

A Framework for Questionnaire Design To Elicit Requirements for Ubiquitous, Mobile and Wearable Learning Technologies

^[1] Alaa Alkhafaji, ^[2] Sanaz Fallahkhair, ^[3] Mihaela Cocea

^[1] The University of Portsmouth/, School of Computing, UK

^{[1][2]} Al-Mustansiriyah University/ College of Science/Department of Computer Science, IRQ

^[2] The University of Brighton/School of Computing, Engineering and Mathematics, UK

^[3] The University of Portsmouth/School of Computing, UK

Abstract- Mobile and ubiquitous technologies can provide opportunities for people to learn whenever they choose and wherever they are. Mobile services and applications could play an important role in supporting learning more effectively and efficiently. One key factor of measuring effectiveness and usefulness of mobile, ubiquitous and wearable technologies is to address user acceptance. In order to enhance users' acceptance, we need to consider their requirements in the design of services. A questionnaire is considered a good instrument in the user-centred design approach for gathering requirements from a wide-scale sample. Designing a questionnaire could influence the effectiveness and usefulness of the systems; therefore, a framework for designing a questionnaire needs to be devised. This paper introduces our approach to the development of a framework for questionnaire design. A focus group study was conducted to design this framework. The study has investigated how people may use mobile and ubiquitous technologies for learning purposes in cultural heritage contexts. This framework suggests a number of themes that need to be considered in designing a questionnaire, including learners and devices; the notion of learning; motivation and attitude; services and features; information; usability, acceptance and usefulness; and finally challenges and interventions. We intend to use this framework in our research for the requirements elicitation phase of a mobile and wearable learning environment to support learning from outdoor cultural heritage sites. A scenario was developed for depicting the results in order to help design a proof-of-concept mobile and wearable application (SmartC).

Key words: — Mobile technology. Cultural heritage. Informal learning. User-centred design. Questionnaire design.

I. INTRODUCTION

Mobile learning (m-learning) promises to free people from the boundaries of time and place, providing opportunities for people to learn regardless of their location [1]. In addition, m-learning encourages people to undertake new life experiences as well as promoting lifelong learning [2, 3]. M-learning also offers people an opportunity to learn within different contexts, thus enabling people to learn while they are doing their daily activities [4, 5]. Learning from experience could be considered as informal learning in which enables learners to be in charge of their own learning instead of being a content consumer. Engaging in aspects of cultural heritage may form a significant facet of the informal learning process. Since cultural heritage reflects the identity of societies [6], it could be important for people to learn more about the historical significance of heritage sites. This may help people to appreciate their history, which could further promote a sense of loyalty and engagement [7]. Given that, it could be useful to provide technologies that support learning from cultural heritage

sites. It is widely believed that utilising a user-centred design approach improves user acceptance of new technologies [8]. Within this methodology, consideration of user's requirements takes a significant role [9]. In this respect, a questionnaire technique has been widely used in capturing user's requirements. In fact questionnaire design may have been an important factor that could affect the quality of the result [10]. In terms of developing new technologies, a worthy result could lead the introduction of useful technologies that meet user's interests [11-13]. In other words, the acceptance of these technologies could be associated with questionnaire design in which the requirements of users have been gathered and presented. Thus, along with the rapid growth designing new learning services [14], there is an increasing need of designing an effective questionnaire form. Since designing questionnaires is challenging [15], providing a framework to serve as a questionnaire design guide may contribute to an increased likelihood of obtaining sensible data. This paper introduces a framework for questionnaire design to assist researchers in capturing requirements for developing mobile informal learning services.

II. RELATED WORK

The user-centred design approach is employed in the Human Computer Interaction (HCI) field in order to meet users demands and preferences by considering their requirements [16]. Considering users requirements could enhance the interaction between users and systems [17, 18]. Consequently, this could lead to the production of effective and satisfying technologies in many disciplines such as m-learning, mobile health, etc. [9]. In turn, these could motivate people to use those new technologies, including mobile learning services, either for work or leisure which may enhance their learning [11, 19]. Questionnaires technique has been widely used for gathering user requirements in the field of mobile learning from a wide range of people.

