^3. The system was designed to be used in indoors and outdoors cultural heritage setting. The system employs a set of intelligent sensors (smart

crickets) attached to the artefact that could be detected by mobile devices via Bluetooth (indoors) or Wi-Fi (outdoors) when getting close to it; the device could retrieve multimedia content regarding the detected artefacts and display it to users.

An adaptive context-driven tour was developed by Hagen, Modsching, and Kramer (2005), which enable tourist to retrieve information regarding different contexts based on location. An audio guide tour starts when the tourist enters the proximity of the tour building block (TBB) to deliver information regarding the related TBB, and it ends once he/she exits the proximity. The guide provides tours for systematic match of TBB based on the tourist profile.

A context-aware self-guided tour app developed by Park, Hwang, Kim, and Chang (2007) for the old palace Deoksugung in Seoul utilising PDA augmented with a GPS receiver. The guide provides information regarding: current location, attractions nearby and details about specific buildings in multimedia content. It provides a multi-lingual audio guide, also it provides different modes based on the type of visitors (children, adult, old person).

A number of mobile apps were designed for indoor cultural heritage settings to be used at museums. For example: (a) Hall and Bannon (2006) have developed ubiquitous computer technology for children when visiting a museum, which stimulates active participation, involvement and learning; (b) Collins, Mulholland, and Zdrahal (2008) have developed a mobile app using the text-messaging functionality to assist learners in observing exhibits; (c) Vavoula, Sharples, Rudman, Meek, and Lonsdale (2009) have introduced a mobile app, Myartspace, to be used by students between museums and classrooms. The app uses an inquiry-led learning that enables students to capture information during a museum trip as part of school learning events and send to a website where they can view or share them at school or at home; (d) Sung, Hou, Liu, and Chang (2010) have developed a mobile guide system employing a problem-solving strategy to provide historical narratives as backgrounds for the exhibits; (e) Suriyakul Na Ayudhya and Vavoula (2017) developed a mobile app to support families learning at a science museum in Thailand. The app helps adults within families to help children understand concepts at the science museum. However, it was not designed particularly for cultural heritage museums.

AR recently has been utilised in cultural heritage context to enhance visitors' experience. Some projects have been designed for indoors cultural heritage sites. Damala, Cubaud, Bationo, Houlier, and Marchal (2008) have developed a multimedia mobile guide utilising AR for a museum setting, which was designed and implemented for Fine Arts in Rennes, France.

The prototype delivered information regarding artefacts based on detecting a painting; once a painting was detected, an overlay layer appears which enables visitors to navigate through information regarding the detected painting. Other studies employed AR in indoors cultural heritage settings such as: (Casella & Coelho, 2013; Chang et al., 2015; Fritz et al., 2005; Haugstvedt & Krogstie, 2012; Zoellner, Keil, Wuest, & Pletinckx, 2009). Some others were introduced for outdoors settings such as: (a) Archeoguide (Vlahakis et al., 2001) utilises AR for ruined sites to help visitors visualise the site using "Head-Mounted Display (HMD) in the form of a pair of see-through sunglasses for displaying AR worlds featuring monument reconstructions on top of their natural surroundings are also attached to the laptop"; (b) Liarokapis and Mountain (2007) introduced a tourists guide to deliver multimodal information through mobile device at open-air heritage places. The guide utilises LBS and AR for delivering information in real-time through a digital map. (c) Takacs et al. (2008) utilised AR for outdoors cultural heritage setting based on mobile devices – LBS also have been employed in their study using location-tagged images.

Utilising wearable computing such as smart eye glasses to learn from cultural heritage sites is yet immature in the literature; a few technologies were introduced with this respect. Sparacino (2002) used infrared sensors to assess the semantic location of visitors in order to deliver information through a wearable glasses-like device. The information is delivered in a form of a personalised story teller through exhibitions. The glasses-like device features a display in front of the right eye which shows additional information based on the physical object in front of the user. The information is then merged into one augmented reality image. Leue, Jung, and tom Dieck (2015) utilised Google glasses to deliver information regarding paintings that were identified using the image recognition technique. The information was augmented on a real-world view through the glasses while at the same time a visitor was looking at the painting in an art gallery. Koren and Klamma (2015) developed a wearable computing technology for learning about physical artefacts to support informal learning at museums settings utilising mobile and wearable computing i.e. smart glasses and watches.

It is clear that none of the aforementioned systems supporting learners to learn at outdoor cultural heritage on-the-move, where learners receive information based on location automatically and intelligently while moving without the need of their intervention. Learning on-the-move would enhance learners' experience of cultural heritage as it saves the time and effort learners spend looking for information regarding sites. In addition, none of the

aforementioned systems provide notifications based on location when learners pass nearby sites or attractions. This could be a very helpful feature for learners who are in new places where they do not know what is interesting surrounding them, which help them invest their visit's time effectively.

2.6.3. Discussion

Despite the growing body of literature that has investigated the potential of mobile location-based apps, only a few studies have considered visitors/learners' requirements in designing mobile ubiquitous learning environments based on location-based learning services. Considering learners' requirements would enhance satisfaction and engagement as the new technology will meet learners' needs, which encourages them to use it (Brown & Chalmers, 2003). Moreover, a small number of studies have been conducted to enhance learning from cultural heritage sites, in which the learning experience at sites requires learners/visitors to walk around to observe the real attraction while at the same time acquiring information, unlike the more settled contexts such as learning history at home (Alkhafaji, Fallahkhair, & Cocea, 2015). This PhD research has considered learners' requirements in designing a smart and ubiquitous learning environment to be used in outdoors cultural heritage contexts based on mobile and wearable technologies.

2.7. Technologies used at cultural heritage sites – on-site technologies

Authorities of cultural heritage sites constantly introduce new ways for presenting historical information with the aim of enhancing visitors' engagement as well as sites interpretation. An overview of some on-site technologies adopted by some museums in the south of England is presented below.

Indoors cultural heritage settings such as museums adopt technology to help a better interpretation. Some adopted technologies include oral-history reordering, which is sometimes accompanied by dolls representing famous characters back in time, such as at the D-Day Museum in Portsmouth. Audio portable devices, some of them with a headset, have been used for years at some museums, such as the Roman Bath museum. The audio guide, which is sometimes not included with the entrance ticket, contains a pre-recorded audio description for all artefacts at the museum indicating them with a number which is the same number that is attached beside the real artefact. The device works when the visitor presses the number

corresponding to the artefacts on the device keyboard. A brief audio description starts with a picture illustrating the artefact on the device and an option of more details if desired. In this case visitors have to be in the museum and get close to artefacts in order to see the number related to a specific artefact and press it on the device to receive information. Besides, visitors might need extra time to understand how it works, which is not an ideal situation for a short visit nor a visit with kids probably (see Figure 2.2).

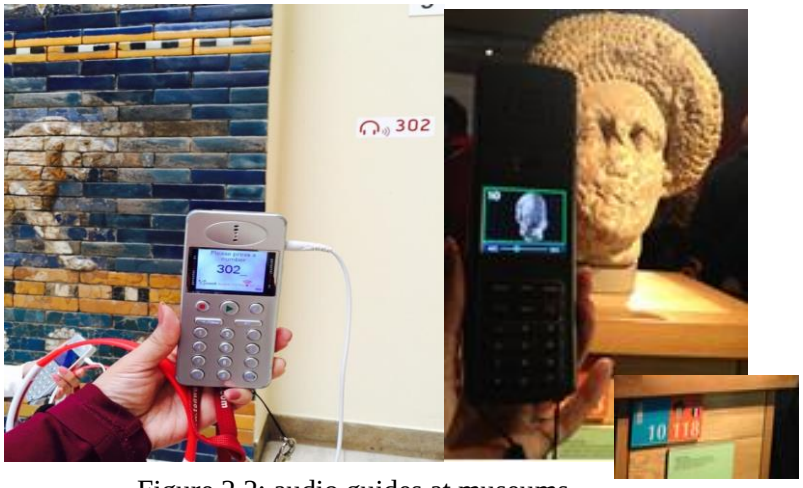


Figure 2.2: audio guides at museums

Interactive screens are used at some museums such as Mary Rose and the National museum of the Royal Navy in Portsmouth. The interactive screens provide services which include interactive quizzes and a search facility to find out information regarding people and events back in time. More sophisticated technologies are adopted at some other museums, such as the Birmingham museum. These technologies include interactive games, boards, and quizzes, which are provided to draw visitors' interest, which would enhance their engagement. Simulations of life back in time are presented using little boxes containing dolls representing people and life back in time with ability to move when visitors press a button to show a real situation. However, there was not any portable audio guide for visitors to listen to information while walking around the museum. Visitors need to stop by fixed audio devices to listen to information, which might need longer time to finish the tour on a busy day as everyone wants to get information, or otherwise skips some artefacts if visitors have only a short time (see Figure. 2.3).

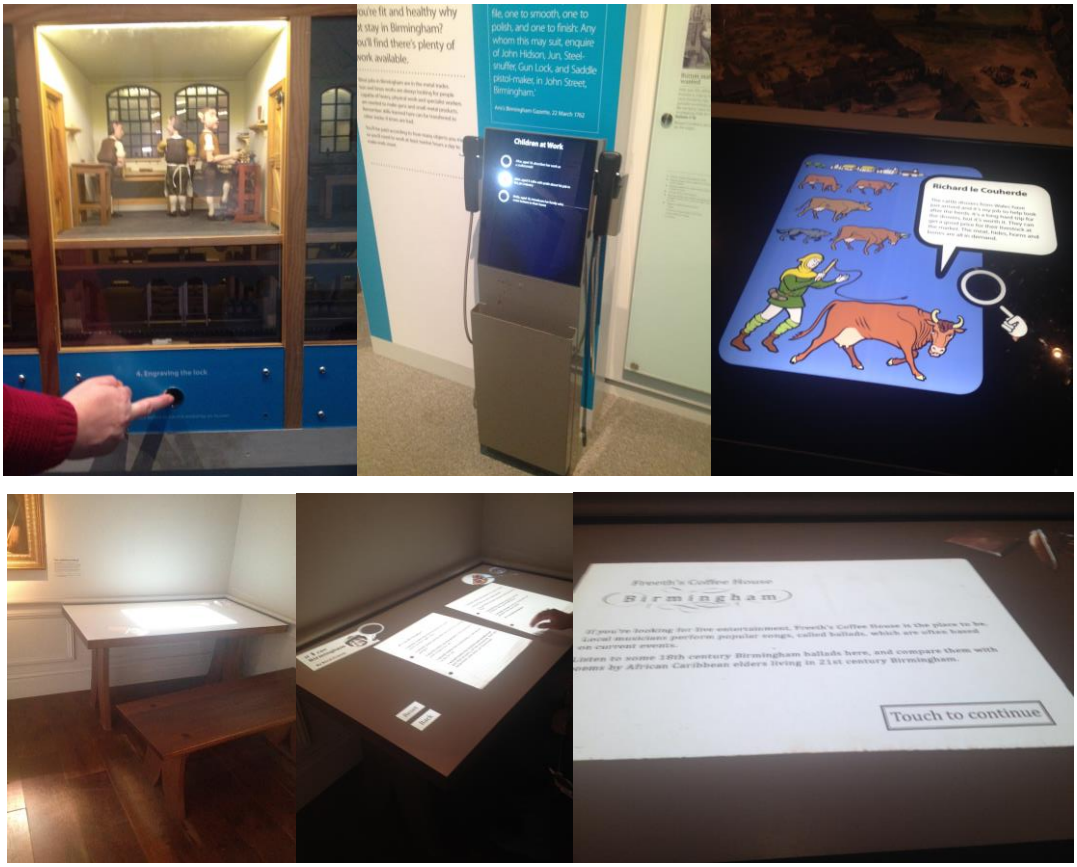


Figure 2.3: technologies were adopted in the Birmingham museum: dolls illustrate jobs and life back in time, fixed an audio device, an interactive game and an interactive board

Other technologies and resources in indoor settings include a screen displaying events at that time, labels attached to artefacts and a paper-based description. Moreover, some individual museums provide websites and/or mobile applications for their visitors (e.g. the international museum of the Royal Navy in Portsmouth). However, visitors need to access or download the corresponding service for each museum or site they would like to visit, which is not a very practical way.

Context-aware computing using technologies such as Bluetooth and Wi-Fi has been employed in a project for outdoors cultural heritage setting called Wayteller,[3] to present historic information as an audio narrative. Three Wayteller devices were installed at Raglan Castle in different points at the site, which deliver a brief audio message to visitors on their mobile phone via Bluetooth based on their location. Most outdoor cultural heritage attractions in Portsmouth – as discussed in the previous chapter – have only labels with a brief description about the related attraction, which might not be enough for some people who are eager to learn about history and how it affected their current life.

[3] http://www.wayteller.co.uk/index.shtml

From the overview presented so far, it is clear that the indoors setting has drawn the attention of authorities more than the outdoors setting, which needs more attention as it is as significant as the indoors setting sites. Outdoors setting attractions, such as sites and monuments often people pass by when moving around to do their daily routine, need to draw people's awareness of them and make it easier for people to know about the surrounding cultural heritage attractions. This also has been pointed out by a member of staff of a cultural heritage site, who stressed outdoors cultural heritage settings are not interpreted as well as needed (see Chapter 6).

2.8. Conclusion

This chapter has provided a review of several aspects that are relevant to this research, which are: learning theories, existing models, frameworks and guidelines, and technologies supported informal learning in the cultural heritage context. The review of the theories of learning acts as strength evidence when designing a framework for developing ubiquitous learning environments with respect to cultural heritage sites, which is the aim of this research. The remainders help have an idea what has been done so far in this context. In the context of harnessing technology to enhance visitors' experience, there has been little work that studied visitors/learners behaviours and habits pre and post a visit to cultural heritage sites and drawn requirements for designing smart and ubiquitous technology. Additionally, few learning models, framework and guidelines were proposed for cultural heritage sites. Cultural heritage contexts require different aspects to be considered that other contexts do not necessarily need, such as time constraint as visitors need to invest the time of the visit effectively to gain more knowledge in a short period of time. Additionally, visitors might be accompanied by children, who are sometimes difficult to control, thus the experience needs to be smart and easy in terms of receiving information to help them enjoy the visit and get their children to enjoy learning history. Moreover, little work has been done to support visitors of sites to learn on-the-move as it could be a very helpful feature for informal learning at sites, which involves a lot of movements for acquiring information.

Outdoors culture heritage sites seem to not be very well interpreted; most of them have only labels attached to an attraction explaining briefly about the corresponding attraction. That might not be enough for visitors who are eager to learn about stories that happened back in time. Visitors need to look for information online if they want to get more information regarding the attractions they have passed by or maybe have a human guide for instant

information. Given that, there is a necessity of harnessing new technologies to help revive the past in the modern time and bring it closer to people, which would promote the sense of belonging. That consequently, would encourage conservation of sites. This research aims to contribute to this field in order to support learning from cultural heritage sites using smart and ubiquitous technologies. The next chapter presents the methodology followed to achieve this aim.

Chapter three

3. Research Methodology

Chapter 2 has discussed the related technologies that have been used to enhance informal learning at cultural heritage sites. The discussion highlighted the lack of technologies that consider end-users' perspectives, which could affect users' acceptance (Kangas & Kinnuen, 2005). Thus, this research considered users' requirements in designing a new learning technology. This chapter describes the research design that serves the gathering of user requirements for developing smart and ubiquitous learning environments based on mobile and wearable technologies with respect to cultural heritage context. It outlines methods and techniques that were adopted to answer the research questions and achieve the objectives of this research, which were stated in Chapter 1.

This chapter is structured as follows: Section 3.1 gives an overview of the user-centred design approach; Section 3.2 discusses the methodologies used in the field of technology enhanced learning; Section 3.3 discusses the research methods applied and the rationale for choosing them; 3.4 discusses the targeted sample; 3.5 discusses the socio-cognitive engineering methodology, which is used in this PhD research; Section 3.6 discusses the analysis methods; Section 3.7 discusses the evaluation methods; Section 3.8 concludes the chapter.

3.1. User-centred design

User-centred design (UCD) refers to the design processes wherein end-users are involved to influence the design of artefacts (Abras, Maloney-Krichmar, & Preece, 2004; ISO, 2009). Involving end-users in the design process would enhance user experience and interface design as they will meet users' needs and requirements (Norman, 1986). The user-centred design approach, which it was used in this research, has been widely used to consider user experiences and user requirements for system development (Andone, Dron, & Pemberton, 2006; Fallahkhair, 2009; Naismith et al., 2005; Winter, 2016). UCD was used in this PhD research in two stages: (a) the data collection stage (gathering user requirements); (b) the evaluation stage; as shown in Table 3.1 accompanied by the corresponding chapter (CH).

Table 3.1: the user-centred design stages

The stage	The study	CH
Data collection	Focus group	4
	Survey	5
	Interview	6
Evaluation	Experts' evaluation	11
	Users' evaluation	

3.2. Methodologies applied in the field of technology enhanced learning

The field of technology enhanced learning (TEL) is interdisciplinary, which concerns the harnessing of technology to support learners in taking learning opportunities more effectively. Research in technology enhanced learning involves two main disciplines; learning and technology. Thus, researchers need to comprehend how learners perform learning and how they are interacting with technology (Sharples, 2006) on one hand, and on the other hand, new technologies need to be introduced to enhance the learning experience.

A number of methodologies have been proposed as learner-centred design methodologies, with most of them designed mainly for school children such as: (a) the TILT model (tasks, interfaces, learner's needs, tools) (Soloway, Guzdial & Hay, 1994), (b) the Informant Design Framework (Scaife, Rogers, Aldrich & Davies, 1997), and (c) the CARSS framework (Context, Activities, Roles, Stakeholders, Skills) (Good & Robertson, 2006). Another methodology is the Persistent Collaboration Methodology (PCM), however, it does not explicitly say it involves children as a source of collecting the design requirements, but instead it involves teachers in the design process who speak on behalf of children to provide their needs, as argued by Good & Robertson (2006). These aforementioned methodologies were designed mainly for involving children in conducting research, this PhD research was proposed for a wider range of generations; however, the research was conducted with adult participants only.

Some other methodologies, which have not necessarily been proposed mainly for TEL, but have been used for introducing new learning environments in the form of a software system, are described below.

The Identification-Development-Refinement (IDR) methodology was proposed for interdisciplinary design (Winters & Mor, 2008). IDR involves three stages: (a) Pattern identification, which aims to identify potential patterns through the use of typologies and case studies; (b) Pattern development, which is about the developing of a set of patterns based on design evidence from the case studies from the first stage; (c) Pattern refinement, which aims to improve the patterns through collaborative discussion and reworking.

Research designs or experiment research methodologies were introduced in several versions by a number of researchers (e.g. Collins, Joseph & Bielaczyc, 2004; Reeves, 2006; Nieveen, McKenney & Van den Akker, 2006). All of them agree on the involved stages of preliminary research, prototyping phase and assessment phase in an iterative manner; Nieveen et al. (2006) added one more stage which is reflection and documentation. This methodology involves investigating previous similar studies and/or understanding human behaviours in the field in the preliminary research stage. The outcome of this stage leads to develop a new artefact, and then leads to the assessment stage which is basically the evaluation stage, which helps to assess the validity of the product and/or identify challenges and problems. That in turn leads to the final stage which is reflection and documentation.

The SCE methodology was introduced by Sharples et al. (2002); it consists of two stages: analysis and design, which are connected in an intersection stage that involves formulating a task model based on the outcomes of the analysis stage. The task model acts as a bridge to inform the design of a new technology in the design and development stage. The design and development stage involves introducing a new technology based on the task model. The SCE methodology has been widely used in the field of technology enhanced learning (Fallahkhair, 2009; Sharp, Taylor, Evans, & Haley, 2008; Taylor et al., 2006; Vavoula & Sharples, 2009). The value of this methodology is not only to introduce a new technology based on the analysis stage, but beyond that, to introduce a model that could be used by researchers and designers for designing a new technology.

The discussion so far reveals that the most suitable methodologies for conducting this PhD research are *design research* and *SCE* as both are not restricted to particular age groups and both support introducing new technologies. Given that this research aims to develop a task model for offering a tool for other researchers to use in designing smart and ubiquitous learning environments with respect to cultural heritage, this makes the design research methodology unsuitable in this context, as it does not support the introduction of a task model. That leaves

one best option to consider, which is SCE; although it might have some limitations in terms of the nature of the methodology as it is for introducing new technologies, which might make it unsuitable for research that does not consider introducing new technologies. However, it could be adapted to use the first stage, which is the analysis stage to serve the purpose of conducting theoretical research.

The SCE is a user-centred design methodology which involves users in designing and implementing new technology throughout the analysis and design stages. This research investigated users' perception, attitudes and behaviours regarding using mobile technology for learning purposes with respect to cultural heritage context. Additionally, it involved potential end-users (learners) in the design process as learners' feedback was obtained during the implementation process, which enabled to improve learner's interactions and experiences.

This research adopted the SCE methodology to add several contributions to the academic knowledge: (a) a task model for designing smart and ubiquitous learning environments with respect to cultural heritage sites (Chapter 8); (b) a smart and ubiquitous learning environment based on the mobile and wearable technologies, SmartC application (Chapter 10); (c) a list of design recommendations for designing such informal learning environments (Chapter 12). The SCE methodology is discussed in more detail in the Section 3.5, including how it was applied for the research in this thesis. The next section discusses the adopted research methods.

3.3. The research methods applied and the rationale for choosing them

The mixed methods approach refers to combining qualitative and quantitative research methods for data collection for one single research. The combination could take different forms depends on the objectives of the research. The main two forms are: (a) the qualitative is a preliminary and quantitative is a follow-up. In this form the qualitative is conducted first to obtain preliminary results to be further investigated in the follow-up method as well as to design the quantitative tool (Creswell, Gutmann, & Hanson, 2003; Ivankova, Creswell, & Stick, 2006; Morgan, 1998); (b) the quantitative is a preliminary method and the qualitative is a follow-up method, which refer to conducting quantitative research first to obtain a wide-range of data and then follow it up by qualitative research for further and deeper investigation (Creswell et al., 2003; Ivankova et al., 2006; Morgan, 1998). The value of combining qualitative and quantitative research methods is the ability of each method to overcome the limitations of the

others. Thus, this PhD research has adopted the mixed methods approach in the gathering data stage (analysis stage based on the adopted methodology – details in Section 3.5). Three field studies were conducted sequentially to gather user requirements; the research methods applied are given below with the rational of choosing them.

The focus group method was chosen to start a series studies to gather user requirements. As in any research method, focus group has its own advantages and limitations. The main advantage of the focus group method is to provide rich qualitative data regarding people's opinions of the aspects being investigated from a group of participants in one session. Consequently, that helps to save the researchers time and effort from conducting individual interviews. In addition, participants interact with each other during the session, which helps generate a diversity of ideas. Consequently, this makes the discussion richer, which helps to have a deep insight regarding the investigated aspects (Morgan, 1996).

The focus group could be combined with other research methods by conducting it first to act as a preliminary source of data to be further investigated in the following studies. Morgan points out that "This strategy has the advantage of first identifying a range of experiences and perspectives, and then drawing from that pool to add more depth where needed." (Morgan, 1996). Additionally, he reports that using focus group first and following it up by a survey serves in designing the questionnaire's content.

The comparison of the focus group with another qualitative research method such as individual interview showed that a focus group discussion with eight participants generate as many ideas as 10 individual interview based on a study conducted by Fern (1982).

In terms of limitations, as it is a group discussion, participants should all fairly take part in the discussion to reach the diversity, which could not be the case if one participant dominates the discussion. However, the moderator of the discussion should guide the discussion and ensure that everybody is sharing their opinions fairly. In addition, as it is a qualitative research method, it has a limitation in terms of the small scale of participants, which might make the results challenging to generalise. However, two field studies (quantitative and qualitative) were conducted after the focus group to overcome this limitation.

The questionnaire survey method is considered the best choice for reaching a wide range participants fairly easily to obtain quantitative data. It helps to obtain broad opinions, which consequently supports the generalisation of the conclusions drawn from its results.

Additionally, the questionnaire survey method helps to conduct further investigations if it is a follow-up quantitative method (Creswell, 2007; Morgan, 1998). Thus, it was chosen in this research to follow up the preliminary method, which was the focus group, to further investigate the preliminary results obtained.

The main limitation of the questionnaire survey method is that the researcher is not able to encourage participants to respond as it is self-administered, which affects the number of respondents; fewer questionnaire forms came back than the original number that was sent out in the first place. Another limitation is that participants most of the times have to choose an answer from a set of given choices, which could lead participants to not think out of the box. However, open-ended question could be provided as an alternative to give participants a room to express their opinion if they need to. The survey was followed up by qualitative research to overcome this limitation, as well as to carry out deeper and further research regarding the survey results.

A qualitative method, interview, followed the survey up to have a deep insight regarding the results obtained. The interview helps in letting the interviewees express their opinions freely to obtain rich data. Additionally it allows the researcher to ask questions related to the aspects being investigated to have their perspectives. The interview is considered a good choice for extracting participants' habits, motivations and attitude regarding the investigated aspect (Oppenheim, 1992). The alternative to the interview could be a field observation that enables researchers to observe participants behaviour. In this research context, the investigated aspects are related to learning, and as learning is an invisible process, the observation technique was not suitable for collecting such data. The best option was letting them express their opinions themselves.

The interview method has some limitations, which include the representatively of the population (Qu & Dumay, 2011), which could be addressed by combining it with a quantitative research method. This research adopted the interview method as a last study within a series of gathering data studies, which followed a quantitative research method, survey questionnaire, to overcome the limitations of both methods, questionnaire and focus group. The next section discusses the targeted sample.

3.4. The targeted sample

The sample targeted in this PhD research consisted mainly of adults; children were not being targeted directly but instead through adults within the group whether family or schools. Adults were chosen to be the targeted group as they are able to express their opinion more clearly, as well as be able to express opinions related to their capacity of parents or teachers in relation to children. Participants were recruited using different channels (details in Chapters 4, 5 & 6) with the aim of recruiting as many participants as possible to obtain the diversity and wide spectrum of opinions. That helps to prevent any bias that might occur if the diversity in demographics had not been fairly met. Selecting participants for each study was based on the sample that responded to the previous study to balance the diversity of participants' demographics in terms age group, occupation, gender and background. For instance, if the majority of the survey study's participants were students, students are excluded from being selected for the next study, which is the interview study. The next section gives an overview of the methodology adopted in this research.

3.5. Socio-cognitive engineering methodology (SCE)

SCE is a user-centred design methodology (Sharples et al., 2002) which considers users' perspective when designing new technologies. Figure 3.1 illustrates the process of the SCE methodology, which consists of two main stages: analysis and design; these are connected in an intermediate stage, which this research calls "intersection stage", bridging the two main stages.

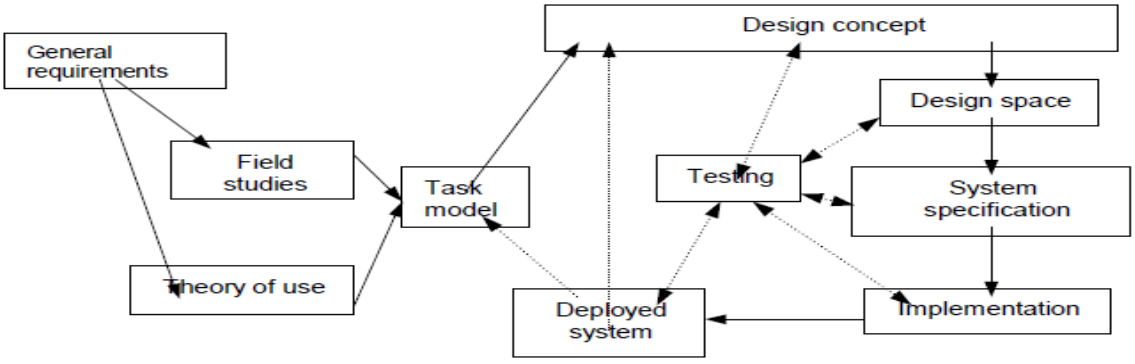


Figure 3.1: socio-cognitive engineering methodology (Sharples et al., 2002)

Each stage involves a number of elements or sub-stages to achieve a specific goal that serves that stage. The analysis stage has two elements, field studies and theory of use. Field studies involve investigating people's behaviours, attitudes and habits regarding the investigated activities, on one hand, and theory of use involves studying theories related to these activities,

on the other hand. These two elements are combined in an intersection stage to formulate a task model, which bridges the analysis stage with the design stage in an iterative manner and provides a set of principles in the form of requirements that could be adopted to inform designing new artefacts in the form of software for the design and development stage.

The design stage consists of an iterative cycle of five sub-stages for designing and implementing the artefact, which include: (1) design concept, involving the translation of the task model into a coherent design picture of a new technology; (2) design space, which involves generating several possible system design elements; (3) system specification is specifying functional and non-functional aspects of the system; (4) implementation of the system involves the translation of the design into a working system; (5) deployment of the system is to put the system in use in real life.

The testing part integrates all the aforementioned sub-stages together, with the results of the test fed forward to understand how to implement and deploy the system, and backwards to fix drawbacks of the design and then help introduce a useful software environment (Sharples et al., 2002).

This research has adopted SCE methodology with the aim of exploring the potential of mobile location-based learning services with respect to cultural heritage contexts (see Figure 3.2). This aim informed the analysis stage, which carried out several investigations for this regard. A sequential mixed methods approach was adopted in the field studies to investigate how people may use mobile technology for learning purposes (Creswell et al., 2003). Three field studies were conducted using focus group, survey and interview techniques to investigate people's behaviours, attitudes and habits regarding using mobile technology for learning in cultural heritage contexts.

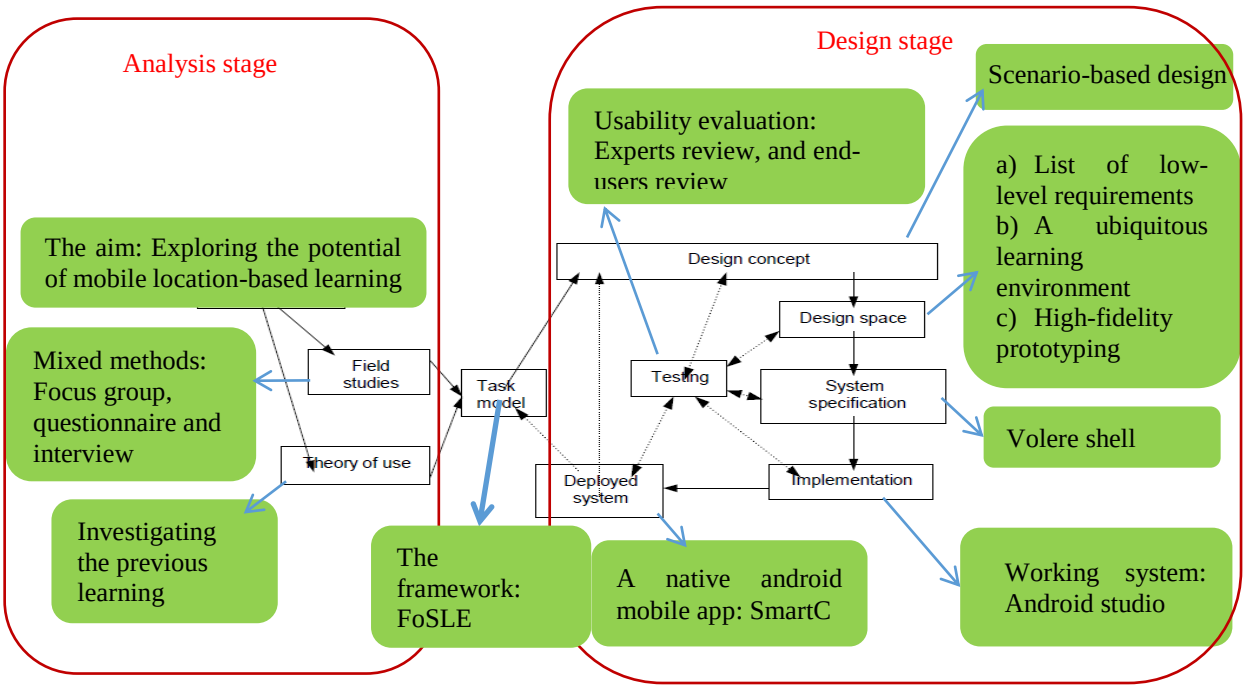


Figure 3.2: research methodology with the adopted methods and techniques

The results of the field studies led to the development of a theoretical framework (task model) supported by the learning theories. The framework was further analysed to pull out general requirements to be adopted in developing new technology-supported artefacts, which informed the design of a proof-of-concept, a smart and ubiquitous learning environment based on mobile and wearable technologies.

Scenario-based design was used to illustrate the design concept; four scenarios were developed to visualise a tangible picture of what could be developed based on the requirements (Carroll, 2000). A design framework was pulled out from the scenarios, which contains a set of low-level requirements (i.e. more detailed requirements).

High-fidelity prototyping was adopted (Virzi, Sokolov, & Karis, 1996) using proto.io to simulate the context of use that was depicted in the scenarios, which were developed based on the identified requirements. The Volere shell was used in the system specification stage, to document the requirements of the services, which were then translated into a working system, which is called SmartC, in the implementation stage. The implementation was carried out to develop a working system based on part of the high-fidelity prototype using Android studio.

Usability evaluation methods were used in the testing part with experts of HCI and end-users in the field. The results of the evaluation studies were used to enhance the list of low-level requirements, which then were re-designed to produce a list of design recommendations for

designing such services (see Chapter 12). More details of the methodology stages with the adopted methods are illustrated in Table 3.2.

Table 3.2: research methodology stages and sub-stages with the corresponding's chapters

Stage	Component	Description		CH
Analysis	Theory of use	Learning theories		2
	Field studies: Mixed methods approach	Technique	Data analysis method	
		Focus group	Thematic analysis	4
		Survey (questionnaire)	Statistical analysis	5
		Interview	Thematic analysis	6
		Interpretation of all field studies and discussion		7
Intersection	Task model	A framework for designing smart and ubiquitous learning environments, FoSLE		8
		Principles (general requirements)		9
Design	Design concept	Scenario-based design		9
	Design space	Low-level requirements		9
		A ubiquitous learning environment		10
		High-fidelity prototyping: Proto.io		10
	System specification	Volere shell		10
	Implementation	Working system: Android studio		10
	Deployed system	A native android app: SmartC		10
	Testing: usability evaluation	Evaluation type	Technique	11
		Experts evaluation	Cognitive walk-through	
			Observation	
			Interview	
		Users evaluation	Questionnaire	
			Observation	
			Group interview	

The following subsections outline the methodological aspects of each stage.

3.5.1. Analysis stage

The discussion of the previous work that was presented in Chapter 2 highlights the need of introducing new learning technologies that respond to learners' needs. Thus, this research involved potential learners in the development process. For the analysis stage, a sequential mixed methods approach was adopted to conduct three field studies using focus group, questionnaire and interview techniques (Creswell et al., 2003). This research used convenience sampling within the non-probability sampling approach; the target group was adult end-users (potential learners).

Based on the discussion in Section 3.3, the focus group method was chosen as the best choice for conducting a preliminary and exploratory research and to inform the design of the questionnaire. The objectives of the focus group study was: (1) obtain preliminary insights of people's attitudes, habits and behaviours regarding using mobile technology for learning at cultural heritage sites as well as understand their needs for developing such services. (2) In addition to gathering preliminary data, the focus group results have been used to inform the design of the questionnaire for the survey study. Pre-prepared questions were asked to obtain users' opinions regarding using mobile technology for learning purposes at cultural heritage sites; six participants took part in the discussion. Eight broad themes resulted from the focus group study: (1) learners and devices; (2) the notion of learning, (3) motivation and attitude; (4) services and features; (5) information, (6) usability, acceptance and usefulness; and (7) challenges and interventions. The results of the focus group study served as a basis of this research to carry out further research (broad & in-depth) regarding the findings of the study (details in Chapter 4).

The next stage was to design the questionnaire based on the themes resulted from the focus group study. A survey study using a self-administered questionnaire technique was developed to gather broad requirements. The survey study was conducted to obtain a wide range of requirements; potential end-users were targeted. Online and paper-based questionnaire versions were used; the SurveyMonkey web-software was used to deliver the online version (details in Chapter 5).

Finally, the interview technique was used to capture more qualitative requirements from potential learners. As learning could be an invisible process and often too difficult for researchers to observe how it occurs, it becomes pertinent to investigate learners' experience

using qualitative research, which enables to extract deep insights of their learning habits and attitude towards technologies.

A semi-structured interview was carried out to gather in-depth requirements, which could help to have a better understanding of how people use mobile technologies for learning purposes at cultural heritage sites. End-users and cultural heritage staff took part in this study; two different sets of pre-formulated questions were used for end-users and official staff of cultural heritage. The interview study was designed based on the results of the survey study (details in Chapter 6).

All studies were integrated during the interpretation of the results of the entire research (results of the three field studies) (details in chapter 7). The following subsection explains the intersection stage in which a framework was formulated.

3.5.2. Intersection stage – towards the development of a task model

In this stage, a theoretical framework (task model) was developed, which acts as a bridge between the two main stages, analysis and design. Discussing the results of the field studies has led to formulate a theoretical framework, which is called FoSLE, for developing smart and ubiquitous learning environments with respect to cultural heritage contexts. The learning theories helped in strengthening the framework. The framework consists of six broad categories that could inform the design and development of such services, which include: (1) learners, (2) content, (3) learning design, (4) interaction design, (5) context, and, (6) challenges and obstacles. These categories have been further analysed to pull out a list of abstract design principles in the form of general requirements, which could be adopted to inform the design of such services; details are given in Chapters 8 & 9. Details of the design stage are given below.

3.5.3. Design stage

In this stage, a prototype mobile app, SmartC, of context aware service was designed and implemented for outdoor cultural heritage settings. SmartC was developed around a set of general requirements that were pulled out from the theoretical framework, which was formulated based on the field studies and learning theories. This app utilises LBS to identify visitors' location, which in turn, allows the device to provide information about nearby cultural heritage sites. The adopted requirements were translated into features and services in this version of SmartC, and they have been chosen because they are popular activities that resulted from this field studies or for conducting further research in context. The features and services

include: (a) receiving notifications based on the location, (b) multimode information format, and (c) seeing attractions how they appeared in the past.

The framework identified in the analysis stage was further analysed to specify general requirements (top-level requirements). The scenario-based design method was adopted to envisage the usage contexts for the new product. Using scenarios is valuable in that it helps designers to explore the design concept and also to depict all the possible design elements by delivering a tangible picture of the learning environment that could be drawn out from the resulted requirements (Carroll, Rosson, Chin Jr, & Koenemann, 1998). Four scenarios have been developed based on the requirements that were pulled out from the theoretical framework. Moreover, design elements, referred to in this research as "low-level requirements" (LRs), were drawn out from the scenarios to aid the design (see Chapter 9).

A high-fidelity prototyping was used to simulate the context of use of the features as well as to show a wide range of design possibilities that could be developed based on the LRs. The prototyping method helps obtain feedback regarding the design in the early stage of the development. That helps identify any issues with the design before developing the working system, which could prevent major issues that might affect the performance of the system (Virzi et al., 1996). Proto.io was used to develop an interactive simulation prototype which responded to almost all requirements that were pulled out from the framework. The prototype was evaluated by one expert of HCI and two potential end-users. A few issues were identified regarding labelling, wording and some elements of interface design such as colours (see Section 10.1 in Chapter 10).

After addressing the issues identified in the high-fidelity evaluation, a working system was developed based on part of the high-fidelity design. The chosen part involved the main features of this research: (1) a location-based notification, (2) multimode information format and, (3) viewing sites how they appeared in the past using AR technology. The Volere shell specification tool was utilised to specify and document the chosen requirements that were included in the design, which helped illustrate the requirements and link them to their source (see Section 10.4 in Chapter 10) (Robertson & Robertson, 2012). Android studio was used to implement the chosen requirements into features and activities in a working system, a mobile application prototype called SmartC (see Section 10.5 in Chapter 10).

3.6. Data analysis methods

The mixed methods approach adopted in this research helped in obtaining broad quantitative data via questionnaire, and also in-depth qualitative data via focus group and interview. Quantitative and qualitative data analysis methods were used to analyse data resulted from the field studies, which include statistical and thematic analysis. Statistical analysis was used to analyse the nominal data that resulted from the questionnaire of the survey study. Simple statistical analysis using SPSS to obtain frequencies was carried out to identify the most popular services and activities amongst participants (Greasley, 2007). Thematic analysis was adopted to analyse qualitative data (Braun & Clarke, 2006) (see Figure 3.3). A computer software, QSR Nvivo 10, was used to support the analysis in terms of managing and organising data (Patricia Bazeley & Jackson, 2013). At the first step of the research, the focus group study, the data was coded in two iterations; first manually and secondly using the software. A mind map and coloured cards were used in the manual version to perform steps 3& 4 of the analysis (see Figure 3.4).

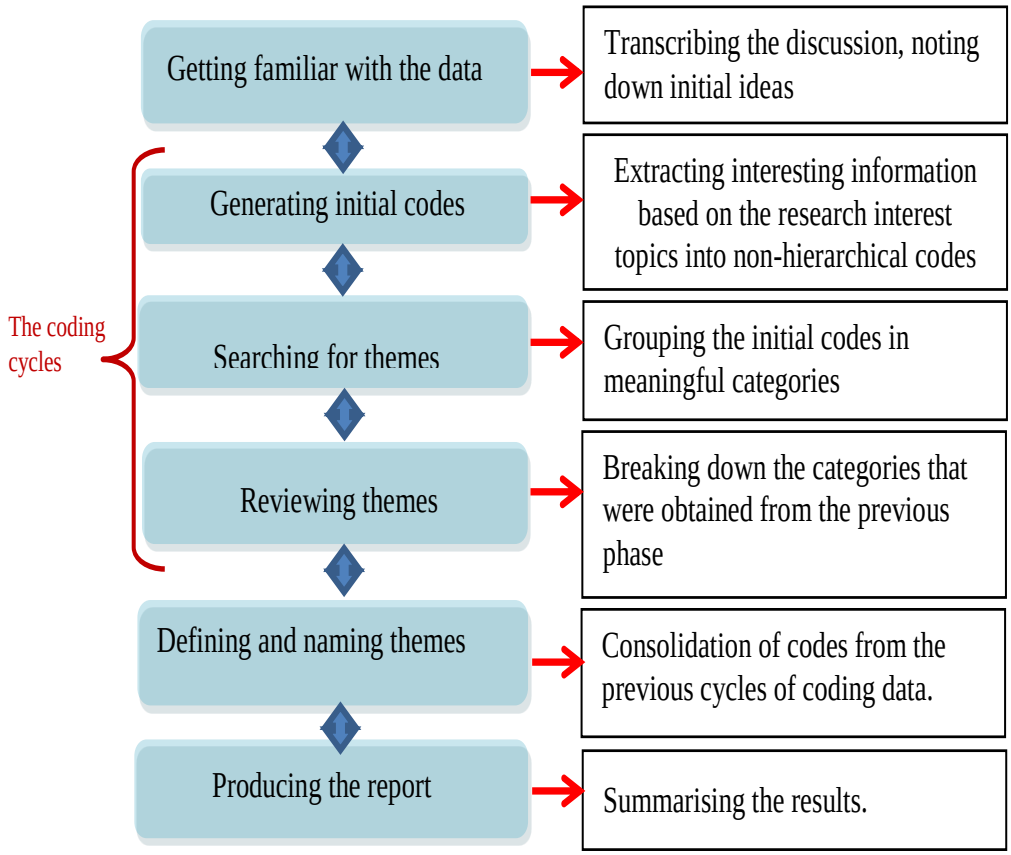


Figure 3.3: thematic analysis stages

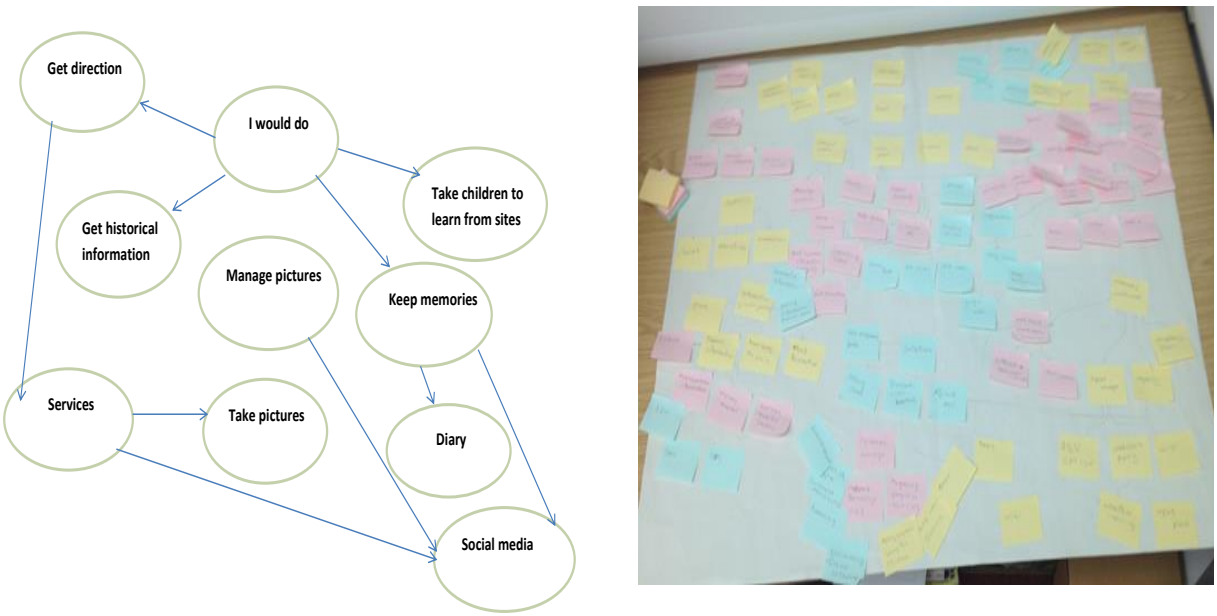


Figure 3.4: thematic analysis stages (the manual version of coding data)

The adopted method consists of six stages that were set out by Braun and Clarke (2006) as shown in Figure 3.3. The coding process was conducted in three cycles: 'generating initial codes', 'searching for themes', and 'reviewing themes'. It is necessary to clarify that throughout the explanation of conducting this method we tend to use 'code' for the extracted information in the first level, 'category' for descriptive level of coding, and 'theme' for a more abstract level (Bazeley, 2009). The details of how each stage of the thematic method was carried out are outlined below.

