

**DESIGNING AND EVALUATING A CONTEXTUAL MOBILE
LEARNING APPLICATION TO SUPPORT SITUATED LEARNING**

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A thesis submitted in partial fulfilment of the requirements of the University of the
West of England, Bristol for the degree of Doctor of Philosophy

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Bristol

January 2015

Abstract

This research emerged from seeking to identify ways of getting Human-Computer Interaction Design students into real world environments, similar to those in which they will eventually be designing, thus maximising their ability to identify opportunities for innovation. In helping students learn how to become proficient and innovative designers and developers, it is crucial that their 'out of the classroom' experience of the environments in which their designs will be used, augments and extends in-class learning. The aim of this research is to investigate firstly, a blended learning model for students in higher education using mobile technology for situated learning and, secondly, the process of designing a mobile learning app within this blended learning model. This app was designed, by the author, to support students in a design task and to develop their independent learning and critical thinking skills, as part of their Human-Computer Interaction coursework. The first stage in designing the system was to conduct a comprehensive contextual inquiry to understand specific student and staff needs in the envisaged scenario.

In addition, this research explores the challenges in implementing and deploying such an app in the learning context. A number of evaluations were conducted to assess the design, usability and effectiveness of the app, which we have called sLearn. The results show an improvement in scores and quality of assessed work completed with the support of the sLearn app and a positive response from students regarding its usability and pedagogic utility. The promising results show that the app has helped students in developing critical thinking and independent learning skills. The research also considers the challenges of conducting an ecologically valid study of such interventions

in a higher education setting. There were issues discovered in regards to the context of use such as usability of interface elements and feeling self-conscious in using the app in a public place.

The model was tested with two other student cohorts: User Experience and Engineering students, to further investigate best practice in deploying mobile learning in higher education and examine the suitability of this learning model for different disciplines. These trials suggest that the model is indeed suitable and, the engineering study in particular has demonstrated that it has the potential to support the learning in-situ of students from non-computing disciplines.

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Acronym List

DUE	Designing the User Experience
GPS	Global Positioning System
GUI	Graphical user interface
HCI	Human-Computer Interaction
UCD	User-Centred Design
HE	Higher Education
HOTS	Higher Order Thinking Skills
ID	Interaction Design
PACT	People, Activities, Context, and Technology Framework
PDA	Personal Digital Assistant
SUS	System Usability Scale
UI	User Interface
UX	User Experience

1 Chapter One: Introduction

In recent years, mobile learning has been growing as a significant research area encompassing educational technologies, mobile and wireless computing, and mobile Human-Computer Interaction. It is growing more and more in popularity with the advancement of mobile technologies and the widespread use of smartphones and tablet PCs and has been incorporated into many disciplines such as Science (Chu *et al.*, 2010; de-Marcos *et al.*, 2010; Jones *et al.*, 2013), Computing (Hwang *et al.*, 2010; Seraj and Wong, 2012), and Language Learning (Chen and Hsu, 2008; Guerrero *et al.*, 2010) to name but a few. Research into mobile learning has evolved from a focus on primary and secondary education to include mobile learning in higher education (HE) in recent years. Researchers have been investigating various ways to enhance HE students' learning experience, provide help to institutions in order to employ the new technologies (Kukulska-Hulme, 2012), understand students' perspective (Marwan *et al.*, 2013; Gikas and Grant, 2013; Khaddage and Knezek, 2013), and to investigate promoting higher order thinking skills through mobile learning (Norouzi *et al.*, 2012; Cheong *et al.*, 2012).

The idea for this research emerged from teachers of interaction design at the University of the West of England seeking more efficient and effective ways of exposing their students to real world environments, similar to those in which they will eventually be designing. Using the traditional model where students are sent out into real-world environments with a brief to be evaluative and analytical, without the presence of a teacher, can lead to a superficial and frustrating experience. This is especially true for students with beginning levels of analysis and limited critical thinking skills. It is not always possible for

teachers to accompany students and, moreover, it might not be beneficial for students to have immediate input from teachers, but rather to have prompts to provoke the development of their own thinking.

This thesis is thus driven by the desire to explore and exploit the opportunities offered by current mobile devices to help enrich the learning experience of HE students learning in real world environments.

The following sections start with an overview of the contextual mobile learning model used in this thesis. This overview also describes the initial concept, motivation and scope of this research, aims, objectives and research questions. Finally, the thesis structure is outlined and publications are listed.

1.1 A contextual mobile learning model

This thesis investigates the structure of a blended learning model (Littlejohn and Pegler, 2007) using mobile technology for students in higher education. Within this model the purpose of the mobile application is to provide students with contextual information to support learning *in-situ* where the learning context and location are taken into consideration. This contextual information prompts the students to explore various aspects of the immediate environment, supporting their understanding of the context (Parsons *et al.*, 2007).