Studies such as Sharples, Corlett, & Westmancott [20], Naismith, Sharples, & Ting [21], and Candello [22] used questionnaires as a tool to solicit user requirements for developing mobile learning services. However, authors haven't discussed how the questionnaire was developed. A probable resource for developing a questionnaire in these studies is based on either literature or research questions, or both. It is worth noting, it has commonly been assumed that pulling a preliminary thoughts from users could be helpful in designing a questionnaire [10]. A number of studies have introduced frameworks for designing questionnaires.

Gendall proposes a framework that integrated with Labow's framework, which could help researchers in designing a questionnaire. The framework consists of two parts: "General principles and Specific principles". General principles are concerned with, "...the types of questions you can reasonably ask; the types of words you can reasonably use; the concepts you can explore; the methodology you can employ" [23]. The specific principles are concerned with, "...question design, question wording, and formatting or layout" [23]. Another framework has been introduced by Rattray and Jones [24]. This framework presented some important factors which include reliability, validity and scales [24]. Stehr-Green et al. [25] provide a set of steps for designing a questionnaire. Those steps include: identify the leading hypothesis, identify information needed to be tested, write the questions, organise the questions, test the questions and revise the questions. Similarly, a series of articles have been presented by Boynton and Greenhalgh to guide researchers to design good questionnaires. Those articles try to raise the awareness of researchers regarding some issues such as what type of

data they intend to capture, what is an appropriate technique to choose the sample of population, and piloting and administering questionnaire [10]. Reviewing these previous studies has revealed there is a lack of theoretical resources to guide researchers for designing a questionnaire in the field of mobile learning [8, 23, 24]. All the studies that presented in this review have provided a set of steps that could guide researchers in the process of designing a questionnaire (e.g. outline your hypothesis and research questions then let them inspired your questionnaire). Nevertheless, none of the previous studies has dealt with the potential topics that might be useful to be covered in questions. Furthermore, there are no standard questionnaires for collecting requirements especially in the field of informal mobile learning. Though, there are some studies that introduce a standard questionnaire for evaluating new technologies such as System Usability Scale (SUS) [26]. Taken together, the contribution of this study is to provide a framework for questionnaire design in the field of informal mobile learning. This framework considered some aspects that need to be taken into account when designing a questionnaire which haven't been considered in the previous studies.

III. THE FOCUS GROUP STUDY

A focus group discussion was carried out in the University of Portsmouth with six participants. They were recruited among the PhD student community. A Doodle notification was sent to them by email asking to state day/time that is suitable for organising the discussion meeting. All of them were familiar with mobile technology. A focus group approach was conducted in order to identify themes in which could inform questionnaire design. Questions were asked regarding how they use or would like to use mobile technology at outdoor cultural heritage contexts. The discussion took around one hour and twenty minutes; it was recorded and subsequently transcribed. Participants who took part in this discussion aged from 28-50, three male and three female, all of them were students. They came from different backgrounds; two are English, two are Arabic, one is Nigerian, and one is Indonesian.

A. Data analysis

The data was analysed by using a thematic analysis method which consists of six phases that were set out by Braun & Clarke [27]: (1) Getting familiar with the data; (2) Generating initial codes; (3) Searching for themes (4) Reviewing themes (5) Defining and naming themes; (6) Producing the report (see Fig. 1). As noted by Braun & Clarke [27], themes could be „data-driven“ which is emerged from data without any prior ideas about it, or

theory-driven”, which means that data has been coded around some initial ideas from the literature. Whilst both sources were used in this study, the obtained themes are more „theory-driven” as the researchers have had some initial ideas regarding this research from the literature. However, a few themes have also emerged from the data.