1) Getting familiar with the data

This stage involved transcribing the verbal data, reading and re-reading through the entire dataset and also noting down some initial ideas.

2) Generating initial codes

This included deconstructing information from its original dataset into initial codes. These codes were assigned clear labels to act as rules for inclusion. The details of coding are given below:

An open coding stage was carried out, which is extracting information from the original dataset into initial 'non-hierarchical codes'. Information was extracted from each participant's transcription to define a node or nodes based on the answer. For example, if the participant mentioned something like generating interests for using mobile devices at cultural heritage sites, the node could be 'Motivations'. As we went through the dataset any similar patterns

were assigned to the nodes that were already defined. When a new piece of information emerged, a new node was defined to assign this new information to (see Table 3.3).

Table 3.3: illustration of generating initial codes

Initial code	The quote
Seeing cultural heritage in the past, brigs it to life	"… it's putting flesh on the bones, like if you went into a castle that was ruined and then if you saw how it was in the past and it's just bringing stories to life put flesh on bones" "…so technology can be really useful but primarily on the site I think its bring to life for people in real time is important things"
Financial issues	"…when I travelled to another country I don't use the internet on my phone because of roaming cost" "…I guess only the negative thing is ... the tower of London is quite expensive to go and… 18 pounds for an adult the ticket it's pretty expensive"

3) Searching for themes

This stage included re-ordering initial codes, re-labelling and merging similar codes in order to ensure that labels for inclusion accurately reflect the contents. The initial codes that were identified from the previous stage were grouped together in meaningful categories.

4) Reviewing themes

This included breaking down the categories that were obtained from the previous stage into sub-categories to offer a clear insight into meaning of the categories. Furthermore, it offered an opportunity to review potential themes that might have emerged from the defined categories in the previous stage. Nodes were re-constructed into sub-categories.

5) Defining and naming themes

This stage included consolidation of codes from the three cycles of coding data (2, 3 & 4). Sub-themes were defined and named according to the meaning of each group that resulted from the previous stage.

At the end of the "Defining and Naming Themes" stage, a list of themes has been produced based on the results from these previous stages.

6) Producing the report

Based on the analysis of the data, a report was produced to summarise the analysis stages as well as the results.

3.7. Evaluation methods

A series of empirical studies were carried out to assess the prototype in terms of the aspects of usability, usefulness, and acceptance. Two studies were conducted separately with experts of HCI and end-users. A combination of observation and interview techniques were used in these studies alongside the cognitive walkthrough in the experts' evaluation study and questionnaire in the users' evaluation study. A well-known local site in Portsmouth was chosen to conduct the studies, the Historic Dockyard. This was chosen due to the fact that it is an outdoor setting site with several attractions, which makes it easier for participants to walk around and receive notifications regarding specific attractions.

The experts' evaluation was conducted first to identify any usability problems before testing with end-users. A combination of cognitive walkthrough, observation, and a brief semi-structured interview was used in the field. Experts of HCI were asked to walk around the specified site and follow a number of pre-formulated steps to achieve a number of goals using the app. In addition, they were asked to answer contextual questions after the tour regarding their experience of using the app in terms of interaction and usability aspects to identify any navigation problems (Wharton, Rieman, Lewis, & Polson, 1994). Semi-structured interviews and observations were used alongside the cognitive walkthrough technique to obtain qualitative data from different dimensions.

The evaluation with end-users was conducted to obtain users' feedback regarding aspects of usability, usefulness and acceptance of the app. Four separated sessions were conducted; questionnaires, observations and group interviews were used. The questionnaire consisted of several sections including: usability, usefulness and overall acceptance. The ISOmetric questionnaire was adopted in the usability section (Gediga, Hamborg, & Düntsch, 1999); feature rating was used to measure the usefulness of the app.

3.8. Conclusion

This chapter outlined the research methodology used in this research. The user-centred design approach was adopted in this research using the SCE methodology. SCE consists of two stages: analysis and design, which are pulled together to introduce new technology-supported artefacts. A mixed methods approach was used to conduct three field studies to investigate user requirements utilising focus group, questionnaire and interview techniques. A task model in a

form of theoretical framework was formulated based on the results of the field studies along with the learning theories. A set of general requirements was drawn out from the framework to help with conceptualising the design, which in turn informed the design. A scenario-based design method was used to visualise the design concept in order to identify the context of use. A set of low-level requirements were pulled out from the scenarios to guide the design of the new technology, which identified the possibilities of the design space. High-fidelity prototyping was adopted to illustrate the possibilities of the design space in an interactive manner, for which some features were chosen to be translated into a working system using android programing. Experts of HCI and end-users evaluated the prototype in terms of usability, usefulness and acceptance.

Chapter four

4. The focus group study

Chapter 3 outlined the research methodology and methods applied in this research. A sequential mixed methods approach of a combination of three research methods was used in this research to gather user requirements for designing smart and ubiquitous learning environments. The adopted methods include: focus group (details in this chapter), survey (Chapter 5) and interview (Chapter 6). The focus group technique has been widely used for exploring the potential of developing new technologies as well as developing instruments for conducting research (Boynton & Greenhalgh, 2004; Oppenheim, 1992). It was adopted in this research primarily to explore the potential of developing mobile technology for learning purposes at outdoor cultural heritage sites to inform the design of the questionnaire.

4.1. Methods

A focus group discussion (Creswell, 2003, 2007; Kitzinger, 1995) was carried out with the aim of gathering preliminary requirements to inform the questionnaire design. It was conducted at the University of Portsmouth; participants have been recruited amongst the PhD students' community of the University of Portsmouth. Ten people were invited to take part in this focus group study with the aim of recruiting as many participants as possible with diversity of different demographic background, six participants showed up on the day. A Doodle notification was sent to set a day/time that was suitable for everybody who was taking part, in order to organise the meeting; all of them were familiar with mobile technology. It is important to note that the sample selected for this study were chosen from different background to have a wide spectrum of opinions. Four pre-prepared questions have been asked, which are listed in Table 4.1. The discussion took around one hour and twenty minutes, and it has been recorded, and afterward transcribed.

Table 4.1: pre-prepared questions accompanied by the objectives for the focus group study

No.	Questions	Objectives
1	Would you like to write down what comes up to mind when someone says using a mobile device at cultural heritage sites, (e.g. positive or negative aspects, services, environment).	To find out how participants experience and use mobile devices at cultural heritage sites
2	How many of you are using a mobile device?	To find out if participants actually use mobile devices
3	Are you using a mobile device for learning? Why?	To find out if participants use mobile devices for learning and why
4	What do you think, why people would visit cultural heritage sites?	To find out what is participants point of view of what could motivate people to visit sites

4.2. Participants

Six participants took part in this discussion; their age ranged from 28 to 50; three were male and three female; all of them were students. They were from different backgrounds: two English, two Arabic, one Nigerian, and one Indonesian. All of them were familiar with mobile technology and have used it for different purposes; however, they had different levels of interest in cultural heritage.

4.3. Data analysis

The data was analysed using the thematic analysis method that was set out by Braun and Clarke (2006). The researcher went through the original dataset to pull out participants' views regarding using mobile technology for learning purposes; full details of the analysis phases have been described in Chapter 3, Section 3.6.

As this study was conducted to explore the potential of developing mobile location-based learning services, it was essential to increase the reliability of the findings, thus the data were coded in two cycles manually and electronically. First, for manual coding, paper, highlighter, coloured paper and pencil were used. Second, for electronically coding, the QSR Nvivo 10 was used (Bazeley, 2009; Patricia Bazeley & Jackson, 2013). The electronic version was used to increase the reliability of data coding by looking at the data from a different angle; using the

software helped to take in-depth insight into the dataset. It is more accurate than manual coding in terms of avoiding missing some potential themes that might be important, due to the easy-checking facility offered by of the software, rather than going through the transcription manually every time to check (Basit, 2003). A list of themes resulted from the study, which were used as a starting point for the survey study (Chapter 5).

4.4. Results

The focus group study revealed a set of broad themes, which serve as initial requirements for developing a mobile learning service, as well as inform the questionnaire design. These themes are:

- Learners and devices
- The notion of learning
- Motivation and attitude
- Services and features
- Information
- Usability, acceptance and usefulness
- Challenges and interventions

The themes are discussed in detail in the following sub-sections; they are supported by quotes from the participant as strength evidence. It is important to note, any English errors within the provided quotes are due to the material being spoken (not written), as well as the fact that some participants are not native English speakers. These were not corrected to avoid introducing unintended meaning.

4.4.1. Learners and devices

Learners could be categorised as groups and individuals, and also could be categorised as adults (elderly and youngster), and children with their parents, grandparents, and teachers in a school trip. Learners interact with cultural heritage sites using mobile devices such as mobile phones, tablets and wearable devices (e.g. google glasses):

> *"direction of mobile technology, where going, so, not necessarily based on what happening now, what might be popular in the future, google glasses emerging, is that be soothing, is gonna take off…".*

In terms of mobile applications (apps), participants reported that it is important to consider all types of devices to meet the different interests of people, "*…different people has different preference"… "…what kind of apps that people comfortable with?*".

A common view amongst participants was considering a user profile. Participants stressed that it is important to consider user preferences, "*…personalize your app to suit your convenience…*", which encourages designing a user model that takes into account user's preferences based on user's interests (Cocea, 2011).

4.4.2. The notion of learning

The discussion has revealed different opinions about what the notion of "learning" means. One participant considers learning as the process of getting information through academic courses only, so, mobile learning is the facility to access online courses through a mobile device, such as MOOCs (Massive Open Online Courses). The rest were divided between considering learning as: (1) the process of retrieving information and retaining it for using when needed regardless of the sources; (2) any type of information that people obtain during their daily life (e.g. looking at trains or buses time):

> "*For instance, if you trying to look for a route and look at on your mobile phone, the next time you gonna go to this place you know how to use the map, you learnt something. If you look at train times, you gonna learn that…"*

4.4.3. Motivation and attitude

Participants had diverse reasons for visiting cultural heritage sites and also for using a mobile device whilst there. The main reasons that motivate people to visit cultural heritage sites are: (1) learning, (2) entertainment, (3) discovering other countries' cultures. Some participants stressed that visiting historical sites could play a significant role in helping people to learn about history, either for themselves or their children: "*I would like to take my children to historical site to help them learn from them…".*

Moreover, some participants pointed out that the nature of people who are interested in heritage sites and enjoy history, would drive them to visit these sites. Entertainment could be a reason for visiting cultural heritage sites. Curiosity in discovering cultures, either their own cultures or other communities' cultures, might influence people to visit heritage and historical sites:

> "*…I might go to visit cultural heritage or historical sites if I am on holiday in another country*", *"I would discover society's cultures, so the best way is to visit cultural heritage and historical sites…* ".

Additionally, there was a sense amongst participants that mobile apps that provide almost all services visitors/learners could need at cultural heritage sites, would encourage them to use these apps as all their needs are addressed in one single app.

4.4.4. Services and features

The main debate in the discussion was about some existing services that are being used by people, which could be utilised for cultural heritage contexts; for instance, the 'Google Now' app that notifies people about aspects based on their interests (Google, 2014). Some features they are hoping to find in a mobile app were mentioned, such as connecting the app with the social media to share information and photos; keep memories and manage pictures and diaries*:*

> "*…I go there, I want see memories, I wanna write down, take picture and save them…", "what about integrating with social media whatever you do, because you wanna to keep [memory] some people like Instagram and stuff like that to keep memories*…"

Furthermore, provision of interesting services may motivate them to visit cultural heritage sites. For instance, providing some useful information about some interesting aspects or facilities that could bring people's attention, "*… I like Charles Dickens; probably I wanna have coffee in place like Charles Dickens' lounge…"*

In addition, participants claimed that it is important to provide information in different formats, such as text, images, audio and video. Moreover, it would be advantageous if the service can provide different styles to present historical information, such as a story narrator, that might attract children, which in turn encourages parents or grandparents to use it when taking children for a day out, *"…they can listen to a story while they are visiting the site…"* or utilise a quiz information style, "*...quizzes for example…", "... you can make [quizzes] in different levels…*". Finally, participants suggested providing a unique and international code to be recognised everywhere which will help the app to be for global use.

4.4.5. Information

Information plays a significant role in developing mobile learning services for cultural heritage contexts. The reliability and usefulness of the information could encourage people to use this app. The debate in the discussion was about how people can obtain the right information at the right time. Participants stressed that the quality of the information and the way that could be obtained is very important in terms of: (1) generating reliable information, which should be generated immediately in real time; managing and maintain data in an efficient manner,"…*how many places you gonna generate this information for, is just England!?*…". (2) pulling information from the cloud, which is easier in terms of avoiding the need to be generated immediately, however, it needs to be checked in terms of authenticity, "…*if you are using information from the cloud, you have to think about the authenticity*…" .

Moreover, participants suggested providing some other useful information – for instance, how busy the site is on a particular day or at a specific time, or some information about transportation to the site. This information could be helpful in terms of avoiding a crowded day or to know about the type of transportation that is available,"…*it can give you information like taxis, buses, it could be helpful or how far from the bus station*…". In addition, participants mentioned that enabling users to review comments that were generated by other visitors might help them to have an initial idea regarding historical sites before the visit.

4.4.6. Usability, acceptance and usefulness

Participants highlighted some factors that may affect people's acceptance of using a new technology, such as ease of use, as well as provision of useful features and information. Participants stressed that a complicated app that asks many questions and offers many and unnecessary choices could make it difficult to use, which may dissuade people from using it,"…[*if the app is] more complicated, more interaction and more question you will lose number of users…* ".

Additionally, participants suggested giving users a choice to disable or enable some services when not needed (e.g. switch off the notification service). This could give them an opportunity to choose what they prefer to acquire in a certain time. That may motivate them to use the app in a way they do not feel restricted, *"… make it easy when you can switch things off or not…"* – this would provide users with different levels of interaction and thus, satisfy the diversity of interests, which would increase satisfaction.

4.4.7. Challenges and interventions

Participants underlined some challenges regarding using mobile devices at cultural heritage sites, such as poor network quality in some remote places. In addition, the small size of the screen of some devices, such as mobile phones, might not be comfortable for elderly who have sight problems, so they might prefer to use tablets – "*…that is an implication for elder people who may be would find it difficult to look at a small screen…*".

The scalability might cause a problem in terms of the amount of retrieved data. For instance videos and images tend to take a large amount of space in a mobile device memory (Alkhafaji, Fallahkhair, & Cocea, 2014). That could be an interesting aspect for further research.

Furthermore, participants pointed out that to help people engage with the app, a level of trust must be established – "*… [people] may not feel comfortable with something knows where they are…*". Confidentiality is an important aspect in such apps; people might not like apps that ask for personal information. This might lead to issues about why the app asks all these questions or how it knows about a particular aspect:

> "*…when google suddenly gives you an advert about some stuff you've been looking at, you are thinking how it knows that, and you thinking am not sure I like this…".*

In addition, participants, emphasised that there are some people, probably the old generation, do not feel comfortable with new technologies and may find it challenging to use, which may affect their attitude towards using mobile devices:

> "*…is just I personally wouldn't, because I don't have that sort of easy to use a mobile phone…*", "*…there is a generation of people who like to have a physical book rather than an app…*".

However, it would be more useful to provide some interesting features that could bring their interest and encourage them to use it at cultural heritage sites; for instance, tailoring the app based on their interests or making it user-friendly:

> "*…is like a trigger that makes somebody who never use that kind of things go and use it…", "...I can remember saying I would never have a touch screen phone…then few years later you get you can't imagine life without it…".*

Finally, another interesting issue was mentioned by some participants who reported that the weather could be considered as a problem in the UK, which may prevent people to use their mobile devices in outdoor settings. However, some participants stated that using a Bluetooth headphone set might solve this problem.

Altogether, the results of the focus group discussion act as a preliminary stage of gathering user requirements. They gave an elementary idea about how people would like to use mobile technology in cultural heritage contexts. In the other words, the results show how people would like to interact with the contexts via mobile app services. In turn, they helped have a deep insight regarding the interaction between users and the contexts, which served as a foundation stone to carry out further research as well as designing the questionnaire.

4.5. Summary and conclusion

This chapter presented the first study within the series of three studies to gather user requirements. This study was conducted using focus group to explore the potential of developing mobile location-based learning services with respect to cultural heritage sites as well as to inform the design of the questionnaire for the next study, which is the questionnaire survey study. The thematic analysis method was adopted to analyse the qualitative data; a set of broad themes resulted from this study: (1) learner and devices; (2) the notion of learning; (3) motivation and attitude; (4) services and features; (5) information; (6) usability, acceptance and usefulness; and (7) challenges and interventions. Based on these themes, a questionnaire was developed for the next stage of this PhD research, to design and conduct the survey study for gathering users' requirements; the survey study is presented in the next chapter.

This study encountered few limitations which will be addressed in the next two studies; the limitations include: (a) small-scale of six participants; (c) limited to PhD students. Although this study was small-scale with six participants, it gave in-depth preliminary requirements for carrying further research. Two studies (quantitative and qualitative), which included more participants with wide-range of demographics, followed up to overcome the limitations of the focus group study (see Chapters 5 & 6).

Chapter five

5. The survey study

The previous chapter presented the first step of gathering user requirements, i.e. the focus group study. The themes identified in the focus group study were used in the development of the questionnaire for the survey study, with the aim of collecting user requirements from a larger and broader user base. The survey study was conducted to have a broad insight regarding developing such services.

5.1. Methods

A questionnaire technique (Blaxter, 2010; Creswell, 2003; Lazar, Feng, & Hochheiser, 2010) was utilised which was delivered to participants either online, via SurveyMonkey, or on paper. The questionnaire was designed based on the themes that resulted from the focus group study (see Section 4.4). However, the questions of the questionnaire were not grouped around the themes as some questions covered several themes.

A pilot test was conducted to evaluate the validity of the questions with volunteers consisting of experts of HCI and end-users, which helped enhance the questionnaire design by pointing out the weaknesses of the questions. The questionnaire involved different sets of questions: multiple choices with one option, multiple choices with several options, and open-ended questions (see Appendix A).

Non-probabilistic sampling was adopted using the convenience sampling method to recruit participants (Barnett, 1991). In order to reduce chances of bias, the questionnaire was distributed amongst adults via multiple channels with the aim of recruiting participants with a wide range of diversity in terms of demographics, channels were: (a) the University of Portsmouth student and staff community via staff and student emails; (b) social media via Facebook; (c) University of Portsmouth Heritage Network (UoP Heritage Network) via Google Community; (d) and the University of Portsmouth Ageing Network (UPAN). The questionnaire was sent to approximately one thousand people. The study was carried out between 17th Feb 2015 and 17th March 2015.

5.2. Participants

189 participants responded to this survey; the participants' age ranged from 18 to 70+ years old. 47% of participants were male and 52% were female. The vast majority of participants (86%) lived in the UK with the remainder in a number of locations. 47% of participants were students, 33% were employed and 12% were retired. The remainders were: unemployed (4%) and self-employed (3%). Additionally, 3% of participants stated different occupations such as researcher, independent, and semi-retired. Some participants stated two different occupations such as student and part-time employee, which explains why the total is more than 100%; and one participants did not answer the gender question.

5.3. Data analysis

The main objective of this survey study is to have a broad insight regarding the popular activities and services among participants via mobile devices. A secondary objective is to have a wide spectrum of opinions regarding how they would like to use mobile technologies at cultural heritage sites and their preferences when using such technologies. The paper-based data was integrated with the SurveyMonkey data via the "adding data manually" link. The data was exported from the SurveyMonky software to SPSS. The data was cleaned in preparation for the analysis by applying the following: (a) missing data was labelled as "No Answer"; (b) deleting the duplicate records. A simple statistical analysis was carried out to obtain frequencies of the nominal data using the SPSS software (Field, 2013; Greasley, 2007). Open-ended questions were analysed thematically.

5.4. Results

The results have been grouped based on the main topics that are involved in this research which include: (1) using mobile devices; (2) cultural heritage and mobile technology; (3) services and interventions; (4) the notion of learning; (5) obstacles and challenges and (6) future intervention. The results are presented in the following sub-sections.

5.4.1. Using mobile technology

The results reveal that the vast majority of people (99%) use mobile devices. Moreover, 99% of respondents use "mobile phones" and 51% of respondents use "tablets" whereas "wearable computing" takes 1% of responses. A possible explanation for the low responses on wearable

computing is that respondents considered only the provided example of "Google glasses", which were not very popular at that time, and they did not realise another devices, such as fitness monitors are also wearable devices as some participants did not tick the "wearable devices" choice, but stated "*fitness monitor device*" in the "other" option. Thus, this result needed to be interpreted with caution and a further investigation was carried out during the next study of gathering requirements (details in Chapter 6). A small number of respondents reported different types of mobile devices such as satnav, kindle, laptop and fitness monitors. Interestingly, the results clearly show that people use different mobile devices for multiple services whilst they are doing their daily activities.

Figure 5.1 shows the popular services that people like to use which include: (1) calling (98%), (2) texting (95%), (3) capturing photos videos and audios (87%), (4) accessing emails (86%), (5) getting directions (using a map) (84%), (6) checking the weather (72%), (7) listening to music or watching videos (72%), (8) learning (62%), (9) playing games (53%), (10) getting a news alert (49%), (11) shopping (46%), (12) managing diaries (42%), (13) financial transaction (41%), (14) 1% of respondents stated "*never do"* use services on mobile phone. Additionally, 7% of respondents stated services that they use through their mobile device including: reading books, storing notes, accessing social media, get sport results, as a clock alarm, as a stop watch, networking with other people, watching TV, checking trains and buses times, listing to the radio, and finally as a recorder.

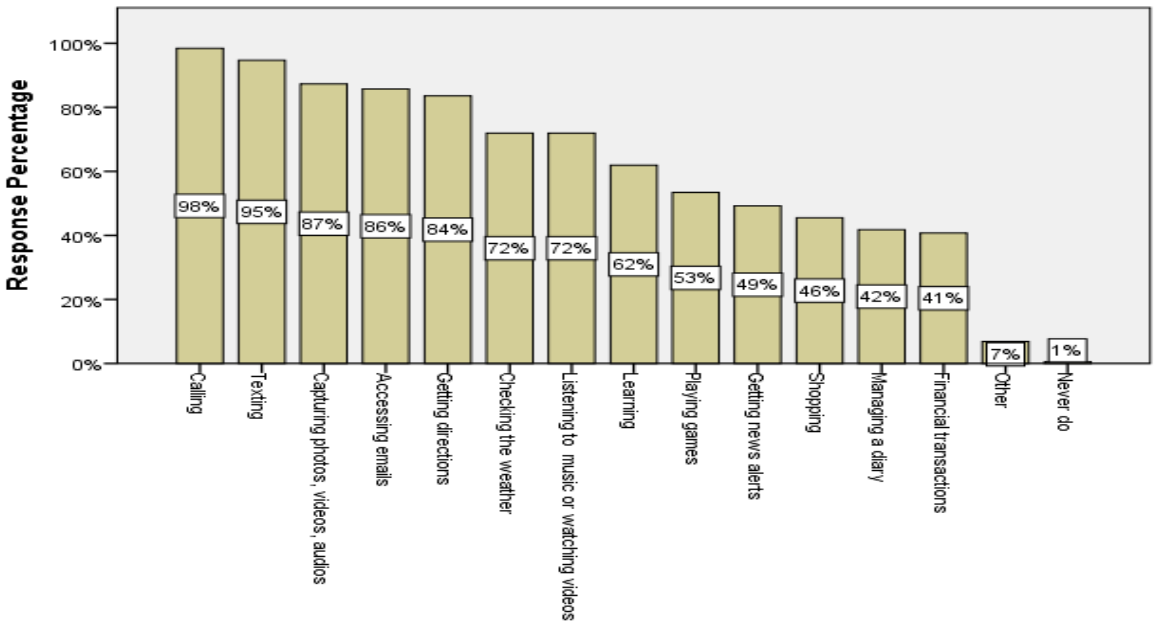


Figure 5.1: what do use your mobile device for?

The results show that people use mobile devices in different places and contexts, which include: at home (96%), whilst traveling (89%), on holiday (78%) and in the office (67%). Some interesting contexts stated by some participants include: in the class, in the university and everywhere as one participant stated (see Figure 5.2).

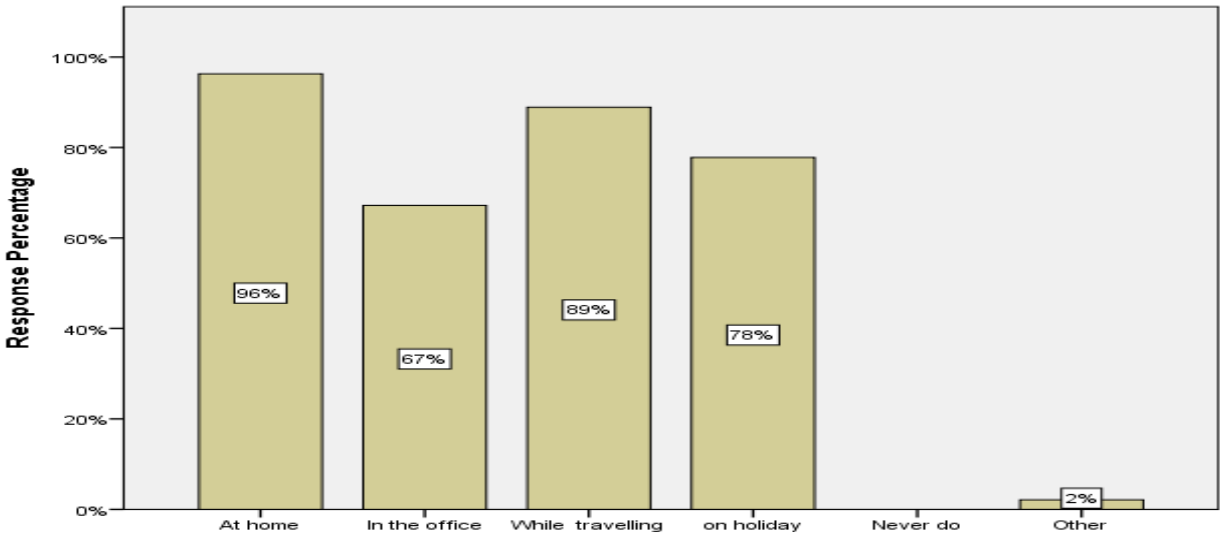


Figure 5.2: where do you use your mobile device?

The results indicate that the vast majority of respondents (82%) use mobile devices for learning on their own. The vast majority of respondents (93%) stated that using mobile devices would assist them accessing information whilst they are moving and doing daily activities. Additionally, the results reveal that people use location services on their mobile phone as 87% of respondents stated they use a map to find out where they are; it is interesting to note that the predominant use of location services is for personal navigation.

5.4.2. Cultural heritage and mobile technology

The results clearly show that the majority of respondents (82%) are interested in visiting cultural heritage sites.

The results reveal that some participants are interested in visiting cultural heritage sites regularly such as once a year (25%) or once a month (16%), whilst 33% of respondents prefer to visit cultural heritage sites when they are on holiday. In addition, some respondents reported that they would visit cultural heritage sites up to 4 times a year. Some respondents stated that they visit cultural heritage sites only during the summer season (see Figure 5.3). In addition to these encouraging results, there are some respondents who hardly ever visit cultural heritage

sites (13%). This may be explained by the fact that participants do not have enough time and also due to the costs issue, as most of the respondents who ticked "*hardly ever*" were students.

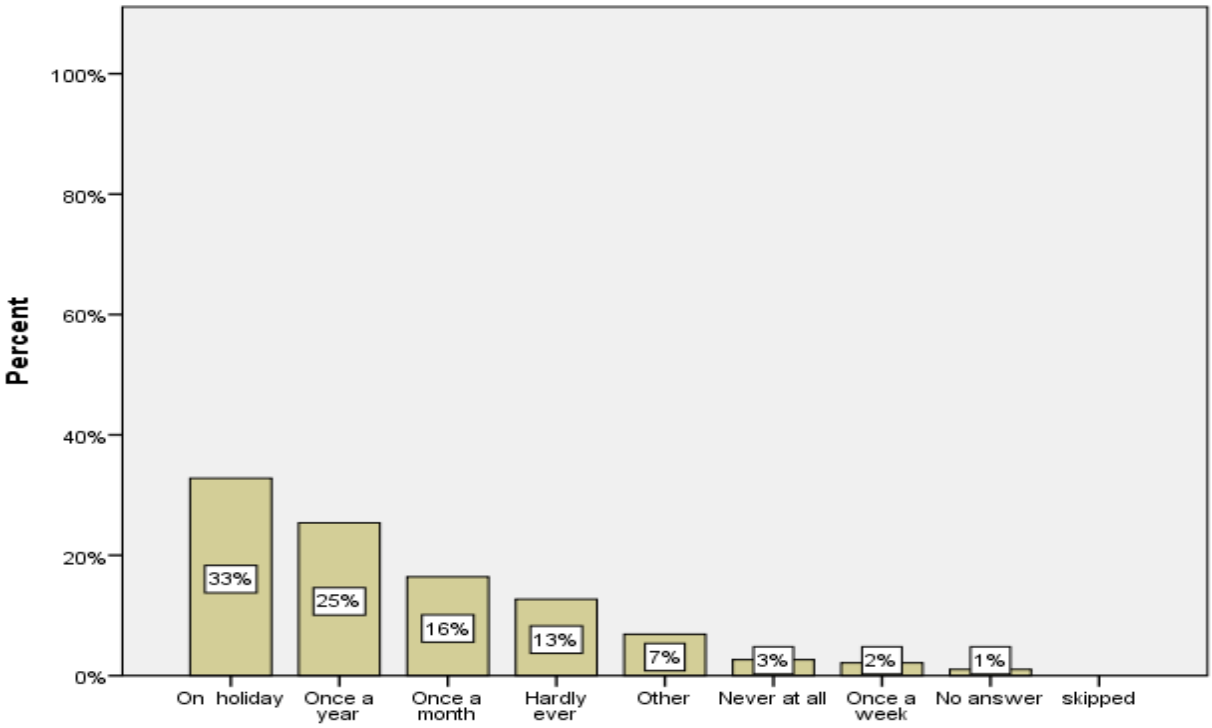


Figure 5.3: how often do you visit cultural heritage sites?

Respondents who were interested in visiting cultural heritage sites, stated some reasons for visiting these sites. The main reason was learning which gained 86% of responses. The other reason was curiosity as 70% of respondents stated that they like to investigate the culture of other communities. The other mentioned reasons were: envisaging the stories behind these sites (58%), entertainment (54%), and for their children sake (35%). Finally, feeling proud and belonging is a reason for some people that drives them to visit cultural heritage sites (33%). Additionally, the respondents reported some other reasons which could be summarised as: (1) people like to see the architecture, and (2) to dream and to imagine being at these sites as they were in the past.

Figure 5.4 shows some aspects that help motivate people to visit cultural heritage sites and using mobile technology there, which include: getting information about a significant achievement in that period of time (66%); listening to a brief description about some events that have happened in a certain place (59%); getting information about how these events affect our current life (56%); watching a simulation might attracts people to go to visit a certain site

(44%). Furthermore, giving people a task like solving a riddle that describes a particular event could be a trigger for some people (18%).

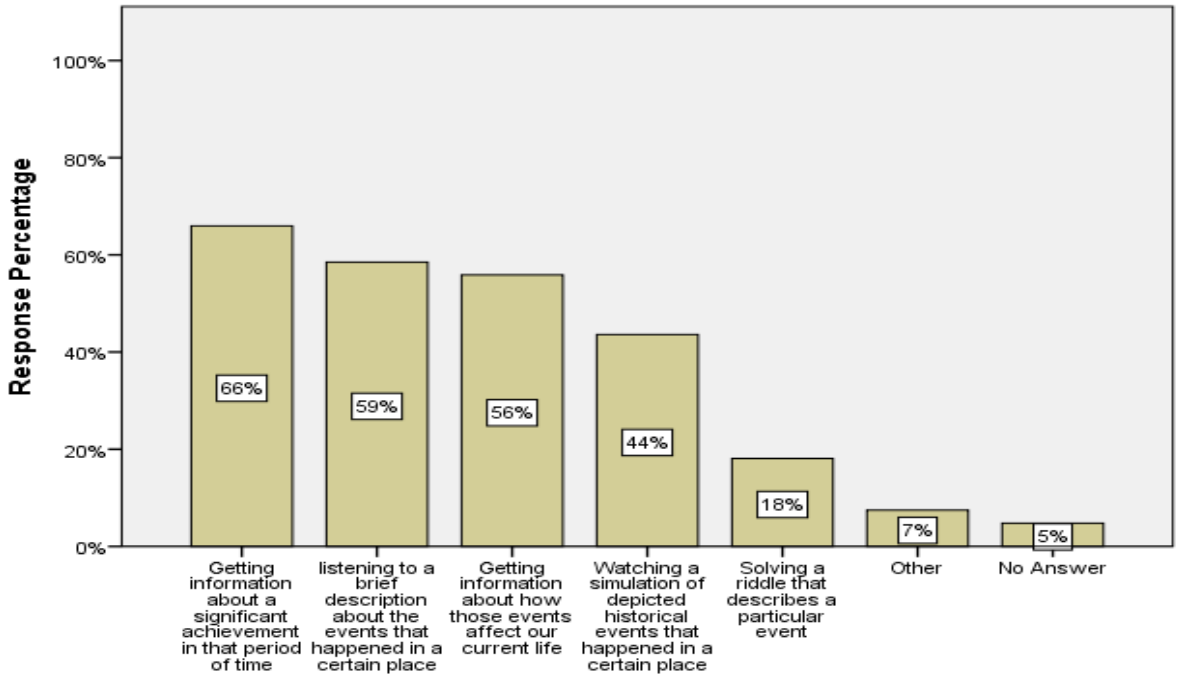


Figure 5.4: motivations for visiting cultural heritage sites

Some participants stated a number of additional aspects that may motivate them to visit cultural heritage sites, such as: reading a brief description about some events and doing some original search. Additionally, an interesting aspect stated by respondents, is imagining events, sites and people back in time; further investigation was carried out to explore more about this aspect in the next study (see Chapter 6).

Another question participants were asked is how they like organising their visit as participants reported that they would prefer to organise their visit in advance. The results reveal some aspects that they would like to do, which include: checking prices (78%), checking the distance (70%), checking the weather (62%), checking the transportation (61%), and also reviewing comments online (56%). Some participants mentioned more aspects such as checking reliable websites (e.g. National Trust) and checking the location.

Results emphasise that people would prefer to use mobile devices at cultural heritage sites as they believe it facilitates accessing information about their history. 76% of respondents stated that they would use mobile devices at cultural heritage sites and also 89% reported that mobile devices would facilitate getting information regarding the history of heritage places. Some

respondents stated some mobile apps that they normally use when visiting cultural heritage sites as 24% of respondents use mobile apps as a guide at cultural heritage sites. These apps include the on-site apps that are provided by some sites such as Bletchley Park and Spinnaker Tower. Moreover, some people use Google map, Wikipedia, and the official website of a certain place.

5.4.3. Services and interventions

With respect to how people would like to receive historical information, the results show that 72% of respondents prefer to receive formal information, 59% prefer to receive information as stories, 15% of respondents like quizzes and 13% like solving riddles that describes historical information. Additionally, some participants stated different styles for receiving historical information, such as labelling, researching (i.e. enabling research about a particular site and use all types of resources such as word-of-mouth), and seeing some pictures about how the site used to be in the past. The results suggest that images and texts are the most popular amongst respondents as 74% of respondents reported that they prefer images, 70% of respondents prefer texts, whereas 49% of respondents preferred video and 47% preferred audio.

Participants stated that they would like to use different services at cultural heritage sites including : (1) getting directions (75%), (2) finding the nearby cultural heritage places (65%), (3) finding the nearest services (56%), (4) getting historical information while walking around (53%), (5) finding out extra information about the sites (53%), (6) pre-organising the visit (50%), (7) sharing aspects (such as pictures and videos) (37%), (8) getting a set of recommended sites based on user's profile (35%), (9) listening to a description about the event of a certain site (34%), (10) connecting the app with the social media (31%), (11) saving their favourites sites (29%), (12) designing their own tour (28%), (13) using a camera (28%), (14) receiving notifications based on the user profile (25%) – further investigation was needed regarding this aspect, (15) considering the surrounding environment (20%), (16) generating a comment (15%), (17) creating a network with friends or family during the trip (14%), (18) personalising the app (10%) (see Figure 5.5). Although only 10% of respondents ticked *"personalise my app"* as a favourite service, 62% of respondents ticked "*Yes*" for customising their app, which means people do like customising their apps. This inconsistency might be due to how respondents construe the term of "*personalising the app*" as they might not realise that these two terms refer to the same concept. A further investigation was carried out in the next

step of gathering requirements for exploring more about personalising the app as well as receiving notification based on the user profile.

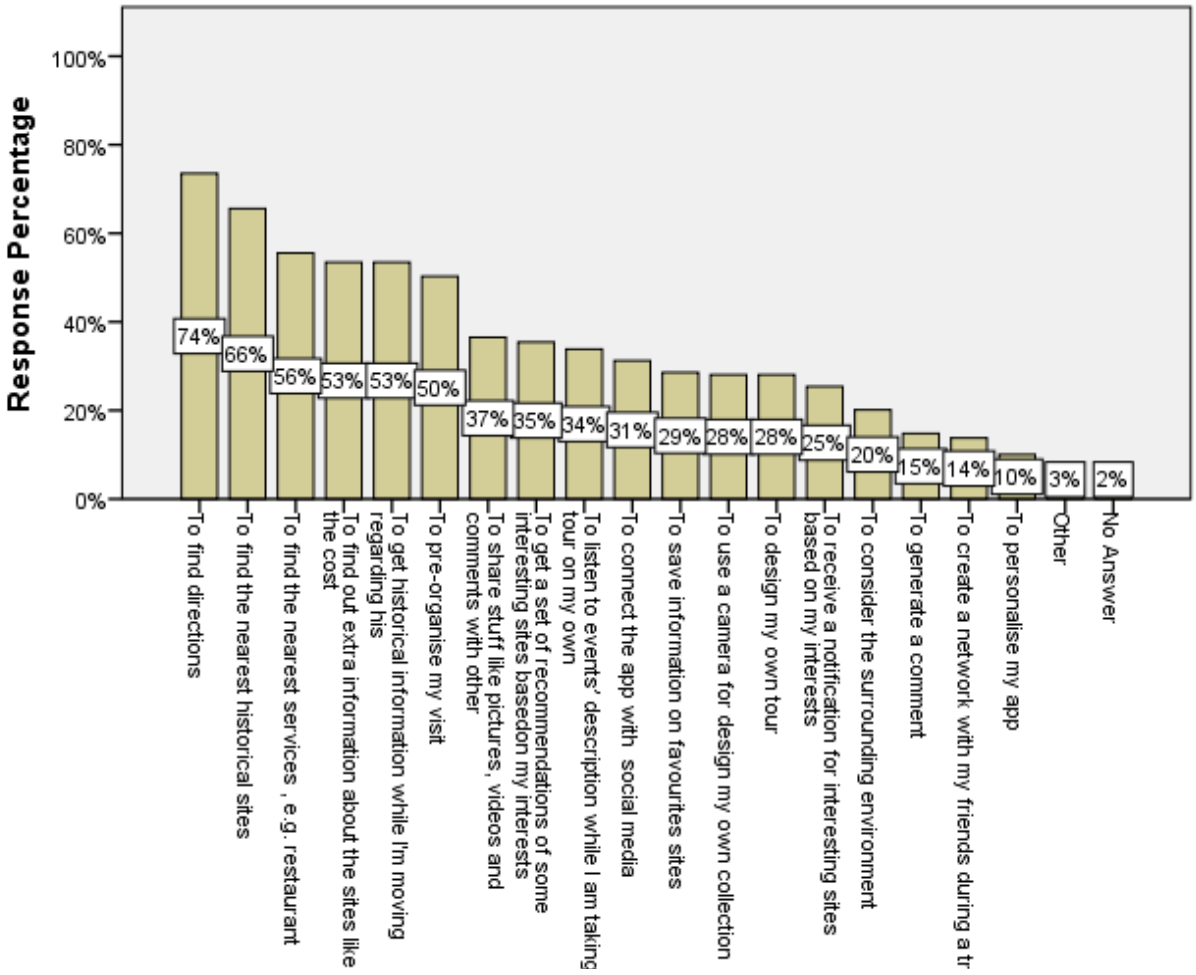


Figure 5.5: the suggested services

Participants were asked to state up to three features that they would like to customise. The most popular features that have been stated by participants are: (1) language, (2) colour, (3) delivery format, (4) information, and (5) font. Noticeably, the responses to this question are relatively poor as around 50% of participants did not answer this question. That might be due to this being an open-ended question, as it was noticed throughout this study that people preferred the multi-choices questions.

5.4.4. The notion of learning

In order to profoundly understand how people perceive learning, participants were asked to choose the services that they think are considered a type of learning. The results reveal that 85% of respondents considered online courses as learning, 78% of respondents said accessing

online services is a type of learning, 76% of respondents regarded that accessing specific information is considered as learning and 67% of respondents considered using a dictionary as a type of learning. Interestingly, only 36% and 31% of respondents believed that accessing general information and getting directions respectively, are types of learning. It is worth mentioning that some people suggested other aspects that they consider as a type of learning, which include using Google, booking holidays, playing games and accessing learning videos on YouTube.

Using mobile devices for learning supports the learning on-the-move concept as it would facilitate acquiring information while moving around doing daily routines.

5.4.5. Challenges and Obstacles

The results highlight some challenges regarding using mobile devices for learning purposes at cultural heritage sites. Some respondents stated that they do not use mobile devices for learning purposes (18%). These respondents were asked to state what is/are the reason(s) behind not considering using mobile devices for learning. 29% of them stated they prefer paper-based resources, 18% of respondents stated there are no interesting applications, 12% of respondents stated it is too complicated to use, and 6% of respondents stated there is no interesting content; finally, the majority of respondents stated other reasons for not using mobile devices for learning purposes. These reasons could be summarised as: capabilities of mobile devices; preferences of using a home PC; difficulties to use mobile devices; and information is not very well-organised.

Another issue was that some people disliked visiting cultural heritage sites for different reasons, which form 18% of responses: (1) 50% of them reported that they are not interested, (2) 44% of them said they do not have time to visit, (3) 39% said it is expensive, (4) 12% reported different reasons for not visiting cultural heritage sites such as: visiting cultural heritage in other countries, and also not liking some kind of sites e.g. cathedral, "*Cathedrals are scary*"; as with some other questions, some participants considered the provided example only. However, two participants noted that they were not sure how to answer this question, which might be due to not understanding the question well as they were not native speakers.