The thesis also investigates the process of designing this mobile learning app within the blended learning model. It is envisaged that careful consideration of the design of the mobile learning application and the content provided can be beneficial for augmenting students' learning. This is supported by the work of Cook *et al.* (2008) among others who say that targeted learning hints from the lecturer and the ability to provide the learner with a collaboration facility can

'...maintain a balance between effective support and intrusion' and could bridge the gap between formal and informal learning (Cook *et al.*, 2008, p.16-17).

The following figure shows the blended learning model developed in this research, of which the app is a part.

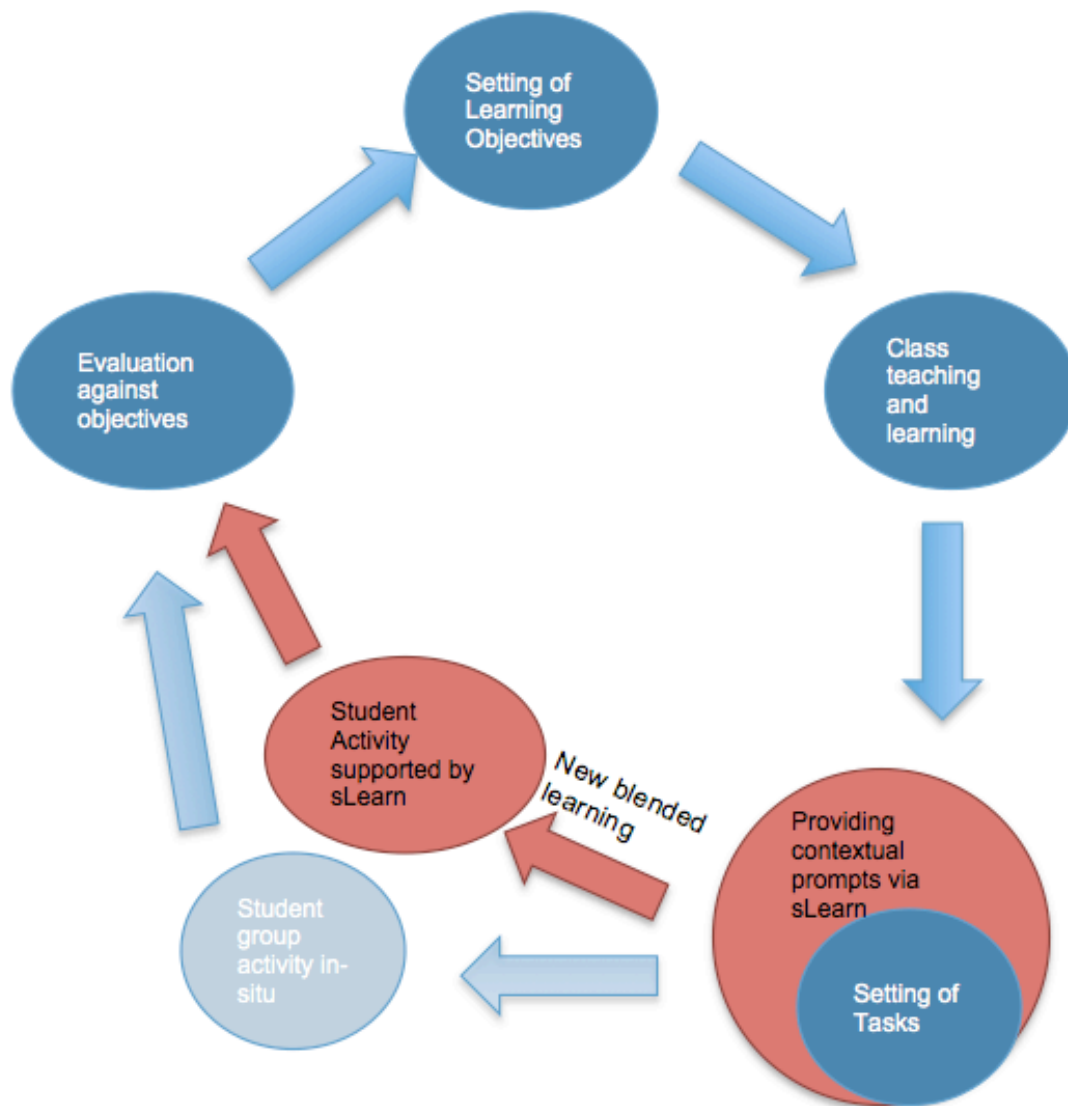


Figure 1 Blended learning model

The basis for developing the blended m-learning model was drawn from the lecturers' experience and supported by the literature as follows:

- Students struggling to analyse real world environments and develop new ideas could be provided with the appropriate guidance from a mobile application. This is supported by the work of Cook *et al.* (2008) mentioned above.
- Mobile learning applications can provide contextual information that could help students stay focussed on the purpose and outcome of the activity, rather than being distracted by the process (Ryu and Parsons, 2008). Thus, this maximises their benefit from the real world experience while still implicitly developing an understanding of the process.
- Sharing comments, ideas and perhaps stories if desired, may enable students to benefit from their peers' knowledge and different perspectives as known in the collaborative learning theory (Naismith *et al.*, 2004). Incorporating technology to support collaborative learning was successful in promoting sharing and collaboration as will be shown in examples of research discussed in chapter two.