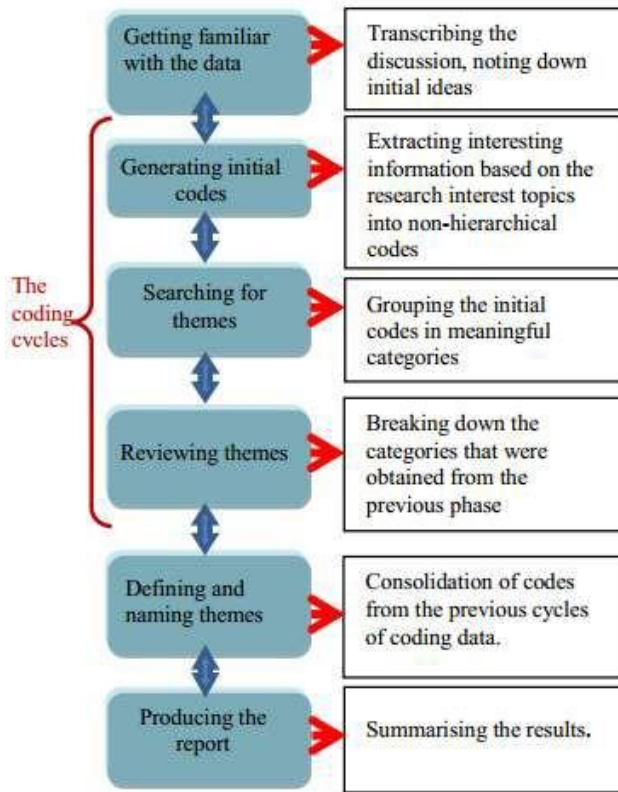


Figure 1. Thematic analysis phases

The data were coded manually and electronically [28]. First, manually: paper, highlighter, coloured paper and pencil. Second, electronically, using computer software: (QSR Nvivo 10) [29, 30]. The electronic version was used to increase the reliability of coding data by looking at the data from a different angle. Using Nvivo helped to take in-depth insight to the dataset. Its value is that it is more accurate than do it manually in terms of avoiding missing some potential themes that might be important, due to the easy-checking by using software rather than go through the transcription manually every time to check [31]. The coding process was conducted in three cycles: „generating initial codes”, „searching for themes”, and „reviewing themes” as shown in Figure 1. A list of themes resulted from the analysis phase, which are given in the next section.

B. The Results – the framework

The results suggest a framework to inform questionnaire design, including a number of themes that need to be considered are as follows:

1) Learners and devices

Learners could be categorised as groups and individuals, also could be categorised as adults (elderly and young people), and children with the parents, grandparents and teachers in a school trip. Learners interact with the cultural heritage sites using mobile devices, which include mobile phones, tablets and wearable devices (e.g. google glasses). In terms of kinds of mobile apps, participants reported that it is important to consider all types of operating systems to meet the multi-variation interest of people regarding types of mobile devices, “...different people has different preferences”..., “...is it a cross platform app...”, “...what kind of apps that people comfortable with...”. Participants stressed that it is important to consider user preferences, “...personalise your app to suit your convenience...” which means designing a user model that includes all user preferences based on user interests [32].

2) The notion of learning

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

3) Motivation and attitude

The 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) entertaining, 3) discovering other countries cultures. Some of participants stressed that visiting historical sites could play a significant role in terms of helping people to learn about the 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 of participants pointed out that the nature of people, who are interested in those sites and they enjoy history, would drive them to visit those sites. Entertainment could be a reason for visiting cultural heritage sites. Additionally, curiosity in discovering cultures, either, their own cultures or other society’s 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..." .

Participants emphasised that a mobile app that provides almost all services that visitors/learners could need at cultural heritage sites, would encourage people to use it. That because it has all their needs providing in one app, "...the mobile app that provide a user's journey [everything that visitor needs starting from planning the visit ending by reviewing what they've done there] would be so helpful".

4) Services and features

The main debate in the focus group discussion was about some existing services that are being used by people that could be utilised for cultural heritage contexts; such as the „Google Now“ app that notifies people about aspects based on their interests [33]. Additionally, some features that they are hoping to find in a mobile app; such as connecting the app with the social media to share information, photos, etc., keep memories and manage pictures and diaries, "...I go there, ...,I want see memories, I wanna write down, take picture and save them..." .

Moreover, 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 attention, "... I like Charles Dickens; probably I wanna to have coffee in place like Charles Dickens" lounge..." .

In addition, participants claimed that it is important to personalise the app to meet user preferences, which could in turn, motivate people to use it, "...personalise your app to suit your convenience..." . In addition, it would be advantageous if the service can provide a story narrator, that might attract children which consequently 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, "...quizzes for example..." , "... you can make [quizzes] in different level..." . Finally, participants suggested providing a unique and international code to be recognised everywhere, which will help the app to be for a global use.