Finally, some participants said that they do not use mobile devices at cultural heritage sites (23%); respondents stated several reasons for that: (1) 57% of them claimed that the mobile device distracts them during the tour, (2) 20% of them do not use mobile devices due to the poor network quality, (3) 13% of them reported that it is not easy to follow the instruction,

(4) 11% of respondents said that the available applications do not meet their needs. In addition, 15% of respondents reported different reasons which include: weather limitations, "*would need a waterproof tablet*"; not using it on holiday, "*Don't take mobile on holiday and only visit sites on holiday*"; preferring to get information using a laptop at home; some people claimed that a mobile device is not suitable to be used for learning from cultural heritage sites.

5.4.6. Future intervention

Participants were given an opportunity to add any comments or suggestions. Due to the fact that this is an open-ended question as it was pointed earlier, a small number of participants responded; some suggestions were added, which might help in designing such services. As was pointed earlier, the results confirm that people like to customise their mobile app. Some participants emphasised that it would be more helpful if the app customises itself based on user's history:

> "*I would prefer that the app customized itself based on my previous experiences. I rarely use customizations like colours, but I like services such as Google Now that customize themselves based on my history".*

Moreover, some participants suggested to give an estimation of time for completing the tour especially at a large site. In their point of view that would help manage time and choose the important parts of the site. In addition, participants stressed that providing some extra information that could be available prior to the visit would be useful such as cost and family activities. Another important suggestion was to give an option to switch off the service when it is not needed: *"Device needs to be flexible as user may not want it on all the time".*

Rather contradictory, some participants stated that they do not believe in technology, and that mobile devices are not suitable for such services. Some others pointed out that their mobile phone is old and has no capability of accessing the internet, "*I have not yet started using IT on a mobile. I only use a simple Nokia for texts and calls",* however, these were only from two participants.

5.5. Summary and Conclusion

This chapter presented the survey study that was conducted as a second step within a series of studies to gather user requirements. The questionnaire technique was utilised to gather broad requirements. The questionnaire was designed based on the themes resulted from the focus

group study. 189 participants (potential end-users) responded to this survey, which were recruited using convenience sampling. The results of this study show no real correlation between participants' demographic characteristics and the popular services and activities. Some findings of this study needed to be explored further before drawing final conclusions as: (a) they seemed not very well perceived by participants, or, (b) they refer to a trendy aspect or technology, which include: learning collaboratively, using wearable technology, seeing life back in time, applying personalisation mechanisms for mobile apps and receiving notifications based on current location. Although the results indicate that participants differ in perceiving learning in general and using mobile devices for learning in particular, they clearly show that participants use mobile devices for learning while they are moving around but they do not necessarily realise they are doing so. That clearly supports learning on-the-move as mobile devices facilitate receiving information while on the move due to their nature in terms of the size and the practical aspects of using them without so much effort.

The last step of gathering requirements was conducted using the interview technique, which helped gather in-depth requirements as well as carry out a further investigation regarding the aforementioned findings of the survey study. As the majority of respondents of the survey study were students, the strategy of recruiting participants for the interview aimed to balance the diversity in terms of occupation by excluding students which otherwise might introduce bias. The interview study is presented in the next chapter.

Chapter six

6. The interview study

The survey study that was presented in the previous chapter using the questionnaire technique helped obtain broad insight. This chapter presents the interview study that helped obtain further and deeper qualitative insights regarding the use of mobile technology for learning purposes at cultural heritage sites. In addition, this study was carried out to further research about some findings that resulted from the survey study such as: (a) learning in a group, (b) using wearable computing (e.g. smart glasses), (c) seeing life back in time, (d) receiving notifications based on current location, and (e) personalising mobile apps.

6.1. Methods

A semi-structured interview technique was used in this study to collect qualitative data to obtain more details regarding how people use mobile devices for learning. The interviews were designed based on the results of the survey study (see Chapter 5); an in-depth investigation was carried out regarding some issues that have arisen from the survey study alongside gathering user requirements. For example, learning collaboratively and using wearable computing (e.g. smart eye glasses) are investigated further, as the previous results suggested that: (a) people might not prefer learning in a group; and (b) people might not be very keen to use wearable computing for learning. In addition, the personalisation of mobile apps and receiving notification based on user profile are also being investigated. Moreover, an interesting aspect that emerged from the results of the survey study, which was seeing sites to the way they looked in the past needed to be further explored. Although this aspect appeared in comments a couple of times in the survey results, this research carried out a further investigation to explore its potential as the trend of technology at the time was moving towards giving people an opportunity to experience life back in time – some museums adopted such technologies such as the British Museum (BBC, 2015).

Potential end-users and official staff members of cultural heritage sites participated in this study. The end-user participants were recruited using two different methods with the focus on participants who are not students in order to balance the diversity in terms of occupation which

otherwise it might introduce bias. First, this research targeted the participants of the survey study who have accepted to be interviewed. One participant was selected from each age group (i.e. 19 and under, 20-29, 30-39, 40-49, 50-59, 60-69, 70+); three out of ten participants responded to the request. Furthermore, this study also used a convenience sampling of five participants from outside the survey respondents' community, as well as recruited official staff who worked at Historic Dockyard. Two different sets of questions were used for staff's and end-users' interviews. End-users were asked about their attitude and behaviour regarding using mobile technology at sites, and also about services they use at sites and other services they would like to include with such apps. Members of staff were asked mainly about technologies sites actually use to present information, as well as what needs to be provided to improve visitors' experience at sites. An email was sent to each participant separately to state the date and time for the interview. The interviews were recorded; their duration ranged between 25 and 50 minutes.

6.2. Participants

Ten participants took part in this interview study; eight were potential end-users and two were staff members of cultural heritage sites. The end-users were aged between 28 and 70, two males and six females; all of them were interested in cultural heritage, and all of them lived in the UK. One was Polish, while the remainder were British; one was retired and the rest were employed. The staff members worked at the Historic Dockyard. One of them was working in the international museum of the Royal Navy and the other was working in the Mary Rose museum. It is worth mentioning that four staff members, who were working in the Historic Dockyard, were contacted; only two of them responded. Moreover, a couple of emails were sent to the general email-address of the Historic Dockyard requesting participation in this research, but unfortunately, no response was obtained. Likewise, two emails were sent to the Portsmouth City council for the same purpose, one sent to the general email-address and the other targeted a member of staff who seemed to be in charge of heritage places in the city; similarly, there was no response.

6.3. Data analysis

A thematic analysis method was used to analyse the qualitative data (Braun & Clarke**,** 2006**)** as explained in Chapter 3 (section 3.6). The QSR Nvivo 10 computer software was used to support the analysis in terms of managing and organising data **(**Bazeley & Jackson**,** 2013**)**. It

was necessary to have a second iteration of coding, which gave a level of validation of the findings of the first iteration. The second iteration was carried out by a junior researcher who was disconnected from this research. The junior researcher generated initial codes with samples of quotes of the interviews. The resulted initial codes were consistent with the original initial codes performed by the researcher of this PhD research.

The opinions of officials were analysed separately and then added to the related themes as strength evidence. Officials were asked mainly about: (1) the current technologies that they are using to present historical information, (2) how they restore their data, (3) challenges they encounter, and (4) recommendation to enhance visitors' experience at their sites. A list of themes resulted from this study; details are presented in the next section.

6.4. Results

The qualitative approach that was used in this interview study helped obtain a further and deeper insight into how people use or would like to use mobile technology for learning purposes with respect to cultural heritage contexts. As it has been reported earlier, this study carried out a further investigation regarding some findings that resulted from the survey study. The results of the further investigation showed that the aspects of learning in groups and using wearable computing for learning at sites are popular amongst interviewees. Additionally, interviewees showed a great interest in personalisation of apps, as well as receiving notifications on-the-move regarding cultural heritage sites. Moreover, seeing life back in time attracted all interviewees significantly; details of the investigation's results are given below.

The results of this study suggest a set of broad themes which show some similarities with the themes that resulted from the focus group study. The themes are: (1) learner's characteristics, (2) learning content, (3) useful information, (4) learning on-the-move, (5) experiencing life back in time, (6) wearable technology for learning, (7) learning types and preferences, (8) services and activities, (9) devices and context of use, (10) learning in the context, (11) interaction with the contexts, and (12) challenges and obstacles. The strength evidence that was obtained from the officials will be mentioned where appropriate.

6.4.1. Learner's characteristics

Participants emphasised that people differ in their characteristics and learning habits. Different groups of people in terms of demographics visit cultural heritage sites and these different groups typically have different needs and interest. Different types of visitors, in terms of age,

are visiting cultural heritage sites every day including children, adults and elderly. Also, visitors could be a school party, families, groups of adults or individuals. In addition, this study suggests visitors of cultural heritage places have different reasons to visit and get motivated differently. Some participants reported they visit sites for learning from sites, whereas some others visit to enjoy themselves and feel the places. In addition, exploring the culture and history is a reason for some participants for visiting sites.

All these types of visitors have different preferences, thus, it is important to consider them in designing new learning services, as otherwise some groups will not be using them. Participants stressed that it is significant to introduce a learning service that meets learners' needs, as six participants mentioned this aspect.

However, an interesting point of view was raised as one interviewee claimed that personalising the app might prevent people from finding out new aspects that could be interesting:

> "*I'm usually interested in practically in anything and everything, so I always want to find out what's round the next corner what am I missing, natural curiosity*".

Staff members mentioned that their visitors differ in how they experience the sites and also they come to visit in different types of groups:

> *"…some people they really like reading and read every label in that home place, another people just looking into the videos…"*

> *"…there is a school party for children may be 10-11 they will be other visitors who in their eighty's, and will be people my age [fifty's] and would be people younger people with their families…"*

6.4.2. Learning content

Learning content is an important element in such services as it is the material that learners use to learn. Participants mentioned different types of information that they would like to have regarding cultural heritage sites. These types include: (a) archaeology aspects; (b) development of the site (i.e. how the site has developed over time; (c) hidden stories; (d) interesting facts; (e) people's life back in time; (f) sense of discovery (i.e. keep some information as a mystery to encourage people to visit sites to discover more); (g) how people back in time used to live, "…*what is the reality of people who lived and provided the infrastructure…".* In addition,

participants emphasised that they would like to receive information that motivates them to visit cultural heritage sites before the visit has taken place such as human achievements back in time.

Participants showed a great interest regarding an aspect they described as interesting, which was the addition of personal experiences and stories that people may have witnessed regarding some sites, alongside the historical information. Some participants found that it is quite interesting and could bring the sites to life:

> "*…it makes it a lot more personal it makes it a lot more human, that is not just a piece of bricks, but it brings the whole personal angle to it a new level that someone actually experience it someone has done something that it's important or it's an important memory for just particular person, that I don't know when they were child or when they were growing up or something, and it's something happened and it worth share, I think it would be really interesting that those personal experiences of people yeah, absolutely, just it takes you into a different level it's not just dry facts, in 1973 this happened and 2008 this happened, yes it's interesting but also having the more personal side of it that would be really interesting"*

Although most participants agreed that adding personal stories to the historical information is interesting, some of them were slightly cautious in terms of the quality of the contribution and also the way that it is written, which might need to be moderated to be worth reading.

In terms of storing the historical information, a member of staff mentioned that they do not have a standard scheme for storing the content, but each museum or site has its own repository, and not necessarily a database. The staff member emphasised that having a joint database that connects at least the related museums or attractions that share the same events back in time would facilitate retrieving data, as well as to make sense of these attractions as one object rather than individual objects:

> *"we have an archive and also a multi branch of the museum we've got at the moment these collection are spreaded across five different sites that we are putting together [approaches] at the moment trying to bring all those [visualises] together"*

6.4.3. Useful information

The results show that the information that visitors of historical sites would like to have is not only historical information, but also other aspects such as getting directions, the weather, and tickets' prices. Moreover, having information about how busy the site is at a certain time is really useful in order to help have a better experience: "*…useful information would be as well, like opening times, prices of tickets, how to get there …"*

However, interestingly, one participants argued that it is quite interesting to not get directions as people might end up in an interesting place and discover new places; in other words, it is part of the experience: *"…because if get lost then that the part of the joy actually because you usually find some really wonderful things by getting lost…"*

6.4.4. Learning on-the-move

The results suggest that supporting people to learn on-the-move could have a significant impact on enhancing learning from cultural heritage sites. Most participants noted they use mobile devices for learning on-the-move when needed. Results show participants are curious and keen to learn about places or events when passing by whilst carrying out their daily routines. Participants stressed that having notifications that providing instant historical information while they are moving would save their time and effort:

> *"…it would be nice if it was telling you a bit more in general rather than reading a guide book or trying to look on the internet which can be quite difficult sometimes yeah I think it [receiving information on-the-move] is a lovey idea"*

Two out of eight end-users reported they do not use mobile devices at sites, as they consider technology as an intrusive tool. However, one of them claimed he might use it if it adds value to the experience.

6.4.5. Experiencing life back in time

Participants expressed a very positive attitude regarding seeing attractions how they looked back in time. Moreover, they reported that they would like to experience life back in time and immerse within the atmosphere of the site. They would like to know how people used to live at that time, how sites have developed over time and how we ended up having what we had in terms of history. Participants stressed they would let their imagination to take over and travel back in time to imagine themselves as part of the life at that time:

"…there is sort of dream like quality to going to older building and filling in the gaps for yourself and imagining and creating how it might have been, and imagining yourself may be with a princess walking down the amazing steps, you with a grand lady having tea in this room…"

Participants stressed that experiencing life back in time would bring sites to life and help people appreciate their history and start to see these sites differently:

"D*uring the war the capital city […] was completely, completely destroyed and absolutely nothing left and the re-built it and for a very long time I absolutely hate it … I think I thought it was the ugliest city in the world ok everything was ugly and I start walking around and you know you have some boards on building saying oh in this place this person did this you know, someone was killed here or something happened here and it made me think about the place differently I just learnt I just realised that it's a place of wonderful history that something you would be proud of something to just tell other people about it thinking it's not just a city it's got these old wonderful stories link to it it's just makes you see the place differently and think about the past*"

6.4.6. Wearable technology for learning

Participants responded differently regarding the use of wearable computing, such as smart glasses, as a second screen for acquiring information at sites. Four out of the eight end-user participants showed a great interest for using the glasses at sites while walking around a site, which would give them free hands. In addition, it supports them receive information regarding artefacts simultaneously while they are looking at them as one participant put:

"..often you have a guide or whatever and in front of you will say 'no 5' and press no 5 and listen to it, but sometimes your eyes just don't look at the right place for whatever reason and that means you miss something, that actually could be interesting to you, so, I guess if you have that kind of technology [Smart glasses] it would make sure you had a full experience and you did not miss anything"

The other four of them showed less interest in using the smart glasses at cultural heritage sites for personal preferences. A probable explanation for that is because it was not quite common to use smart glasses at that time, as they did not imagine how it works. However, two of them

reported they would use the glasses for part of the experience such as viewing sites how they appeared in the past:

> "*I guess as part of the whole experience of visiting a site I wouldn't want the whole experience to be through the glasses, so maybe as part of seeing the reconstruction*".

One member of staff noted the glasses have a lot of potential at their site, which might help visitors to focus on seeing artefacts, as well as on their steps when visiting ships for a safety reason:

> "*I think that have a lot of potential with things like our ships because there is always a safety issue with people going up and down ladders and cases in the ship holding a phone not looking where they going, so I think there is definitely possibility I thought"*

6.4.7. Learning types and preferences

Different types of learning could support different characteristics of learners. People like to learn in different ways, such as in groups (collaboratively) and on their own (individually). Another type of learning that has arisen from the data is social learning, as participants mentioned they liked the social part of some activities, such as geo-cashing; when doing such activities in groups, it would enhance the learning experience as well as promote the sense of community. In addition, they have different preferences for learning either on their own or within groups such as: outdoor activities (e.g. geo-cashing), games, quizzes, listening to stories or formal information, and being in the atmosphere (feeling the sites):

> *"I think I'm more visual and atmosphere person and I think also I like to feel free when I am walking around the museum…"*

Members of staff said they provide different types of activities that help school children to engage as well as understand history. For instance, learning by doing; they offer an activity that allows children to dress up like people back in time, which might help them to learn and at the same time enjoy the activity. Additionally, they provide a service that allows school children at the site to communicate with their friends or relatives online who are not at the site via Skype to show them around. That would give an opportunity to children who could not be there for any reason to enjoy a live tour. In addition, that would be a good choice for children with needs who are not able to be at the site; this could be an interesting direction for further research.

6.4.8. Services and activities

The results show that participants use or would like to use different services and perform different activities using their mobile devices at cultural heritage sites such as looking up information and getting directions. Some services suggested by the current study include: (a) location-based tours; (b) receiving notifications regarding cultural heritage sites based on location; (c) seeing attractions how they used to be in the past; (d) having a service that motivate people to visit cultural heritage sites (e.g. watching a short video talking about significant achievements of humans at a particular time); (e) enabling learners, who are at the site, to share the experience with others, who are not physically there, by making video calls (distance-visit); (f) track visitors' route; (g) sharing the experience:

> *"...probably want an app that connected to audio tours not visual something that I can listen to [on] iPhone for example could track where I am then I would automatically know where I was and be able to give me the correct information based on where I'm standing"*

The majority of participants confirmed that they would like to add comments or reviews regarding historical places, "*…I do sometimes write reviews in the trip adviser, so yes, I quite like to write a review if it's[the site] very good or not so good".* Interestingly, one participant commented that writing a review to report the weaknesses of the site could help authorities to identify what has been missed by an oversight.

A member of staff stressed the importance of harnessing new technologies to enhance the experience of outdoor settings as it would help interpret the site better:

> "*outdoors is the tricky ones for us because it's a heritage site, so there are quite kind of listed buildings on the site and there are quite serious restrictions from the landlord about what we can do around the building, I think there is an opportunity for technology around the outside of the site because ,I think there is [a question about whether the site] is doing any good we can't use it anyway ... I think that's where we struggle interpret the scale of the site, we do very well in the building but less well outside* "

6.4.9. Devices and context of use

Devices are the tools that users use to access learning services, such as mobile phones, tablets and smart glasses. All participants confirmed that they use mobile devices in almost all their

daily activities, "*I use it [a mobile device] pretty much for everything*". Mobile phones and tablets are the most popular devices amongst participants. Some participants mentioned that they use them in different contexts as the mobile phone is used mainly when they are on-the-move, whilst the tablets are used when they are in a more settled situation, such as at home or in the office (i.e. when they are in a sitting position). Others claimed that they use them similarly given which one is available.

6.4.10. Learning in the context

The results reveal that people use mobile devices at cultural heritage in different contexts. The majority of participants would use mobile devices when they are in a new place which helps them in finding their route or finding out more information about this new place. The current data suggests that people visit cultural heritage sites individually, or with a group of friends or family. It was also suggested that being with a group might bring different experiences than being on their own; being with others helps remember information and thus learn more. On the other hand, being on their own helps them enjoy the site and let their curiosity and imagination to take over, and being in the atmosphere which benefits them in holding the sense of the site:

> *"...when I was in [...] for some time just being alone walking through the old town at night and smelling the Jasmin flowers and light was very beautiful, just the atmosphere of that moment hesitates me for that was 2007, I can remember that feel it very personal, personal experience, when you with somebody else may be you talk about, oh its Jasmin that's interesting its feels beautiful, but may be you don't hold this sensation"*

A member of staff reported that learning about the site as a whole would benefit the site significantly, which would help make sense of the site as a one organisation rather that individual museums:

> "*I think the most important thing for us I think is we quite disjointed as a site at the moment, we have three different museum on the site, there is the national museum of the royal navy, there is Mary Rose, there is the worrier and then very different, interpreted very differently and there isn't a linking thread that makes people understand that these one, a whole dockyard it was a single organisation and everything in it ....., that's I think the most important thing we could use*

mobile technology to deal with to help people understand the site rather than individual museums within it"

6.4.11. Interaction with the contexts

The results indicate that people interact with the context in different manners. They use different resources and tools to acquire information whether they are provided by the site or through their own devices. Participants showed interest in having aspects that motivate them to visit heritage places before the visit takes place and they reported different aspects that could get them interested in visiting sites, which they would like to obtain before the visit. In addition, most participants stated that they would like to organise their visit beforehand, which helps in saving their time and effort by having everything prepared, so that there is no need to look for things on the day such as transportation.

The results indicate the majority of participants dislike being overwhelmed with many services and information; they would prefer to have sufficient and effective services that give them just what they need without so much information. Participants mentioned different types of information format that they would like to use via technologies such as text, images, audio and video. Moreover, participants emphasised that they would like the app to promote a sense of discovery, which allows learners to discover things by themselves and leave room for an adventure. In addition, they would like having services that could be adapted based on their preferences. Furthermore, participants preferred to have a choice to switch services off when they are not needed:

"...I think the information that you receive and platform which presented to you are directly affecting how enjoyable the experience was but also the amount of information you take back from it..."

6.4.12. Challenges and obstacles

A number of challenges highlighted by the current study regarding using mobile technology for learning at cultural heritage sites. The challenges could be summarised as follows:

a) Confidentiality: some participants were concerned about sharing personal details with apps which may be used unfairly.

b) Financial issues: the current data indicates that financial aspects could prevent people from either visiting cultural heritage sites or using mobile devices there as stated by a number of participants. It was also suggested that they do not use internet abroad due to the financial

aspects, which might lead them to not use this service as they visit cultural heritage only when they are on holiday.

c) *People's preferences:* individual's preferences could be an issue as some people are not very keen in using technology at cultural heritage sites. From their point of view technology takes their imagination away: *"…I know personally I would get frustrated with technology instead of enjoying being in historical place…"*.

6.5. Summary and Conclusion

This chapter has presented the interview study that was carried out as the last step within the series of studies for gathering user requirements. The study was carried out to gather qualitative in-depth user requirements, as well as carry out a further investigation regarding some findings that resulted from the survey study, which are: (a) learning in groups; (b) using wearable technology; (c) personalising mobile apps; (d) seeing life back in time; (e) receiving notifications based on current location. The results of the investigation were mostly positive regarding the aforementioned aspects. This study used eight potential end-user and two members of staff of cultural heritage sites. The thematic analysis method was used to analyse the obtained qualitative data. A set of broad themes resulted from this study, which are: (1) learner's characteristics, (2) learning content, (3) useful information, (4) learning on-the-move, (5) experiencing life back in time, (6) wearable technology for learning, (7) learning types and preferences, (8) services and activities, (9) devices and context of use, (10) learning in the context, (11) interaction with the contexts, and, (12) challenges and obstacles. Although the results of this study revealed consistent outcomes with the two previous studies, focus group and survey, they have highlighted additional qualitative insights from users that otherwise could not have been captured. The next chapter brings the results of all the field studies together, based on which a theoretical framework is formulated.

Chapter seven

7. Interpretation of the results

The previous three Chapters (4, 5 & 6) presented the field studies that were conducted to gather user requirements for developing smart and ubiquitous learning environments utilising mobile and wearable computing to be used at cultural heritage sites. The field studies were carried out using a sequential mixed methods approach with data gathered using focus group, questionnaire survey and interview techniques. This chapter discusses the results with the aim of pulling them together to formulate a theoretical framework in Section 7.1 and Section 7.2 illustrates how the categories of the framework were formulated and derived from the field studies. Finally, an overall summary and implications of the results are concluded in Section 7.3.

7.1. Discussion

The results of the empirical studies were relatively consistent. The results of both the questionnaire survey and interview studies were in-line with the results of the focus group study, which helped to validate the results despite the fact that the focus group was small-scale with six participants. The results offer a useful insight regarding using mobile technology at cultural heritage sites. As it has been reported earlier, some results of the survey study should be interpreted with cautious, and further investigations were carried out for a better understanding. Collaborative learning seemed like it was not a favourite activity amongst questionnaire's respondents as they did not choose activities that indicate sharing experiences and knowledge with a group as their favourites. The results of the interview rejected that assumption and suggest that people would like to learn in groups as well as individually; this is also in-line with the literature (Caballé, Xhafa, & Barolli, 2010; Laurillard, 2009; McLoughlin & Lee, 2008; Sharples, 2005b). Being with a group has its own benefits for people and it is not only helping them sharing knowledge and experiences, but also reinforces the sense of community as well as makes the process enjoyable, which could make the learning process more effective.

An interesting issue revealed by the results of the focus group study is the perception of learning. People have different understandings about the meaning of 'learning' (Schmeck, 1988). Further investigations were carried out within the questionnaire and interview studies to explore more about this aspect. Interestingly, the results suggest people conceive learning differently – they might learn incidentally and informally, which most of the time is happening unconsciously with little awareness that learning takes place. Given that, learning could be defined as acquiring information throughout a lifetime either through educational systems, formal learning, or life experiences, informal and incidental learning (Ainsworth & Eaton, 2010; Marsick & Watkins, 2001). Based on the results of this PhD research, learning could be classified into several levels according to the people's perception: (1) acquiring formal information that could help enhance individuals' professional life through formal courses (e.g. online courses); (2) acquiring information that could enhance individuals' skills (e.g. looking up for specific information online such as a cooking recipe); (3) acquiring informal information that could help enhance individuals' personal knowledge (e.g. using a dictionary or looking up information regarding history); (4) acquiring general information that could assist in an individual's daily-life (e.g. checking directions). On this basis, learning from experiences could include all aforementioned learning levels. Since learning interweaves with people's daily life, it could be challenging to be distinguished as learning (Vavoula, 2003). According to the results we can infer that most of time learning happens incidentally while people may not be aware that they are learning. This includes visiting sites, as visitors often are not aware they are learning since they perceive it as a form of entertaining. According to Sharples, Taylor, and Vavoula (2005) learning is mobile; learning could occur while people are on-the-move doing their daily activities whether for leisure or daily routines. Given that, it would be helpful for people to be given information on-the-move regarding the surroundings based on location without the need of any intervention from them; it would save their time, which this thesis refers to as learning on-the-move. The learning on-the-move concept has developed throughout this PhD research. The participants of the field studies showed a great interest in receiving contextual information that tells them stories automatically while moving based on their current location – contextual learning. This concept is supported by the situated learning theory that refers to learning based on context through social interaction (Lave and Wenger, 1991). Visitors of sites usually interact with the context and other visitors during the visit and they have different motives to visit.

According to the results of the field studies, visitors of cultural heritage sites get motivated to visit sites differently and visit for different reasons; thus, visitors could be classified accordingly into three types: (a) visitors who are interested in boosting their knowledge and in learning about history and heritage places, who could be considered as "knowledge-driven"; (b) visitors who are interested in satisfying their sense of discovery and curiosity to explore history at heritage sites, which could be considered as "explorers"; (c) visitors who are interested in satisfying their emotions in terms of feeling the places as it makes them feel emotionally connected to them and imagining life back in time, who could be classed as "nostalgists". These different types need to be considered in designing new technologies for cultural heritage sites; in addition they experience sites differently.

Learners experience learning in different contexts at cultural heritage sites using various tools and resources. They visit sites individually and in groups (family or friends), and are also in different age groups, which, consequently, result in different needs and preferences based on their individual/group learning characteristics and habits. In addition, they would like different levels of content, such as basic, intermediate and advanced, to meet their level of understanding. Even though it was a controversial aspect amongst official staff, participants found it interesting to add personal experiences to the original database of historical information in a form of forum. However, it would need to be monitored and moderated to be worth reading or listening to be run through services.

The field studies suggest a number of services and activities participants showed a great interest to receive at cultural heritage sites. Location-based services were the most popular services amongst participants of the field studies, which include receiving notifications and instant historical information on-the-move based on location regarding sites. In addition, experiencing life back in time drew participants' interest as they were very keen to see how life back in time used to be. Additionally, sharing the experience was a very interesting aspect amongst participants especially interviewees, which could be managed in several ways such as sharing the experience on social media or creating a network between visitors at site to communicate in real time. Furthermore, generating comments regarding sites could be very significant for enhancing attendance, which is always an objective of cultural heritage sites authorities (Silberberg, 1995); also it would draw the authorities' attention to any weaknesses their sites might perform and urge them to improve the experience. Consequently, in the long-term, that would have a great impact on preserving sites as the visitors' attendance is a key aspect that

contributes to sites maintenance (Silberberg, 1995), which in turn would contribute to enhance learning from sites as it would enhance sites' interpretation.

The results also suggest that learners would like to receive useful, interesting and sufficient services. In addition, results suggest the need for flexibility, such as turning off the notifications when they are not needed. It was also suggested that learners prefer to customise the mobile services based on their profile. An interesting issue was that although the results of the survey showed that wearable devices are less popular amongst respondents than mobile phones and tablets, the results of the interview revealed there is a potential of harnessing wearable computing with informal learning. This would provide a second screen for acquiring information. Additionally, it helps visitors enjoy the experience while observing attractions in the real-world and connect their sight with artefacts at the same time as acquiring information. It frees visitors' hands as information is viewed within the vision's area directly as well as keep the head up (Berndt & Carlos, 2000). Another interesting aspect about the smart eye glasses is that it could be deployed in a way that enables visitors to instruct them using their voice only, which would be used more conveniently as it frees visitors' hands completely. This is in contrast to the mobile devices as visitors needs to move their sight back and forth between attractions and devices, while carrying the devices in their hands, which therefore, might prevent them from emotionally engaging with attractions.

Using wearable computing such as smart eye glasses could make a significant turn in the interaction between learners and context (Amft, Wahl, Ishimaru, & Kunze, 2015; Yano, Nitta, Ishikawa, Yanagisawa, & Togawa, 2016). It takes the learning experience towards ubiquitous learning, and also offering different interaction preferences to meet different characteristics, which would enhance learning from sites. Ubiquitous learning supports learners taking learning opportunities whenever they need regardless of time and place which would very much support the concept of learning on-the-move; this aspect was further investigated in the field during the evaluation study, with details provided in Chapters 10 & 11. The results indicate visitors of cultural heritage sites do not perceive visiting sites as a learning process, but rather as an entertaining and pleasurable process. Hence, enhancing learners' engagement in the experience is essential for encouraging learners to visit sites and use such services there, which in turn would enhance learning from these sites. Learners' engagement could be enhanced by offering services that draw their interest. The results reveal learners construe learning differently and perform learning in different manners as they differ in their characteristics, motivations and habits.

The field studies have underlined some challenges. Physical aspects of the devices, such as the small screen and the network capability of the mobile phone could discourage people from using them for learning. However, the increasing capabilities of tablets and smartphones help provide a solution for these two problems. The lack of time might be preventing people from visiting sites, and here is where receiving notifications while doing daily activities could make a significant difference for enhancing learning on-the-move (Alkhafaji et al., 2014). Lack of interest in cultural heritage sites and people preferences might be an issue. However, technology is growing so rapidly, which introduces different services that might draw people's interest and enable them to choose how to experience the sites. Some new technologies that have been released recently would help people experience history by enabling them to use their senses, such as smell, touch and hearing, as well as seeing life back in time (BBC, 2015). Some other challenges were highlighted which could be interesting issues for further research: (a) caution in sharing personal details; (b) financial issues; (c) poor quality of network.

The results indicate that a small number of people find mobile devices distracting during the tour. The possible explanation for this issue may be that people do not like to keep looking at their mobile phone during the tour as they want to look around and enjoy historical sites as much as possible. The smart eye glasses may help people enjoy the sites while simultaneously receiving information through the glasses via their mobile devices. In addition, some interesting issues have emerged through the studies such as the weather, as some people reported that a waterproof device needs to be used in outdoor settings given how frequently it rains in the UK. The smart glasses and a Bluetooth headset might help solve this problem.

Although learning is the main reason that drives people to visit cultural heritage sites, visitors or learners do not see visiting sites as a learning process, but as a form of entertainment. Thus, it is significant to enhance learners' experience by enhancing their engagement, which could be achieved by introducing services that add value to the experience and capture learners' attention, such as considering different learning preferences.

The results show learners tend to use tools and resources that they are familiar with, which made it slightly difficult to introduce new services that use new technology such as smart eye glasses without offering a context of use in real life. Hence, a further investigation was carried out regarding the use of smart eye glasses in the field to have a deep insight regarding this aspect – details are given in Chapter 11. The next section illustrates how the field studies helped

in shaping a theoretical framework for the design of new technologies to support informal learning at outdoor cultural heritage sites.

7.2. From the field studies to the framework

The discussion of the field studies results has led to formulate a theoretical framework for designing smart and ubiquitous learning environments based on mobile and wearable computing to learn informally from cultural heritage sites. The framework consists of six broad themes with each theme having several sub-themes that were developed throughout the field studies. For instance, the theme "content" was developed based on themes from: (1) focus group, i.e. the theme *information*, which refers to information that needs to be included in the system; (2) interview: a) the them *learning material*, which is the historical information that visitors use to learn from sites, and b) the theme *useful information*, which include information that help visitors in their trip to sites such as transportation; (3) the aforementioned themes from the qualitative studies were consolidate with results from the quantitative study, survey, to come up with the final list of themes. A summary of how each theme/category was drawn out from the field studies is illustrated in Table 7.1.

Table 7.1: illustration of the framework's categories

Categories		Justification	Examples of extracted information from the field studies
Learner		The learner is the core element in the informal learning process which is the person who is performing the learning. People visit cultural heritage sites individually, and in different types of groups (e.g. friends, family). Additionally, there are different types of people in terms of age, such as children, adults and elderly. Each type has different needs and different characteristics which need to be considered in designing new technologies for learning. The results of the survey show that learners would like to customise the app based on their interests to make it more personal; 62% of respondents ticked "Yes" for customising their app. Six interviewees out of 8 preferred personalising their apps as they want to make sure they would have access to something they prefer rather than being bothered by something that they are not interested in.	"*…different people has different preference" (Focus Group, FG).* "*if you had like a particular interest in certain aspects of the site you can may be tailored to that, you can select what things are more interesting to you"* (Interview study (IS)) *"…perhaps that could be special apps for adults and children, students perhaps that can you trying to get more younger people interested in history because I think a lot of children when they go to historical sites they think it's boring so may be using this technology involves them more, engages them…" (IS)*
Content		The results of the survey indicate learners like getting historical information while they are walking around, and finding out extra information about sites (e.g. public	*"… you can make [quizzes] in different levels…*" (FG) *"for learning from history, I think just giving me just sufficient information to*
Learning material	Useful informati		

Categories		Justification	Examples of extracted information from the field studies
		services or opening times) as it gained 53% of responses. All interviewees agreed that the content is very important as it is the material that they use to learn. Six out of 8 interviewees wanted to know how we ended up having what we have in terms of cultural heritage.	*understand the historical context of the social context of where I am, not too much information, I don't want it to be like a lecture, but just enough to understand this is would've been like at this period of time of history, this is why the building is here, this is would've happened in this building, this is what happened as a result"* (IS) *"I like to see pictures of the place as it used to look in the past" (*questionnaire study (QS)). "*…it can give you information like taxis, buses, it could be helpful or how far from the bus station…*" (FG).
Learning design		Learning is the main reason that drives people to visit cultural heritage site as 86% of the questionnaire respondents stated that. The other reason is curiosity as 70% of respondents stated that they like to investigate the culture of other countries. Another mentioned reason is envisaging the stories behind these sites (58%). All these reasons could be categorised under the learning category. Thus, it is important to assist learners in designing their learning journey in terms of organising the visit and provide services to be used prior, during and after the visit	*"I would like to take my children to historical site to help them learn from them…" (FG)* *"…going around place with other people does mean there will be a conversation, conversation tends to improve memory so it gets you thinking more or probably remember more about the site because I've been talking with my friends and I might not remember that room very well but I will remember the conversation we had in that room about that statue or that painting or those artefacts…" (IS)* "*…is like a trigger that makes somebody who never use that kind of things go and use it…" (FG)*
Motivations	Types of learning and learning preferences		

Categories			Justification	Examples of extracted information from the field studies
Interaction design			Interaction design is considered a key aspect in drawing the users' attention to new technologies. As users deal with services via interfaces, it becomes essential taking good care in designing such services. Providing interesting information in multiple modalities for delivering historical information and also making it easy to use would help in motivating people to use this service. Also, learners use different resources and devices at sites. Learners would like to interact with the contexts using different services. Learners like to receive historical information in different formats and styles as the results indicate. The results of the survey suggested that images and texts are the most popular amongst respondents as 74% of respondents reported that they prefer images, 70% of respondents prefer texts, whereas 49% of respondents preferred video and 47% preferred audio. The results of the survey show that 72% of respondents prefer to receive formal information, 59% prefer to receive information as stories, 15% of respondents like quizzes and 13% like solving riddles that describes historical information.	,"…[*if the app is] more complicated, more interaction and more question you will lose number of users…* " (FG). *"…they can listen to a story while they are visiting the site…"* or utilise a quiz information style, "*…quizzes for example…",* (FG) *"…probably want an app that connected to audio tours not visual, something that I can listen to [on] iPhone for example could track where I am then I would automatically know where I was and be able to give me the correct information based on where I'm standing" (IS).* (Seeing sites how looked in the past)*"…It's interesting because sometimes is difficult to visualise something when you can't [imagine] how would've been, so for me that's interesting especially may be somewhere is ruined…" (IS).* *"…I think the information that you receive and platform which presented to you or directly affect how enjoyable the experience was but also the amount of information you take back from it…" (IS).* *[would like to have] Guidance about cost/walks & routes/family activities and 'exterior' facilities would be useful.", "Device needs to be flexible as user may not want it on all the time" (*QS*)*
Usability aspects	Adaptation	Interacting with the contexts		

Categories	Justification	Examples of extracted information from the field studies
Contexts	Learning takes place at any time and in any context as there is no restriction of time and place for learning. The results confirmed that people use mobile devices for learning whenever they need regardless of time and place. Visitors experience sites differently such as individually or in a group, and within the groups also people come with friends, family or a guided group. All these aspects need different contexts for learning. Hence, considering different contexts could have a significant impact on the learning experience in which adaptation mechanisms can be considered to effectively respond to different surrounding environments and contexts of use.	"*…I might go to visit cultural heritage or historical sites if I am on holiday in another country*" , *" I would discover society's cultures, so the best way is to visit cultural heritage and historical sites…* " (FG). *"…there is sort of dream like quality to going to older building and filling in the gaps for yourself and imagining and creating how it might have been, and imagining yourself may be with a princess walking down the amazing steps, you with a grand lady having tea in this room…".(IS).* *"…I can remember that feel it is very personal, personal experience, when you with somebody else may be you talk about, oh its Jasmin that's interesting it feels beautiful, but may be you don't hold this sensation [of the place]" (IS).*
Challenges and obstacles	Although learning in outdoors settings has its own benefits, it might raise some challenges with using mobile services such as weather issues. In addition, using mobile technology at sites might raise some issues as the results highlight. 23% of participants noted they do not use mobile devices at cultural heritage sites for several reasons: 1) 57% of them stated that the mobile device distracts them during the tour, 2) 20% of them do not use mobile devices due to the poor network quality, 3) 13% of them reported that it is not easy to follow the instruction, 4) 11% of respondents said that the available applications do not meet their needs.	*"…I think it [technology] takes [away] some of the dream and the fantasy…", "…I don't think and I don't think I would [use technology at sites], I know personally I would get frustrated with technology instead of enjoying being in historical place, that for me is the extreme opposite of the experience that I want to have, I want to get lost in the history and in the time before technology"(IS).* "*… [people] may not feel comfortable with something knows where they are…*" (FG)

7.3. Conclusion

This chapter has discussed the overall results of the field studies that were conducted to gather user requirements for developing smart and ubiquitous learning environments based on mobile and wearable technologies with respect to cultural heritage sites. The field

studies were conducted using a sequential mixed methods approach with data gathered using focus group, questionnaire and interview techniques. The discussion helped in combining the results of all studies which led to introducing a theoretical framework for such services. The three field studies were relatively consistent in almost all aspects. A few aspects that resulted from the survey study needed to be explored deeply in the next step, which was the interview study. These aspects were regarding: (a) learning in groups; (b) using wearable technology; (c) seeing life back in time; (d) personalising mobile apps; (e) notifications based on current location. The results of the interview were positive regarding the aforementioned aspects, which played an important role in guiding the implementation strategy in the design phase. A concept of learning on-the-move was shaped throughout the field studies. This concept refers to acquiring the right information at the right time and place through ubiquitous devices without the need of the intervention of users, in other words smartly and intelligently; this concept is also supported by the proposed framework. An illustration of shaping the framework based on the results from the field studies has been given in this chapter. Categories of the proposed framework with the justification and examples from the results of the field studies were presented. Details of the framework are presented in the next chapter.

Chapter eight

8. Shaping a framework for smart and ubiquitous learning environments (FoSLE)

The previous chapter has discussed the results of the three field studies (see Chapter 4, 5 & 6) and pulled them together towards shaping a theoretical framework. The studies were conducted to gather user requirements for developing smart and ubiquitous learning environment utilising mobile location-based services to be used at cultural heritage sites. The studies investigated users' attitude, behaviour, motivation and habits to understand their needs and preferences regarding the use of such services. The findings of the study along with theories of use, which are presented in section 8.2, served to shape a theoretical **F**ramework f**o**r designing **S**mart and Ubiquitous **L**earning **E**nvironments, i.e. FoSLE, utilising mobile location-based services and wearable computing. The framework focuses on supporting informal learning on-the-move at outdoor cultural heritage sites by acquiring the right information at the right time and place based on location. The framework is designed to assist researchers who are working in the same field; it consists of six broad categories: learner, content, learning design, interaction design, context, and challenges and obstacles. This chapter presents several aspects that helped in shaping the framework: section 8.1 presents a summary of theories of use which were presented in detail in Chapter 2. Section 8.2 presents the framework; Section 8.3 discusses the previous models and framework that support informal learning and outlines the differences to the FoSLE framework. Section 8.4 outlines the conclusions of this chapter.

8.1. Theories of use

Chapter 2 discussed learning theories and types of learning that contribute to informal learning based on ubiquitous technology; this section present a summary of these theories and types of learning that helped shape the framework alongside the field studies.

Experiential learning concerns supporting learning from experiences throughout an individual's lifetime (Kolb, 1981). Individuals learn when experiencing life and through a trial

and error process, which often happens incidentally and spontaneously (Dewey, 1938). Learning also happens during social life when individuals are interacting with the community, as social learning concerns supporting learning via observing others' behaviours, attitude and cognition (Bandura, 1977; Vygotsky, 1978). In other words, learning occurs by engaging with the community while doing formal or informal activities (e.g. learning about history via playing a game regarding historical events). In the same vein, collaborative learning is an approach of learning that concerns learning by sharing experiences between learners which could also be considered social learning (Bruffee, 1984). Mobile location-based systems could provide a feature to enable learners to share experiences with each other during and after the visit to cultural heritage sites regardless of where they physically are. Mobile location-based services could offer such opportunities by enabling learners to do activities with the other learners and interact with them in cultural heritage contexts. For instance, the system could provide features that enable learners to do activities with the community using their current location.

Lave and Wenger (1991) argue that situated learning is the acquisition of knowledge through a community of practice where social interaction in the context is the main component of the learning process. Learning occurs at any time and place as there is no restriction for acquiring information and enhancing knowledge. In the cultural heritage contexts learners interact with attractions and artefacts in different contexts while they are wondering around a historical place. Consequently, they normally acquire information regarding these artefacts and attractions on-the-move, which may not leave enough time for interacting with the community where they can build their knowledge and at the same time receiving historical information in different contexts. Thus, ubiquitous learning based on mobile and wearable technologies could offer a better experience of acquiring information in cultural heritage contexts. For instance, providing location-based information regarding sites and at the same time enabling learners to share experiences with an online community.

Conversational learning is an approach that support learning when learners are having a conversation with each other (Sharples, 2005a). Pask (1976) defines conversational learning as "conversational systems which allow mental activities to be described in terms of dialogue and behaviour" (Pask, 1976, p. 128). Conversation helps construct knowledge between learners, which in turn enhances their knowledge (Pask, 1975). Conversation tends to enhance memory and consequently enhance learning as the discussed information stays longer in an individual's memory. That could be offered by mobile location-based services with a feature that enables

learners to have a conversation during a visit to a cultural heritage site, while not necessarily being next to each other.

8.2. The framework

A theoretical framework for designing a ubiquitous learning environment based on mobile and wearable technologies was formulated based on the three field studies. The learning theories serve as strength evidence to the framework, which will be mentioned where appropriate. The framework consists of six broad categories: learner, content, learning design, interaction design, context and, challenges and obstacles. Table 8.1 illustrates how the framework has been formulated based on the field studies and theories of use; details of each category are given below. It is important to clarify that more related extracted information from the qualitative studies is given in Appendix B, which will be referred to where appropriate. The extracted information is given a code based on the study name or types of participants. The extracted information from the focus group study is give a prefix (FG) followed by a number which refers to the order of the extracted information in the Appendix B. The extracted information from the interview study is classified into end-users (EU) and staff (ST), with both acronyms used to distinguish the type of user, which are followed by a number that refers to the order of the extracted information in Appendix B (each participant type has a different order). Abbreviation used in Table 8.1 are given below.

Source	SC
Theory of use	ToU
Focus group	FG
Survey study	SS
Interview study	IS

Table 8.1: the FoSLE's categories with examples

categories	Justification	Examples	SC
Learner	Learners performs and conceive learning differently	"in addition to the constructs of intelligence, and personality, there is also cognitive style as a distinct construct, and that style is different in nature and in the way it affects behaviour" (Riding & Rayner, 1999, p. 8).	ToU

categories	Justification	Examples	SC
	Respondents stated they would like to customise their app based on their preferences	62% of respondents ticked "Yes" for customising their app.	SS
	Participants emphasised that people differ in their characteristic, motivations and habits	"*if you had like a particular interest in certain aspects of the site you can may be tailored to that, you can select what things are more interesting to you"*	IS
		"*…different people has different preference"*	FG
Content	Respondents reported they like to receive historical information as well as useful information such as transportation.	The results indicate learners like getting historical information while they are walking around, and finding out extra information about sites (e.g. public services or opening times) as it gained 53% of responses.	SS
	Participants mentioned different types of information that they would like to have regarding cultural heritage sites such as life back in time.	*"for learning from history, I think just giving me just sufficient information to understand the historical context of the social context of where I am, not too much information, I don't want it to be like a lecture, but just enough to understand this is would've been like at this period of time of history, this is why the building is here, this is would've happened in this building, this is what happened as a result"* *"I like to see pictures of the place as it used to look in the past"*	IS
		"*…it can give you information like taxis, buses, it could be helpful or how far from the bus station…*"	FG
Learning design	Experiential, social, collaborative, situated and conversational learning	"conversational systems which allow mental activities to be described in terms of dialogue and behaviour" (Pask, 1976, p. 128)	ToU

categories	Justification	Examples	SC
	Respondents noted they visit cultural heritage mainly for learning. The vast majority of respondents claimed that using mobile devices would assist them accessing information whilst they are moving and doing daily activities.	Learning is the main reason that drives people to visit cultural heritage site as 86% of the questionnaire respondents reported that. The other reason is curiosity as 70% of respondents stated that they like to investigate the culture of other countries. Another mentioned reason is envisaging the stories behind these sites (58%). All these reasons could be categorised under the learning category.	SS
	Participants stressed that having instant historical information while they are moving would really save their time and efforts. Participants stated they perform learning differently and have different learning preferences.	*"…going around place with other people does mean there will be a conversation, conversation tends to improve memory so it gets you thinking more or probably remember more about the site because I've been talking with my friends and I might not remember that room very well but I will remember the conversation we had in that room about that statue or that painting or those artefacts…"*	IS
		"I would like to take my children to historical site to help them learn from them…"	FG
Interaction design	Respondents stated that they would like to use different services and multiple levels of interaction at cultural heritage sites.	76% of respondents stated that they would use mobile devices at cultural heritage sites and also 89% asserted that mobile devices would facilitate getting information regarding the history of heritage places. *"Device needs to be flexible as user may not want it on all the time".*	SS
	People interact with the cultural heritage context in different manners. They use different resources and tools to acquire	*"…probably want an app that connected to audio tours not visual, something that I can listen to [on] iPhone for*	IS

categories	Justification	Examples	SC
	information whether are provided by the site or their own devices.	*example could track where I am then I would automatically know where I was and be able to give me the correct information based on where I'm standing"*	
		"…I think the information that you receive and platform which presented to you or directly affect how enjoyable the experience was but also the amount of information you take back from it…"	
		"… [*if the app is] more complicated, more interaction and more question you will lose number of users…* "	FG
Contexts	People use mobile devices in different places and contexts, which include: at home, whilst traveling, in the office, and on holiday.	Results show that people use mobile devices at different places and contexts which include: at home (96%), whilst traveling (89%), in the office (67%), and on holiday (78%). 33% of respondents reported that they visit cultural heritage sites when they are on holiday.	SS
	People visit sites individually and in groups; being with a group might bring different experiences than on their own; being with others helps remember information which enhances the learning experience.	*"…I can remember that feel it is very personal, personal experience, when you with somebody else may be you talk about, oh its Jasmin that's interesting it feels beautiful, but may be you don't hold this sensation [of the place]"*	IS
		"*…I might go to visit cultural heritage or historical sites if I am on holiday in another country*"	FG
Challenges and obstacles	The results highlight some challenges regarding using technology to learn at cultural heritage sites.	Some respondents said that they do not use mobile devices at cultural heritage sites (23%). "*Don't take mobile on holiday and only visit sites on holiday*"	SS

categories	Justification	Examples	SC
	A number of challenges were highlighted by the field studies: confidentiality, financial issue and people's preferences.	*"…I think it [technology] takes [away] some of the dream and the fantasy…", "…I don't think and I don't think I would [use technology at sites], I know personally I would get frustrated with technology instead of enjoying being in historical place, that for me is the extreme opposite of the experience that I want to have, I want to get lost in the history and in the time before technology"*	IS
		"… *[people] may not feel comfortable with something knows where they are…*"	FG

8.2.1. Learner

The learner is the core element in the informal learning process as he/she is in-charge of their learning experience. People differ in their characteristics and habits in all life's aspects including learning (Kaasinen, 2003). Consequently, they do not perform learning in the same manner, they perceive learning differently (Schmeck, 1988), take a learning opportunity in different ways and have different learning preferences (Sadler-Smith, Allinson, & Hayes, 2000). Individuals' characteristics and strategies in conceiving learning could refer to individuals' cognitive style (Tennant, 1988). Riding and Rayner (1999) argue that "in addition to the constructs of intelligence, and personality, there is also cognitive style as a distinct construct, and that style is different in nature and in the way it affects behaviour" (Riding & Rayner, 1999, p. 8). In addition, the authors define cognitive style as "an individual's preferred and habitual approach to organising and presenting information" (Riding & Rayner, 1999, p. 8).

Tough (1979) points out that people mainly undertake a learning project to gain new knowledge and skills that could improve people's life such as changing one's habits or completing tasks related to one's job, home or family. Learning could happen spontaneously while people carry out their daily activities, and they might not even be aware that they are learning. As identified in the previous chapter, learning could be classified into several levels according to the people's perception: (1) acquiring formal information that could help enhance individuals' professional

life through formal courses (e.g. online courses); (2) acquiring information that could enhance individuals' skills; (3) acquiring informal information that could help enhance individuals' personal knowledge; (4) acquiring general information that could assist in an individual's daily-life.

Individuals' characteristics and habits influence people behaviour in all contexts including cultural heritage. As identified in Chapter 7, the visitors of cultural heritage could be classified into three types: (a) knowledge-driven, (b) explorers or (c) nostalgists. Given that, visitors differ how they perceive history, which needs to be considered in designing new technologies for cultural heritage sites. People visit sites individually and in groups (family or friends). Each group has different needs and preferences, and it is clear from the current data that people prefer to customise their apps based on their preferences (see extracted information in Appendix B: FG1, FG3, FG10, ST1 & ST2), but more than that, they really prefer the app to customise itself intelligently by tracking their route and history of previous interactions.

8.2.2. Content

The content is an important element in the learning process whether it is a learning material or useful information as both types would assist learners in performing learning more efficiently. The learning content is the material that learners consume to construe history as well as help make sense of historical sites. Designing a content object could make delivering information more efficiently and could help in making sense of the attractions in one or different area(s) as a one object (see extracted information in Appendix B: FG14, ST3 & ST6), which would enhance the interpretation of sites (Tilden, 1957). The value of the content object is that it connects all the related attractions whether they have experienced the same events over time, or experienced different events in one particular period of time. In order to envisage the full picture of events that have had happened at that site, different types of historical information need to be involved, which in turn helps people have a full experience of sites. Furthermore, to help learners engage with the content, reliable and interesting historical information should be provided, with applying an adaptation mechanism to the learning materials based on learner's needs (FitzGerald, 2012).

8.2.2.1. Learning material

Learning material is the material that learners consume to perceive history and understand stories of human achievements. Through the studies, different types of learning material were

identified which could be categorised as: life back in time, archology aspects and developments of sites over time, human achievements, and linking the past with the present.

Life back in time of people who lived at a particular site in a certain age would be very interesting for visitors of cultural heritage sites. It is always that sort of curiosity of visitors to discover how people back in time used to live, eat, cook, wear, what type of conversation they used to hold, how they managed to survive during a tough time, such as a war. Additionally, visitors are interested to know about the personal life of famous characters and what type of personality they had. Visitors would appreciate any sort of interesting facts beyond the formal information or any jokes people back in time used to tell (see extracted information in Appendix B: EU2, EU8, EU20, & EU21).

Archology aspects and development of sites over time could be an interesting piece of information which might bring learners' attention to how a particular site ended up in a certain state. Additionally, it draws attention to how it has been founded or preserved over time, which would motivate authorities to help preserve them (see extracted information EU23 & EU24).

Human achievements are an important learning material that could promote a sense of pride and belonging as visitors will learn how they ended up having these achievements. Moreover, it is material that could motivate learners to visit sites that have witnessed these achievements. Additionally, it would give visitors strength in serving their communities, which encourages them to contribute to these achievements.

Linking the past with the present in terms of reading about some personal experiences that people have had at that time would be very significant in bringing sites to life as it would be seen from different views. That could be achieved by enabling visitors to tell their experience regarding events that they have witnessed, if any, at a particular site (see extracted information in Appendix B: EU3 & EU21).

8.2.2.2. Useful information

The results of the studies suggest that learners also would like to receive information that assists them in their learning journey at sites. Participants of all studies reported various sorts of information that could be useful including: location-related, surroundings-related, and public facilities (see extracted information in Appendix B: FG15 & EU4).

Location-related: visitors usually like to have an idea about the location that they are heading to. Information related to the location of sites would assist visitors in their journey and make it

effective. Visitors might need information that guides them to get to the place easily such as the transportation available, directions, and the distance. Ticket prices and opening times are very useful information for visitors as they need to consider the cost of their trip, and if there are any offers they can obtain for instance. In addition, they need to know if the site is opened before heading to it. That would help visitors invest their time effectively.

Surroundings-related: visitors often check information regarding the surrounding environment of the place they are visiting. The information related to the surrounding environment would help visitors to have a better experience as they can choose the time that suit their preferences. Information they usually like to know beforehand is related the weather, the time the site is likely to be less busy and also how big the site is.

Public facilities: visitors often visit cultural heritage sites for entertaining and usually they like to do activities there to enjoy their visit. They need to know what activities the site provides. They need to know if there is a place to eat or a place for their children to have some fun. Additionally, they would like to know if there is a carpark available, also what kind of shops are there.

8.2.3. Learning design

Learning is the main reason that drives people to visit cultural heritage sites for themselves or for their children, either locally or abroad to discover other communities' cultures (see extracted information in Appendix B: FG4 & FG6). It was also reported that visiting cultural heritage sites helps in raising awareness of culture and attaching people to their communities as well as preserving these sites. Moreover, envisaging the stories behind the cultural heritage sites may support people to maintain the link between the past and the present, which in turn sustains the culture. In addition, cultural heritage sites are also seen as a form of 'worthy' entertainment, as most people visit cultural heritage sites at least once a year, which could contribute significantly to the countries' income. Therefore, it is significant to utilise every means that make learning experiences at sites more efficient and pleasurable.

As taking a new learning experience could be a challenge especially if it is a self-directed process, it is important to assist learners in designing their learning journey (Laurillard et al., 2013). The learning design might include: motivation that drives learners to visit cultural heritage sites (e.g. watching a historical film about that period of time), learning types and learning preferences. Learners perform different types of learning in different contexts such as

individually, collaboratively, socially as well as learning on-the-move as the current data highlighted (see extracted information in Appendix B: EU25 & ST8). In short, providing different activities and services that meet learners' needs in different stages during their visit to cultural heritage sites would facilitate their learning experience. Moreover, enabling different types of learning could make the learning process more enjoyable and effective.

8.2.3.1. Motivation

The results of the field studies indicate that learners prefer aspects that add value to their knowledge and experience in terms of visiting cultural heritage sites and using technology there. Providing some features and services that bring learners attention and add value to their visit could motivate them to visit cultural heritage sites. This research suggests that learners would like to receive information prior to their visit that might raise their interest. Different types of motivation factors were identified that learners are used to do or would like to have prior to their visit, for example, reading a book or watching a film about historical stories or events that have happened in a particular site, and highlighting human achievements.

Reading about events that happened in the past could draw the readers' curiosity to visit places mentioned by the book they have read. That would reinforce the sense of the historical events and might deepen them in their memory for longer. When someone reads a book describing events, they would imagine these events; visiting the sites that have witnessed those events would help them to match their imagination with the real world, which might help hold the sense of sites in their memory. The same is true when watching a film as it would induce people to visit sites mentioned in the screen (Riley, Baker, & Doren, 1998), although it may leave less space for viewers' imagination to take over.

Another aspect is getting information regarding human achievements; often people are curious to know how the world has developed over time, how they ended up having what they have at a particular time. Thus, knowing about human achievements back in time that have left some amazing inherited culture would generate their interest to visit these sites that witnessed such achievements. These achievements could be described in the form of riddles, which challenge people to learn more about them to be able to solve the riddle. Moreover, presenting some information mysteriously would draw learners' attention and also stimulate their curiosity to explore more about these events; that in turn could generate people's interest and drive them to visit cultural heritage sites.

8.2.3.2. Learning types

Learners differ in their learning habits; they conceive learning differently and perform learning in different manners. This research indicated learners like to be in charge of their learning and taking learning opportunities informally and be self-directed (Eraut, 2004; Livingstone, 1999; Marsick, Volpe, & Watkins, 1999). Supporting various types of learning could help enhance the experience of informal learning such as: (a) learning on-the-move, where learners receive contextual information at the right time and place based on location intelligently and automatically; (b) social and experiential learning, where learners learn by interacting with each other's or through experiencing life; (d) and, individual and collaborative learning, where learners take learning opportunities individually on their own, or collaboratively in groups.

Recently, life is developing in a rapid pace towards a mobility world as it involves a lot of physical movements of people in order to undertake their daily routines. The rapid pace of life might cause a decrease in the amount of time that people spend to learn on their own or look for information regarding aspects of their interest. In this sense, learning-on-the-move and ubiquitous learning could provide a better option for learners to keep up their learning routines with the developing pace of life. That would enhance the learning experience by saving the time of looking for information as learners receive instant and contextual information on-the-move regarding the surrounding sites and artefacts when passing by while they are doing their daily routine (Cobb & Bowers, 1999).

Visiting sites and doing activities in groups would promote the social learning concept as well as the sense of community. In this sense, learners would take learning opportunities in a more social way, which often they do not mean to take consciously, but instead they are enjoying being with others, which consequently helps engage learners and enhance learning (Bandura, 1977). Engaging learners with learning activities without them intending to do so would enhance experiential learning (Dewey, 1938; Popkewitz, 1998; Vygotsky, 1978). For instance, engaging visitors of sites in a geo-cashing activity to look for historical information or artefacts would help them to learn about history through their experience.

Learning collaboratively is also an important type of learning as learners when visiting sites with family and friends tend to have conversation regarding artefacts (Bruffee, 1984). Conversation is meant to boost memory as well as help learners to learn more from each other (Sharples, 2005a). Additionally, collaborative learning helps learners communicate with each other and learn at the same time. In addition, the findings indicate that learners also enjoy

experiencing sites on their own which could be recognised as individual learning (Cohen, 1991). Experiencing sites individually would help learners to immerse in the environment and spend more time discovering stories behind these sites. That would support learners in holding the sense of the experience which in turn enhances learning.

8.2.3.3. Learning preferences

Learners tend to have different preferences to perform learning based on the contexts of learning (Sadler-Smith et al., 2000; Schmeck, 1988). There are some learners who are visualising and enjoy seeing artefacts, which might let their imagination to take over. Others like challenging and adventures such as quizzes and geo-cashing (see extracted information in Appendix B: FG10), which might help them to remember information to which they were exposed to during the activity. Additionally, some learners like to engage with a story that tells a historical event in an interesting way (see extracted information in Appendix B: EU17, EU18 & EU19). Learning by doing is a preference for some learners in which they engage in an activity that might demonstrate life back in time (see extracted information in Appendix B: ST8).

8.2.4. Interaction design

Interaction design is considered a key aspect in drawing the user's attention to new technologies (Savio & Braiterman, 2007). This research identified a few aspects within the interaction design that would influence the use of services such as usability aspects, adaptation and interaction with the contexts.

8.2.4.1. Usability aspects

Usability aspects play an important role in encouraging learners to use learning services as they would like user-friendly services that do not overwhelmed them by complicated features with many options. Simple services with clear instructions and just sufficient information are more likely to be used based on the findings of this research. As learners interact with services using different devices and via interfaces, it becomes essential to take good care in designing the user interface. Designing a user interface could be key in bringing learners attention, and it also needs to be easy to use. Labels should be clear and reflecting what they lead to. Colours also need to be easily seen in different contexts. Additionally, services might not be needed all the time, so to keep them on always would affect the experience and make it a disruption rather than a helpful tool. Therefore, providing options to abort or switch off services when they are

not needed at any stage of the experience, as well as smoothly switching between different devices, would make the use easier (see extracted information in Appendix B: FG19 & EU26).

8.2.4.2. Adaptation

Adapting services according to the surrounding environment and learners' profile in terms of contents, devices, functionality and interfaces could be substantial within the interaction design. Contexts and surroundings might prevent leaners from enjoying the experience, for instance, sunny spells might make the screen of the device difficult to be seen. In addition, learners' preferences might also lead to not using learning services if the services did not meet their preferences or if they are overwhelmed by services for aspects that do not interest them (see extracted information in Appendix B: FG3 & EU27). Hence, the adaptation might be a significant aspect within the interaction design to overcome such drawbacks.

8.2.4.3. Interaction with the context

One goal of informal learning services for outdoors cultural heritage sites is interacting with the context and artefacts. Such services aim to encourage learners to be physically at sites and interact with the contexts as it is believed that it is a powerful approach to learn about history as a member of cultural heritage staff reported. Learners interact with the contexts using different types of mobile devices for almost all daily activities including learning at cultural heritage sites. Multiple tools and resources are used to access services at sites such as mobile and wearable devices (see extracted information in Appendix B: FG8, EU9 & EU13). Two main aspects within interaction with contexts were identified: services and activities, and delivering historical information, which are given below.

Services and activities: as the previous two categories highlight the importance of the content and learning design in learning services, this category identified various services and activities that help accessing content and performing learning. The identified services and activities are: (a) location-based services, (b) networking services, (c) social activities, (d) experiencing life back in time, (e) organising the visit and (f) sharing experiences. Location-based services support learning on-the-move by giving instant and contextual historical information based on the current location. Networking services would support collaborative learning as well as enable visitors to communicate with each other during and after the trip. Social activities enable learners to socialise with others and at the same time learn by interacting with each other and by the experience as well. Experiencing life back in time is a service that enables learners to see or experience life in the past. This is an interesting issue that was raised by the field studies,

which indicate that visitors are keen to see and imagine life back in time. Organising the visit would help visitors invest time effectively by looking up useful information beforehand, which might assist them in their trip and make it easier. Sharing experiences with others supports collaborative and social learning, which enables learners to tell their experiences for others to benefit from it (see extracted information in Appendix B: FG8, FG9, EU6, EU12 & EU33). Services and activities are not enough on their own to engage learners; they need to be supported by an interesting way of presenting information.

Delivering historical information: The way that information is presented plays an essential role in the amount of information that learners take back from their visit, based on the findings of this research. Learners vary in their cognitive style and learning preferences. They perform different procedures for learning and use different tools and resources. Learners do not always treat visiting cultural heritage sites as a learning process; they rather consider it as a form of entertainment. From this stance, the quality of engagement needs to be considered to encourage them to carry out this experience, such as receiving historical information in an interesting way. Thus, historical information should be presented in multiple modalities and styles to suit a wide range of preferences. Another way of presenting information is delivering information through multiple screens and allowing learners to choose between them to suit the current context of use. Another way is to support learners to engage their sight with the artefacts when observing them while simultaneously receiving information through wearable devices such as smart eye glasses. Wearable devices soon will be interweaved in an unobtrusive manner with the learning procedures of learners to the extent that learners forget they are wearing them (Park & Jayaraman, 2003; Starner et al., 1997). Wearable devices, such as smart eye glasses, could be instructed using visitors' voice (Hwang, 2014), which would free visitors' hands completely. In this sense, wearable devices would enable learners to interact with contexts conveniently and effectively, which would significantly enhance the interaction. That, in turn, would enhance learning from cultural heritage sites (see extracted information in Appendix B: FG11, EU9, ST4, EU12 & EU15).

8.2.5. Context

With the emergence of mobile and ubiquitous devices and their use for learning, learning became ubiquitous and could take place at any time and in any context as there are no restrictions for learning. Learners take learning experiences whenever they need regardless of time and place using mobile and wearable devices, which supports the concept that learning is

"mobile" (Vavoula & Sharples, 2002). Learners experience sites differently and they operate in different learning contexts. Hence, considering different contexts could have a significant impact on the learning experience; adaptation mechanisms can be considered to effectively respond to different surrounding contexts of use (Winters & Price, 2005). This research identified a few learning contexts in terms of time, place, type of visit and learners' physical state (see extracted information in Appendix B: EU11, EU14, EU28, EU29 & EU30).

8.2.5.1. Learning context in terms of time

Visitors visit sites at different times and occasions such as quiet times, holidays and working days. Some visitors like to enjoy the experience without distractions, so they chose a relatively quiet not busy time. That helps them to have an effective and relaxing experience as there is not much interference with other visitors' noise or presence. Most visitors visit sites on holidays as this research revealed; visitors on holiday tend to have extra free time to explore historical sites, and they might be willing to do some activities and have extra historical information. The same is not true with visits on working days, as they need to be integrated within their normal daily routine, leaving less time to spend on exploring history. However, that does not prevent some visitors from visiting sites at any time they want even during working days. Additionally, some visitors like to visit sites more than once as they enjoy repeating the experience of sites over and over again.

8.2.5.2. Learning context in terms of places and settings

This research suggests that a considerable number of visitors of cultural heritage sites visit these only when they are abroad. Visitors of other countries are keen to learn about the cultures of these countries. They visit sites as much as they can while they are abroad but they might not think of visiting local sites. Some visitors, who are very passionate to learn about history, visit sites locally and abroad more often whenever they have time. They enjoy being at historical sites and consider the visit as an entertainment trip.

8.2.5.3. Learning context in terms of types of visit

Different motives drive visitors to visit cultural heritage. Some visitors like to visit sites on their own as it helps them to hold the sense of the place and letting their imagination to take over. Additionally, when they are on their own, they can spend as much time as they want looking around without worrying that someone might be waiting for them. That could be recognised as an individual learning context, where the learners spend time on their own filling the gaps for themselves about history and having a personal experience at sites. Some other

types of visits could be for getting children to learn about history; that could be families bringing their children to visit sites or school authorities bringing the kids for a school party at cultural heritage sites. That would bring a different experience for families and school authorities as they need to make it an enjoyable learning process for kids, as well as taking historical information back from the visit. In addition, visitors are sometimes accompanied by friends or family, which also brings a different experience as they experience sites as a group. They enjoy being with others and learning about history at the same time. That could be recognised as a group learning context. Moreover, some visitors are not able to be at sites physically for some reason such as they are in a far geographic area. Some museums offer a service that enables them to visit the site at a distance while they are at home or school using a video call, which could be recognised as a distance learning context.

8.2.5.4. Learning context in terms of learners' physical state

Learners' physical state sometimes determines the context of learning. Results suggest that learners mostly tend to use their mobile phone for learning while they are moving and tablets when they are in more settled situations – at work for instance. Moreover, learners use their desktop PC or laptops when they are in a more relaxing state, such as at home as they find it easier to navigate through.

8.2.6. Challenges and obstacles

Although learning in outdoors settings has its own benefits (Dillon et al., 2006), it might raise some challenges with using mobile services according to this research. These issues should be taken into account when designing such services and providing some alternatives for learners to have a better experience at sites. Challenges could be categorised as: confidentiality issues, financial issues, tools and devices related issues, surroundings related issues and, learners related issues (see extracted information in Appendix B: FG20, FG22, FG23, EU5, EU10 & EU16).

8.2.6.1. Confidentiality issues

Apps often ask users for personal details such as preferences or locations to offer them better options that suit them. Some of this information is used unfairly by some apps, which might lead users to not provide such information. The results of the field studies indicate that learners are slightly cautious in sharing personal details with apps. They do not want to be a target of unwanted advertisements; also they are not very happy to disclose where they physically are. These aspects might hinder the process of learning on-the-move.

8.2.6.2. Financial issues

Visiting cultural heritage sites might cost visitors a decent amount of money for the whole trip. Additionally, using guide devices that are provided by sites could cost extra money, as well as using internet on their mobile devices. The results show this issue might prevent learners from visiting cultural heritage sites or using mobile devices there.

8.2.6.3. Tools and devices related issues

Some technical issues were highlighted by the current data such as the quality of the network. Using internet on mobile devices often needs a good signal quality otherwise it does not work properly. Learners of this study reported that they might not use mobile devices for learning at cultural heritage sites due to a poor network quality. Physical aspects of mobile devices, such as the small screen could discourage people from using them for learning. As it has been reported, the small screen might affect learners who have sight problems to properly see what is on the screen. Additionally, the network capabilities of some devices are also considered an issue as some learners stated that they use old-fashioned devices with no network support. The results indicate that a small number of people find mobile devices distracting during the tour. Another issue is the absence of good quality apps in terms of content, as the content could make the learning process less effective if there is no sufficient information or if the learners are being overwhelmed by too much and unorganised information.

8.2.6.4. Surroundings related issues

The issues of surroundings could be distracting learners' attention or movements. The challenges of the surrounding environment include: day time (day or night), weather (rainy or sunny), and level of noise (i.e. noisy or quiet). The time of the day often affects how effectively learners could read or see what is on the screen. The weather could be a major disruption for visitors of outdoors culture heritage settings as the results indicate. In addition, most participants of this research preferred to visit sites when it is fairly quiet as they would like to have an effective and relaxing experience to take learning opportunities at their pace and enjoy being in the atmosphere, which might be difficult to achieve if the site is busy.

8.2.6.5. Learners related issues

Some issues emerged from the field studies that are related to the learners themselves, such as lack of interest. Some learners do not find visiting sites interesting. The results reveal that some visitors find cultural heritage site like an abandoned bunch of bricks and they are not very keen to explore them. Learners' preferences might be an issue as some visitors are not very keen to

use technology at cultural heritage sites for several reasons that were reported. Reasons, from their point of view, include: (1) it takes their imagination away as they would like to use all their senses there; (2) it might prevent them from discovering interesting aspects such as places as it has been reported that not using a navigator could lead to find an interesting place; (3) customising the app might lead to missing some interesting services or information; (4) some learners reported that they are more paper-based users as they like to read paper-based maps or a book instead of relying on technology; (5) the lack of time might be an issue as learners reported that they sometimes cannot find free time to visit sites.

8.3. Comparison of the previous models and frameworks with the FoSLE framework

Learning is always inspiring researchers to explore it further and introduce models and frameworks to assist practitioners and other researchers in the field of learning. A number of models and frameworks have been introduced to support informal learning in different contexts. Chapter 2 discusses learning models and framework in detail, which are summarised in this section to highlight their similarities and differences with the FoSLE framework.

The discussion in the Chapter 2 revealed that some presented models and frameworks showed some similarities with the proposed framework, FoSLE, in terms of the context they were proposed for, which is outdoors cultural heritage, such as (Candello, 2009), supporting learning on-the-move at outdoors setting, such as (Hwang, 2014), for interaction design (Candello, 2009; Saeed et al., 2014) as well as some others for supporting different aspects in informal/ lifelong learning contexts, such as (Barbosa et al., 2011; Fallahkhair, 2009; Nino et al., 2007; Saccol et al., 2009; Taylor et al., 2006; Vavoula, 2003; Zhang et al., 2005); however, none of them was introduced for supporting the particular need of learning on-the-move at outdoors cultural heritage. Additionally, few of them considered learners' perspectives when formulating the models/frameworks, which could be an essential requirement for delivering an adaptive learning mechanism. Given that, each model/framework would not be sufficient for designing such services, which would need to be integrated in order to deliver an environment that has the essential elements for such services.

Based on the discussion so far, it is clear that there is a lack of models/frameworks that could support essential elements in designing informal learning services for outdoors cultural heritage sites. These aspects include: interaction design, designing a content object and also support

different types of learning. In addition, none of the aforementioned models support learning on-the-move, where learners receive instant information regarding the surroundings based on location at sites. Supporting learning on-the-move is considered an important type of learning in the current time, which helps learners keep up with the rapid pace of life. Learning in cultural heritage context has different needs in terms of content, activities and interaction to make it efficient and pleasurable, as learners see it as a form of entertainment and not necessarily learning. Table 8.2 illustrates the differences in features between the related models and the proposed one, FoSLE.

Table 8.2: illustrating the differences between FoSLE and the other models that support designing apps

Model/frameworks	Informal/ non-formal learning	Outdoors Cultural heritage	Enhance learning	Ubiquitous learning	Features							
					Learner model	Learning design	Context related	Interaction design related	Content object	Communication	Learning on-the-move	Challenges related
FoSLE	x	x	x	x	x	x	x	x	x	x	x	x
Vavoula's	x				x	x	x					x
Fallahkair's	x		x	x	x		x	x	x		x	x
Taylor's	x		x	x			x			x		
Saccol's	x		x	x	x	x	x			x		x
Barbosa's	x		x	x	x	x	x			x		x
Nino's	x									x		
Zhang's	x									x		
Saeed's								x				
Zheng's	x			x						x		
Hwang's	x		x	x	x	x					x	
Candello's	x	x						x				

As given in Table 8.2, the models have some features in common as all of them are designed for learning. Although all of them consider learners as a core element in the learning process, not all of them consider learners' characteristics in presenting services and features. Some of them consider learning types and the contexts where learning occurs. It is clear from the above table that the models Vavoula's, Taylor et al's., Saccol et al's, Barbosa's and Hwang's are the most related to the proposed model, FoSLE, as they have more features in common. However, FoSLE is the only one that was designed for learning on-the-move at outdoor cultural heritage sites and at the same time considered learners' perspectives

Additionally, although FoSLE seems to share some features with the other models, the details of these features are not the same, as the context is different. For instance, challenges are different in outdoors cultural heritage contexts than in other contexts. In essence, FoSLE is a novel model that support ubiquitous learning on-the-move in outdoor cultural heritage context for introducing new learning technologies.

8.4. Conclusion

This chapter presented a theoretical framework of smart and ubiquitous learning environments utilising mobile location-based learning services and wearable computing to be used at cultural heritage site, FoSLE. FoSLE was designed to enhance the experience of visitors of cultural heritage sites and support them to take learning opportunities on-the-move in different contexts. Three field studies were pulled together to formulate the framework supported by the related learning theories. A summary of learning theories and a comparison with previous models and frameworks were presented. FoSLE is designed to assist researchers and designers who are working in this field for designing smart and ubiquitous learning environments for outdoors cultural heritage sites. It is designed to enhance informal learning from these sites. The framework consists of six broad categories, which are: learner, content, learning design, interaction design, context, and, challenges and obstacles. FoSLE was further analysed to pull out general requirements to inform the design of ubiquitous learning environments to be used at cultural heritage sites; details are given in the next chapter.

Chapter nine

9.Requirements for designing smart and ubiquitous learning environments based on mobile and wearable technologies with respect to cultural heritage sites

Chapter 8 has presented a framework for designing new smart and ubiquitous learning environments based on mobile and wearable technologies with respect to outdoors cultural heritage sites, FoSLE. FoSLE resulted from the results analysis of the field studies that were carried out to elicit user requirements (details presented in Chapters 4, 5 & 6). This chapter presents the shaping of the requirements for designing smart and ubiquitous learning environment, which include general requirements that act as design principles (top-level requirements) and low-level requirements that are an intermediate step between the top-level requirements and the system design; in other words, top-level requirements are more abstract and the low-level ones are more specific and detailed. The general requirements were devised from the FoSLE framework and were further analysed to pull out low-level requirements. The general requirements form a link between the framework and the design of new technologies; this chapter describes the shaping of the general requirements that were devised from the framework, as well as the low-level requirements. This chapter is structured as follows: Section 9.1 outlines the general requirements; Section 9.2 is about drawing out the design solution elements (low-level requirements act as design recommendations); Section 9.3 illustrates the use of the requirements for system design; and Section 9.4 concludes the chapter.

9.1. General requirements

A set of general requirements (GRs) has been devised from the theoretical framework to inform the design of a smart and ubiquitous learning environment utilising mobile location-based services. Nine design principles in a form of general requirements were devised from the framework, which act as top-level requirements; Table 9.1 illustrates the relation between the

framework and the GRs by highlighting the corresponding category from the framework for each requirement.

Table 9.1: Linking the requirements to the framework

No.	GRs	Category
1.	The service should maintain a learner model	Learner
2.	The service should maintain a content object	Content
3.	The service should help generate learners' interest	Learning design
4.	The service should support different types of learning and learning preferences	
5.	The service should support learning on-the-move	
6.	The service should support learners to communicate with each other	
7.	The service should support learners to interact with the context easily and efficiently	Interaction design
8.	The service should support learners to take a learning opportunity in different contexts	Context
9.	The service should consider the challenges that might arise in using mobile devices in outdoor settings.	Challenges and obstacles

GR 1. The service should maintain a learner model:

People differ in their characteristics, habits, interests and motivations in all life's aspects including learning. They do not perform learning in the same manner; people's characteristics and preferences should influence the design of mobile informal learning services.

GR 2. The service should maintain a content object:

Content is an important element in the learning process, and within the cultural heritage context, it helps learners to make sense of history, which in turn helps learners appreciate history. A few aspects need to be considered for acquiring a full picture of historical events and stories:

GR 2.1 the service should provide information that shows a connection between sites that share the same events.

GR 2.2 the service should provide useful information that assists learners in their learning journey such as the weather, transportation and opening times.

GR 2.3 the service should maintain learning content that enhances learners' engagements by providing different types of historical information, such as life back in time and development of sites over time.

GR 2.4 the service should provide different levels of details of information to suit different learners.

GR 3. The service should help generate learners' interest:
Learners would like to receive a service that motivates them to physically visit cultural heritage sites.

GR 4. The service should support different types of learning and learning preferences:
Different types of learning support different characteristics of learners as they are diverse in their learning habits. The service should support learners to learn socially, experientially, individually, and collaboratively.

GR 5. The service should support learning on-the-move:
With the rapid pace of our daily life, people might miss exploring history; by allowing people to learn on-the-move, the app could support them to learn more about history, which in turn helps them appreciate history. Using learners' current location helps to provide instant and contextual information regarding the nearby attractions while doing their daily activities.

GR.6 The service should support learners to communicate with each other:
Supporting learners to interact with each other would have a good impact on the amount of knowledge they take back from the experience as they exchange knowledge as well as stimulate each other's knowledge.

GR 6.1 the service should allow learners to share the experience in different contexts and format.

GR 6.2 the service should allow learners to communicate with each other regardless of where they physically are.

GR 7. The service should support learners to interact with the context easily and efficiently:
Visitors of cultural heritage sites learn from sites by interacting with attractions and artefacts. As they consider the visit as a form of entertainment, the interaction with the context should be pleasurable.

GR 7.1 the service should maintain flexible services and functionalities that can be switched off if they are not needed or simply abort the task at any stage.

GR 7.2 the service should provide different formats and styles to present information.

GR 7.3 the service should provide different functions and services that assist learners in taking a learning opportunity.

GR 7.4 the service should allow learners to use different mobile devices that suit their convenience.

GR 7.5 the service should allow learners to organise their visit beforehand.

GR 7.6 the service should assist learners to immerse in the experience.

GR.7.7 the service should offer a better interaction experience by offering different ubiquitous and wearable devices with the artefacts using ubiquitous and wearable technologies.

GR 7.8 the service should offer an opportunity for learners to experience life back in time.

GR 7.9 the service should be context-aware when delivering historical information.

GR 8. The service should support learners to take a learning opportunity in different contexts: Learning could take place at any time and in any context as there is no restriction of time and place for learning. The results of the field studies confirmed that people use mobile devices for learning whenever they need regardless of time and place. Thus, different contexts should be considered when designing such services.

GR 8.1 the service should allow learners to use features and activities as groups.

GR 8.2 the service should allow learners to have a personal experience on their own at sites.

GR 8.3 the service should allow learners to use services when they are off the site.

GR 9. The service should consider the challenges that might arise in using mobile devices in outdoor settings.

Challenges and problems that might arise during the experience could hinder the process of learning. That in turn, could discourage learners from using the service at sites.

GR 9.1 the services should consider learners' interest and provide alternatives in terms of functionalities.

GR 9.2 the service should consider the surrounding environment and apply an adaptation mechanism based on the surroundings.

GR 9.3 the service should consider learners level of familiarity with technology and provide sufficient explanation regarding each feature and activity.

9.2. Drawing out the design solution elements (low-level requirements)

Design solution elements, which are called low-level requirements throughout this research (LRs), were developed by using the scenario-based design method. Scenarios serve to specify the design concept, which help to visualise the context of use. LRs serve to specify the design space and provide a wide-range of design possibilities, which then led to introduce a ubiquitous learning environment. The scenarios were developed based on the general requirements that were outlined in Section 9.1, which then led to pull out a set of LRs that act as an intermediate step between the general requirements (top-level) and developing features and services in the working system (see Figure 9.1); details are given further in this section.

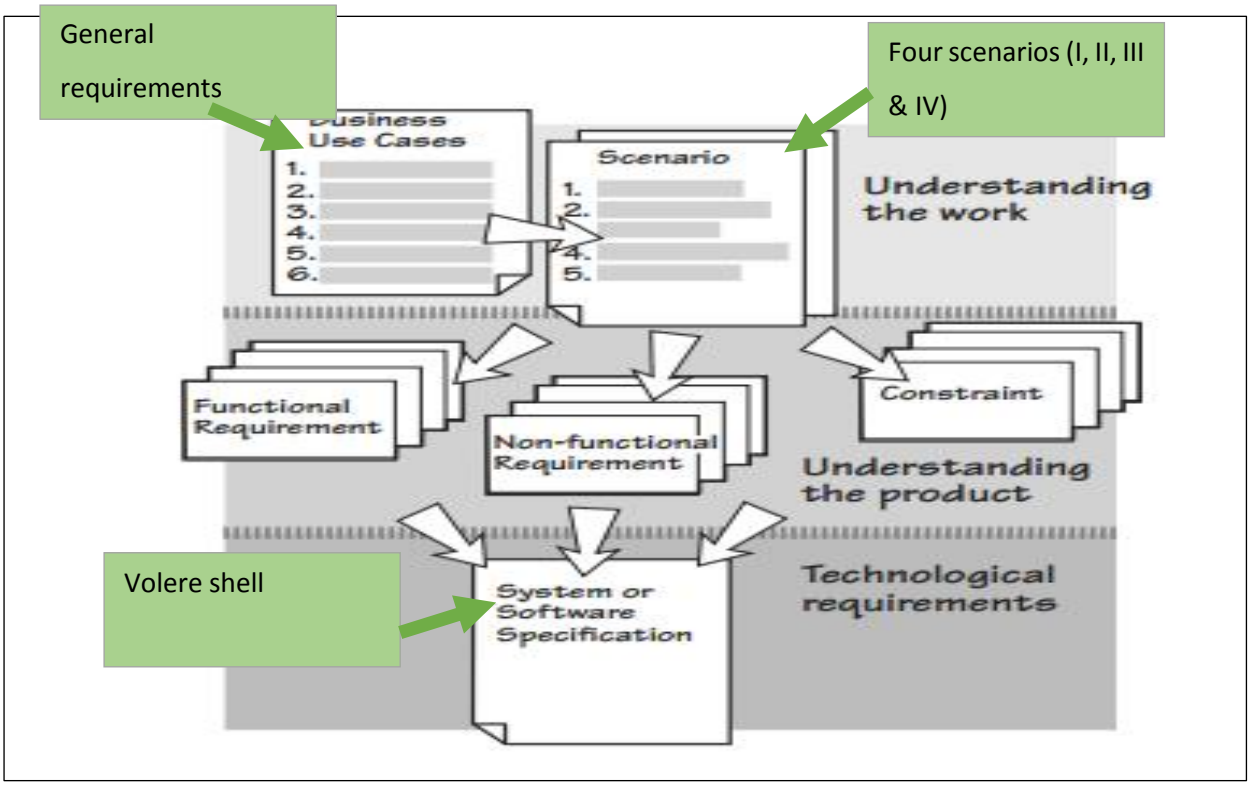


Figure 9.1: illustrating the process of developing the requirements (Robertson & Robertson, 1999)

9.2.1. Scenario-based design

The scenario-based method is used in the field of HCI to identify the suitable environment for developing new technologies (Andone et al., 2006; Fallahkhair, Pemberton, & Masthoff, 2004). This project used the scenario-based approach as a means to depict the context of use based on the general requirements presented earlier with the functionalities that facilitate the learning process (Carroll, 2000). Four scenarios were developed to assist in translating the

general requirements into design elements (low-level requirements) and then guiding the design of the proof-of-concept app. The scenarios are presented in a narrative form below.

Scenario I: Joseph is an engineer who works in an oil company; his job involves a lot of travelling across the world. He likes history and he is keen to learn about it especially when he passes nearby historical places. Unfortunately, he does not have enough time to discover the stories behind those historical sites that he visits. Once, while he was in Malaysia with his team, he met one of his old friends who was there on holiday. Joseph asked him to go for a coffee together and on their way to the coffee shop they passed a historical temple. Joseph noticed that his friend received a mobile phone notification indicating "this is a historic temple known as 'Buda cave' ". Joseph asked him about this notification; he answered "this is a mobile phone app which enables people to receive an automatic notification when historical sites are nearby. The app also provides the users with different choices for presenting the information (i.e. pictures, audio, video or text). I prefer the audio format, which allows me to listen to the information while I am walking. This app gets Joseph's attention as he could use it while travelling. In this way, he can discover the stories behind the historical sites that he likes without the necessity to spend a significant amount of time surfing the Internet.

Scenario II: Dana and Sam are parents of three children; Sarah is 6, Jannah is 8 and Tom is 10. They are keen to get their children to learn about culture and history. They believe that the best way to do it is by taking them to visit cultural heritage sites. However, they are concerned about how to get them to enjoy the trip and learn at the same time especially that the kids are different in their preferences and how they like to learn. Sarah and Jannah like to listen to a story, whereas Tom likes challenges such as quizzes. Sam has noticed that some of his colleagues use a mobile app when visiting cultural heritage sites. This app enables them to personalise it based on their preferences and also gives them an opportunity to choose how they prefer information to be presented (learning preferences). Sam downloaded this app on his mobile phone as well as to his wife's mobile phone and also to the kids' tablets. During a summer holiday, they took the kids to visit the Southsea Castle in Portsmouth. Sarah and Jannah chose listening to the historic information about this castle in a story form. Sarah chose to listen to the story as an audio cartoon film, while Jannah chose to listen to a story that was told by a narrator. Tom chose to get information by taking a quiz that asks him to find the tunnel for instance and tick the right choice about why this castle was built? At the same time

the family created a network between them, which enabled the parents to track their kids' route, share information, and also to enjoy their trip together as a family group.

Scenario III: Sarah is an undergraduate student; she enjoys visiting historical sites. She preferred to experience the heritage sites with her friends and family members to share knowledge and experiences. She has got a mobile app which enables her to create a network with other people either at the site or elsewhere. The network could be created in two situations: in or off the site. In the first one (the entire group at a cultural heritage site), the app enables her to communicate with other members of the group while they are on a trip. That helps her to know about other artefacts that have been visited by other people (e.g. to know about the HMS Warrior ship in the Dockyard while she is in the Mary Rose museum). In turn she could tell them about the interesting things in the museum as well. In addition, they can have a conversation between them regarding the trip or plan for the next step such as going for lunch. This communication between members of the group could happen by either talking directly with each other by using a chatting service in the app, either text or voice, or by reviewing what other members have posted like photos or comments. On the other hand, same facilities could be used by the members of the group who haven not joined the trip. In this situation, the member of the group who has not joined the group could watch a live tour by using the video call service. Therefore, Sarah is pleased to use it at cultural heritage sites and also she recommended it to other people, which helps them communicate with each other and share information in different contexts.