5) Information

Historical information plays a significant role of 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 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 addition, 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 it doesn't 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 useful information such as, how many visitors are visiting the site in a particular day or time, or information about transportation. 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..." . Additionally, participants mentioned that enabling users to review comments that were generated by other visitors might help people to have an initial idea regarding a historical site before visiting it.

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 asking a lot of questions and providing many choices could make the app complicated and not easy to use, which may dissuade people from using the software, "...[if the app is] more complicated, more interaction and more question you will lose number of users..." .

In addition, participants suggested giving the users a choice to disable or enable some services (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 which they do not feel restricted by such an annoying app (e.g. annoying notification), "... make it easy when you can switch things off or not..." this would provide users with multilevel of interaction and thus, cater for the diversity of interests leads to increased adoption.

7) Challenges and interventions

Participants underlined some challenges regarding using a mobile device in cultural heritage sites such as; a poor network quality in some remote places. The small screen

size of some devices, such as mobile phones, might be not comfortable for elderly people who have got sight problems so they might prefer to use a tablet, "...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 retrieval data. For instance videos and images got tend to take a large amount of space in a mobile device memory [34]. Nevertheless, using cloud computing as storage for the historical information might be considered as a solution for this issue. Furthermore, participants pointed out that to enable people to become engaged with the app, a level of trust must be established, "... [people] may not feel comfortable with something knows where they are...". Additionally, confidentiality is an important aspect in such an app; 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 give 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 the new technologies, which may find it not easy to use. That would 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 services such as personalising the app that could bring their interest and encourage them to use it at cultural heritage sites, "...is like a trigger that makes somebody who never use that kind of things go and use it...", "... I can remember saying I wouldn't never have touch screen phone...then few years later you get you can't imagine life without it...".

Finally, another interesting issue has been 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 may solve this problem.

In summary, the results of the focus group discussion act as an important part of a questionnaire design process. It helped in shaping a framework for questionnaire design. The results show a set of themes that need to be considered

when designing a questionnaire. Accordingly, a framework has been devised from this study for researchers who are using a questionnaire technique to capture user requirements. In the process of a user-centred design approach, designing a questionnaire is considered a foundation stone for capturing requirements. Hence, developing a framework could assist researchers in designing a questionnaire in order to obtain a worthy and meaningful data.

The results of this study suggest the following framework that consists of seven themes as follows:

A. Learners and devices: Considering types of learners in designing a questionnaire form as well as types of device that they might prefer. The learner characteristics and profile should be considered.

B. The notion of learning: Considering how people understand learning; different people have different perception of what learning is.

C. Motivation and attitude: Considering what motivations might trigger people to use a mobile device for learning purposes.

D. Services and features: Considering services and features that people use and those that they would like to use in order to include them in developing a new technology.

E. Information: Considering type of information, the way that it delivered (learning preferences), the size, and the reliability.

F. Usability, acceptance and usefulness: Considering usability aspects in terms of ease of use, accessibility, and people attitude regarding new technologies.

G. Challenges and interventions: Identifying the challenges and limitations that might be countered in designing a new technology. Some solutions need to be identifies as well.

IV. SMARTC PROTOTYPE APPLICATION ON MOBILE AND WEARABLE SMART GLASS

The results of this study also serve as preliminary requirements for designing smart and ubiquitous learning environments. Scenario-based method was used to visualise these requirements in order to develop an alpha version of such prototype for evaluation purposes [35]. A scenario was developed based on the results for guiding the design of such services, which is given below. Scenario: 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). Multimodal information in the form of text, image and video provided based on notifications on mobile screen and also send to SmartC interface on Android smart glass to support wearable technologies. SmartC applications, both on mobile and wearable interfaces depicted in the following figure (see Fig. 2 & 3).