Scenario IV: Mary is the mum of a 16-year-old Amy. Mary is very passionate about cultural heritage and wants to get her daughter to learn about her culture. Amy does not find visiting cultural heritage sites very interesting as she sees sites as ruined abandoned places like a dead habitation. Mary found a mobile app that has an interesting service that enables visitors to experience life back in time which helps visitors to be closer to the past. The service could be delivered through the mobile phone's camera or smart eye glasses. Mary thought that might help changes Amy's perspective about historical places. This service enables visitors to travel inside history and watch people's life back in time. She took Amy to a historical place that used to be a battlefield back at a particular period of time and encouraged her to use this service. Amy chose to use the smart eye glasses with a headset as she thought that would enable her to immerse in the atmosphere. The service displayed a real situation of the life back in time. Amy imagined herself walking down a street watching and listening to events surrounding her. Amy enjoyed the experience a lot, which gave her a real picture of how life back in time used to be

and she understood stories behind events that happened back in time. That experience helped her appreciate history and made her feel proud about her culture. It helped change her opinion about visiting cultural heritage sites; Amy now sees that place differently, like the site is brought to life and not only a bunch of abandoned bricks.

9.2.2. **Translating the scenarios into LRs – first version of the list of design recommendations**

General requirements act as top-level requirements, which are further analysed into design elements as low-level requirements, mediated by scenario-based design using the scenarios presented in the previous section. The aforementioned scenarios helped identify activities that could be supported by the new artefact, which in turn helped pull out LRs that could be adopted to design a working system. LRs illustrate a wide-range of design possibilities, which act as recommendations for designing such services. Table 9.2 illustrates the translation of the general requirements into design elements mediated by scenario-based design and accompanied by the framework's category they are belonging to.

Table 9.2: illustration of translating the general requirements to design elements

Framework's category	General (GRs) Requirements	Scenario	Design framework	Examples of the design solution element (LRs)
Learner	GR1: The service should maintain a learner model	I & II	Assist learners in personalising the service based on their interests	• Collect information about learners' interests by either tracking learners' route and save preferences, or let learners provide personal information regarding their interests when first sign up, such as the favourite types of cultural heritage sites. • Use learners' profile to give recommendations of services and activities • Enables learners to choose their favourite aspects (e.g. colour, learning preferences).
Content	GR2: The service should maintain a content object	II & IV	Assist learners to have a full picture about stories that a certain site has experienced back in time.	• Store historical information in a joint database that includes all attractions which are sectioned under cities and regions (e.g. Portsmouth/ Dockyard: HMS victory and HMS M.33.) • Provide historical information about: • Human achievements at that time

Framework's category	General (GRs) Requirements	Scenario	Design framework	Examples of the design solution element (LRs)
				• Events that these sites have had back in time • Stories behind these sites • Life back in time • How sites used to appear in the past • Development of the site over time • Information about archaeology and excavation of these sites • Interesting facts and funny stories about famous characters (e.g. a famous character was telling a joke about such and such during lunch time) • Provide useful information based on sites (e.g. public service such as cafes, toilets, transportations, ticket prices, and the weather.)
Learning design	GR3: The service should help to generate learners' interest:	II, III & IV	Encourage learners to visit cultural heritage sites and to take new learning opportunities	• Provide a functionality that helps motivating learners to visit cultural heritage sites (e.g. a short video talking about the significant achievements of human that had achieved at a particular site back in time)
Learning design	GR4: The service should support different learning types and preferences	I, II, III & IV	Assist learners to choose the way that would like to learn and make it an enjoyable process	• Provide different services and activities to support different types of learning such as Geo-cashing activity, games regarding historical events or characters. • Provide various preferences of learning content that suit different types of learners (e.g. stories, quizzes, and riddles.)
Learning design	GR5: The service should support learning on- the- move	I, II, III & IV	Assist learners to learn while they are doing their daily routine	• Delivering instant information regarding historical places when passing by
Learning design	GR6: The service should support learners to communicate with each other	I, II, III & IV	Support learners to share knowledge and experiences regardless of their physical locations	• Enable learners to create a network with each other to share thoughts and ideas while they are at the site (i.e. online community).

Framework's category	General (GRs) Requirements	Scenario	Design framework	Examples of the design solution element (LRs)
				• Enable learners, who are at the site, to create a network that enables video calls with friends and family who are not physically at the site to share with them the experience and help them to see the site using the device camera (distance visit).
Interaction design	GR7: The service should support learners interact with context easily and efficiently	I, II, III & IV	Make the app a pleasurable tool and easy to use for all learners	• Provide a service that enable learners to look up useful information beforehand to organise their visit properly (e.g. the weather, tickets and prices, transportation.) • Provide services that help receiving historical information based on the learner's current location (e.g. a location-based tour, a map contains nearby sites). • Provide different information format to deliver historical information (e.g. audio, video, text and images). • Adopt a feature that enables learners to immerse themselves in the experience and use their senses to experience life back in time (e.g. use a new technology such as immersive devices to provide a simulation that enable learners to smell, listen, touch and imagine themselves taking part of that time). • Provide an opportunity for learners to switch between services or abort them easily (e.g. give a "cancel" choice if they do not want to proceed). • Provide features that enable the app to switch between day and night modes based on the time of the day.

Framework's category	General (GRs) Requirements	Scenario	Design framework	Examples of the design solution element (LRs)
				• Allow learners to use wearable and immersive technologies at sites.
Context	GR8: The service should support learners to take a learning opportunity in different contexts	II & III	Support learners to learn in different contexts in terms of times of the visit, the type of the visit, and type of visitors.	• Support learners in sharing experiences in both contexts – in and off the site. • Support learners in using services to experience sites individually or in groups. • Support a group visit (e.g. with kids, either their kids or school children, with a group of friends or family). • Support learners to re-view the attractions when they are off the site after the visit.
Challenges and obstacles	GR9: The service should consider the challenges that might arise in using mobile devices in outdoor settings.	I, II, III & IV	Support learners to overcome challenges and provide alternatives that suit learners.	•Handling the potential errors (e.g. no Wi-Fi connection is available) by displaying error messages or caution messages to make them aware of what they are doing (e.g. "this service is using your data", "this service requires an internet connection"). • Enable learners to switch between devices easily (e.g. between wearable computing such as Smart glasses and the mobile phone). • Provide feedback messages and explanations about how a service works.

Although four scenarios were developed, scenario I was adopted to be fully implemented in a working system with an element of the immersive experience from scenario IV. The next section presents the adopted requirements and rationale behind the decision.

9.3. From requirements to system design

Section 9.1 outlined the general requirements which act as top-level requirements. Section 9.2 visualised the design concept in the form of a scenario narrative design which was further analysed to pull out low-level requirements. The low-level requirements provide a wide-range of design possibilities, which specified the design space providing an overview of what could be developed to deliver smart and ubiquitous learning environments. These requirements could

inform the design of several systems as it is difficult for one single system to address all these requirements. Designing different systems to respond to these requirements is out of the scope of this project due to time constraints.

A design and implementation stage of a proof-of-concept of mobile application prototype was carried out in two phases: phase 1, designing a high-fidelity prototype; phase 2, developing a working system, which is called SmartC. The high-fidelity prototype included all the general requirements using some of the related low-level requirements. Some of the general requirements were excluded in the working system for one of two reasons: (1) time restriction; (2) implementation restriction, which means it is difficult to implement it at the current time for technological reasons. Table 9.3 illustrates the general requirements with the rationale why they have or have not been chosen.

Table 9.3: illustrating the excluding requirements and the reasons for that

GRs	Reason to exclude
GR1: maintaining a learner model	Time restriction (time of the evaluation sessions): users need to create their own account on their own devices to experience the features properly.
GR 3: generate learners' interest	Time restriction
GR 6: support learners to communicate with each other	Implementation restriction

Maintaining a learner model requires learners to create their own account to allow the device to collect data regarding their preferences either automatically or by letting learners to provide their own preferences. This process needs the learners to use the app on their own devices and experience it for a few times in order to properly assess the related features. The same is true for generating learners' interest as this requirement requires features to motivate learners to physically visit sites, which need to be used before the visit. Supporting learners communicate with each other needs to implement either a virtual network community or a form of social media to enable learners to communicate efficiently, which is difficult to implement from technical perspective.

The involved general requirements were translated into features and services using the related low-level requirements that were illustrated in Table 9.2. The involved requirements and the rationale are illustrated in Table 9.4.

Table 9.4: illustrating the involved LRs with the rationale for choosing them

LRs	Rationale
Delivering instant information regarding historical places when passing by	An essential feature to support learning on-the-move, and also just-in-time and situated learning
Provide different information format to deliver historical information	Highly stressed by the results of the field studies
Adopt a feature that enables learners to immerse themselves in the experience and use their senses to experience the life back in time	To carry out further research related to immersive technology Highly stressed by the results of the field studies
Allow learners to use wearable and immersive technologies at sites	To carry out further research related to immersive technology
Handling the potential errors	Highly stressed by the results of the field studies

As illustrated in Table 9.4, different rationales were behind each involved feature. The features were chosen because of the following reasons: (1) further research was needed, (2) it was stressed by the results of the field studies; (3) it is an essential element for ubiquitous learning to support learners to learn on-the-move. Receiving notifications based on location would assist learners to learn about attractions when passing nearby while doing their daily routines. Presenting historical information in multimode information format would accommodate different preferences, which meet different learners' characteristics. Providing a service that shows how attractions appeared in the past was highly stressed by the participants as potential end-users, which warrants further research. The same is true regarding harnessing wearable computing (i.e. smart eye glasses). Handling the potential errors by informing learners about processing a request of using features or explaining how features work would assist learners overcome challenges, which is implemented by displaying messages explaining the

app/features in different stages. Full details of the implementation process and description of the working system are given in the next chapter.

9.4. Conclusion

This chapter has presented the process of shaping the requirements, i.e. both the general (top-level) and the low-level ones. General requirements were devised from the FoSLE framework, which was presented in Chapter 8. Nine general requirements were described which cover different dimensions of designing smart and ubiquitous informal learning environments for outdoor cultural heritage sites. These top-level requirements act as a bridge between the theoretical framework and the design of the new artefact, which is called SmartC. The general requirements were visualised using the scenario-based design method to provide a tangible picture of the contexts of use. Four scenarios were presented in a form of a narrative design; the scenarios were further analysed to pull out low-level requirements, which provide a wide-range of design possibilities. The involved and excluded requirements were highlighted with the rationale of the decision. Details of the design and implementation of SmartC are presented in the next chapter, Chapter 10.

Chapter ten

10. The design and implementation of a smart and ubiquitous learning environment utilising mobile location-based services and wearable computing

Chapter 9 outlined the general requirements that were devised from the FoSLE framework, which helped inform the design of smart and ubiquitous learning environments based on mobile and wearable technologies. This chapter presents the design and implementation of a smart and ubiquitous learning environment based on these requirements. A high-fidelity prototype was designed based on the general requirements to illustrate a wide-range of design possibilities that could be implemented in several versions. Some of the design possibilities have been chosen to be fully implemented in the first version of the working system which is called SmartC. Section 10.1 presents the design of the high-fidelity prototype and Section 10.2 describes the proposed technology, SmartC. Section 10.3 presents the architecture of the proposed system, while Section 10.4 presents the system specification using the Volere shell. Section 10.5 presents the implemented system and Section 10.6 presents a proposal scheme for content deployment. Section 10.7 summarises similar technologies and compares them with the proposed one, and Section 10.8 concludes the chapter.

10.1. The high-fidelity prototype

So as to simulate the context of use and the possible features that could be developed based on the requirements outlined in the previous chapter, a high-fidelity prototyping method was used. The high-fidelity prototype was designed based on the scenarios described in the previous chapter, which were based on the general requirements that were identified in the same chapter. A wide range of the design possibilities were identified, which could be implemented in a number of systems. Table 10.1 outlines the features that were included in the high-fidelity prototype, with their corresponding general requirement.

Table 10.1: features included in the high-fidelity prototype

Features	GRs	Framework' category
Getting directions	GR 5: The service should support learning on-the-move	Learning design
Notification based on location		
Location-based tour		
Nearby sites		
Favourite list	GR1: The service should maintain a learner model	Learner
Public services	GR2: The service should maintain a content object	Content
Information services		
Chat service	GR6: The service should support learners to communicate with each other GR7: The service should support learners to interact with the context easily and efficiently	Learning design Interaction design
Generate comments		
Sharing service		
Multimode information format	GR4: The service should support different types of learning and learning preferences	Learning design
	GR7: The service should support learners to interact with the context easily and efficiently	Interaction design
Seeing sites in the past	GR7: The service should support learners to	Interaction design

	interact with the context easily and efficiently	
	GR2: The service should maintain a content object	Content

The prototyping method helps identify any issues with the design in the early stages to prevent major issues that might affect the working system (Virzi et al., 1996).

Proto.io was used in this stage to develop an interactive simulation prototype which is designed to be a context-aware system that identifies the learner's location. That, in turn, allows the device to provide contextual information about what is nearby in terms of cultural heritage sites. The main interfaces and features are given below (see Figure 10.1).

The app asks a permission to use the learner's current location to prepare a list of nearby sites and provides an opportunity for learners to choose the preferred sites. In addition it provides an opportunity to receive notifications when learners pass close to an attraction based on location and their profile. Additionally, it provides information in multimode format and the "see it in the past" service. The main aim of developing this prototype is to illustrate what could be developed based on the general requirements that were outlined in the previous chapter. Another aim is to obtain feedback regarding the design in the early stages of the development. Some of the features were chosen to be fully implemented in a working system; details about this are presented in Sections 10.4 & 10.5.

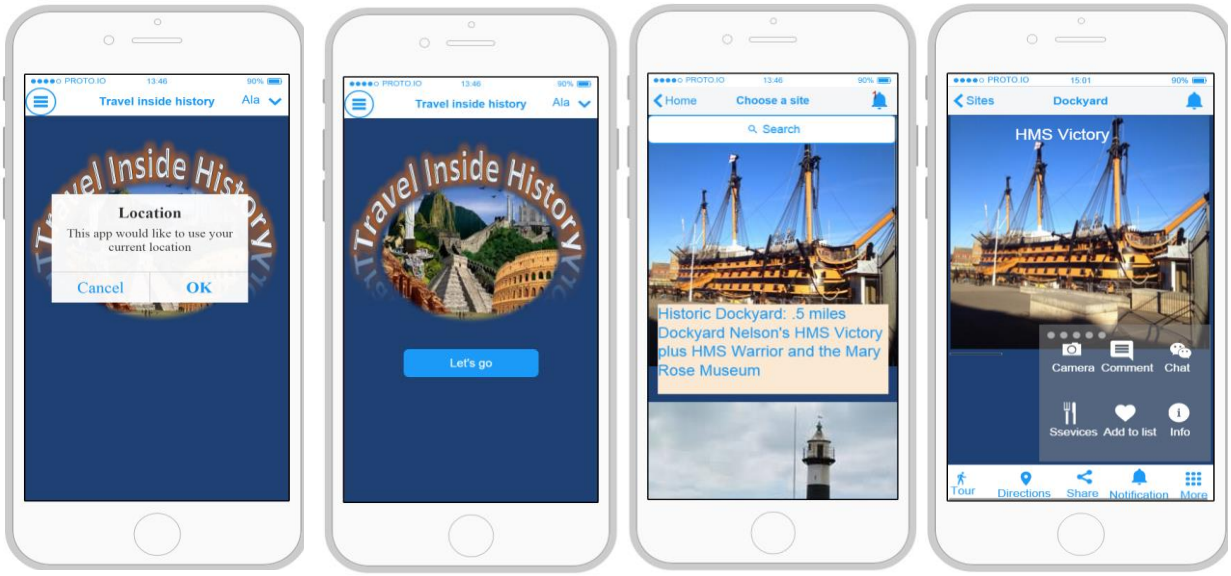


Figure 10.1: illustration of the high-fidelity

The prototype was evaluated by one expert in HCI, who has around four years of experience, and two potential end-users, who participated in the interview study. The think-aloud method was used to obtain feedback from participants (Lewis, 1982; Someren, Barnard, & Sandberg, 1994). It has been used in the field of HCI, which allowed the researcher to capture the participants' thoughts as soon as they come to mind when they are performing tasks using a prototype (Jaspers, Steen, Van Den Bos, & Geenen, 2004). The evaluation with the HCI expert was carried out first at the University of Portsmouth – notes were taken during the session that lasted around 20 minutes. The evaluation sessions with the end-user participants was carried out at the same time as the interviews, which were recorded.

The prototype was shown to the participants on the computer due to some technical issues that prevented accessing it using a mobile phone. The participants reacted positively towards the design of the prototype and emphasised that it could be a useful tool for learning from sites. Few issues were identified regarding labelling, wording and some aspects of the interface design such as colours. As it was mentioned before, part of the prototype was chosen to be fully implemented into a working system. The next section describes the proposed system.

10.2. The smart and ubiquitous learning environment: SmartC

One objective of this PhD research is to provide a learning tool that assists people to learn informally about cultural heritage on-the-move and to be used at outdoor settings. A smart and ubiquitous learning environment was developed as a proof-of-concept, which is called SmartC. SmartC utilises context-aware technology to provide historical information on-the-move, harnessing mobile and wearable technologies. The implemented version of SmartC was designed around a subset of general requirements that were outlined in the Chapter 9. It is an informal learning environment which delivers contextual historical information to enhance learning from outdoor cultural heritage sites. Additionally, it is to support people to learn about sites while they are doing their daily routines. The contextual information is delivered through the mobile device's screen and smart eye glasses based on location in the form of notifications. The notification comes up when learners pass close to an attraction to draw their attention that there is an attraction nearby, which could interest them. Learners have an opportunity to access more information regarding that attraction when viewing the notification message. The smart eye glasses help learners to engage their sight with the attractions and artefacts simultaneously with receiving information.

SmartC also supports learning preferences as it provides multimode information format to accommodate a wide-range of characteristics. Audio and text descriptions are provided to allow learners to choose the way they like to receive information. Video also is available to illustrate the history of attractions, which could help learners to perceive historical stories efficiently. Images of attractions also are provided to help learners associate the given information with the corresponding attraction. SmartC provides an opportunity for learners to see how attractions used to look in the past in order to help learners imagine these sites back in time. This service is based on the location of attractions as it works only if the device faces the attraction.

10.3. Architecture of SmartC

SmartC is a native android app, which was designed for smartphones and to be used in outdoor cultural heritage settings. A Sony XPERIA android device was used throughout the design and implementation stage. Sony android smart eye glasses were used in this research which helped investigate how learners react to it in the field; details about this are given in Section 11.4. The smart eye glasses device is connected to the mobile phone via a Bluetooth connection.

Android studio was used to develop this app. A database (SQLite) was utilised to store data and Java programming language was used to handle retrieving information when requested by learners. The database is saved on the mobile device itself, thus, once the app is downloaded into the device, no internet connection is needed to retrieve content unless it is a video information format, in which case an internet connection is needed to retrieve it from the cloud.

This app uses geo-fence technology, which is placing a virtual boundary around a geographical area. It works when a user enters or leaves the area, which is identified by latitude and longitude of the area (Garzon & Deva, 2014). For this app, a circle shape of a radius of 100m was used to identify the geographical area of each involved attraction. The mobile device gets triggered when a learner enters that virtual zone, which it is tracked using the GPS of the device. The device pushes a notification to alert the learner when he/she gets close to an attraction. Notifications are pushed via the app through the mobile-based interface and the glasses-based interface simultaneously when the mobile device gets triggered. It is important to clarify, setting a radius of 100m might sound a big distance for attractions that are located in the one single site such as Historic Dockyard, which they are relatively close to each other. However, it was used to overcome a technical issue that was captured during testing the app in the very early stages of the design. The issue was that the location of some attractions is quite deep

inside the attraction yard, which is hard to be picked by the device unless learners get very close to the attraction, which they do not necessarily do (see Figure 10.2). The next section describes the system specification using the Volere shell.

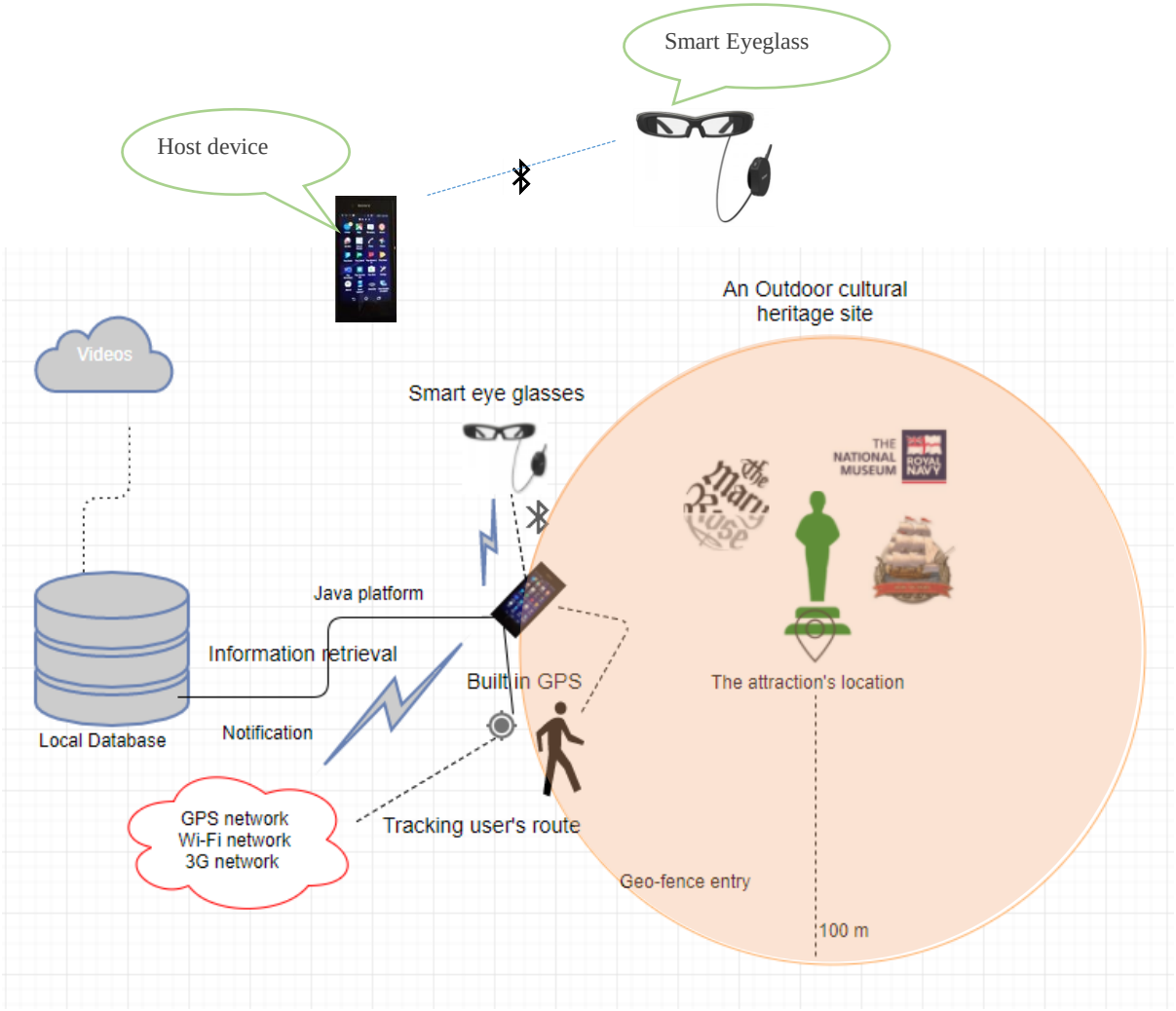


Figure 10.2: illustration of SmartC's architecture

10.4. SmartC: the working system specification

Section 9.4 illustrated the involved requirements in the design of the proof-of-concept. This section presents the working system specification using the Volere shell (Robertson & Robertson, 1999), which helps to document the low-level requirements (LRs) that were later translated into features and services for a working system. Details are given using the templates of the Volere shell. The template specifies the adopted requirements and links them to the source (scenarios and/or general requirements presented in Chapter 9), and also provides the rationale for using them. Additionally, it provides an illustration of how these requirements will be fulfilled in the system.

Requirement	LR 1:Delivering instant information regarding historical places when passing by
Requirement type	Low-level
Event/use case	Scenario I
Description	The system should allow learners to receive instant information on-the-move regarding cultural heritage sites based on location.
Rationale	It is an essential feature in learning on-the-move. In addition, the results of the field studies reveal learners like receiving instant information while doing their daily routines
Originator	General requirements 5
Fit criteria	The requirements will be fulfilled once the system implements delivering notifications based on location about cultural heritage sites when passing by.
Supporting material	Section 10.5

Requirement	LR 2: Provide historical information about how sites used to appear in the past
Requirement type	Low-level
Event/use case	Scenario I & IV
Description	The system should provide information to show how sites looked in the past
Rationale	The results of the field studies suggest learners like seeing sites how appeared in the past
Originator	General requirements 2
Fit criteria	The requirements will be fulfilled once the system provides information in a form of image to show how sites looked in the past
Supporting material	Section 10.5

Requirement	LR 3: Provide historical information about Stories behind these sites
Requirement type	Low-level
Event/use case	Scenario I, II, III & IV

Description	The system should provide information to tell the stories behind these sites
Rationale	The results of the field studies suggest learners like find out stories behind sites
Originator	General requirements 2
Fit criteria	The requirements will be fulfilled once the system provides historical information to tell the stories of what happened at that time in the form of text and audio
Supporting material	Section 10.5

Requirement	LR 4: Provide different information format to deliver historical information
Requirement type	Low-level
Event/use case	Scenario I & II
Description	The system should deliver historical information regarding cultural heritage sites in different information formats to suit a wide-range of preferences.
Rationale	The results of the field studies suggest learners like different information formats to receive historical information
Originator	General requirements 7
Fit criteria	The requirements will be fulfilled once the system provides multimodalities to deliver historical information
Supporting material	Section 10.5

Requirement	LR 5: Adopt a feature that enables learners to immerse in the experience and use their senses to experience life back in time
Requirement type	Low-level
Event/use case	Scenario IV
Description	The system should allow learners to see how sites and attractions looked in the past based on location
Rationale	The results of the field studies indicate learners like to experience life back in time in different way such as seeing attractions as they looked in the past

	In addition, this requirement is used to carry out further research about users' opinion related to this feature.
Originator	General requirements 7
Fit criteria	The requirements will be fulfilled once the system provides a service that allows learners to see attractions how they looked in the past using augmented reality technology
Supporting material	Section 10.5

Requirement	LR 6: Allow learners to use wearable and immersive technologies at sites
Requirement type	Low-level
Event/use case	Scenario IV
Description	The system should offer a technology that allows learners to immerse in the experience as well as associate their sight with artefacts while receiving historical information
Rationale	The results of the field studies indicate that learners like using smart eye glasses at cultural heritage sites to free their hands during the experience In addition, further research was needed to explore more about this aspect as some participants were slightly cautious in using it, as it was not as popular.
Originator	General requirements 7
Fit criteria	The requirements will be fulfilled once the system provides a service to allow learners to use smart eye glasses to receive notifications simultaneously with the mobile phone, and offer a seamless swap between the smart eye glasses and the mobile phone
Supporting material	Section 10.5

Requirement	LR 7: Handling potential errors
Requirement type	Low-level
Event/use case	General requirements 9

Description	The system should provide a sufficient explanation regarding its features and functions as well as error messages to allow learners to overcome challenges and problems
Rationale	The results of the field studies highlight that it is important to help learners overcome challenges and problems in all stages of the experience
Originator	General requirements 9
Fit criteria	The requirements will be fulfilled once the system provides error and process messages.
Supporting material	Section 10.5

The aforementioned requirements were translated into features and services in the working system; details are given in Table 10.2 below.

Table 10.2: illustrating the involved the requirements with the rationale of choosing them

Framework's category	GRs	LRs	Features	Rationale
Learning design	GR5	LR1	Receiving notification regarding cultural heritage based on location	An essential feature to support learning on-the-move, and also of just-in-time and situated learning; To carry out further research in context
Content	GR2	LR 2, 3	Providing information how attractions looked in the past. Providing historical information regarding stories behind sites	Highly stresses by the results; To carry out a further research in context
Interaction design	GR7	LR4	Multimode information format	Highly stressed by the results
Interaction design	GR7	LR5	Seeing attractions how appeared in the past	Highly stresses by the results
Interaction design	GR7	LR6	Harnessing smart eye glasses	To carry out further research in context

Challenges and obstacles	GR9	LR7	Displaying messages showing the process or explaining how features work	Highly stressed by the results

10.5. SmartC: the working system

The previous section outlined the requirements that have been chosen to be fully implemented. The adopted requirements were translated into features and services in this version of SmartC, which responded to the most popular activities that resulted from the field studies, which are: (1) receiving notifications based on the location, (2) multimode information format and, (3) see sites in the past. As it was mentioned earlier, the main features have been pulled out from Scenario I & IV. The design of SmartC was kept simple to prevent experts and users getting overwhelmed by many functions, which might obstruct them from fully experiencing the app.

SmartC utilises LBS to identify visitors' location, which in turn, allows the device to provide contextualised information about nearby cultural heritage sites. In addition, it utilises augmented reality technology to show attractions how they appeared in the past. AR is an excellent feature that would enhance learners' experience in outdoors settings of cultural heritage sites (Vlahakis et al., 2001). AR technology could satisfy learners' imagination of how sites appeared in the past and how people back in time used to live. Moreover, the wearable computing employed in this research could facilitate delivering information to learners in an unobtrusive manner through smart eye glasses, which would enhance learners' engagement. Smart Eye glasses free learners' hands while walking in outdoors setting of sites. In addition, they would help engage learners' sight with the attractions they are looking at while simultaneously receiving information regarding these attractions; thus they do not need to move their sight back and forth between their mobile device and the attractions that might prevent them from emotionally engaged with the attractions. SmartC provides different services and functionalities, as it was outlined in Table 10.2, to assist learners in their learning journey at cultural heritage sites, which include:

1. Receiving notifications based on location: Learners get an alert when passing close to an attraction in the form of vibration and sound to inform them there is an attraction nearby which could be interesting. Notifications are delivered through mobile devices and smart eye glasses simultaneously. Learners have a choice to access information about that attraction or abort it if not interested.

2. Multimode information format: learners can receive historical information in different information formats (i.e. text, image, audio & video), which offer a wide range of choice to accommodate different preferences.
3. Seeing attractions how they looked in the past: this service gives an opportunity for learners to see how attractions used to look back in time, which helps to bring past to life. This service uses AR technology to attach an old image to a live camera view when the device is facing the attraction. In the other words, it is a location-based service.

Learners can access these features through the app' interface; details of the interface design are given in the next section.

As SmartC was designed for outdoor settings of cultural heritage, it was important to choose a site that contains several outdoors attractions. Thus, it was decided to choose a local and well-known site in Portsmouth, i.e. the Historic Dockyard, to conduct the evaluation study. The advantage of the chosen site is that it includes several attractions located in one large site and that they are relatively near to each other, which makes it easier for experts and users to walk around and take a quick tour in a small period of time (during the evaluation session).

10.6. The SmartC interface design – first version

SmartC was designed in two versions: the first version was based on the high-fidelity prototype; the second version was an enhancement of the first version based on the results of the experts' evaluation. The first version included a subset of features of the high-fidelity prototype. Some features were not developed and excluded from the interface design in the working system due to pragmatic constraints as clarified in Chapter 9. They were also excluded from the interface design to prevent any confusion that inactive features might cause within the interface. Without extra features and functionalities, there was an expectation that users and experts would focus more on the content presentation and interaction design. The included functions were relevant to gather experts' and users' opinions in the evaluation phase as outlined in section 10.3. The first version is presented in this chapter, which was designed based on subset features of the high-fidelity prototype design; for the second version, more details are given in the next chapter which reports the evaluation studies and how the system was changed based on the results.

SmartC is a context-aware system to help learners of cultural heritage sites to comprehend the history of these sites on-the-move. Learners receive instant historical information while they

are walking close to attractions in outdoor cultural heritage settings. SmartC is designed based on mobile and wearable technologies; details of the interface based on both technologies are given below.

Mobile-based interfaces – first version

The mobile-based screen has five main interfaces that respond to the users' actions, which include (see Figure 10.3):

1. The main interface contains an image of the app's logo and a button "Travel inside history", which is the start button that starts the service.
2. The notification interface with two switches that enable users of the app to switch the notification ON and OFF according to their need. Messages appear on the screen to tell users that notification is ON or OFF after pressing the corresponding button.
3. The received notifications are listed in the message centre of the device; each one has a name and image of the attraction that it notifies for, so users can easily choose what they want to view.
4. The notification message comes in a dialogue form and contains the name and the image of the corresponding attraction, and two options, i.e. to view details or cancel, which enables users to choose what they want at that time. The notification could be viewed through the mobile device or the glasses (see Figure 10.4). However, in this version of the app, the learner needs to use the mobile phone only to access the historical information.
5. When users choose to have more details, they will be directed to an attraction's page. The attraction's page contains two navigation menus that lead to access functions and services. In addition, a text area overlays the image of the corresponding attraction with information about the attraction.
6. The "See it in the past" page shows an old image of a certain attraction attached on a live camera view when facing the corresponding attraction – it works based on the attraction's location.
7. The audio page displays an audio talking about the corresponding attraction and a control bar.
8. The video page displays a video talking about events related to the attraction that happened back in time with a video control bar.

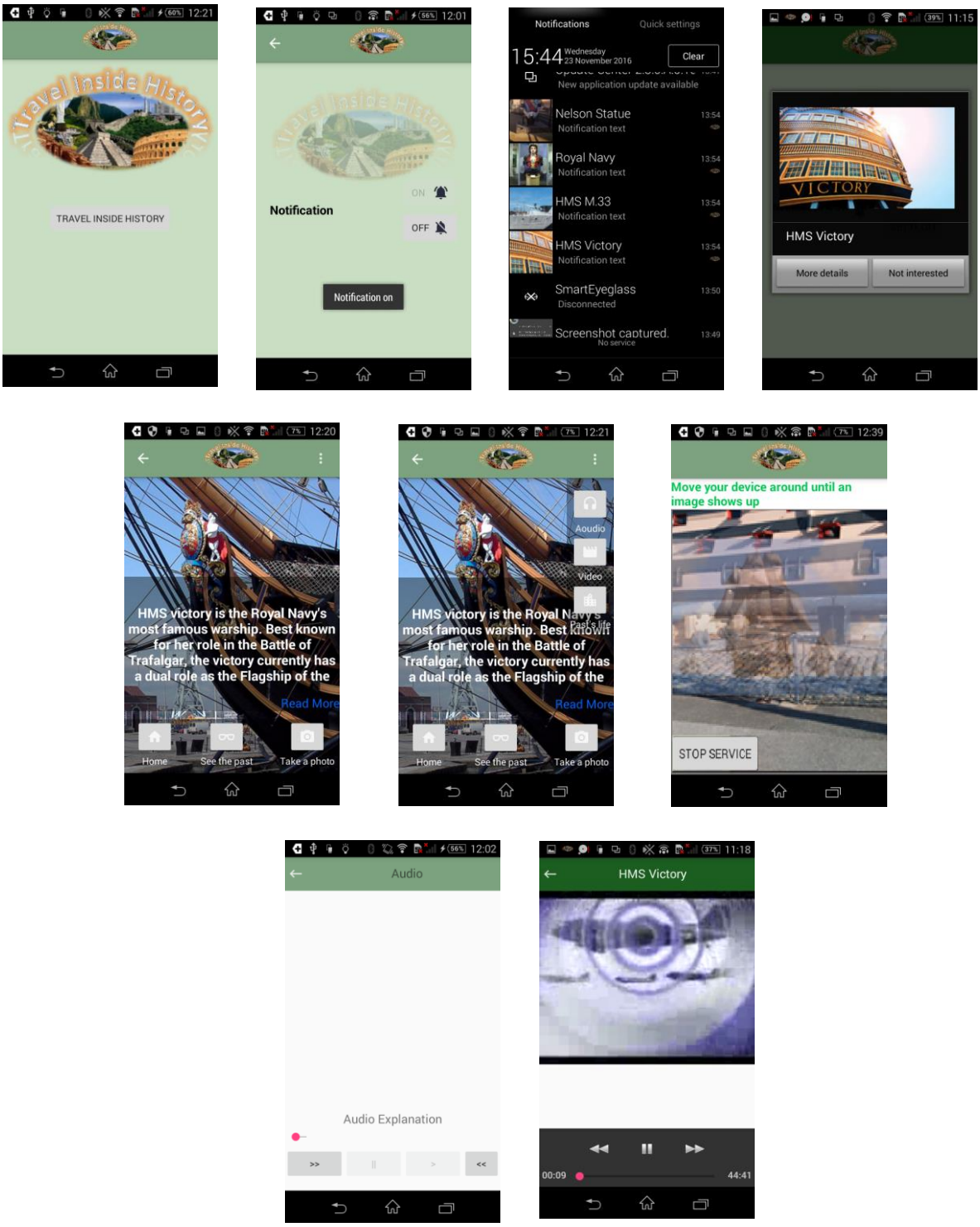


Figure 10.3: The main interfaces of SmartC in the mobile device (first version)

Smart Eye Glasses-based interfaces

SmartC pushes notifications through smart eye glasses simultaneously with the mobile device. Different interfaces were designed to display a notification through the glasses (see Figure 10.4):

1. The name and the logo of the app appear on the glasses when no notifications were pushed.

2. The notification comes up on the desktop interface of the glasses in the form of sounds and a flashing icon, to inform the learner there is an attraction nearby.
3. The notifications' interface with the name of the attraction can be viewed, which gives learners an opportunity to see if the attraction is of interest before taking their mobile phone out of their pocket to access more details.

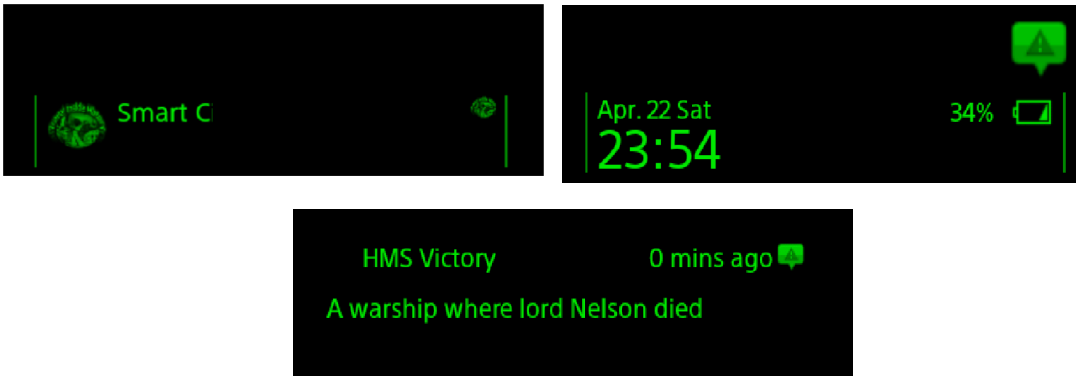


Figure 10.4: illustration the notification of SmartC in the Smart Eye Glass

10.7. The content deployment

As it was mentioned earlier, the Historic Dockyard was chosen as a proof-of-concept to conduct the evaluation study; the content was prepared for attractions involved within the site. As it is very important to provide reliable content, an official member of the cultural heritage site was contacted to obtain content for the attractions that were included in the app. Due to the fact that he was too busy, he directed the researcher to use the official website of the Historic Dockyard and the websites of each individual attraction. Thus, the historical information was obtained from the aforementioned resources and also the BBC website (BBC, 2014; Historic-Dockyard, 2016).

An image of each attraction was provided with all pages related to that attraction, which helps learners associate the information they are receiving with the related attraction. The content, specifically the learning materials, was presented to learners in different forms: (1) an audio form for learners who prefer to listen to information rather than read; (2) text was provided for learners who would like to read or have hearing difficulties; (3) content in an image form was provided for connecting the provided information to the corresponding attraction; (4) content in a video form was provided to illustrate events related to this attraction – this service was for some included attractions, which might help learners to understand events back in time in a

better way. The content was stored in a database in the forms of text, images and audio files; the video files were pulled from the internet, as the size of the files was too big to be stored in the device.

Content was provided for five attractions within the Historic Dockyard site, which are: (1) HMS Warrior; (2) HMS Victory; (3) The international museum of the Royal Navy; (4) HMS M.33; (5) Mary Rose; (6) Lord Nelson's Statue. It is important to clarify that this content is for consumers as this version of SmartC is for end-users and does not include an admin side. In that case the provided content will be prone to be dated if it is not connected to an authorised repository that informs the app with the up-to-date information. However, we assumed that historical information is less likely to be updated as there is not much expectation of new information regarding the past. Nevertheless, curators constantly change the way they present content to make it more interesting and to enhance visitors' engagement. Thus, it is essential to adopt a standard scheme for storing historical information in a sharable repository, which allows stakeholders who are working in the same field, such as curators and designers of such apps, to integrate their work effectively. That could be achieved by using one of two scenarios:

1) Collaborate with cultural heritage sites by doing one of the following:
    a) Create a sharing repository with curators of cultural heritage sites and let them maintain the content of the attractions, which then could be integrated with the apps to feed them dynamically.
    b) Establish an agreement that allows access to their database to inform apps with content.
2) Adopt a mechanism to pull content out dynamically from cultural heritage organisations' websites such as UNESCO, National Trust and English Heritage to feed the apps' database.

The first scenario needs collaboration with cultural heritage organisations, which is relatively difficult to make. However, the content would be more reliable as the authorised staff will be in charge of the content, which would ensure that learners always get worthy and authentic historical information. The second one seems to be easier to obtain, but learners might be concerned about how reliable the content is. In addition, it will be limited to the presented content by the organisations, which will leave not much room for creativity. That in turn might affect learners' engagement to some extent as participants of the field studies stressed that they would like to receive reliable and interesting information that adds value to their experience.

According to that, this research tends to favour the first scenario as it offers more reliability of content as well as gives space for creativity for designers, which is one of the key elements to engage leaners. Thus, a scheme is suggested that could be adopted by stakeholders to maintain a smooth and reliable content deployment (see Figure 10.5).

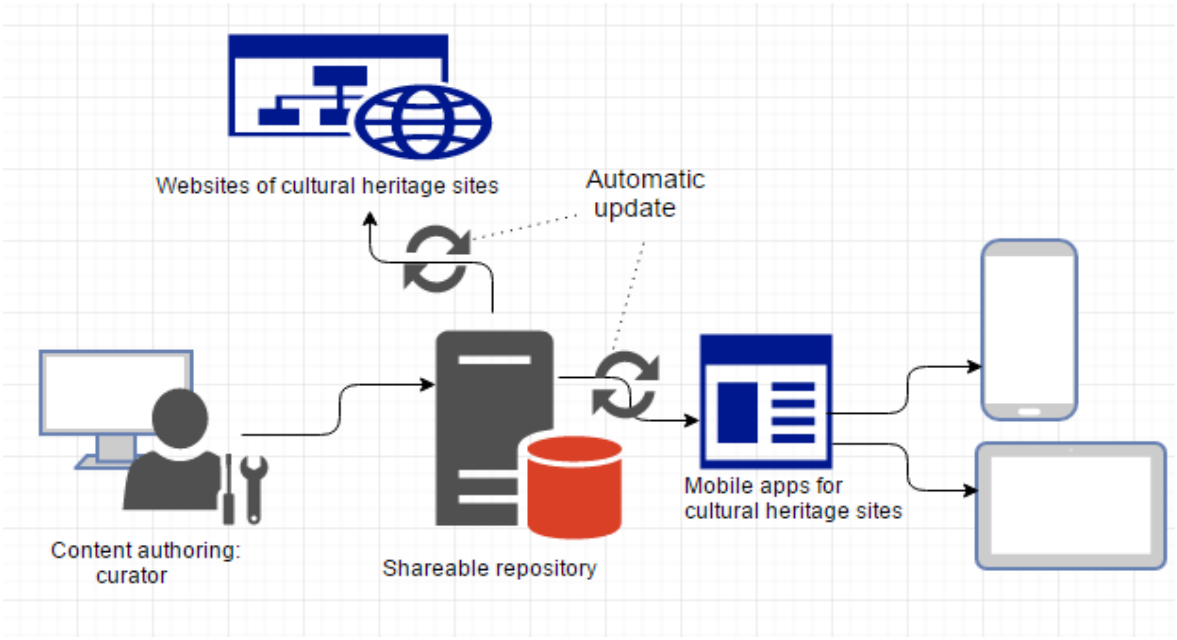


Figure 10.5: illustration of the first scenario for content management

Although SmartC shares some features with some technologies, as discussed in Chapter 2, none of them utilised LBS and AR with the harnessing of mobile and wearable computing for outdoor cultural heritage sites – a comparison of similar technologies with SmartC is given in the next section.

10.8. Comparison of SmartC with similar technologies

Culture heritage constantly attracts designers to provide tools to enhance visitors' experience at cultural heritage sites. A number of studies have developed systems for this purpose. Chapter 2 discussed similar studies in details, which will be summarised in this section. Different technologies were adopted to develop services to contribute to enhancing the visitors' experience, as well as the interpretation of cultural heritage sites. These technologies include Virtual reality (De Paolis et al., 2009; Gaitatzes et al., 2001; Mavrogeorgi et al., 2009), augmented reality (Casella & Coelho, 2013; Chang et al., 2015; Demiris et al., 2006; Vlahakis et al., 2001), near field communication (Angelaccio et al., 2012) and location-based services (Candello, 2012; Schmidt-Belz et al., 2003; Van Aart et al., 2010). This project utilises

location-based services to develop a context-aware service to be used at outdoor cultural heritage sites, as well as adopting an element of AR technology to show how sites used to be back in time. As context is any information that could describe the situations of an entity, and entity could include: a person, network, location and content, systems could be context-aware to user-profile, content or location (Abowd et al., 1997). SmartC is a context-aware to location utilising location-based services – in other words, location-aware. A comparison of the proposed system with similar technologies is given in Table 10.3.

Table 10.3: illustration of differences of similar technologies

Technology	Features								
	Context-aware	LBS	Multimodalities	Notification	information on-the-move	AR	See sites in the past	Outdoor settings	Audio
SmartC	x	x	x	x	x	x	x	x	x
Crumpet: Schmidt-Belza, Zipf, Laamanen, Poslad, and Schmidt (2003)	x	x							
ARCHEOGUIDE: Vlahakis et al. (2001)	x	x				x	x	x	
Candello (2012)		x						x	x
Van Aart et al. (2010)	x	x						x	
Angelaccio, Basili, and Buttarazzi (2013)		x							
AR GUIDE: Damala et al. (2008)			x			x			x
The Historical Tour: Haugstvedt and Krogstie (2012)	x					x		x	
Chang et al. (2015)						x		x	

Table 10.3 summarises technologies that are most related to the proposed one, SmartC. It is clear that none of the aforementioned systems support learners to learn about cultural heritage on-the-move. Learning on-the-move would enhance learners' experience of cultural heritage as it saves time and effort that learners would spend looking for information regarding sites. None of the aforementioned systems provide notifications based on location when learners pass nearby sites or attractions. That could be a very helpful feature for learners who are in new places where they do not know what is interesting surrounding them, which help them invest their visit's time effectively. None of the previous systems provides a service that allows

learners to see attractions as they appeared in the past using AR technology based on location. None of them harnessed wearable computing – smart eye glasses, which gives an opportunity to learners to immerse themselves in the experience and free their hands by providing a choice to receive notifications through the glasses. The value of SmartC comes from the multiple adopted technologies, such as LBS and AR, with the affordance of multiple modalities. The provision of such service would offer a better experience for visitors, which could enhance their understanding of the past. It pulls together different services and features in one app, as presented in Table 10.3, which would enhance visitors' engagement at sites and improve sites interpretation, and consequently might enhance learning from outdoor cultural heritage.

10.9. Conclusion

The design and implementation of a smart and ubiquitous learning environment, SmartC, has been discussed in this chapter. SmartC is a context-aware app using learners' location to provide historical information regarding the nearby cultural heritage sites on-the-move. A comparison with the similar technologies has been made, which revealed that none of the similar technologies support learning on-the-move, which could be essential to keep up with the rapid pace of life. In addition, it provides a notification service to inform visitors what is interesting surrounding them, which could help invest time effectively and efficiently. SmartC also utilises wearable computing, i.e. smart eye glasses, to help visitors of cultural heritage sites immerse in the experience and connect their sight with attractions while simultaneously receiving information regarding the corresponding attraction. Additionally, wearable computing frees their hands from carrying their device all the time for information acquisition. SmartC provides different features and services such as: (1) multimode information format; (2) seeing an attraction how it used to be in the past; (3) location-based notifications. SmartC was designed around a subset of requirements that was outlined in Chapter 9. SmartC was evaluated in the field by experts of HCI and potential end-users; the details of this evaluation study are given in the next chapter.

Chapter eleven

11. Evaluation of SmartC

Chapter 10 discussed the design and implementation of a proof-of-concept mobile app, SmartC. One of the main objectives of this project is to introduce a useful and easy to use piece of technology that could enhance the visitors' experience of cultural heritage sites, as well as improve sites' interpretation, as visitors will be encouraged to use it at sites.

This project carried out an empirical usability evaluation in two cycles with experts of HCI and potential end-users. Usability is defined as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO, 1998). Along with the usability assessment, the prototype was assessed in terms of usefulness and acceptance. As SmartC was designed to be used in outdoor settings of cultural heritage, it was important to conduct the studies in the field to assess the app in the context of use. The Historic Dockyard in Portsmouth, UK was chosen to conduct the studies; the Historic Dockyard is a naval-base site that has a number of outdoor attractions, which make it easier for participants to take a tour at a site and visit a few attractions in a short duration. The results of the evaluation studies contributed to enhance the first list of design recommendations (low level requirements – see Section 9.2.2) that were identified in Chapter 9 for developing such services. The current chapter presents the results of the evaluation studies, which is structured as follows: Section 11.1 presents the experts' study; Section 11.2 presents the users' study; Section 11.3 summarises both studies (experts and users); Section 11.4 outlines the conclusions.

11.1. The experts' evaluation study

An experts' evaluation study was conducted with experts of HCI to point out any usability problems with the SmartC app before conducting the user study. The feedback obtained during the study helped to enhance the proposed system in order to prevent any major problems to make sure that users will be able to use the app smoothly. It is important to mention that experts of cultural heritage were contacted by email to invite them to evaluate the prototype, but they were unavailable at the time of the study.

11.1.1. Methods

This study used a combination of cognitive walkthrough tasks (Wharton et al., 1994), observation and interview. Experts of HCI were invited to take part in this study. The participants' comments and suggestions were pulled together to improve the prototype.

Study design

This study was carried out in five separate sessions, where each session was pre-arranged with individuals based on their own preferred time; the duration of each session was around 1- 1:30 hours. Four of them took place in the Historic Dockyard in Portsmouth between 2nd and 4th August 2016, and one of them took place at the Brighton Festival on 16th August 2016.

The cognitive walkthrough technique was used in this study to obtain feedback from experts regarding the usability aspects. Cognitive walkthrough is a well-known technique to assess the ease-of-use of prototypes by using the app with the aim of achieving specific tasks. The tasks were chosen to evaluate a subset of features of the SmartC, which are: (a) receiving notification based on location (through the mobile phone and the smart eye glasses); (b) audio description of historical information; (c) seeing an attraction how used to be in the past. These features were chosen to be evaluated because they form the core feature of the SmartC app; the only excluded features were: (a) take a picture and the reason for that it is a simple action; (b) video information format and the reason for that it is quite similar to the audio information format in terms of both are multimode information format; details of GRs and categories of the FoSLE framework that they are belong to were given in Chapter 10 Table 10.2.

The experts received an explanation about how the technique works at the beginning of each session, and then they were given a sheet containing a list of tasks to follow using the app, SmartC; each task contains a set of actions that were needed to achieve a particular goal. Next, they were invited to take a tour around the sites and use the app accompanied by the researcher. The tasks used in the cognitive walkthrough are given in table 11.1 accompanied by the part of the framework they examined.

Table 11.1: tasks adopted for the cognitive walkthrough study

No	The task	Feature	Framework' category
1	Launch the app and receive a notification (through mobile device and smart eye glasses)	Learning on-the-move	Learning design
2	Listen to an audio explanation about a specific attraction	Multimode information format	Interaction design and content
3	1) View an image illustrating how a specific attraction used to look in the past.	Seeing the past feature	Interaction design and content

Subsequently, experts were given analysis sheets containing four questions to be answered for each single action regarding their experience in using the SmartC app. The experts needed to answer "yes" or "no" for each question and give suggestions for improving the app; the questions were (Wharton et al., 1994):

A. Will the user try to achieve the right effect?
B. Will the user notice that the correct action is available?
C. Will the user associate the correct action with the effect they are trying to achieve?
D. If the correct action is performed, will the user see the progress is being performed towards a solution?

Observations and brief interviews were used in this study along with the cognitive walkthrough technique to collect qualitative data from different dimensions. The observations were carried out simultaneously with the first technique (cognitive walkthrough) as both were carried out during the tour at the site. During the session all experts verbalised their thoughts regarding the performance of the app, which made it easier for the researcher to understand their point of view. Notes were taken by the researcher while the experts were using the app to capture any difficulties that they might experience. A brief interview with each expert followed after the tour. Experts were asked about their overall attitude towards the app. Moreover, they were asked if they would like to add anything about their experience in using the app.

11.1.2. Participants

Five experts were invited to take part in this study. The participants had between 5 and 15 years of experience in HCI in academia and/or industry. All participants were working in academia; one participant was a PhD student and a part time-lecturer, and the others were lecturers.

11.1.3. Data analysis

Although experts needed to answer "yes" or "no" for the questions they were asked, not all of them answered this way as some of them were not sure about some actions, which led them to answer "maybe or possibly" for some questions. Furthermore, some experts stated percentages for both options (yes and no). That made it harder to obtain frequencies of answers, however, the experts' provided comments and suggestions to fix some issues – most of them were considered to improve the app. Details of the results are given in the next section.

11.1.4. Results

Experts' evaluation was used in this study to identify usability problems before conducting a user study. The results highlight some issues that needed to be taken into consideration for the next version of the app. The results of the evaluation helped enhance the app based on the experts' recommendations.

The results of the cognitive walkthrough indicate that the interaction design of the app is relatively good as the experts were positive regarding it. The results suggest the app is mostly easy to navigate through. However, a few issues were pointed out regarding labelling and the visibility of some functions. The experts gave some recommendations regarding these issues which were taken into account to enhance the app's usability.

As it was mentioned earlier, experts were given three tasks. Each task had a set of actions needed to be followed in order to achieve the goal (task). Based on experts' experience in using the app, they gave a number of recommendations to improve the usability of the app, which include:

1) Make the name of the app appears within the app.
2) Re-word the starting button "Travel inside history" and make the button more obvious.
3) Add some explanation within the notification's page about how the app works, and also make it more obvious if the notification is "On" or "Off".

4) Make the multimode functions (e.g. audio and video) visible as currently they are in a separate menu and users may not know it exists.

Moreover, a few more recommendations were given by experts, such as labelling and rewording some buttons, changing the colour of some texts, as they were not readable on a sunny day, and giving adequate feedback (see Table 11.2). Furthermore, although participants agreed that using smart eye glasses in outdoor setting might be challenging as the visibility is poor sometimes especially if it is sunny, four of them thought it could be useful for learners who are familiar with it.

Table 11.2: Issues highlighted by experts and the recommendations

No	Issues	List of recommendations
1	The name of the app does not appear on the app's interfaces	Add it to the logo or make it visible in the title
2	The 'Travel inside history' button is not obvious	Re-label it to something like 'start', Make the button more obvious, or Remove the first screen
3	The notification is not clear if it is indicating 'On' or 'Off'	Re-label them to ' switch it off/on', OR, make the button more obvious, OR, add a message indicating clearly it is On/Off
4	After setting notification 'On' is not clear what to do next	Add a brief description explaining how it works
	Viewing notifications is not quite obvious for not android users	Adding instruction how to view them, i.e. 'drag the screen down'
5	Using blue for 'Read more' to see more details	Change the colour, OR, remove it and make the text scrollable instead
6	The 'Stop the service' button in "see it in the past" is not quite obvious what it does	Use standard back button instead
7	The old image of an attraction is flashing when changing location slightly	Try to freeze it with a live view once the user has it
8	Hiding the audio button in the action menu	Make it visible as users might do not know it exists. E.g. add it to the bottom tool bar instead of 'take picture' button
9	Play button is not quite recognisable (>)	Use the standard play (►)button
10	Using different button for pause and play audio	Toggle the play/pause

No	Issues	List of recommendations
11	Not obvious what the feature ‘Taking picture” enables	Display a message telling users where the picture will be saved

The results of the interview were consistent with the results of the cognitive walkthrough method. Experts had a positive impression about the app; they liked the idea of receiving notifications based on the location. Moreover, they liked the interaction and the design of the interface. However, experts stressed some issues that were needed to be considered to make it more usable such as: (a) merging the starting screen with the notifications’ screen as all of them agreed that would make the app simpler; (b) Adding a brief explanation before starting off the app to explain how it works.

Finally, the observational results are summarised in the following. In general, all experts used the app comfortably and easily, however the weather was an issue as it was raining during the first session which prevented the expert from having a proper tour at the site. In addition, a few other issues were identified during the sessions which could be summarised as:

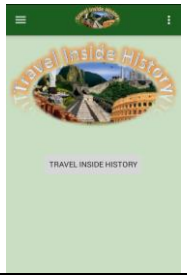
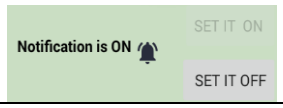
1. The visibility of the content (texts and images) in outdoor settings. Two out of five experienced difficulties in seeing some text clearly.
2. Three out of five did not know how to start off the tour to receive notifications due to the lack of clarity of labelling the starting button;
3. Two of them were not knowing if the notification is ‘on’ or ‘off’ due to:
    a) poor visibility on a sunny day,
    b) bad labelling;
4. All experts who are not Android users, did not know how to view the received notification, which is a mobile phone feature (i.e. related to the brand/operating system on the mobile phone);
5. Two of them did not know how to play/stop the audio;
6. One of them did not notice the “See it in the past” button in the bottom toolbar, but instead thought it is within the action menu;
7. All Android users used the phone’s back button instead of the app’s one;
8. All of them did not notice the “Read more” link that expands the attraction’s description, instead they were trying to scroll it down to see the rest of the description;

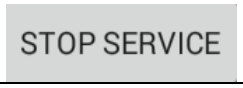
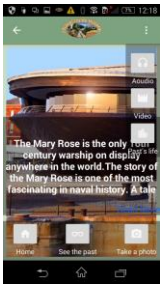
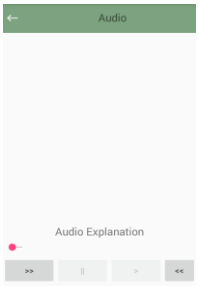
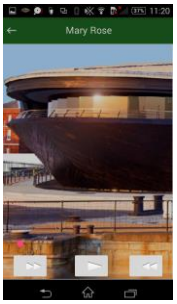
9. Four of them found that using the smart glasses is slightly complicated due to some usability issues such as poor visibility in outdoor settings and the need to be in a specific position to be able to see the glasses' main interface. Moreover, the control pad was not easy to use. However, they reported that once they become familiar with it, then it was easier to use.

11.1.5. Enhancing the current version of SmartC

A new version of the app was introduced based on the results of the experts' evaluation study to be used in the user study. Table 11.3 illustrates how the issues mentioned in the previous section were addressed in the new version of the app; the issues are numbered based on the original numbering in the Table 11.2 Regarding issue no 7, it was decided to keep it to investigate how users react towards a live camera view.

Table 11.3: illustration of the issues and how were addressed

No	The issue	How it is solved
1	The name of the app does not appear on the app	
2		This page has been removed.
3		
4	There was no explanation about how the app works	
5	'Read more' is not quite visible	Made the text scrollable

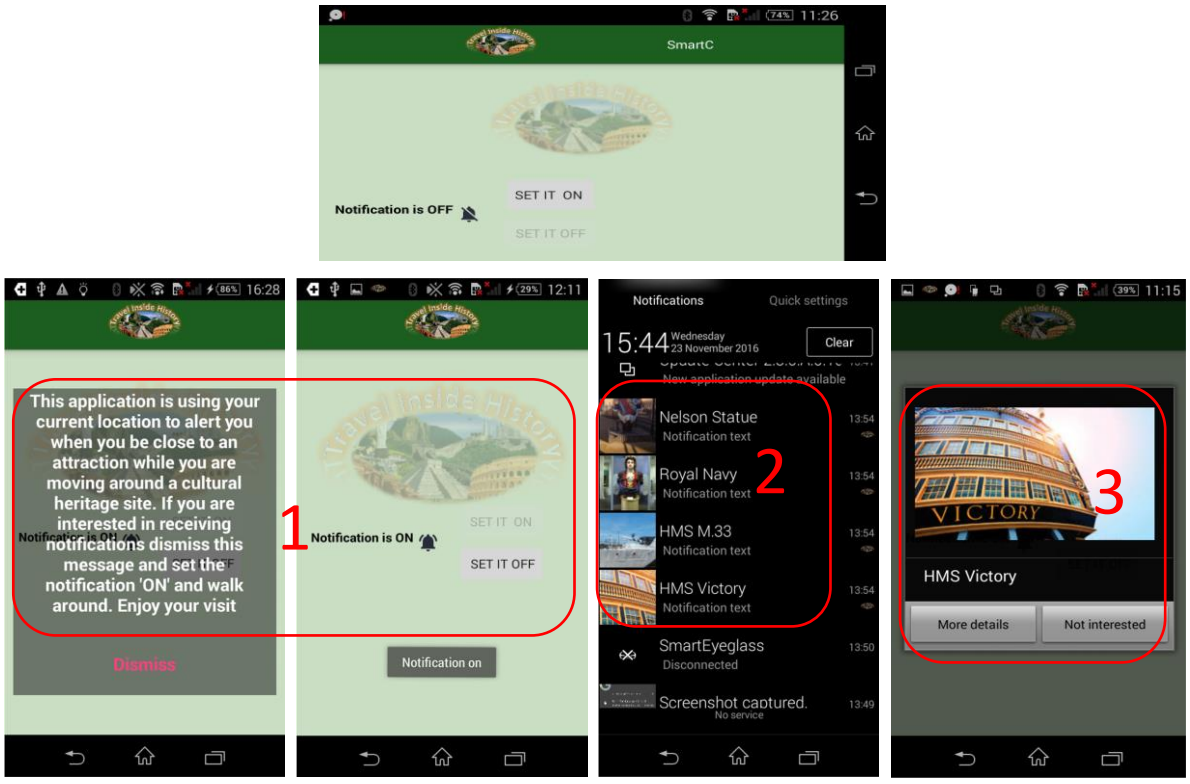
No	The issue	How it is solved
6		
8		
9 & 10		
11	Not obvious what the feature 'Taking picture ' does	A message appears to inform the user where photos have been saved

Mobile-based interfaces – second version

The SmartC app was enhanced based on the results of experts' evaluations; the description of the enhanced version is given below, which was used in the user-evaluation sessions – it is important to clarify that the "video" was not included within the task that experts were asked to used due to the similarities with the audio task (see Figure 11.1):

1. The main interface contains an image of the app's logo and two switches that enable users to switch the notification ON and OFF according to their need, and also a message area that changes based on the action. In addition, an overlay message appears on the screen to explain how the app works when users launch the app for the first time.
2. The received notifications are listed in the message centre of the device; each one has a name and image of the attraction it notifies for, and users can easily choose what they want to view.

3. The notification message comes in a dialogue form and contains the name, image and two options, i.e. to view details or cancel, which enables users to choose what they want. The notification could be viewed through the mobile device and the glasses (see Figure 10.4). However, in this version of the app, the learner needs to use the mobile phone only to access the historical information.
4. When users choose to have more details, they will be directed to an attraction's page. The attraction's page contains the main navigation menu that leads to access functions and services (i.e. "audio", "see it in the past" and "more", which contains "video" and "camera"). In addition, a text area overlays the image of the corresponding attraction to display a description related to the attraction.
5. The "See it in the past" page shows an old image of a certain attraction attached on a live camera view when facing the corresponding attraction.
6. The audio page displays an image of the attraction and an audio control bar.
7. The video page displays a video talking about events related to the attraction that happened back in time with a video control bar.



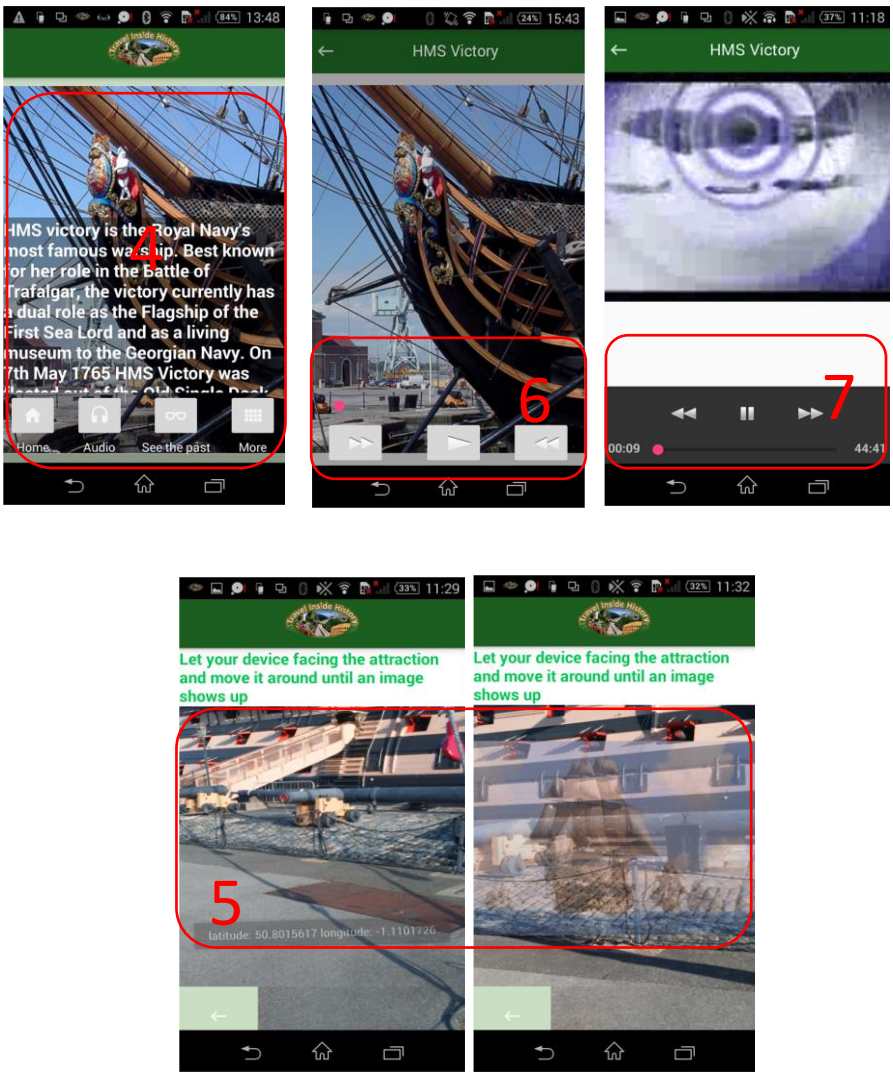


Figure 11.1: The main interfaces of SmartC in the mobile device (second version)

11.1.6. Discussion

The experts' evaluation facilitated capturing usability problems before conducting the user study to prevent any major issues that might obstruct the study. The results show the experts reacted positively regarding the app and there was no major issue within the interaction design. Nevertheless, a few issues were highlighted by experts.

Issues underlined by experts include: labelling issues, using two menus in the same page which might be confusing, and lacking of a brief explanation of how the app works. Beside the aforementioned issues, some technical issues arose during the study at the Historic Dockyard such as difficulties in obtaining notifications sometimes unless re-starting the service. Interestingly, there was no such issue during the study that was conducted in Brighton. A

possible explanation for this inconsistency is the poor network signal at Dockyard as a member of staff mentioned, which is due to many radars around in the site as it is a naval-base site.

Almost all issues mentioned by experts were addressed based on their suggestions. However, a couple of issues that were already fixed for the user study did not work on most of the devices, such as the message that explains how the app works when it starts.

Regarding the technical issues, i.e. the poor network signal at the site, while unable to address it, to lessen its effect, the radius of the attractions' location was increased to ensure that the notification for an attraction is triggered from a longer distance.

In general, the results suggest that the experts managed to use the app comfortably, and also they were tolerant to errors and some challenges of the surrounding environment such as rain and sun spells. Furthermore, the experts found the chosen version of smart eye glasses not very user-friendly, however, they emphasised that it could be easy-to-use if the user is familiar with it. A new version of the app was introduced based on the experts' feedback to be used in the user study; details are given in the next section.

11.2. The users' evaluation study

A user study was conducted to evaluate the SmarC app that was designed to be used at outdoor cultural heritage sites. This study was carried out in order to obtain users' feedback regarding their experience in using the app, which, in turn, helps to capture usability issues. That in turn, reinforces the enhancement of the framework for smart and ubiquitous learning environments based on mobile and wearable technologies (see Chapter 8). This study used the enhanced version of SmartC based on the experts' study results. Although the issues that were mentioned by experts were addressed in this version, a few did not work properly on some devices. These issues are: (a) the message that explains how the app works when it starts (see Table 11.2, issue no. 4); (b) the app name did not appear in the portrait layout. In addition, there were technical issues regarding the proximity; to address it, the radius of the attractions' virtual boundaries was increased. However, this solution made the service less precise as it caused receiving notification regarding more than one attraction at one time.

11.2.1. Methods

This study used potential end-users to evaluate the app. A combination of three methods was used which includes: questionnaire, observation and a brief group interview. The convenience

sampling method was used to recruit participants via emails and social media. A permission to use the Historic Dockyard in Portsmouth, UK, as a proof-of-concept was obtained from the authorities of the site. Participants were given android devices with the application and a sheet contains a description of how the app works. They were asked to use the app while they were walking at the site.

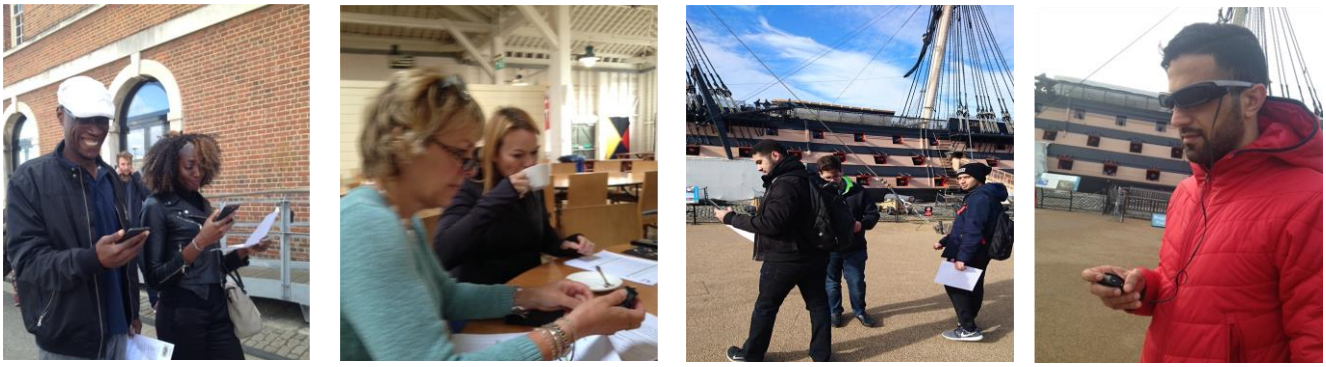


Figure 11.2: the user study

Study design

The study was carried out in four sessions which took place at the Historic Dockyard between 10th and 12th October 2016; each session lasted around 2 hours; the tour and the discussion took around one hour each. This study used a combination of three techniques: questionnaire, observation and group interview. The questionnaire technique involves different types of questions: scale of five, closed questions of two choices (yes/no) and open ended questions. The questionnaire consists of three sections: usability evaluation, features rating, and overall acceptance.

The usability section consists of six categories that were adopted from ISO metric questionnaire (Gediga et al., 1999). The categories are: suitability for learning, self-descriptiveness, controllability, conformity with user expectations, error tolerance, and learnability (Fallahkhair, 2009). The category "suitability of individualization" was omitted as the related features to this category were not included in this version of the app for pragmatic reasons as explained in Chapter 9. Each included category involves a set of statements that participants were asked to state to what extent they agree or disagree with. A Likert scale of five was used, where 1= predominantly disagree and 5= predominantly agree. Moreover, participants were given an opportunity to indicate 'No opinion' to prevent a random selection.

This study also gathered users' feedback regarding the app's features in order to find out how useful these features were to users in their learning journey. Participants were asked to rate a

number of features of the app on a scale of five giving that 1 = useless and 5 = useful. Furthermore, participants were asked regarding their overall attitude towards this app.

A brief group interview was held with participants after filling the questionnaire to obtain in-depth opinions regarding their experience in using the app in the field. Participants were asked about their experience using the app and also to point out any challenges that they had, if any. In addition, they were asked if there are any suggestions they would like to add to make the app better. Notes were taken by the researcher to document participants' answers.

An observational technique was used in order to capture any problems or difficulties users might experience when using the app. Notes were taking during the tour by the researcher as the authorities of the site did not allow filming the tour due to the naval-base security issues.

11.2.2. Participants

26 participants took part in this study; all of them were residents in the UK/Portsmouth; their age ranged between 20 and 71; they were 18 males and 8 females from different nationalities: Iraq, Britain, Germany, Iran, Sweden, Libya, Nigeria, Senegal, Jordan and Colombia. Their occupations were: 19 students (undergraduate, master and PhD), one engineer, one project manager, one unemployed, one teaching fellow and three retired.

11.2.3. Data analysis

SPSS was used to analyse the numeric data that was obtained from the user study; the cleaning data phase was carried out first as a preparation stage for the analysis phase. As it was mentioned earlier, participants were given an opportunity to state "No opinion" in the usability section of the questionnaire. "No opinion" answers were treated as a missing data, i.e. as "No Answer". A simple statistical analysis was carried out to obtain the mean for the data (for more details see Appendix C). Details of the results are given in the next section.

11.2.4. Results

A usability evaluation study with users was carried out in order to highlight the weak and strong points of the app from the user's perspective. Due to the nature of the informal learning as there is no standard scheme for the assessment of informal learning (Skule, 2004), it could be difficult to measure the effectiveness of learning and to assess how much information users take back from the visit. However, suitability for learning was assessed within the usability section. The main scope for this evaluation study was to assess the interaction design, which contributes to the field of mobile HCI. The results of the three techniques are given below.

The results of the usability questionnaire show that participants reacted positively regarding the usability aspects of the app. The average of each category ranged between 3.06 and 4.25, which indicates participants found it usable and easy to use (see Table 11.4).

Table 11.4: the usability results

The category	The average
Suitability for learning	3.94
Self-descriptiveness	4.05
Controllability	3.71
Conformity with user expectations	3.84
Error tolerance	3.06
Learnability	4.25

Alongside the evaluation of the interaction design, there was an assessment of how suitable the app was for learning. The results suggest the average of this category is 3.94 (see Table 11.4). This indicates SmartC is suitable for learning, which would facilitate acquiring information at outdoors cultural heritage sites effectively. In this light, although the evaluation from a learning perspective was relatively in a small scale, SmartC would be considered as a useful tool for learning.

Regarding the usefulness, the results indicate that all features provided by the app are useful, as the mean ranges between 3.75 and 4.77. Participants liked receiving notifications based on location. Moreover, the results suggest that the audio explanation is the most popular information format amongst participants. Participants stressed that seeing attractions how they appeared in the past is very interesting and has a lot of potential. Four participants used the smart eye glasses during the evaluation study in the field. Three out of four liked receiving notifications through the glasses and found it useful as it freed their hands from carrying the mobile device during the tour. One participant did not like it as she likes to see the attractions with her own eyes; however, it is a personal preference; the device could be disabled if it is not needed (see Table 11.5).

Table 11.5: the features rating

The Feature	The Mean
The audio explanations	4.77
The attraction's image within the notification's dialogue	4.69
Receiving notifications based on the location	4.63
The text explanations	4.58
The attraction's image within the attraction's page	4.44
The attraction's image within the audio page	4.40
The historical/documentary videos	4.40
Seeing attractions how looked in the past	4.15
Take a photo	4.04
Short messages giving feedback about tasks process	3.94
Error messages	3.92
Receiving notifications on the glasses	3.75

Participants were asked to state up to three features that they liked or disliked; most participants made comments about features instead of stating which feature they liked or disliked especially for the disliked features category – they did not state any feature that they did not like. Table 11.6 illustrates the stated liked features.

Table 11.6: liked features

No	Liked features	No	Liked features
1	Taking photo, audio explanation, photos of sites	5	See the past
2	Photos of attractions	6	The content in general (history description)
3	Audio explanation	7	Text explanation
4	Videos	8	Receiving notification

Participants added a few comments that highlighted some weaknesses in relation to the features of SmartC, which helped in designing the design recommendation for developing such services. Some of these comments are given below:

"Lack of map, lack of direction, lack of [map] with direction of the attractions in historical time sequence"

"Hard to receive notification, simple design"

"Volume of audios not high enough, little bit fiddly to see photo in past, not able to see the video after [leaving] attraction"

With respect to the overall acceptance, the vast majority of participants liked the app and stated they are happy to use it and recommend it to friends. Participants made some comments to illustrate their choice of why they would like to use the app. Some of these comments are given below:

> "*It provide flexibility of spreading knowledge, it is like you have one of those guidance in your pocket all the time*."

> "*It is helpful, easier and lighter to use comparing to the old style ... guides for [sites]"*

> *It is a good idea especially if you don't know the site"*

> *"Idea of the app is quite interesting. It would be useful for open area like dockyard"*

> *"Having an app for android on my phone is more feasible when visiting such sites rather than using devices provided by the sites, which need a bit of time for learning how to use it."*

> *"Because of the content and seeing it in the past gives a good [idea] to how it was"*

> *"It is very user friendly, you get interesting information that you would not get it just walking around, save spending on tourists audio devices"*

> *"I find it very useful and useful save a bit of time if you are in heritage"*

One participant only mentioned that he would not use it because he likes to read every label attached to the attractions, however, he stated that he would recommend it to friends:

> "*No, because usually I walk around the attractions and read about the detailed information given and take my time to understand the writing"*

Participants were given an opportunity to add comments or suggestions to improve the app; Table 11.7 illustrates some of these suggestions and comments.

Table 11.7: examples of comments and suggestions

Examples of comments and suggestions that were made by participants
"colors: choose colours that suits all, some people have a problem to see some colors (design the app for wide audience)"
"there isn't any backward if I want to repeat the previous place, I don't like glasses because I want to see the place naturally in a naked eye"
"It would be a good idea if we can re-call the notification again or select the attraction from the menu. giving a location tolerance to the"" see the past"" or other features to allow the user to see the past even from distance"
"I think that its accuracy should be improved. also, the user should be able recover an attraction after passing the attraction"
"I am not very good with android technology so feel perhaps I'm not the best judge of this application, found it interesting and helpful when going to attraction"
"It has many possibilities and developments. Maybe notification of facilities would also be good toilets, cafe etc."

A brief group interview was held with participants after filling the questionnaire to obtain in-depth opinions regarding their experience in using the app in the field. Participants were very positive towards it and found it interesting and easy to use. However, they pointed out some challenges that they experienced during the tour, which include:

1) Receiving notifications for the same attraction a couple of times when passing near it.
2) Losing the current notification (i.e. when viewing a notification for a certain attraction and then move to another one, could not go back to the previous one).
3) Not very easy to see the old image in the "see it in the past" feature constantly as it is based on the location and it disappears once the device moves slightly.
4) The video needs an internet connection which was not very good at the Historic Dockyard.
5) The audio did not stop when the participants used the back button of the device.

Participants suggested a number of aspects to be included with the app to make it better such as:

1) Adding directions to take you to the attractions.

2) Providing the distance to the attraction that users get notified about it from their current location.

3) Adding a map with all attractions to make it easier to see what is near.

4) Providing an option to download the video.

5) Giving users the opportunity to access the attraction's information they passed by whenever they want (i.e. saving their routes to see them off the site).

6) Adding notifications about public services like cafes or toilets.

7) Considering the day time (day or night) in the design as the sun spells make it harder to see the screen sometimes.

8) Making the audio louder as it was not easy to listen to in a group.

9) One participant suggested to have a list of the nearby attractions instead of receiving notifications based on the location. From her point of view users may not get close enough to an attraction to get a notification which may lead to missing attractions. However, the main point of providing notifications based on the location is to support people to learn on-the-move while they are doing their daily activities.

The observational technique used to observe how participants interact with the app during the tour. Fortunately, the weather was nice most days, with only one session on a cold day, which was not expected and consequently participants were not well-clothed. That affected the tour slightly as they were not very comfortable walking around in outdoor settings. Participants divided themselves spontaneously into groups. There were some participants who walked around individually listening to an audio explanation and finding out more about attractions on their own. Some others used the app in a group using one device, and also there were some participants who walked around as a group but using the app individually. All the groups were walking around, having conversation regarding attractions, helping each other with using the app and discussing some weaknesses and strengths of the app. Participants were comfortable in using the app and navigating through, and also managed to use almost all the features easily. It is also true that participants who were walking in groups collaborated to find attractions and helped each other use the app and overcome challenges, and also interacted with their surroundings more often than those who walked alone. Most participants liked receiving notifications based on their current location; also they liked the content especially in an audio format which they found very useful. The service of "see it in the past" drew participants'

attention and helped participants to engage with the attractions and to find out more information about them. Participants did not spend a considerable amount of time reading the texts on the screen, instead they play the audio to listen and walk. It was noticed that participants did not manage to find some attraction easily, for instance, they received a notification regarding HMS M.33 while they were near Nelson's statue, which they could not see, as HMS victory was blocking the sight. However, they emphasised that providing the picture on the app that illustrates how the attraction looks like helped them to find it. It was also noticed that the app did not work properly through some participants' personal devices, which was due to the fact that some required resources on the device were not enabled, such as camera and location-based services. In addition, a number of challenges were noticed during the tour:

1) Due to many radars around, as it is a naval-base site, Wi-Fi, GPS and 3G did not work properly which affected the performance of the app slightly. Consequently, the notifications were sometimes hard to receive which needed to re-start the notification (switch it off and switch it on again).
2) For the same previous reason, video did not play for a couple of times at some points, which needed participants to move their location slightly to be able to obtain a good signal to play the video.
3) The surrounding environment included challenges such as: day time (day or night), weather (sunny or rainy), and noise. All these matters could also affect the users' experience, which are needed to be considered in designing such services.
4) Visitors' level of knowledge regarding technology could obstruct the experience. Some participants had problems in using mobile devices in general, which made the use of the app slightly harder.
5) The technical differences of the android devices in terms of operating system, as some devices show a good quality in picking locations more than others. In addition, some explanation messages did not appear on some devices which made it challenging for some participants to figure out how some services actually work.

Altogether, the results of the interview and the observation are consistent which gives a level of confirmation of the findings.

In relation to assessing how learners react to the app, SmartC was shown to a participant who took part in the field studies (in both questionnaire and interview). It is important to mention, during the interview study, he did not show a great interest in using technology at cultural

heritage sites. He commented that he would not use technology at sites unless it adds value to his visit. Interestingly, he showed a great interest to use SmartC at sites after it was shown to him in an informal environment, which could be interpreted that this app could add value to his visit.

11.2.5. Discussion

The user study was conducted to obtain users' perspective regarding SmartC in terms of usability, usefulness and acceptance. The results suggest that users' attitude was positive regarding the app and found it user-friendly.

Participants, in general, found the app useful and easy to use and with a lot of potential for facilitating acquiring historical information on-the-move. In addition, the results indicate the app is suitable for learning. The results suggest that learners/visitors of cultural heritage sites enjoy the visit and the learning experience in groups as they can have a conversation regarding attractions and also enjoy being with friends and family that clearly support social and collaborative learning.

Interestingly, some results of the users' study were inconsistent with the field studies. For instance participants of both studies questionnaire and interview were not very keen in using smart eye glasses, whereas the results of the user study suggest users seemed to be happy using them in context. The results of this empirical study indicate that users had different opinions regarding this aspect in context, as three out four reacted positively towards using the glasses, which raises the potential of utilising smart eye glasses for informal learning in outdoor cultural heritage setting. In addition, an interviewee was not very keen in using technology at sites when they were asked about it, but he was happy to use SmartC when it was shown to him in an informal environment, which gives an indication that SmartC could add value to the visitors' experience at sites.

Although the results suggest that SmartC is easy to use, some challenges came up during the tours with users, which were addressed to enhance, in sequence, the framework, the general requirements and the app. Additionally, as a result, a list of design recommendations for developing such services was developed. The challenges could be categorised into: (a) interaction design, (b) surrounding environment, (c) learners' knowledge and preferences, and (d) technical issues, which also could be all categorised as context. Details of each category are given below.

In terms of interaction design, some issues need to be taken into account to make the experience better.

1) The messages (error and feedback) need to be more obvious (e.g. keep it for longer, make it brighter, or make it in the middle of the screen);
2) The audio should stop when leaving the page using any means (the app standard button or the device standard button);
3) The volume of the audio and video need to be loud enough to be heard within a group; however a headset splitter could be used to overcome this issue;
4) The image that illustrates how an attraction appeared in the past in the "see it in the past" feature needs to be less faded and should be displayed for longer, even when changing the direction of the device slightly, to be easily seen.

The challenges of the surrounding environment include: day time (day or night), weather (sunny or rainy), and noisy or quiet. All these matters could also affect the experience which could be addressed by providing different themes (i.e. colours) for day and night.

Visitors' level of knowledge and preferences could obstruct the experience. Some participants had problems in using mobile devices in general which made the use of the app challenging. In addition, some participants' preferences did not meet the core features of the app (notification) as one participant reported. These aspects can be addressed by adding more messages that explain how each feature works. That might help to make it relatively easier for people who are not very confident in using mobile technology. Users were relatively tolerant and patient with errors and the surrounding environment when it comes to using mobile apps. They managed to use all features of the app and found the app useful and easy to use, and a useful tool for learning informally.

Some technical issues came up during the study, as it was mentioned earlier, which include: (a) receiving the same notification more than once, (b) poor network signal which makes it hard to play a video or even receiving a notification, (c) android devices differences in terms of operating system, as some devices showed good quality in receiving notifications, and others showed poor quality in displaying some messages. The evaluation studies for both experts and users, have encountered several limitations which are discussed in the next section.

11.3. Limitations encountered in setting the evaluation studies

Setting this empirical evaluation studies involved several aspects that needed to be considered in order to make the contexts of use (the context in which the service will be evaluated) as ideal as possible, such as the venue of the study, participants taking part in the study and tools contributed to deliver the experience.

Setting the venue needed to consider a few aspects such as the: (a) weather as it is for outdoor settings; (b) the size of the site in terms of the area and the number of attractions included, as it should have several attractions which are needed to be relatively close to each other to make it easier for participants to have the tour but not too close that might affect the experience, i.e. receiving notifications. In terms of the area, it needed to not be too large, just big enough for participants of all ages to have a proper tour at the site to visit all involved attractions comfortably in a short period of time. The Historic Dockyard was chosen, which has several attractions in outdoor settings that are relatively close to each other but not too close to effect receiving notifications. This choice also served the type of participation the evaluation studies adopted, which were organised groups and individuals; more details about this are given later in this section.

Conducting a field study in the outdoor setting experienced some challenges such as the weather, as there was a slight disruption due to unexpected weather conditions in a couple of sessions, one in each study for the expert and the user evaluation. It rained in the first session, which prevented the expert from having the tour in full around the whole site. In the second one it was relatively cold and participants were not prepared for such weather as it was not meant to be as cold in October. However, in both sessions, the tour was enough for drawing a conclusion regarding using the app. This limitation was addressed by taking advantage of cafes and seating areas with shelters to refuge and discuss the experience amongst participants for a while.

Based on the discussion so far, aspects need to be considered to serve in choosing a suitable venue for conducting an empirical study could be summarised below.