Figure 2. SmartC wearable glass interface

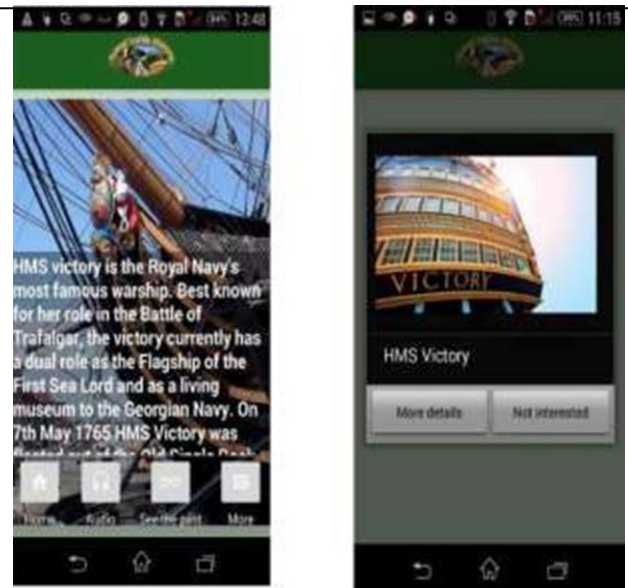


Figure 3. SmartC mobile interface

V. CONCLUSION AND FURTHER WORK

A framework for designing a questionnaire has been introduced in this paper. The related work that has been reviewed in this paper clearly showed there is a dearth of studies that are conducted for the mobile informal learning field. Nevertheless, none was dedicated to methods for gathering user requirements. This study attempted to fill this gap by introducing a framework for designing a questionnaire for gathering user requirements in the field of mobile and ubiquitous informal learning.

A focus group study was used to design this framework. The framework consists of a set of themes to be considered when designing a questionnaire in the field of mobile and ubiquitous informal learning. The themes are: learners and devices, the notion of learning, motivation and attitude, services and features, information, usability, acceptance and usefulness, and Challenges and interventions.

Considering these themes could help researchers in designing a questionnaire. Subsequently, it could enhance learning by helping to capture the right requirements from users. The results also serve as preliminary requirements for developing such services; a scenario was developed based on the results and consequently a prototype mobile app was designed for the evaluation purposes. The study that has been presented in this paper forms the first stage of a research project, which intends to develop smart and ubiquitous learning environments with respect to cultural heritage contexts. Finally, we presented SmartC

applications with its dual interfaces on mobile and smart wearable glasses, which aims to support informal learning from cultural heritage domain. There are a number of areas that we envision to carry out further work. Firstly, to conduct further steps to fulfil the requirements elicitation, which includes (a) developing a questionnaire, based on the results presented in this paper, and (b) distributing the questionnaire. Secondly we are also planning to develop a task model based on the results of our questionnaire and additional interview studies using a socio-cognitive engineering methodology [36]. Finally, an enhanced version of a prototype of a mobile app will be developed as a proof-of-concept based on the task model.