Choosing a site that is suitable for such empirical studies in the field is relatively subjective to a number of aspects such as: (a) type of participants targeted, as if the targeted sample is elderly or children the criteria is different than adults who are willing to walk around a big site in a short period of time; (b) the duration dedicated for the study as dedicating two hours for a

session is different than a day per session; (c) the type of participation, having an organised tour with a group of participants led by the researcher is different than individual session with the researcher, and this also is different than participants having a tour independently on their own based on their convenience. The first type is constrained by the time participants are willing to dedicate to the study as a whole as they need to be all at the venue at a certain time and finish at a certain time; a group interview post the visit with all participants took part in each session to give their feedback. The second type, is conducting individual session which is slightly different than the first one as it needs only to be convenient to one participants whilst the first one it should be convenient to all participants taking part. The third one, where participation is not constrained to a number of hours but instead it is open to their time and preferences. This type is not necessarily to be in groups as often the individual experience is needed, which the venue could be in a spreaded area and the participants could choose the convenient time and which part of the tour they want to have based on their preferences. This type could be an excellent option for evaluating aspects such as personalisation as participants could create their own account and use the service for a few days to have the full experience to give useful feedback.

The first type of participation adopted in this PhD research for the evaluation studies to observe the experience in both forms individual and groups and note how participants would like take the tour, individually or in groups, as well as capture any issues might arise. Thus, choosing the venue was based on this which led to choose a site that not too big but big enough to hold a number of attractions, i.e. Historic Dockyard. Adults were targeted in this research from different age groups with the aim of balancing the demographics. The chosen site was considered convenient for participants of all ages to take a tour as it has several places with shelters to have a rest when needed, and that was very helpful during the sessions that experienced unexpected weather conditions as mentioned earlier. Therefore, it is very important to select the site that could provide some alternatives such as cafes if possible in case they are needed, and that would help address the weather limitations as well.

Tools used to help conducting the studies were mobile devices and smart eye glasses. Android mobile devices with different operating systems were used to carry out the studies. The differences in operating systems caused some challenges as some of them showed a higher performance in terms of picking locations and sending notifications than others. That caused a slight contrast in participants' opinions regarding receiving notifications based on location, however, the contrast opinions did not affect the results which were positive regarding this

aspect. The smart eye glasses were harnessed to capture users' feedback regarding using them in the context. The available version was Sony, which was not very easy to use by most participants, experts and end-users. That caused receiving some cautious feedback regarding the smart eye glasses in general because of the utilised version. That could lead to an inference that tools (i.e. versions of devices) contribute in such studies should be chosen wisely to avoid any confusion that might unnecessarily cause by a certain version, which might provide a false impact that could have been prevented.

The observational technique used in both studies, i.e. experts and users, could have been improved if we could video the participants behaviour during the session. However, verbalising the impression by participants provided in-depth insight regarding their experience.

In summary, a number of aspects contribute to conducting an empirical study in the field, which could affect the experience if they are not taken good care of; they are summarised as follow:

1) Identifying the best suitable context of use that could better serve the goals and at the same time consider the participants.
2) Identifying the type of participation that best serve the evaluated aspects and participants.
3) Identifying the suitable methods that could best serve the goals and at the same time could make the most of the context of use.
4) Choosing the best of the available tools (i.e. devices) that could best serve the goals at a specified context of use.

11.4. Insight and reflection of the studies

The evaluation studies presented in this chapter provided an important insight into how people interact with technology in context to learn about historical events that have happened in a certain site back in time. That helped enhance the list outlined in Chapter 9 and shaping the final list of recommendations. The results of the evaluation studies highlight a number of aspects that need to be taken into consideration in designing such services, which could be categorised as:

1) Personalising the app: participants would like the app to keep their route history to enable them to save the sites where they have been and to re-view the information when they want to.

2) Enhancing the interaction: participants stressed that adding more messages that explain how each service would work could make the interaction between the learners and the app more efficient. In addition, adding the distance for a certain attraction from the current location

of learners would be easier for learners to find the attraction. Furthermore, including some services such as public services, directions, and providing an option for downloading the video would make the experience better for learners.

3) Considering the surrounding environment: based on the results, taking the surrounding environment into consideration in designing the app could support enhancing the experience.

4) Considering the contexts: the results indicate that it is important to consider the contexts that the learning process occurs in terms of time, place, way of learning, and individuals or groups.

5) Providing sufficient feedback regarding potential errors: the results highlight that it would be helpful for learners if the app gives sufficient feedback messages explaining the errors if they happened and how to fix them or find alternatives (e.g. downloading videos to watch it in their own time rather than stick in a place with a good network quality at the site).

All the aforementioned aspects were used to revise the first version of the list of design recommendations that was identified in Chapter 9. The previous version of the list was re-design to produce the final list with more details, which involves three main parts: content provision, learning design and interaction design; details are given in the next chapter. The next section shows how the framework could be used by researchers and designers to design an app for outdoor cultural heritage.

11.5. Using the framework to design an app

To show how the framework could help in designing an app, let us assume that a designer/researcher wants to design one aspect from the framework, which is "individual learning" in the category of learning design. The designer should pull out a set of general requirements that serve the need of the design as well as the design elements – general requirements and design elements provided below could have some overlap with the provided requirements in the Chapter 9 due to some similarities in the nature of the needed requirements. Table 11.8 shows the parts of the framework that involve to fulfil this design.

Table 11.8: using the framework by researcher

Category	Aspect needs to be implemented	General requirements	Type of information provided	Design elements
Learning design	Experiencing sites individually would help learners to immerse in the environment and spend more time discovering stories behind these sites.	The service should allow visitors to have a personal experience.	What type of experience visitors would have on their own	Provide activities visitors can do on their own (e.g. see themselves taking part in an event back in time)
Interaction design	Experiencing life back in time is a service that enables learners to see or experience life in the past	The service should adopt a functionality that help visitors experience life back in time	What services could serve this type of experience	Provide a functionality that help people to experience life back in time (e.g. using AR)
	Another way to deliver information is to support learners to engage their sight with the artefacts when observing them while simultaneously receiving information through wearable devices	The service should offer an opportunity for visitors to use wearable computing	What devices could benefit this experience	Adopt the use of smart eye glasses
Context	When they are on their own, they can spend as much time as they want looking around without worrying that someone might be waiting for them	The service should consider the context when visitors visit on their own to allow them spend extra time in discovering stories	Identify the context of use	Provide detailed information

To use the framework, a set of general requirements is necessarily to link it with the design stage as it is not applicable directly. That would be an excellent tool for researchers who want to design their own requirements based on a given framework, whereas some others need a

ready-to-use set of requirements or recommendations to save their time of pulling design elements through general requirements. Thus, a list of design recommendation elements was designed to assist designer in designing such services, of which they only need to pick the set of recommendations they need for their design; the next chapter presents this list.

11.6. Conclusion

This chapter has presented two empirical studies to evaluate the SmartC app; the two studies were carried out with experts of HCI and potential end-users separately. Observation and group interview were used, which allowed participants to describe their experience themselves as well as allow the researcher to observe their behaviour during the studies. The experts' evaluation was conducted first to capture any usability problems to prevent any major issues with the app before conducting the user study. The results suggest there were no major issues with the interaction design. Experts pointed out some issues regarding labelling and visibility of some texts and buttons, and they gave some suggestions to fix them. The suggestions were taken into consideration to improve the app in preparation for the user study.

The results of the users' study suggest that users found the app useful and easy to use. Users' attitude towards the app was positive. Smart eye glasses were used to assess how users deal with them in the field. The results were positive regarding the glasses, which raised the potential of harnessing smart eye glasses to enhance the interaction with cultural heritage contexts for the information acquisition. Users contributed a few suggestions to improve the app, which were taken into consideration in designing a list of recommendations for developing such services. An example of how the framework could be used by researchers was given. The next chapter outlines a list of design recommendations that resulted from this PhD research.

Chapter twelve

12. A list of recommendations for designing smart and ubiquitous learning environments based on mobile and wearable technologies to be used at outdoor cultural heritage sites

Chapter 11 presented the evaluation of SmartC in the field, which contributes to enhance the first version of the recommendations identified in Chapter 9. Accordingly, a new list of design recommendations was devised for developing smart and ubiquitous learning environments with respect to outdoor cultural heritage sites harnessing mobile and wearable technologies. This chapter is structured as follows: Section 12.1 discusses shaping the recommendations; Section 12.2 outlines the list of design recommendations; Section 12.3 outlines the conclusions of the chapter.

12.1. Shaping the list of recommendations

The results of the entire PhD research have led to introduce a list of design recommendations, which was shaped based on two elements: the field studies (Chapters 4, 5 & 6) and the evaluation studies (Chapter 11). These elements were pulled together to shape the list of design recommendations to assist designers who are interested in designing smart and ubiquitous learning environments. The list involves 84 design recommendations, which are distributed into three main parts: (a) content provision, (b) learning experience design and (c) interaction with the contexts design. The next section presents the list of recommendations with details of how these elements have contributed to shape the recommendations and links them to the general requirements.

12.2. The list of design recommendations – the final version

As discussed in Chapter 2, guidelines and recommendations are frequently introduced for designing new technologies, (Candello, 2009; Farkas & Farkas, 2000; Seong, 2006; Winter, 2016), with most of them focused on interface design. Android and iOS have already introduced guidelines for human interface; the results of the field studies and the evaluation studies were in line with these in most aspects such as accessibility and usability (Android developer; iOS developer, 2017).

The present set of recommendations considers different aspects within the app design that are related to the content and the interaction with the context at outdoor cultural heritage settings. The issues that have already been considered in the Android and iOS guidelines will not be mentioned to avoid redundancy (details about these issues are available in Appendix D). This research introduces a list of design recommendations, which consists of three main parts that cover different dimensions of designing smart and ubiquitous learning environments. These parts are: content provision, learning experience design and interaction with context design. Each part covers different aspects of the design which would make it easier for designers to choose the part that is more convenient to fulfil their artefacts design's requirements, or to choose the convenient elements from each part to accomplish the entire design. As was mentioned earlier, this version of the recommendations is the enhanced version of the recommendations that were identified in Chapter 9. The previous version was revised based on the evaluation studies and then re-designed to introduce a new version with three main parts and more details. The identified design recommendations are aimed to assist designers with such services by providing relatively high-level design recommendations while leaving room for creativity to designers to choose the feature(s) that would suit any specific recommendation for their design. The design recommendations (DR) are given below accompanied by the general requirements (GR) that they belong to and the source (SC) they were identified from. The source is abbreviated as in the following table:

Focus Group	FG
Survey study	SS
Interview study	IS
Evaluation study	ES

12.2.1. Content provision

Content is an important element in designing learning services especially for cultural heritage sites as it provides details of events that happened at a particular site back in time. In addition, it enhances learners' engagement with the context, thus it is essential to take good care of the content deployment.

Content provision			
No.	Design Recommendation (DR)	GR	SC
Managing content			
1	Store historical information in a joint database that includes all attractions in which they are sectioned under cities and regions	2	IS
2	Use a sharable resources technology to make the historical information accessible to different stakeholders such as designers and curators		IS
Provision of historical information			
3	Provide information about human achievements related to a certain cultural heritage site that happened in a particular age	2	SS & IS
4	Provide information about events that these sites have had experienced back in time	2	SS & IS
5	Provide information about stories behind these sites	2	SS & IS
6	Provide information about life back in time and how people used to live in terms of clothes, food, housing and life style	2	IS
7	Provide information about how sites used to appear in the past	2	SS & IS
8	Provide information about development of the site over time	2	IS
9	Provide information about archaeology and excavation of these sites	2	IS
10	Provide information about interesting facts related to people and famous figures back in time	2	IS
11	Provide information about funny stories regarding famous figures	2	IS
Provision of useful information to assist learners in their learning journey and organise their visit			
12	Provide information about public services such as cafes and restaurants	2	FG, SS & IS
13	Provide information about transportation		
14	Provide information about ticket prices		
15	Provide information about the weather		
16	Provide information about the level of busyness of the site during a week and a day		

12.2.2. Learning experience design

Learning design could involve different stages, which help assist learners to take a new learning opportunity and make it an enjoyable process:

Learning experience design			
No.	Design Recommendation (DR)	GR	SC
Supporting people in taking learning experiences and motivate them to visit sites			
17	Provide activities that support learners to socialise while learning such as Geo-cashing games regarding historical events or characters.	4	IS
18	Provide activities that support learners to share experiences and knowledge such as a group quiz	4	SS & IS
19	Adopt functionalities that help motivate learners to visit cultural heritage sites and taking new learning opportunities such as providing a simulation of human achievements in a particular age	3	FG, SS & IS
20	Adopt functionalities to notify learners about cultural heritage sites when passing nearby (e.g. notification)	5	FG, SS, IS & ES
21	Adopt functionalities to deliver instant information about cultural heritage sites based on location (e.g. notification messages)		
22	Provide learning preferences that satisfy the sense of challenge such as riddles and quizzes	4	FG, SS & IS
23	Provide learning preferences that enhance learners' engagement such as stories		
24	Provide learning preferences that satisfy learners' curiosity such as conversational activities with actors dressed like figures back in time		IS

12.2.3. Interaction with the context design

Different elements could enhance learner's interaction with contexts, which consequently enhance learners' engagements as well as learning at sites. Maintaining learners' profiles, maintaining usable, accessible and easy to use features, designing an augmented reality view for attractions and using smart eye glasses could contribute positively to learners' experience at sites. Thus, these were embedded within the context interaction design part as they are more relevant to this aspect when designing new artefacts in the form of software.

Interacting with the context			
No.	Design recommendation (DR)	GR	SC
Maintain a learner's profile			
25	Allow learners to create their own account	1	FG, SS & IS
26	Collect information about learners' interests by tracking learners' route and save preferences.	1	FG, SS & IS
27	Allow learners to provide their preferences when first signing up, such as the favourite sites of cultural heritage	1	FG & IS
28	Give recommendations of cultural heritage sites based on learners profile	1	SS & IS

29	Allow learners to customise the app based on their interest	1	FG, SS &
30	Allow learners to save their favourite sites to re-view them whenever they want – even when they are off-site	1,7 & 8	FG, SS, IS & ES
31	Let the app save learners' route (attractions that learners passed by) and enable them to re-view the visited attractions whenever they want.	1, 7 & 8	SS, IS & ES
Maintaining usable, accessible and easy-to-use apps			
32	Provide an audio information format to present historical information	7	FG, SS & IS
33	Provide text information format for learners who prefer reading		
34	Provide images of attractions and life back in time for leaners who prefer this format		
35	Provide videos about events back in time related to a certain site		
36	Use an adaptation mechanism to adapt interfaces based on the level of brightness of the day time	7 & 8	SS, IS & ES
37	Use an adaptation mechanism to adapt sounds level based on the noise level at sites	7 & 8	ES
38	Allow learners to switch between different tour types easily such as group and individual's tour	7 & 8	FG, SS, IS & ES
38	Allow learners to switch services off when they are not needed	7	FG, SS & IS
39	Allow learners to navigate the visited sites and attractions' pages back and forth	7	ES
40	Provide in-app help in different forms such as: a) A separate page with a big library of instruction b) Popup contextual instruction for each service c) Description within first page explaining the overall functionality of the app	7 & 9	ES
41	Provide an image of an attraction with all pages related to this attraction to make it easier for learners to find it and engage with it	7 & 9	ES
42	Make the videos and audios stop when learners leave the page by any means (e.g. standard back buttons or the device's one)	7	ES
43	Make the notification message obvious and clearly indicate which attraction it is about (e.g. provide name and image of the attraction)	7	FG & ES
44	Allow learners to discard the notification if they are not interested	7	FG & ES
45	Allow learners to save the attraction they are being notified for a later time if they are not interested for the time being	7	FG & ES
46	Give an opportunity for learners to switch between services or abort them easily if they do not want to proceed	7	FG, SS, IS & ES
47	Allow learners to choose the level of information details such as brief or detailed	7 & 2	FG & IS
48	Provide different levels of learning materials to suit different learning ability such as: basic, medium and advance quizzes	7	FG & IS

49	Provide a location-based tour for nearby cultural heritage sites	5 & 7	SS, IS & ES
50	Provide a tour for individuals that allows learners to have a personal experience on their own	7 & 8	SS, IS & ES
51	Provide a group tour for families and friends that allows a group of learners to enjoy the experience together at a site	7	SS, IS & ES
52	Provide a map with nearby sites		
54	Provide directions to sites or attractions from the current location		
55	Adopt features that allow learners to experience life back in time based on location (e.g. employ wearable technology with AR to show life back in time and give learners an opportunity to touch, smell and see)	7, 5 & 2	SS & IS
56	Adopt features that allow learners to see attractions back in time from different angles based on location	7 , 5 & 2	SS & IS
57	Adopt features that satisfy learners' imagination such as adding their photos to a portrait of events back in time.	7 , 5 & 2	SS & IS
58	Provide a service that enables learners to look up useful information beforehand to organize their visit properly (e.g. the weather, tickets prices, and transportation)	7 & 2	FG, SS & IS
59	Provide a service to enable learners to interact with each other during the visit (e.g. chat service)	7 & 6	SS & IS
60	Provide a service that enables learners to find friends at a site	7 & 6	SS & IS
61	Provide a service that enables learners to share their experience when they are off the site after the visit (e.g. social media)	6, 7 & 8	SS & IS
62	Provide a service that enables learners, who are at the site, to create a network that enables video calls with friends and family who are not physically at the site to share with them the experience and get them to see the site live using the device's camera (distance visit).	6, 7 & 8	IS
63	Provide a service that allows learners to share personal stories related to sites or attractions that they have witnessed, if any.	4 & 7	IS
64	Provide a service that enables learners to generate a comment regarding the site they have visited.	4 & 7	SS & IS
65	Provide a choice for learners to immerse themselves in the experience by using immersive technologies at sites (e.g. AR technology).	5 & 7	IS & ES
66	Provide a second screen to deliver historical information to allow learners to choose what is suitable for them by using wearable devices such as smart eye glasses.		
67	Provide a choice for learners to receive information on the smart-eye-glasses' interface while looking at the artefact to free their hands and engage their sight with the artefacts.		
68	Allow learners to switch between devices smoothly.	7 & 8	FG, SS & IS
69	Provide an "Inside a site" location-based tour, which makes the app pick the attractions' location from a small distance based on the area size of the attraction.	7 & 9	ES
70	Provide an "Inside a city" location-based tour, which makes the app pick the attractions' location within a city or a big area from	7 & 9	ES

	a wide distance to help learners to discover what is surrounding them if they are in a new place.		
Augmented reality element design			
71	Attach a view (e.g. old image) that shows how attractions appeared in the past in a live camera view	7	IS & ES
72	Let the augmented view appear when the device is facing the corresponding attraction.	7	ES
73	Make the view that augmented to the live camera view relatively transparent to easily see the corresponding attractions behind it.	7	ES
74	Make the transparency of the augmented image less than 40% to be easily seen on a bright day.	7	ES
75	Make the angle of the picking point (i.e. the attraction location within the augmented reality feature) relatively wide to prevent losing the augmented view when moving the device slightly.	7	ES
76	Add the date of the augmented view with the live view	7	ES
77	Make the augmented view to show different angles of the corresponding attraction based on location	7	IS
Smart eye glasses			
78	Extend the notifications to the smart eye glasses device	7	IS
79	Extend description of attractions to appear in the glasses interface	7	IS
80	Add an image of an attraction with the name of the attraction on the glasses interface	7	ES
81	Add a brief description regarding the attraction that learners are being notified for on the glasses interface to help them decide if they are interested to go for further details using their mobile device	7	ES
82	Make the text very brief as the glasses' interface is very small	7	ES
83	Add only the important points regarding the attraction on the glasses' interface as learners do not prefer a lot of text on the glasses	7	ES
84	Extend the augmented reality element that shows how attractions appeared in the past to the smart eye glasses	7	ES

As it was mentioned earlier, designers could use the part or parts of the list that fulfil their design in both forms enhancing the existing one or designing a new one. For instance, if a designer wants to add a service to facilitate communication between visitors to their existing app, they could choose some services that serve this goal such as design recommendations number 59 & 60, which are promoting the interaction and socialisation between visitors to interact at sites. The designer could (a) adopt the design example provided, if any, or (b) develop the feature that better suits the design; Table 12.1 illustrates how it could be used providing the two mentioned options.

Table 12.1 how to use the recommendations

DR-No	Design recommendations	Features	Feature description
59	Provide a service to enable learners to interact with each other during the visit (e.g. chat service)	Develop a chatting service	A chatting service enables a group of visitors (e.g. family or friends) to create a network between each other to communicate during a visit
60	Provide a service that enables learners to find friends at a site	Develop a service which could be called "any one is near?"	This service enables a visitor to find friends (i.e. new or existing friends who has an account in the same app) who are nearby to encourage socialising at sites

12.3. Discussion and conclusion

The list of design recommendations was identified gradually throughout this PhD research, which was shaped based on the results of the entire research, i.e. the field studies and the evaluation studies. The field studies offered a framework for designing smart and ubiquitous learning environments with respect to cultural heritage sites, which was further analysed to devise a set of general requirements. The general requirements act as a link between the framework and the design of the proof-of-concept by pulling out a list of low-level requirements (design solution elements) using the scenario-based design method. These requirements guided the design of the proof-of-concept, which is called SmartC. Consequently, SmartC was evaluated by experts of HCI and potential end-users, which served to revise the list of the design solution elements and re-design it to introduce a list of design recommendations. The list consists of three main parts covering different dimensions of designing such services, which are content provision, learning experience design and interaction with context design.

The content provision part gives an overview about how the content of learning applications for cultural heritage contexts should be managed and maintained. Additionally, it suggests what types of information should be included regarding the sites' history, and what type of information should be included that could be useful for learners in organising their visit. Content is an important element in designing such services, which could be a key for drawing learners' attention and help them engage with the experience. Hence, it is essential to take good care of deploying the content.

The learning experience design part provides an overview of how the learning journey should be designed in terms of: (1) drawing learners' attention to visit sites; (2) learning activities that help learners engage with the experience; (3) learning preferences of how learners prefer to learn; (4) supporting learners to learn while doing daily activities. These aspects help designers to have an overview of what they need to keep in mind when designing learning environments that would lead learners to learn about history at sites with more joy and engagement.

The interaction with the context design part provides an overview of how learning environments should be designed in terms of: (1) interaction design; (2) features and services; (3) augmented reality element design; (4) smart eye glasses. In addition, it deals with learners' profiles as they could influence the interaction with the context in terms of learners' preferences, which needs to embrace all aspects related to the interaction as the learner is the core element of the whole process of informal learning. This part provides a number of design recommendations that designers need to consider in terms of interaction, which would help in producing useful and easy-to-use apps.

The aforementioned parts would help to guide the design of smart and ubiquitous learning environments to be used in outdoor cultural heritage contexts. The three parts involve 84 design recommendations to cover different aspects to assist designers when introducing new learning environment in such contexts. The recommendations that have been presented in this chapter were accompanied by: (1) the general requirements they belong to; (2) the source that they were pulled from; an example of how the recommendation could be used was provided. This list of recommendations is one of the main outcomes of this research alongside the framework presented in Chapter 8. The next chapter concludes the outcomes of this research and outlines the main contributions, which are the FoSLE framework, and the design recommendations.

Chapter thirteen

13. Conclusions and future work

This thesis has presented research in the field of technology enhanced learning with the aim of enhancing informal learning in the outdoors cultural heritage context, which also made a contribution to the field of Mobile HCI. This research has introduced a task model in the form of theoretical framework to act as a tool to inform the design of smart and ubiquitous learning environments based on mobile and wearable technologies. The framework was further analysed to devise a set of general requirements that could be adopted for designing new learning artefacts in the form of software. A mobile application prototype, SmartC, was developed based on a subset of these requirements to enhance visitors' experience of outdoor cultural heritage sites. SmartC was evaluated in the field by experts of HCI and end-users who informed a list of recommendations alongside the three field studies to assist designers who are interested in designing such services.

This chapter is structured as follows: 13.1. stresses how the research questions have been addressed, summarises the findings of this research; Section 13.2, summary of conducting this PhD research; Section 13.3 discusses threats to validity; Section 13.4 outlines contribution to knowledge and limitations; Section 13.5 gives an overview of the concept of "learning on-the-move"; Section 13.6 sets out directions for future work. The next section summarises the contribution and the research questions, and illustrates how the questions have been addressed.

13.1. Addressing the research questions

This research adopted the SCE methodology to help address the research questions mentioned in Chapter 1, which consequently led to several contributions of this research to the academic knowledge. SCE stresses a two-stage process, which includes: (1) the analysis stage which involves the field studies and the investigation of the learning theories; (2) the design stage which involves conceptualisation of the design concept through scenario-based design and implementation. The first stage involved the formulation of a theoretical framework based on the findings of the field studies and the investigation of learning theories. The second stage involved building a mobile application prototype based on the framework resulted from the

first stage. SCE served to answer the research questions which led to achieve several contributions this research made, which include:

1. Finding out how people may use mobile technology for learning purposes at outdoor cultural heritage sites by conducting three empirical studies (Chapters 4, 5 & 6).
2. Developing a task model (framework) to assist researchers in designing smart and ubiquitous learning environments based on mobile and wearable technologies (Chapters 7 & 8).
3. Developing a set of general requirements based on the task model to inform the design of such services (Chapter 9).
4. Developing a proof-of-concept, SmartC, based on the general requirements (Chapter 10).
5. Designing a list of recommendations for designing such services (Chapters 11 & 12).

Figure 13.1 illustrates how SCE served to answer the research questions. The aim of this research informed the analysis stage. The aim was to explore the potential of mobile location-based learning services with respect to cultural heritage sites.

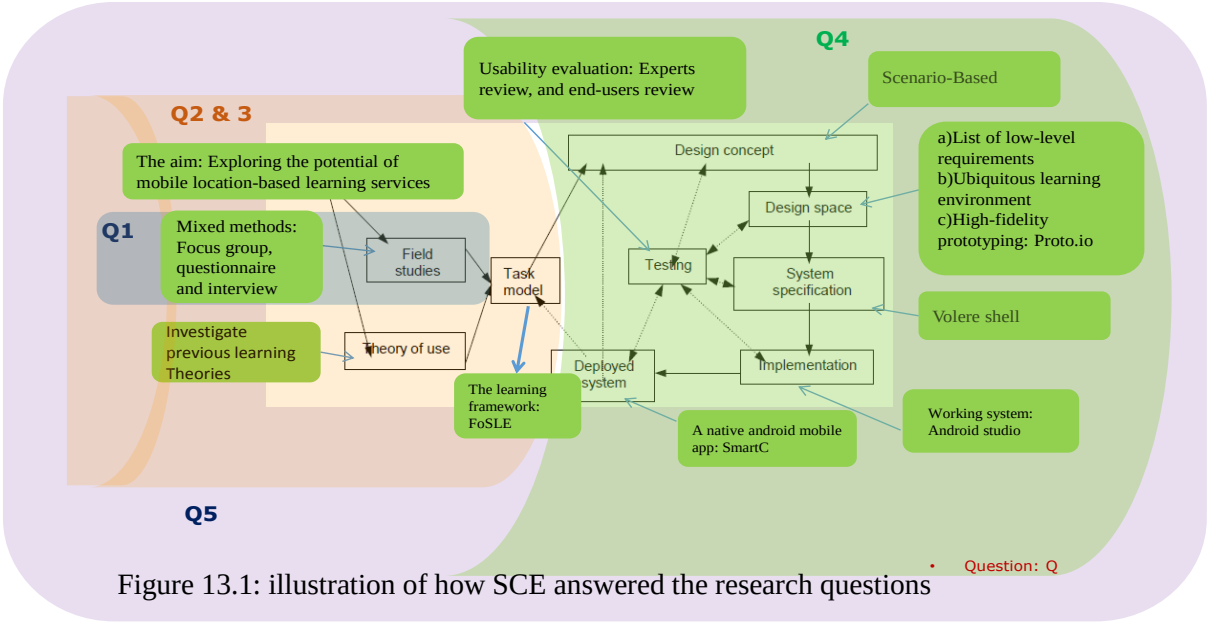


Figure 13.1: illustration of how SCE answered the research questions

The research questions and how they were answered are outlined below.

Q1) How do people use mobile and wearable technologies for learning in the cultural heritage context?

In order to answer this question, this PhD research carried out three field studies adopting a sequential mixed methods approach. Focus group, survey and interview techniques were used

to investigate how people may use mobile technology for learning from cultural heritage sites with the aim of gathering user requirements.

All studies were integrated in the interpretation stage of the results of the field studies (details in Chapter 7). The main findings of these studies are summarised below:

First: perception of learning

People perceive learning differently and often they are not aware they have been learning, thus, learning could be classified into four levels based on learning perception, which are: (1) acquiring formal information that could help enhance individuals' professional life through formal courses; (2) acquiring information that could enhance individuals' skills; (3) acquiring informal information that could help enhance individuals' personal knowledge; (4) acquiring general information that could assist in an individual's daily-life.

Second: learning in different forms (groups and individual)

People are keen to learn in groups, as well as individually, as each form brings different experiences to individuals. Learning in groups, such as collaboratively or socially, brings the joy of being with others and would promote the sense of community. Learning individually brings personal experience, which would promote the sense of places as it helps hold the sense of heritage places.

Third: types of visitors based on their motivations

Visitors are classified into three different types based on their motivations which are:

(1) knowledge-driven: who are interested in boosting their knowledge and in learning about history and heritage places; (2) explorers: who are interested in satisfying their sense of discovery and curiosity to explore history at heritage sites; (3) nostalgists: who are interested in satisfying their emotions in terms of feeling the places as it makes them feel emotionally connected to them and imagining life back in time.

Fourth: the learning on-the-move concept

The concept of learning on-the-move was developed throughout this PhD research. Learning on-the-move is simply acquiring information intelligently and automatically based on changing contexts while moving; in this research the change of context was based on location. In other words, the learning on-the-move supports receiving information in a timely manner without the need of any intervention from users. Learning on-the-move supports the concept of situated learning (Lave & Wenger, 1991); more details in the Section 13.5.

Fifth: visitors interact with the context differently

Visitors of cultural heritage sites interact with the context in different ways in terms of:

I. Devices they use: visitors use different devices based on the context, for instance, they would use tablets in a more settle state (e.g. at home or in the office), whereas the light size of mobile devices made it more suitable to be used on the move. In addition, wearable computing such as Smart Eye Glasses would be excellent devices for supporting learning on-the-move at sites as it frees visitors' hands, which could contribute positively to the experience in an unobtrusive way.

II. Services they use (via mobile devices): a number of services have been highlighted that visitors would like to use at sites such as: (a) organising the visit beforehand; (b) location-based tours; (c) seeing attractions as they appeared in the past; (d) sharing the experience.

Sixth: challenges highlighted by the studies

A number of challenges have been highlighted by the studies which could be summarised as: (a) personal preferences; (b) confidential issues, (c) financial issues; (d) technical issues (e.g. network quality); (e) mobile devices capabilities.

Q2) What are the essential elements for developing smart and ubiquitous learning environments utilising mobile location-based learning services for outdoor cultural heritage sites that meet the user's needs?

The findings of the field studies have contributed to develop a framework, FoSLE, which were supported by the learning theories as strength evidence. The FoSLE framework was developed to encompass the essential elements for designing smart and ubiquitous learning environments utilising mobile location-based services. The framework was introduced to inform the design of smart and ubiquitous learning environments with respect to outdoor cultural heritage contexts. The FoSLE framework consists of six broad categories that could inform the design and development of such services, which are: (1) learner, (2) content, (3) interaction design, (4) context and, (6) challenges and obstacles (see Chapter 8).

Q3) What are the requirements for developing smart and ubiquitous learning environments to support people learn from cultural heritage sites?

The framework, FoSLE, was not directly applicable to inform the design process of new artefacts. The missing link between these two stages was a set of general requirements. A set of general requirements were devised from the framework to inform the design of a proof-of-concept mobile app. The list consists nine general requirements which are:

- The service should maintain a learner model

- The service should maintain a content object
- The service should help generate learners' interest
- The service should support different types of learning and learning preferences
- The service should support learning on-the-move
- The service should support learners to communicate with each other
- The service should support learners to interact with the context easily and efficiently
- The service should support learners to take a learning opportunity in different contexts
- The service should consider the challenges that might arise in using mobile devices in outdoor settings.

These requirements were further analysed to pull out a design framework to guide the proof-of-concept a mobile application prototype (see Chapter 9 Table 9.2).

Q4) How can the requirements be used to guide the development of a learning environment for outdoors cultural heritage settings?

To answer this question, a smart and ubiquitous learning environment was developed as a proof-of-concept based on mobile and wearable technologies, SmartC, as described in Chapter 10. SmartC provides different services and functionalities to assist learners in their learning journey at outdoor cultural heritage sites, which include: (a) receiving notifications based on location; (b) multimode information format; (c) seeing attractions how they looked in the past.

Q5) What are the recommendations that could be inferred from this research for researchers and designers who are interested in the design of smart and ubiquitous learning environments based on mobile and wearable technologies in the cultural heritage domain?

To answer this question, a list of design recommendations was introduced that could be adopted for developing smart and ubiquitous learning environments with respect to cultural heritage contexts. The list involves 84 design recommendations, which are distributed into three main parts: (a) content provision, (b) learning experience design and (c) interaction with the contexts design. Chapter 12 presented the list of the design recommendations.

13.2. Summary of conducting this PhD research

In the informal learning context, learners are in charge of their learning – they are taking the active role in the learning process. Thus, it is important to consider learners requirements when

designing a tool for informal learning which would enhance their engagements especially at outdoors cultural heritage sites, as they do not consider visiting sites as a form of learning but rather as a form of entertainment. The discussion in Chapter 2 revealed that there is a lack of models/frameworks that support designing new smart and ubiquitous learning environments for outdoors cultural heritage sites and at the same time consider learners requirements. Thus, learners' perspectives were considered throughout this research with the aim of filling the gap in this respect. A user-centred design approach was adopted in this research using the socio-cognitive engineering (SCE) methodology to answer the research questions as presented in the previous section.

SCE consist of two main stages, analysis and design, that are connected in an intermediate stage, which is referred to as the "intersection stage", as it bridges the two main stages. Each stage involves a number of elements or sub-stages to achieve a specific goal that serves this stage. The analysis stage has two elements: field studies and theory of use. Field studies are used for investigating people's behaviours, attitudes and habits regarding the investigated activities, on one hand, and theory of use is about studying theories related to these activities, on the other hand. These two elements are combined in an intersection stage to formulate a task model, which bridges the analysis stage with the design stage in an iterative manner and provides a set of principles in the form of requirements that could be adopted to inform designing new artefacts in the form of software environments.

The design stage consists of an iterative cycle of five sub-stages for designing and implementing the artefact, which include: (1) design concept, which involves translating the task model into a coherent design picture of a new technology; (2) design space, which is about generating possible system designs; (3) system specification, which specifies functional and non-functional aspects of the system; (4) implementation the system, which involves translating the design into a working system; (5) deployment of the system, i.e. the use of the system in context. The testing part integrates all the aforementioned sub-stages together, with the results of the tests feeding forward to understand how to implement and deploy the system and backwards to fix drawbacks of the design and then helps to introduce a useful software environment (Sharples et al., 2002).

The aim of this research, which informed the analysis stage, was to explore the potential of mobile location-based learning services with respect to cultural heritage contexts. A sequential mixed methods approach was adopted in the field studies to investigate how people may use

mobile technology for learning purposes in the analysis stage (Creswell et al., 2003). Three field studies were conducted using focus group, survey and interview techniques to investigate people's behaviours, attitudes and habits regarding using mobile technology for learning in cultural heritage contexts. The thematic analysis method was used to analyse the qualitative data that resulted from the focus group and the interview studies (Clark & Braun, 2006). Statistical analysis was used to analyse the quantitative data that resulted from the survey study. The results of the three studies were integrated in the interpretation stage to help shape the task model (the FoSLE framework) (see Chapter 7).

The findings of the field studies were pulled together with the learning theories that were investigated in Chapter 2 to develop a framework for developing smart and ubiquitous learning environments utilising mobile location-based services. The framework acts as the fundamental basis for designing such services to be used at outdoors cultural heritage sites. The framework consists of six broad categories as listed in the Section 13.1. The framework was further analysed to pull out a set of general requirements to be adopted for developing new technology-supported artefacts, which informed the design of a proof-of-concept smart and ubiquitous learning environment based on mobile and wearable technologies (see Section 13.1).

Scenario-based design was used to illustrate the design concept; four scenarios were developed to visualise a tangible picture of what could be developed based on the requirements (Carroll, 2000). A design framework with a set of low-level requirements, which are more specific and detailed requirements, was pulled out from the scenarios. A high-fidelity prototyping approach was adopted (Virzi et al., 1996) using proto.io to simulate the context of use that was depicted in the scenarios, which were developed based on the identified requirements. The Volere shell was used in the system specification stage to document the requirements of this service, which were subsequently translated into a working system in the implementation stage. Android studio was used to implement a native mobile application prototype as a proof-of-concept, which is called SmartC.

Usability evaluation methods were used in the testing part with experts of HCI and end-users in the field. The evaluation studies focused on the HCI aspects in terms of: (a) usability; (b) usefulness; (c) acceptance. Observation and interview techniques were used alongside the cognitive walkthrough and questionnaire in this part to obtain rich data from a small number of participants. Given that assessing the effectiveness of learning in the context of informal learning is challenging (Skule, 2004) as there is no standard factors or criteria to compare

against like in formal learning context, this research assessed the app in terms of suitability for learning instead of the effectiveness of learning, which was carried out in a small scale within the usability questionnaire. Five experts and twenty six end-users participated in the evaluation studies that were carried out separately. The studies included observational and interview studies, and also contextual data was obtained from experts using the cognitive walkthrough method. The results of the evaluation studies suggested SmartC is a useful and user-friendly tool, and also it is suitable for learning. The evaluations results helped enhance the list of the low-level requirements, which were re-designed to produce a list of design recommendations for designing such services (see Chapter 12).

13.3. Threats to validity

Threats to validity refer to the extent to which the research is valid; it is classified into internal and external validity (Downing & Haladyna, 2004; Ihantola & Kihn, 2011). The internal validity refers to how well the study is done in terms of the relationship between a variable of interest (a dependent variable) and several other independent variables; in other words, did the study measure what it claimed to measure? This PhD research involved studies were conducted primarily to collect user requirements based on user's opinions; thus, there is no measurement of an independent variable as such. Consequently we will discuss internal validity in terms of the extent to which the studies captured the elements of interest.

Internal validity – as mentioned earlier – refers to how well the studies are done. This PhD research conducted three field studies with the aim of capturing as many relevant aspects as possible in relation to learning at outdoor cultural heritage sites using ubiquitous devices. The mixed methods approach was used to cover users' perspective in both breadth and depth using qualitative and quantitative methods. The three field studies were conducted sequentially adopting focus group, questionnaire and interview respectively. Whilst the focus group helped to generate preliminary ideas and perspectives regarding the investigated aspect to carry out further research, the questionnaire and the interview served to have breadth and depth insights regarding the investigated aspects. The value of using the mixed methods approach, methods strengthening each other by overcoming each other's limitations, which helps reducing threats to validity (more details were given in Chapter 3).

External validity refers to how well data and theories obtained from one setting apply to another, i.e. the generalizability of the findings. According to (Ryan, Scapens, & Theobald,

2002), external validity involves three problems might threaten the quantitative study, which are: (a) population, (b) time and environmental; and (c) generalisability, which refers whether the results could be extended to a wider context.

In terms of population, this research conducted three studies using participants from different backgrounds, age groups and gender. This research made every effort to prevent bias that might occur by aiming to capture the diversity in terms of opinions. Thus, different channels were used to recruit participants (adults) (details in Chapters 4, 5 & 6) with the aim of recruiting as many participants as possible to obtain the diversity and wide spectrum of opinions. The selection of participants for each study was based on the demographic of the sample responded to the previous study aiming to balance the diversity of participants' demographics. For instance, if the majority of the survey study's participants were students, students were excluded from being selected for the next study, which was the interview study. Given that, this research used as many participants as possible and fairly met the diversity of opinions within the context of the research.

In terms of time, the potential problem is if a particular study in a point at a time can be generalise to a different time period. This research would be valid for long-term as it considered the new trends in technology such as wearable computing and immersive technologies, which have a lot of potential in the cultural heritage field. In terms of environmental aspects, the potential problem is international generalisability. Although this research was conducted in the UK, participants from different backgrounds took part; in addition, some participants were resident outside the UK as they were recruited using social media, which helped to obtain opinions from different cultures.

In terms of transferable results, the potential problem is if the contribution could be extended to other context. Although the context of this research is outdoor cultural heritage, it could be extended to indoor settings by using different context-aware services that suit indoors such as Bluetooth. Additionally, it could be extended to other outdoor contexts such as sport or wellbeing (details in section 13.6.1). The next section gives a brief summary of the contributions of this research and outlines the limitations of each one with recommendations to overcome them.

13.4. Summary of contribution to knowledge

As it was mentioned earlier, this PhD research made several contributions to knowledge that made it unique (see Section 13.1). This section discusses the two main contribution of this PhD research, which are the FoSLE framework and the list of the design recommendations.

1) The FoSLE framework

The FoSLE framework is designed for assisting researchers and designers who are working in the field of technology enhanced learning with respect to cultural heritage. FoSLE is for designing smart and ubiquitous learning environments for outdoor cultural heritage. It supports informal learning on-the-move at sites with the aim of enhancing sites interpretation as well as visitors' engagement, which consequently enhances their experience. The framework consists of six broad categories that act as resources of information to feed into system design (see Figure 13.2). The general scenario for using the framework could be summarised as follow:

Scenario: The framework provides information for developing such services to be implemented in a smart and ubiquitous learning environment (S-ULE) system, which the learner/visitor will use to interact with the real-world (i.e. outdoors cultural heritage contexts). The use of the system will be through a set of general requirements, which then should be translated into features and service in a working system. Figure 13.2 illustrates the scenario.

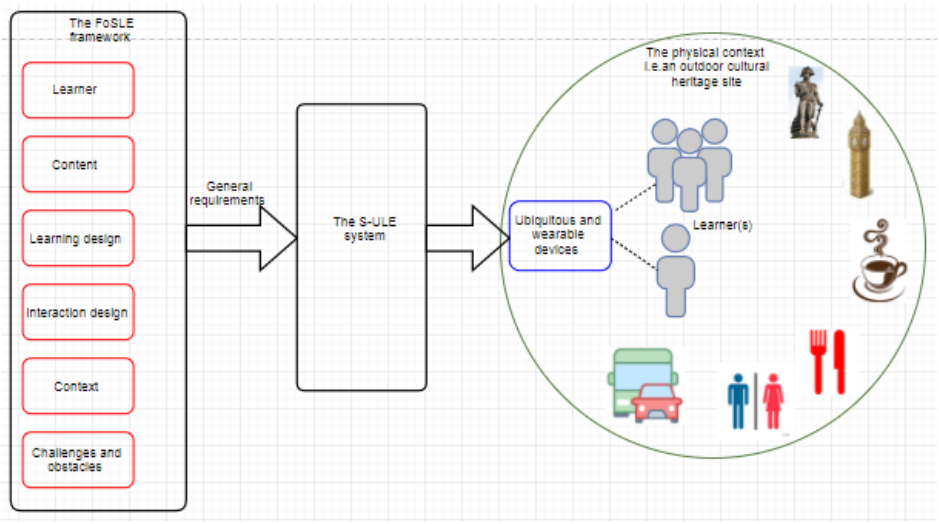


Figure 13.2: the general scenario of using the framework

As it was mentioned earlier and shown in Figure 13.2, the framework provides information for developing such services to be implemented in an S-ULE system, which the learner/visitor will

use to interact with the real-world (i.e. outdoors cultural heritage contexts). The use of the system will be through a set of general requirements, which then should be translated into features and service in a working system (see Chapter 8 & 9). The information provided by the framework's categories illustrates below:

1) The learner category provides information regarding learners, such as learner characteristics, in order to provide a better experience for learners based on their profile.
2) The content category provides information regarding content to be included in such services, which will be accessed using the aspects provided by the interaction design category.
3) The learning design category offers aspects that are related to the learning journey including learning preferences and motivations for visiting sites.
4) The interaction design category offers aspects, such as services and devices that will be used by learners to access contents whether it is learning materials or other information to assist learners taking the learning opportunity effectively.
5) The contexts category provides insights of the potential contexts of use that learners perform whether is the surrounding environments or the context learners use to learn at sites.
6) The challenges and obstacles category provides insights of the potential challenges that learners might encounter while using such services at outdoors cultural heritage sites.

These insights need to be considered in all the above categories to provide a worthy learning tool that makes the learning process even smoother instead of adding more pressure on users when using technology at outdoors setting of sites.

To use this framework efficiently, researchers and designers are advised to choose the part that better serves their design or use the whole framework to fulfil their work as there is no restriction for that. The main concept of it, is to make the design serves the learner in the best way to obtain a better learning experience at sites with the minimum challenges as possible.

The framework itself is limited in terms of:

1) The convenience sampling method might not allow generalising the framework due to the nature of the sample, as it may not be representative of the entire user population.
2) Although participants were from different nationalities and background, most of them were residents in the UK, which may have introduced a cultural bias.

Therefore, to address these limitations, an extension to this work would be the replication of the study with more participants using different sampling methods and broadening the research context to more countries.

2) The list of the design recommendations

A list of design recommendations was drawn out gradually throughout this PhD research. As it was mentioned earlier, the list consists of 84 recommendation elements distributed into three parts. The list was designed for assisting designers in designing such services, which covers a wide-range of a relatively high level of design aspects; these parts are illustrated below:

1. Content provision: this part provides recommendations for the content deployment, which helps in providing a big picture of the sites in one hand; on the other hand, provide useful information that assist learners in the learning trip. This part consists of three sections: (a) managing content; (b) provision of historical information; (c) provision of useful information.

2. Learning experience design: this part provides recommendations for designing the learning experience to help make the learning experience more enjoyable as well as effective.

3. Interaction with the context design: this part provides recommendation for designing a system that is usable, useful, easy-to-use and suitable for learning.

Designers are advised to choose the suitable recommendation element(s) from any part that suits their design's requirements. The chosen elements should be translated into features and services based on their creativity in the development stage to fulfil the working system.

The list of recommendations is limited in terms of:

1) The scope of the evaluation studies were limited to Mobile HCI in terms of the evaluation, with the learning aspects not being widely investigated.
2) The size of the sample is relatively small (for both studies, i.e. experts and end-users) in relation to informal learning at cultural heritage sites, which might affect the nature of issues that were captured.
3) The experts' evaluation was limited to experts in the HCI field, which may have only captured aspects from this perspective.
4) The end-user evaluation study was limited to one local site, and different issues might have arisen in different sites.

An obvious extension to this work would be therefore to carry out more studies including more sites with more end-users participants, and also, include experts from different related fields such as experts of cultural heritage.

The framework and the list of recommendations both contribute to enhance learning experience at outdoor cultural heritage sites by harnessing ubiquitous and wearable computing to support learning on-the-move at sites.

13.5. The learning on-the-move concept

According to Sharples et al. (2005), learning is mobile, which could occur while people are carrying their daily activities whether for leisure or daily routines. Carrying out the daily routines often involves changing in context such as location and given the rapid pace of life nowadays, people might miss out some learning activities due to the lack of free time to spend looking for information on-the-move. That warrants the need of facilitating the acquisition of information while carrying out the daily routines, which would support people to stay connected with the surroundings. That would save the time and effort spent looking for information regarding their interests, which in turn enhance learning. Hence, it would be helpful to deliver information based on the context on-the-move regarding the surroundings without the need for intervention from them; it would save the time and effort of people in looking for information themselves, which this thesis refers to learning on-the-move.

Learning on-the-move is a concept that was developed throughout this research, which refers to acquiring information while moving automatically and intelligently without the need of any intervention from the user – contextual learning, where you can learn based on the context, which here is location. In other words, learning on-the-move is the provision of the right information at the right time in the right place to the right person. Learning on-the-move helps people to learn about their preferable topics – history in this research – while doing their daily routines. It would save time and effort seeking for information as it appears automatically when passing by a point-of-interest based on location. This concept is supported by the situated learning theory as it is concerned with learning based on the context. Situated learning is the acquisition of knowledge through a community of practice where social interaction in the context is the main component of the learning process (Lave & Wenger, 1991). This concept of situated learning is characterised by situation and context, which could be explained as changing position in the real world such as physical location. Cobb and Bowers (1999, p. 2)

explain that, “the individual is considered to be situated is the metaphorical correlate of the physical space in which material objects are situated in relation to each other”. As mentioned earlier, people frequently change their situation in the world space in order to carry out their daily activities. Given that learning on-the-move is the acquisition of information while moving – changing location, this concept is pretty much in-line with the situated learning theory. Learning on-the-move requires changing in context frequently in terms of location and situation in order to acquire information, which helps people who are frequently changing context based on the nature of their life’s routines.

The concept of learning on-the-move applies during the visit of cultural heritage sites when moving around to learn about history. Acquiring information regarding historical events that happened in a particular site requires moving from one attraction to another and changing in context. Thus, acquiring information regarding the nearby sites on-the-move would benefit significantly from harnessing the situated learning theory as it supports learning based on the context.

13.6. Future work

Section 13.4, gave an overview of the contribution to knowledge and highlighted the limitations of this work and provided some suggestions to overcome them; this section suggests extensions to the present work.

13.6.1. Extending the FoSLE framework

The FoSLE framework is for enhancing informal learning in outdoor cultural heritage contexts was developed in this PhD research. It would be interesting to extend this framework to other informal learning contexts, such as sport or promote the fitness culture, to have another insight of how this framework fits in a different context. It is expected the main structure would stay the same with some amendments in the categories details, such as the content category. In addition, a different set of general requirements could be devised to fulfil different contexts.

To extend the FoSLE framework, some amendments to the details of each category need to be made. The detail could be changed based on the type of information each category should provide to serve the given context. For instance, let us assume a researcher wants to use the framework for employing technology to support the wellbeing of people by encouraging people to walk from home to school, work and shops and vice versa – the context could be a

combination of healthcare and fitness at outdoors. Table 13.1 illustrates the framework (types of information) and the amendments that need to be made based on the specified context.

Table 13.1: extending the framework for an outdoor context to promote a well-being culture

Category	Type of information provided by the framework	Example(s) of aspect needs to be added or changed
Learners	Who is using the services	-Children going to school -Shoppers going to shops -People going to work
Content	What is the information that serve this context	-Types of Plants, animals and insects -Events held nearby
Learning design	What type of experience/learning learners would like to have in such context	Learning on-the-move
Interaction design	What services could serve this type of contexts	Information based on location
	What information format could serve this service that would enhance engagements	Multimodalities information format
	How could it make the experience interesting in such a context	-Stories presented in a series which is disclosed sequentially (e.g. each time the learner walks along the road a different part of the story is disclosed) -Adapting services according to the surrounding environment in terms of contents (e.g. provide stories and history of occasions such as Christmas and Easter)
Context	How the context could be different in this type of experience	People use the path frequently such as more than once a day
Challenges and obstacles	What are the challenges that could hinder the process of learning in such context	People use the road frequently (i.e. daily), which might be challenging in terms of providing different information every time they walk along the road

A previous section has already suggested a replication of this work with participants from other countries, which would help to see if the culture would affect learning habits. Moreover, it was also suggested to include official staff who are based at different sites to have a broader insight into what is needed from officials' point of view.

13.6.2. Extending SmartC

As was discussed in this thesis, SmartC was developed based on a subset of the general requirements. It would be interesting to see how features and services could address other requirements, such as:

1) Developing the services that promote collaborative and social learning.
2) Developing the getting directions service to help learners find their way easily
3) Extending the augmented reality feature (see it in the past) to be seen through the wearable device.
4) Improving the augmented reality feature (see it in the past) to include 3 dimensions construction to show how the ruined sites looked in the past from different angles based on location.
5) Extending accessing information to the wearable devices to free learners' hands completely and help them to connect their sight with the artefacts while walking and enjoying the experience.

Another possible area for further work would be developing SmartC for iOS devices to make it available for a wide-range of learners.

13.6.3. Extending the evaluation studies

The focus of the evaluation studies has been on Mobile HCI. Although the usability questionnaire that was used in the evaluation studies has several questions to assess the system in terms of suitability for learning, no specific assessment was carried out to see how much information learners have taken back from the visit using SmartC. This would be a fruitful area for further work.

Another area that needs to be explored is how experts of culture heritage would react towards such technology to be used at their sites. Further work is needed to investigate whether the experts of cultural heritage have the same opinions regarding the system or not.

13.6.4. Managing the content

One area that needs to be further investigated is to extend this work by developing a new content management system in addition to metadata, and schema required for the development of sharable learning objects for cultural heritage domain. As discussed in Chapter 10, in order to provide reliable and up-to-date historical information, this research suggested a scenario for

maintaining content in a shareable repository that could be used by stakeholders to sustain a dynamic update of the content.

Scenario: Create a sharing repository with curators of cultural heritage sites in which they authorise and maintain the content of attractions. The repository could be integrated with other stakeholders such as designers of cultural heritage apps, which offers them a one direction access. In other words, there is no authorisation for modifying the original data. This integration gives designers an opportunity to connect their apps (i.e. websites and mobile apps) to the shareable repository to obtain content dynamically.

In this scenario, curators are authoring the content and storing it in the shareable repository for other stakeholders to benefit from it. As this research suggested, most learners prefer audio content as well as images as it is easier to comprehend; thus, curators should consider providing content not only as text but in multimode format to accommodate a wide-range of preferences. Otherwise, designers of apps will need to consider making the text audible to satisfy learners' preferences. Figure 13.3 illustrates this proposed scenario.

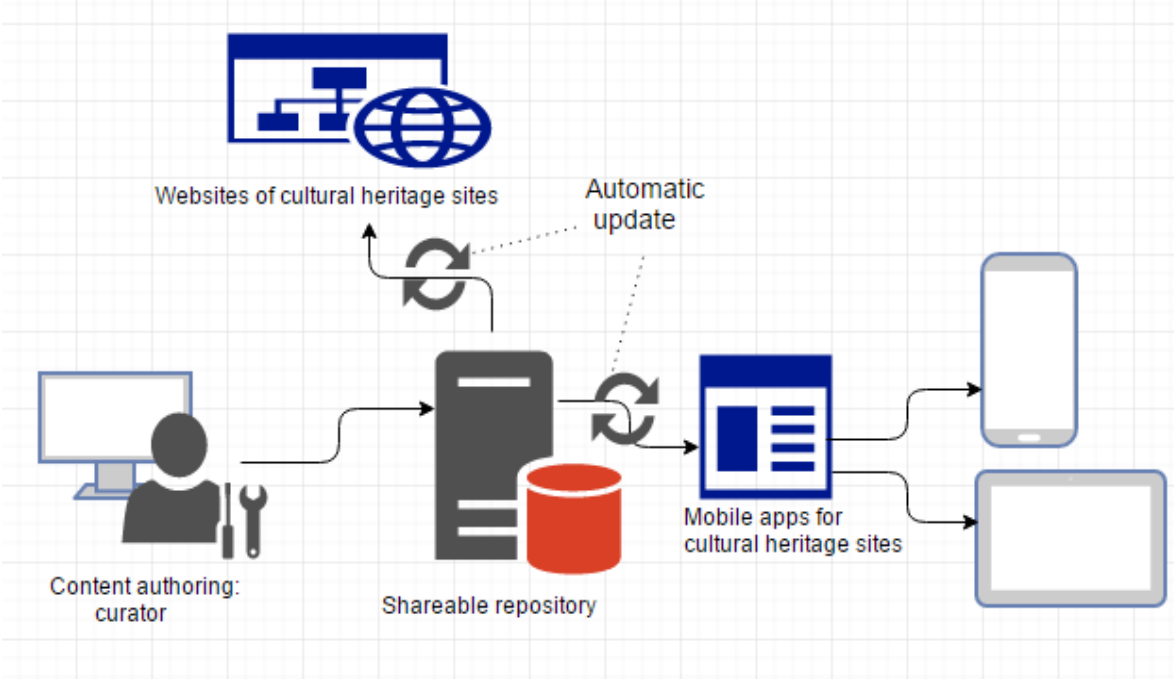


Figure 13.3: illustration of the proposed scenario for content management

This scenario offers a useful choice for integrating stakeholders, who are working in the field of cultural heritage, as it provides a virtual space for them to work towards enhancing sites' interpretation as well as visitors' engagement, which consequently leads to enhance the experience. The interesting aspect of this scenario is that it would lessen the burden on

authorities' shoulders regarding the provision of new technologies that would help bring sites to life, as designers will deal with it. On the other hand, designers will not need to worry about the source of the content as authorities will be in charge. Consequently, it saves time and effort for all stakeholders as they will complement each other's work. This scenario proposes a high-level (more abstract) schema for managing content leaving the choice of the implementation details to designers.

Related publications

Alkhafaji, A. S., Fallahkhair, S., & Cocea, M. (2014). *Smart Ambient: Development of Mobile Location Based System to Support Informal Learning in the Cultural Heritage Domain.* Paper presented at the IEEE 14th International Conference on Advanced Learning Technologies (ICALT), 2014 (pp. 199-200).

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Appendix A: the questionnaire form that was used in the survey study

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I am a PhD Student from the School of Computing/ University of Portsmouth doing research regarding using a mobile device to support learning in an outdoor cultural heritage context. This study is for people who are 18 years old and over. The data will be anonymous and untraceable and will be stored securely for the duration of the project after which it will be deleted. I kindly ask you to assist me in carrying out my research by answering the following questions. You are free to terminate your participation at any point and exclude your data from the study. Many thanks for your time.

Please tick (√) the appropriate answer for you:

Section 1:

Demographic Information:

Group of age:

□19 and under □30-39 □50-59 □70+

□20-29 □40-49 □60-69

Gender:

□Male

□Female

In which country do you live currently?_____

What is your nationality?_____

Occupation:

□Student

□Employed

□Self-employed

□Unemployed

□Retired

□Other, please specify_____

Section 2:

The Research Information:

Q1. Do you use a mobile device?

□Yes

□No

Q2. What type of mobile device(s) do you use? (*Tick all applicable answers*)

□Mobile phone

□Tablet

□Wearable computing device (*e.g. google glasses*)

□Never do

□Other, please specify _____

Q3. What do you use a mobile device for? (*Tick all applicable answers*)

□Calling

□Texting

□Accessing emails

□Capturing photos, videos, audios

□Getting directions (*using a map*)

□Playing games

□Shopping

□Financial transactions

□Learning (*e.g.Access online language leaning services, Wikipedia, Dictionary*)

□Listening to music or watching videos

□Getting news alert

□Managing a diary

□Checking the weather

□Never do

□Other, please specify _____

Q4. Of the following activities, which do you consider to be a type of learning? (*Tick all applicable answers*)

□Accessing online courses

□Accessing online services for learning (*e.g. BBC service for learning English*)

□Getting directions

□Accessing general information (*e.g. checking train times, finding out where is the nearest post office*)

□Accessing specific information (*e.g. Who built the Southsea castle*)

□Using a dictionary

□ Other, please specify_____

Q5. Where do you use your mobile phone? (*Tick all applicable answers*)

□At home

□In the office

□While travelling

□On holiday

□Never do

□Other, please specify _____

Q6. Do you use your mobile device for learning things on your own (*e.g.use things like BBC learning service, learning how to get a particular place by the Tube*)?

□Yes (proceed to Q7)

□No

Q7. If you answered 'No' to question '6', why?

□There are no interesting applications

□There is no interesting content

□Too complicated to use

□I prefer paper-based resources

□Other, please specify _____

Q8. Do you think a mobile device would assist you accessing information whilst you are doing your daily activities (*e.g. using dictionary, get train times*)?

□Yes

□No

Q9.Do you use a map on your mobile device *(e.g. to get directions)?*

□Yes

□No

Q10.Do you use a mobile device to find out where you are (*When you lose your way for example*)?

□Yes

□No

Q11. Would you be interested in using a mobile device to get information while you are moving (*e.g. learn about a historical building close to you while you are walking*)?

□Yes

□No

Q12. Do you like to visit cultural heritage sites (*e.g. historical castles or cathedrals*)?

□Yes (Proceed to Q14)

□No

Q13. If you answered 'No' to question '12', why?

□It doesn't attract me

□It's expensive

□I don't have enough time

□Other, please specify_____

(If your answer is 'No' for Q12, please proceed to Q15)

Q14. Why would you visit cultural heritage sites? (*Tick all applicable answers*)

□To learn about the past

□To encourage children to learn about history

□To envisage the stories behind those sites

□To stimulate an inner sense of cultural pride and belonging

□To investigate the cultures of the country that I'm visiting

□To entertain

□Other, please specify_____

Q15. What might motivate you to visit cultural heritage sites which you would hope to find on a mobile app? (*Tick all applicable answers*)

□ Watching a simulation of depicted historical events that happened in a certain place (The place you would like to visit it)

□ Listening to a brief description about the events that happened in a certain place (The place you would like to visit it)

□Getting information about a significant achievement in that period of time

□Getting information about how those events affect our current life

□Solving a riddle that describes a particular event (*e.g. re-order the event scene by using an image or a text puzzle*)

□Other, please specify_____

Q16. How often do you visit cultural heritage sites?

□Once a year

□Once a month

□Once a week

□On holiday

□Hardly ever

□Never at all (Proceed to Q18)

□Other, please specify_____

Q17. How would you organise your visit before visiting cultural heritage sites?(*Tick all applicable answers*)

□Reviewing comments about the site

□Checking prices

□Checking transportations

□Checking the distance

□Checking the weather

□Never do

□Other, please specify_____

Q18. Would you use a mobile device in the cultural heritage sites?

□Yes (proceed to Q20)

□No

Q19. If you answered 'No' to question '18', why?

□It distracts me during the tour

□The available applications don't meet my needs

□Not easy to follow the instruction

□Poor network quality

□Other, please specify_____

Q20. Do you think that using a mobile device in cultural heritage sites would facilitate accessing information about heritage places and their history? (*e.g. why Southsea castle was built*)

□Yes

□No

Q21. Do you use a mobile app to guide you when you visit cultural heritage sites?

□Yes

□No

Q22. If you answered 'Yes' to question ’21’, could you please name it if there is any particular app_____

Q23. What type of information delivery format you would prefer for a mobile app? (*Tick all applicable answers)*

□Audio

□Video

□Text

□Images

□Other, please specify_____

Q.24. How would you prefer to receive historical information about cultural heritage sites? (*Tick all applicable answers*)

□As stories

□As quizzes

□As a riddle that describes a particular event (e.g. re-order the event scene by using image or text puzzle)

□As formal information (*e.g. narrator or text describes an event*)

□Other, please specify_____

Q.25. What type of service(s) you would use on a mobile device in cultural heritage sites? (*Tick all applicable answers*)

□To find the nearest historical sites

□To find the nearest services, e.g. restaurant

□To find directions

□To save information on favourites sites

□To design my own tour

□To pre-organise my visit

□To use a camera for designing my own collection

□To share stuff like pictures, videos and comments with others while we are on a trip

□To connect the app with the social media services, e.g. Facebook, while I am on the trip

□To get historical information while I am moving regarding historical sites (*e.g. the stories behind those sites, and what are the lessons that we could learn from those stories)*

□To create a network with my friends during a trip

□To consider the surrounding environment (*e.g. day or night, crowded or quiet*)

□To personalise my app (*e.g. choose a favourite theme, make the app remember my favourite restaurant*)

□To generate a comment

□To get a set of recommendations of some interesting sites based on my interests

□To listen to events' description while I am taking a tour on my own

□To receive a notification for interesting sites based on my interests

□To find out extra information about the sites like the cost and opening times

□Other, please specify_____

Q26. Would you like to be able to customise a mobile app based on your interest? (*e.g. choose your favourite colour, your language)*

□Yes

□No

Q27. Would you like to state up to three features you would prefer to be able to customise them?

1. _____
2. _____
3. _____

Q28. Do you have any additional comments you would like to make? _____

_____

Would you like to be interviewed regarding you answers?

□Yes

□No

Q29. If you answered 'Yes' to question '28', please write your name and contact details _____

Your contact details will not be disclosed, it's only for facilitating the contacting process

Please turn the page

Thank you very much for taking part in this research; your contribution is appreciated.

If you have any concerns regarding this research, please contact Alaa Alkhafaji or Sanaz Fallahkhair in the first instance. If you are not entirely happy with their response, please contact the Chair of the School of Computing Research Ethics Committee in confidence by writing to:

Chair of the School of Computing Research Ethics Committee,
School of Computing,
Buckingham Building,

Lion Terrace,
Portsmouth,
PO1 3HE,
UK

Authorisation

□I hereby authorise the author to publish this data in conferences, journals and PhD thesis

Signature

Appendix B: Extracting information from the qualitative research (focus group & interview)

Focus group study	
Code	Examples of extracted information
FG1	"*…different people has different preference"… "…what kind of apps that people comfortable with?*"
FG2	*"direction of mobile technology, where going, so, not necessarily based on what happening now, what might be popular in the future, google glasses emerging, is that be soothing, is gonna take off…"*
FG3	"*…personalize your app to suit your convenience…*"
FG4	"*I would like to take my children to historical site to help them learn from them…"*
FG5	*I might go to visit cultural heritage or historical sites if I am on holiday in another country*"
FG6	*"I would discover society's cultures, so the best way is to visit cultural heritage and historical sites…* "
FG7	"*…I go there, I want see memories, I wanna write down, take picture and save them…"*
FG8	*"...what about integrating with social media whatever you do, because you wanna to keep [memory] some people like Instagram and stuff like that to keep memories…*"
FG9	"*… I like Charles Dickens; probably I wanna have coffee in place like Charles Dickens' lounge…"*
FG10	*"...That quite interesting, because maybe is something for children as well, to design something is accessible for children, they may get something to visit, [and] maybe they can listen to story where they are…"*
FG11	*"It is interesting actually, if you using location-based services on your device, so the device gonna know where you are, then you gonna know where you are in the relation to the place or app, so the cultural heritage site"*
FG12	"*…it can give you information like taxis, buses, it could be helpful or how far from the bus station…*"
FG14	*"How you gonna integrate with different cultural sites? You know cooperating different facilities in cultural heritage sites and different location, that to bring all information together for the assessment"*
FG15	*"But the interesting thing is something will be useful for you to map a user journey, for instance; what the situation they gonna find themselves, one thing as usual before they go somewhere, while they are, or as a memory devices after they've been there…"*

Focus group study	
Code	Examples of extracted information
FG16	"*For instance, if you trying to look for a route and look at on your mobile phone, the next time you gonna go to this place you know how to use the map, you learnt something. If you look at train times, you gonna learn that…"*
FG17	*"… an implication for elder people who may be would find it difficult to look at small screen for getting information, I don't know how about the elder people who are deaf as well"*
FG18	*"it is interesting, define line between something been useful and something been irritate might turning people off"*
FG19	*"… make it easy when you can switch things off or not…"*
FG20	"in Britain the weather is shocking"
FG21	*"GPS can be a problem as well, different people have different means of GPS, or different quality of GPS service, might be not good"*
FG22	*"But you have to put in your consideration as much as you make it more complicated and more interaction with the user and more question you will lose number of users, all of us are looking for an easy application"*
FG23	*"when Google suddenly give you on adverb about some stuff, you've been looking at, you were thinking how did they know that, and you thinking am not sure I like this", people trusting things is quite important"*
FG24	*"Is just something I personally wouldn't, because I don't have that sort of easy to use a phone"*

Interview study	
Code	Examples of extracted information
EU1	"*I'm usually interested in practically in anything and everything, so I always want to find out what's round the next corner what am I missing, natural curiosity*".
ST1	*"...some people they really like reading and read every label in that home place, another people just looking into the videos…"*
ST2	*"…there is a school party for children may be 10-11 they will be other visitors who in their eighty's, and will be people my age and would be people younger people with their families…"*
EU2	"*…what is the reality of people who lived and provided the infrastructure…"*
EU3	"*…it makes it a lot more personal it makes it a lot more human, that is not just a piece of bricks, but it brings the whole personal angle to it a new level that someone actually experience it someone has done something that it's important or it's an important memory for just particular person, that I don't know when they were child or when they were growing up or something, and it's something happened and it worth share, I think it would be really interesting that those personal experiences of people yeah, absolutely, just it takes you into a different level it's not just dry facts, in 1973 this happened and 2008 this happened, yes it's interesting but also having the more personal side of it that would be really interesting"*

Interview study	
Code	Examples of extracted information
ST3	*"we have an archive and also a multi branch of the museum we've got at the moment these collection are spreaded across five different sites that we are putting together [approaches] at the moment trying to bring all those [visualises] together"*
EU4	"…*useful information would be as well, like opening times, prices of tickets, how to get there …"*
EU5	*"…because if get lost then that the part of the joy actually because you usually find some really wonderful things by getting lost…"*
EU6	*"…it would be nice if it was telling you a bit more in general rather than reading a guide book or trying to look on the internet which can be quite difficult sometimes yeah I think it [receiving information on-the-move] is a lovey idea"*
EU7	*"…there is sort of dream like quality to going to older building and filling in the gaps for yourself and imagining and creating how it might have been, and imagining yourself may be with a princess walking down the amazing steps, you with a grand lady having tea in this room…"*
EU8	"D*uring the war the capital city [ ] was completely, completely destroyed and absolutely nothing left and the re-built it and for a very long time I absolutely hate it … I think I thought it was the ugliest city in the world ok everything was ugly and I start walking around and you know you have some boards on building saying oh in this place this person did this you know, someone was killed here or something happened here and it made me think about the place differently I just learnt I just realised that it's a place of wonderful history that something you would be proud of something to just tell other people about it thinking it's not just a city it's got these old wonderful stories link to it it's just makes you see the place differently and think about the past*"
EU9	*"..often you have a guide or whatever and in front of you will say 'no 5' and press no 5 and listen to it, but sometimes your eyes just don't look at the right place for whatever reason and that means you miss something, that actually could be interesting to you, so, I guess if you have that kind of technology [Smart glasses] it would make sure you had a full experience and you did not miss anything"*
EU10	"*I guess as part of the whole experience of visiting a site I wouldn't want the whole experience to be through the glasses, so maybe as part of seeing the reconstruction*"
ST4	"*I think that have a lot of potential with things like our ships because there is always a safety issue with people going up and down ladders and cases in the ship holding a phone not looking where they going, so I think there is definitely possibility I thought"*
EU11	*"I think I'm more visual and atmosphere person and I think also I like to feel free when I am walking around the museum…"*
EU12	*"…probably want an app that connected to audio tours not visual something that I can listen to [on] iPhone for example could track where I am then I would automatically know where I was and be able to give me the correct information based on where I'm standing"*
ST5	"*outdoors is the tricky ones for us because it's a heritage site, so there are quite kind of listed buildings on the site and there are quite serious restrictions from the landlord about what we can do around the building, I think there is an opportunity for technology around the outside of the site because ,I think there is [a question*

Interview study	
Code	Examples of extracted information
	about whether the site] is doing any good we can't use it anyway ... I think that's where we struggle interpret the scale of the site, we do very well in the building but less well outside "
EU13	"*I use it [a mobile device] pretty much for everything*"
EU14	*"…when I was in […] for some time just being alone walking through the old town at night and smelling the Jasmin flowers and light was very beautiful, just the atmosphere of that moment hesitates me for that was 2007, I can remember that feel it very personal, personal experience, when you with somebody else may be you talk about, oh its Jasmin that's interesting its feels beautiful, but may be you don't hold this sensation"*
ST6	*"I think the most important thing for us I think is we quite disjointed as a site at the moment , we have three different museum on the site, there is the national museum of the royal navy, there is Mary Rose, there is the worrier and then very different, interpreted very differently and there isn't a linking thread that makes people understand that these one, a whole dockyard it was a single organisation and everything in it ……, that's I think the most important thing we could use mobile technology to deal with to help people understand the site rather than individual museums within it"*
EU15	*"...I think the information that you receive and platform which presented to you are directly affecting how enjoyable the experience was but also the amount of information you take back from it…"*
EU16	*"...I know personally I would get frustrated with technology instead of enjoying being in historical place…"*
EU17	*"oh quiz would be nice you know when you have to find something and go Frome place to places that sounds really nice, well again going back to the `roman bath I think that they have two different ways of doing it because there is one for adults I think when its more ... more formal and then there is one for kids when they tell a story about what's happening and then there are little videos there is I think…"*
EU18	*"…the formal one just gives you a lot of facts but then stories it's easier to follow I guess it's easier to kind of get involved in the story, I guess may be story will be more interesting…"*
EU19	*"…I'm a bit of child, I'm really like the interactive quizzes so might be after the visit to give me a quiz to see how much I learned about it, it's quite good fun especially if you got children as well may be or you with somebody you can see who is learn the most on the trip…"*
EU20	*"…I'll give an example, if I was I HMS victory and I got the bit where nelson died I would like be able to stand there and listen to further information and facts about nelson how he died what they did to his body have they got him back to England"*
EU21	*"…well it's another story, isn't it, it's putting flesh on the bones, like if you went into a castle that was ruined and then if you saw how it was in the past and it's just bringing stories to life put flesh on bones"*
EU22	*"…well if I go somewhere, I like to know exactly where I'm going, where to find things, what each thing is about, I don't like to go then just kind of look around because if you just looking around you don't get any information at all, you need to*

Interview study	
Code	Examples of extracted information
	know where things are, the relation to each other and in relation to the world now and the world then or whatever like that it is all kind of interesting"
EU23	*"…I guess I can only be true to my archaeological interest in one of the functions of archaeology is sort uncover what's there and interpreted but also then to try to provide you with that phasing how the occupation habitation progressed from the earliest piece of evidence through to the last piece…, yes I'd like to see how things changed…"*
EU24	*"…also if you got photographs of some the existing building so go back to the eighteen century actually to see the continuity in change, that would be interesting"*
EU25	*"I think it's interesting, I mean is not necessarily learning as much but it's more about getting people outside and a bit adventurey and I like that and I think it's nice because is something I'll do with my friends and it's quite, there is a community feel on the app so I feel like people share their experiences quite a lot on there and that's an app , if I want to share thing it would be on geo-casing I think it's quite nice"*
ST7	*"think they can help them to understand human achievement in so many different ways, so have centuries, it's the triumph some [mistakes], they scale of human and duffer, all of that I think is hugely helpful and think how culture has changed"*
ST8	*"we also use a lot of like costumes [of interpreters] so in the site you can talk to people, and we have a lot of volunteers and staff a lot of that"*
EU26	*"I want to be able to turn thing off and put it in the bag not worry about that"*
EU27	*"I think when people getting app and getting lots of information and not interesting it's kind of put them off in using the app, but if it's filtered to the preferences I think that's pretty bit a lot more successful so yes, it would be like a filtered set"*
EU28	*"the iPad is mostly for reading news articles watching YouTube videos things that I want sit down and do my mobile phone will be also to watch new articles, check Facebook, check emails sometimes make phone calls but usually when I'm on the move, walking from the work to home or sometimes in the office"*
EU29	*"if I'm by myself then I don't feel rushed and I can take things at my own pace and I can spend as much time as I want reading the information and I can skip things which is not interesting to me and I got more head space to just think and take , taken the site around me so that quite positive by going around the site by yourself"*
EU30	*"…going around place with other people does mean there will be conversation, conversation tends to improve memory so it gets you thinking more or probably remember more about the site because I've been talking with my friends and I might not remember that room very well but I will remember the conversation we had in that room about that statue or that painting or those artefacts so I think that's very helpful the other thing which is very, which I think I learn from with groups is everybody a teacher, people have different areas of knowledge so when I walk in into a room in the palace in Belgium when I was this summer I walked in with two or three friends and my friends has additional knowledge which they could tell me about so it's an opportunity when you are with friends to share knowledge may be not everybody else has about that topic about that site"*

Interview study	
Code	Examples of extracted information
EU 31	*"the thought of having a mobile phone on my hand or a glass over my eyes or earphone over my ears kind of break my heart I want to touch and feel and breath and use all my senses in a different way"*
EU32	*"when I go overseas I don't use mobile phone for roaming for internet just because I'm frighten of the cost"*
EU33	*"…I do sometimes write reviews in the trip adviser, so yes, I quite like to write a review if it's[the site] very good or not so good".*

Appendix C: the full results of the users' evaluation study

Note: we have made a reverse item technique, during the analysis, to the reverse-scored statements, which became 1= predominantly agree and 5= predominantly disagree, we mark them by the (*) symbol for indicating them. The results show that participants reacted positively regarding the usability aspects of the app as the average of each category is ranged between 3.6 - 4.25 and above which means is usable, the details in table 1.

Table C. 1: usability questionnaire's results

Suitability for learning	Valid	Mean
The app forces me to perform tasks that are not related to my actual learning *	26	3.69
The app lets me completely perform entire learning routines	25	3.88
The functions implemented in the app support me in performing my learning	26	4.15
The way in which data entered is suited to the task I want to perform with the app	22	4.00
Too many different steps need to be performed to deal with a given task *	26	3.54
The way in which data is output is suited to the task I want to perform with the app	25	3.80
The app is well suited to the requirement of my learning	26	4.15
In a given screen, I find all information I need in that situation	26	3.62
The terminology used in the app reflects that of my learning environment	26	4.19
The important commands required to perform my learning are easy to find	26	4.27
The presentation of the information on the screen supports me in performing my learning	26	4.04
Category average		3.94

Self-descriptiveness	Valid	Mean
I understand immediately what it's meant by the messages displayed by the app	25	4.60
When menu items are not available for a certain situation, this fact is visually communicated to me	18	3.89
The explanations of the app gives me clearly refer to the specific situation in which they are output	24	3.83
I can tell straight away which functions are invoked by various of menu items	24	4.21
The terms and concept are used in the app are clear and unambiguous	25	4.40
The app always visually marks the current entry location (e.g. highlighting, a contrasting colour, etc.)	19	3.53
I can easily tell the differences among feedback messages, errors, confirming a task and warning.	21	3.90
Category average		4.05

Controllability	Valid	Mean
The possibilities of navigating within the app are adequate	24	3.67
I can interrupt any dialogue at any time	25	4.08
It's easy for me to move back and forth between different screens.	23	3.52
The navigation facilities of the app support optimal usage of the system functionality.	23	3.87
In order to perform my learning task, the app requires me to perform a fixed sequence of steps	23	3.22
It's always possible to abort a running procedure manually	25	3.92
Category average		3.71

Conformity with user expectations	Valid	Mean
The app is inconsistently designed, thus making it more difficult for me to perform my learning *	25	3.96
I can anticipate which screen will appear next in a processing sequence	26	3.29
The designations are used consistently in all parts of the I am familiar with	20	4.00

Conformity with user expectations	Valid	Mean
I find that the same function keys are used throughout the app for the same functions	21	4.24
When executing functions, I have the feeling that the result are predictable	23	3.35
The messages output by the app always appear in the same screen location	24	4.17
Category average		3.84

Error tolerance	Valid	Mean
When working with the app, even small mistakes have sometimes had serious sequence	22	2.73
My impression is that very little effort involved in correcting mistakes	22	2.73
The app include safety features to help prevent unintended action	18	3.28
The app provides me with useful on how to recover from error situations	16	2.63
I perceive error messages as helpful	16	3.94
Category average		3.06

Learnability	Valid	Mean
I need a long time to learn how to use the app *	26	4.54
It's easy for me to re-learn how to use the app after a lengthy interruption	24	4.29
The explanations provided help me understand the software so that I become more and more skilled at using it	26	4.35
So far I have not had any problems in learning the rules of communicating with the app	26	4.19
I was able to use the app right from the beginning by myself, without having to ask co-workers for help	26	3.77
I feel encouraged by the app to try out new system functions by trial and errors	24	3.96
In order to use the app properly, I must remember a great many details *	25	4.44
I find it easy to use the commands	25	4.44

Learnability	Valid	Mean
Category average		4.25

Table C.2: feature rating's results

Feature	Valid	Mean
Receiving notifications based on the location	24	4.63
The text explanations	26	4.58
The attraction's image within the notification's dialogue	26	4.69
The attraction's image within the attraction's page	25	4.44
The attraction's image within the audio page	25	4.40
The audio explanations	26	4.77
The historical/documentary videos	25	4.40
Seeing attractions how looked in the past	26	4.15
Take a photo	26	4.04
Receiving notifications on the glasses	4	3.75
Error messages	13	3.92
Short messages giving feedback about tasks process	17	3.94

Appendix D: the excluded recommendations from the recommendations because they have already considered in previous guidelines

No.	Design Recommendation (DR)	GR	SC
Interface design			
1	Allow learners to go back always	7	ES
2	Allow learners to go to the home page from any page	7	ES
3	Provide feedback messages with each function to inform learners the request is being processed	7	ES
4	Make the name and the logo of the app appear in the first page	7	ES
5	Make the videos and audios to stop when learners leave the page	7	ES
6	Keep the size videos and audios small as you can to reduce the amount of space the app takes in the device memory	7	FG & ES
7	Make the text in a dark colour if it is bright	7 & 9	ES
8	Make the text in a bright colour if it is dark	7 & 9	ES
9	Enable headset service for the noisy mode	7 & 9	ES
10	Provide the notification message with vibration	7	ES
11	Provide the notification message with sound	7	ES
12	Put functions' buttons in one menu if five or less (or extended menu if more than five)	7	ES
13	Make the menu obvious with a button clearly indicate it	7	ES
14	Associate the functions' button with a name that clarify what they do	7	ES
	Technical side's design		
15	Let the app detect if internet connection is available	7 & 9	ES
16	Let the device detect if the supporting resources is enabled such as camera, Wi-Fi and location services.	7 & 9	ES
	Feedback and error messages' design	7	ES
7	Make messages appear in the middle of the screen	7	ES
18	Make messages in bright colours	7	ES
19	Provide a title for the message to indicate what it is about (e.g. "warning" or "Error")	7	ES
20	Provide a sound that indicates there is an error accrued	7	ES
21	Provide error messages with the "ok" button to make sure that it does not disappear before learners had read it	7	ES
22	Let the feedback messages to stay for longer	7	ES

Appendix E: the consent forms that were used in the focus group and interview studies

CONSENT FORM

Focus Group Discussion (FGD)

Understanding the Themes of Using Mobile Device for Learning in Cultural Heritage Sites

Researcher: Alaa Alkhafaji

Email: Alaa.alkhafaji@port.ac.uk

The data will be anonymous and untraceable and will be stored securely for the duration of the research after which it will be deleted.

What is your knowledge level about the topics in the table below (Low, Medium or High); please tick (√) the suitable box for you:

KNOWLEDGE	LOW	MEDIUM	HIGH
Mobile technology (i.e. Using a smartphone, tablet, etc.)			
Mobile learning (Using a mobile device for learning purposes)			
Outdoor cultural heritage sites (i.e. Historical Dockyard)			
Location-based services (i.e. a Digital map)			
Learning on the move (Learning while you are moving to do your daily task)			
Other…….			

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.

I agree to participate in this study and to the use of anonymised quotes in publications.

_____	_____	_____
Name of Participant	**Date**	**Signature**
_____	_____	_____
Name of Researcher	**Date**	**Signature**

CONSENT FORM

Interview

Understanding how people do use or would like to use mobile devices for learning at cultural heritage sites

Researcher: Alaa Alkhafaji

Email: Alaa.alkhafaji@port.ac.uk

The data will be anonymous and untraceable and will be stored securely for the duration of the research.

What is your knowledge level about the topics in the table below (Low, Medium or High); please tick (√) the suitable box for you:

KNOWLEDGE	LOW	MEDIUM	HIGH
Mobile technology (i.e. Using a smartphone, tablet, etc.)			
Mobile learning (Using a mobile device for learning purposes)			
Outdoor cultural heritage sites (e.g. Historical Dockyard)			
Location-based services (e.g. a Digital map)			
Learning on the move (Learning while you are moving to do your daily task)			
Other…….			

Age: ---------- Nationality:---------- Country: ---------- Occupation:----------

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason.

I agree to participate in this study and to the use of anonymised quotes in publications.

_____	_____	_____
Name of Participant	**Date**	**Signature**
_____	_____	_____
Name of Researcher	**Date**	**Signature**

Appendix F: The Ethic Certificate

University of Portsmouth

Certificate of Fast Track Ethics Review

Project Title:	Smart Ambient:Development of mobile location-based system to support informal language in culture heritage
Student Number:	663974
Application Date:	05/02/2014 11:28:05

You must download your referral certificate, print a copy and keep it as a record of this review.

You should **submit your certificate to your FEC representative for further review**.

The FEC representative for the School of Computing is Carl Adams

It is your responsibility to follow the University Code of Practice on Ethical Standards and any Department/School or professional guidelines in the conduct of your study including relevant guidelines regarding health and safety of researchers including the following:

- University Policy
- Safety on Geological Fieldwork

It is also your responsibility to follow University guidance on Data Protection Policy:

- General guidance for all data protection issues
- University Data Protection Policy

ProjectTitle:
Smart Ambient:Development of mobile location-based system to support informal language in culture heritage

SchoolOrDepartment:
SOC

PrimaryRole:
PostgraduateStudent

SupervisorName:
Dr. Sanaz Fallahkhair

HumanParticipants:
Yes

HumanParticipantsWarning

Certificate Code: FA2E-7D19-7E13-73E8-54AF-F023-67B6-3B23 Page 1 / 3

ParticipantInformationSheets:
A signed declaration field stating that users are happy to participate in the evaluation process and agree to their data being used anonymously will be included on the information sheets provided. It will also be stated on the information sheet that users are free to terminate the evaluation and have their data excluded at any point in the evaluation process.

ParticipantConfidentiality:
There will be a declaration on the participant information sheet stating that all data collected from participants will be anonymous and untraceable and will stored securely for the duration of the project after which it will be deleted.

InvolvesNHSPatientsOrStaff:
No

NoConsentOrDeception:
No

InvolvesUninformedOrDependents:
Yes

InvolvesUninformedOrDependentsWarning
MinimizingRisksOfUninformedOrDependents:
it may be required to use Portsmouth University Students in this research. If this is necessary then only students over the age of 18 and considered to be adults will be used. No students considered to be vulnerable will be used in this research. Participation will be based on the students acceptance to participate, and students will be free to terminate their participation with their data removed at any point during the study.

DrugsPlacebosOrOtherSubstances:
No

BloodOrTissueSamples:
No

PainOrMildDiscomfort:
No

PsychologicalStressOrAnxiety:
No

ProlongedOrRepetitiveTesting:
Yes

ProlongedOrRepetitiveTestingWarning
MinimizingRisksOfProlongedOrRepetitiveTesting:
It may be necessary to ask participant friendly to repeat the evaluation more than one time. If this is necessary, Participation will be based on the user acceptance to participate, and participants will be free to terminate their participation with their data removed at any point during the study.

FinancialInducements:
No

PhysicalEcologicalDamage:
No

HistoricalOrCulturalDamage:
No

HarmToAnimal:
No

HarmfulToThirdParties:
No

Supervisor Review	
Supervisor signature:	Sanaz [signature]
Date:	06/02/2014

Review by FEC Representative	
Name of representative:	Carl Adams
Comments:	
Representative signature:	[signature]
Date:	6/2/2014

Appendix G:

FORM UPR16

Research Ethics Review Checklist

University of Portsmouth

Please include this completed form as an appendix to your thesis (see the Postgraduate Research Student Handbook for more information

Postgraduate Research Student (PGRS) Information			**Student ID:**	663974
PGRS Name:	Alaa Alkhafaji			
Department:	School of Computing	**First Supervisor:**	Dr. Mihaela Cocea	
Start Date: (or progression date for Prof Doc students)		**1/10/2013**		
Study Mode and Route:	Part-time ☐ Full-time ☒	MPhil ☐ PhD ☐	MD ☐ Professional Doctorate ☐	

Title of Thesis:	The development of a theoretical framework for designing smart and ubiquitous learning environments for outdoor cultural heritage
Thesis Word Count: (excluding ancillary data)	79600

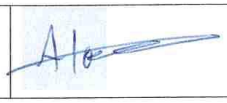
If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University's Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study

Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).

UKRIO Finished Research Checklist: (If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: http://www.ukrio.org/what-we-do/code-of-practice-for-research/)	
a) Have all of your research and findings been reported accurately, honestly and within a reasonable time frame?	YES ☒ NO ☐
b) Have all contributions to knowledge been acknowledged?	YES ☒ NO ☐
c) Have you complied with all agreements relating to intellectual property, publication and authorship?	YES ☒ NO ☐
d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?	YES ☒ NO ☐
e) Does your research comply with all legal, ethical, and contractual requirements?	YES ☒ NO ☐

Candidate Statement:	
I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)	
Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC):	FA2E-7D19-7E1373E854AFF02367B63B23
If you have *not* submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:	

UPR16 – August 2015

Signed *(PGRS)*:		**Date:** 8/12/217