REFERENCES

- [1] M. Sharples, "The Design of Personal Mobile Technologies for Lifelong Learning," *Computers & Education*, vol. 34, no. 3, pp. 177-193 2000.
- [2] S. Fallahkhair, L. Pemberton, and J. Masthoff, "A Dual Device scenario for informal language ". pp. 16-20.
- [3] G. Vavoula, "KLeOS: A Knowledge and Learning Organisation System in Support of lifelong Learning," unpublished, Department of Electronic, Electrical and Computer Engineering, University of Birmingham, 2003.
- [4] E. Brown, D. Börner, M. Sharples, C. Glahn, T. de Jong, and M. Specht, "Location-based and contextual mobile learning. A STELLAR Small-Scale Study," 2010.
- [5] A. Kukulska-Hulme, and J. Traxler, *Mobile learning: A handbook for educators and trainers*: Psychology Press, 2005.
- [6] M. V. González, "Intangible heritage tourism and identity," *Tourism management*, vol. 29, no. 4, pp. 807-810, 2008.
- [7] UNESCO, *Managing Cultural World Heritage Paris: France: The United Nations Educational, Scientific and Cultural Organization (UNESCO)*, 2013.
- [8] A. N. Oppenheim, *Questionnaire design, interviewing and attitude measurement*: Bloomsbury Publishing, 1992.
- [9] E. Kangas, and T. Kinnuen, "Applying User-Centred Design to Mobile Application Development," *ACM*, vol. 48, 2005.
- [10] P. M. Boynton, and T. Greenhalgh, "Selecting, designing, and developing your questionnaire," *Bmj*, vol. 328, no. 7451, pp. 1312-1315, 2004.
- [11] B. Curtis, H. Krasner, and N. Iscoe, "A field study of the software design process for large systems," *Communications of the ACM*, vol. 31, no. 11, pp. 1268-1287, 1988.
- [12] J. D. Gould, S. J. Boies, and C. Lewis, "Making usable, useful, productivity-enhancing computer applications," *Communications of the ACM*, vol. 34, no. 1, pp. 74-85, 1991.
- [13] H. Sharp, J. Taylor, A. Löber, D. Frohberg, D. Mwanza, and E. Murelli, "Establishing user requirements for a mobile learning environment," 2003.
- [14] J. Crabtree, M. Nathan, and S. Roberts, "Mobile phones and everyday life," *Mobile UK*, vol. 1, 2003.
- [15] B. Gillham, *Developing a questionnaire*: Bloomsbury Publishing, 2008.
- [16] A. Monk, "User-Centred Design," *Home Informatics and Telematics*, pp. 181-190: Springer, 2000. K. Vredenburg, An integrated approach.
- [18] R. D. Pea, "User centered system design: new perspectives on human-computer interaction," *Journal educational computing research*, vol. 3, pp. 129-134, 1987.
- [19] K. Vredenburg, J.-Y. Mao, P. W. Smith, and T. Carey, "A survey of user-centered design practice." pp. 471-478.
- [20] M. Sharples, D. Corlett, and O. Westmancott, "The Design and Implementation of a Mobile Learning Resource," *Personal and Ubiquitous Computing*, vol. 6, pp. 220-234, 2002.
- [21] L. Naismith, M. Sharples, and J. Ting, "Evaluation of CAERUS: a context aware mobile guide."
- [22] H. Candello, "Gathering requirements to develop outdoor mobile cultural guides in the field," 2011.
- [23] P. Gendall, "A framework for questionnaire design: Labaw revisited," *Marketing bulletin-department of marketing massey university*, vol. 9, pp. 28-39, 1998.

- [24] J. Rattray, and M. C. Jones, "Essential elements of questionnaire design and development," *Journal of clinical nursing*, vol. 16, no. 2, pp. 234-243, 2007.
- [25] P. A. Stehr-Green, J. K. Stehr-Green, A. Nelson, L. Alexander, G. C. Mejia, P. D. MacDonald, and N. Consultants, "Developing a questionnaire."
- [26] J. Brooke, "SUS-A quick and dirty usability scale," *Usability evaluation in industry*, vol. 189, pp. 194, 1996.
- [27] V. Braun, and V. Clarke, "Using thematic analysis in psychology," *Qualitative research in psychology*, vol. 3, no. 2, pp. 77-101, 2006.
- [28] A. Alkhafaji, S. Fallahkhair, and M. Cocea, "Towards gathering initial requirements of developing a mobile service to support informal learning at cultural heritage sites," *Cognition And Exploratory Learning In The Digital Age (CELDA 2015)*, pp. 51, 2015.
- [29] P. Bazeley, and K. Jackson, *Qualitative data analysis with NVivo: Sage Publications Limited*, 2013.
- [30] P. Bazeley, "Analysing qualitative data: More than „identifying themes“," *Malaysian Journal of Qualitative Research*, vol. 2, no. 2, pp. 6-22, 2009.
- [31] T. Basit, "Manual or electronic? The role of coding in qualitative data analysis," *Educational Research*, vol. 45, no. 2, pp. 143-154, 2003.
- [32] M. Cocea, "User Modelling and Adaptation in Exploratory Learning," *Department of Computer Science&Information Systems, University of London*, 2011. Google. "Google Now," <https://www.google.com/landing/now/>.
- [34] A. S. Alkhafaji, S. Fallahkhair, and M. Cocea, "Smart ambient: a pilot study to contextualise a location- based mobile application to support informal learning from cultural heritage sites." pp. 199-200.
- [35] J. M. Carroll, M. B. Rosson, G. Chin Jr, and J. Koenemann, "Requirements Development in Scenario-Based Design," *Ieee Transactions On Software Engineering*, vol. 24, no. 12, 1998.
- [36] M. Sharples, N. Jeffery, J. Du Boulay, D. Teather, B. Teather, and G. Du Boulay, "Socio-cognitive engineering: a methodology for the design of human-centred technology," *European Journal of Operational Research*, vol. 136, no. 2, pp. 310-323, 2002.