These findings relating to the benefits of a blended m-learning model inform this research in formulating a framework to develop a mobile app to be integrated into traditional teaching. The research itself explores further the effectiveness of the approach within the context of different student cohorts. These were students enrolled in the following modules: Human-Computer Interaction, User Experience, Designing the User Experience and students enrolled in two Engineering courses: Civil Engineering and River and Coastal Engineering.

In order to provide the students with an enhanced and rich experience, this research is also interested in understanding the appropriate design, the usability and user experience issues for such mobile application. The initial situated learning activity was developed for undergraduates enrolled in the Human-Computer Interaction (HCI) module in the Department of Computer Science and Creative Technologies at the University of the West of England.

1.1.1 Scope of the study

This research contributes to the field of Human-Computer Interaction (HCI) and concerns the area of mobile learning and endeavours to improve learning *in-situ* by providing contextual information to learners.

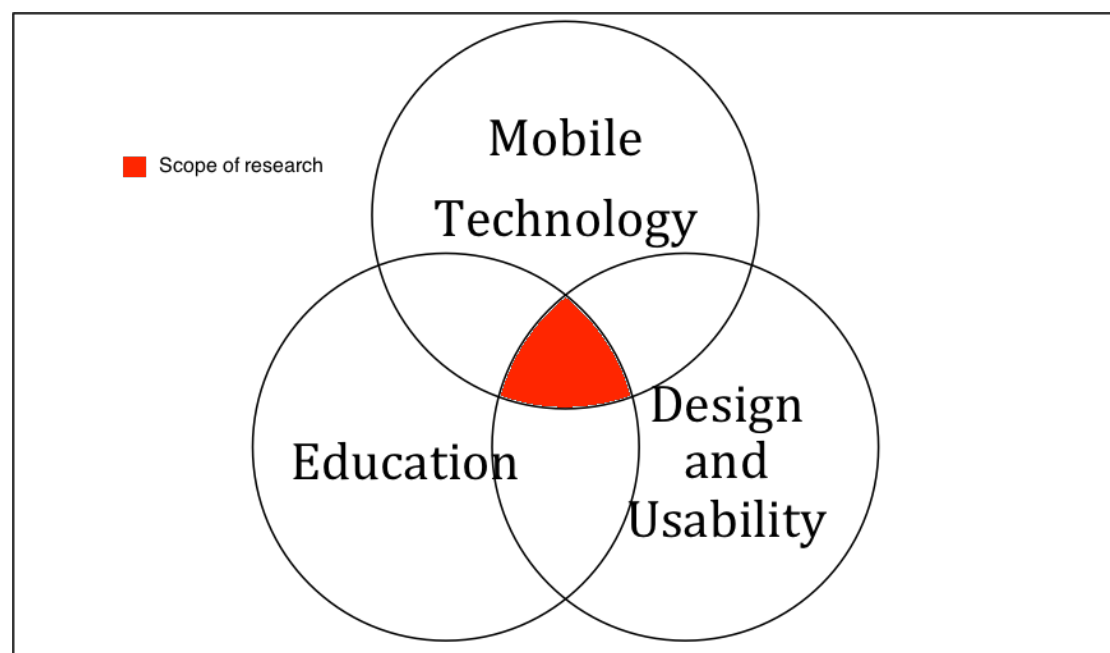


Figure 2 Interdisciplinary Scope of this research

As the figure above shows, the focus of thesis is at the intersection of the disciplines of mobile technology, design, and education. The challenges of designing and evaluating mobile applications for students in higher education are discussed in chapter three.

The intention was to bring together understanding of mobile technology, usability, user experience and pedagogy to form a well-designed m-learning model, adopting an interdisciplinary perspective. Pedagogical and usability studies have helped determine the learning content and the design and functionality of the app.

1.1.2 Aims, Objectives and Research Questions

The aims of this research are to investigate, firstly, a blended learning model for students in higher education using mobile technology for situated learning, and secondly, the process of designing a mobile learning app within this blended learning model.

To achieve these aims the following objectives have been identified:

1. To construct and demonstrate a model for a pedagogical activity assisted by a mobile learning app to facilitate independent study, and reflection and critical thinking in a more structured manner.
2. To carry out and review a user-centred iterative design process for developing the mobile app.
3. To review the user experience and usability of the contextual mobile application prototype.
4. To review students' perceptions of the pedagogical usability provided by the mobile application.

The research questions are:

1. How effective is mobile learning in providing students with the necessary guidance in a situated learning activity without the physical

presence of a tutor/lecturer? Effectiveness will be considered in terms of improving ability for critical thinking and synthesis.

2. What are the pragmatic issues when deploying a mobile learning app in a blended learning environment?
3. What evaluation criteria and techniques can be used to evaluate such mobile learning apps?

1.2 Research Contributions

The outcome of this research lies in the novelty of the design and development of a contextual mobile learning model in HCI that can be applied to different disciplines. The model has been shown to be applicable to the teaching of the subjects of Human-Computer Interaction and User Experience. It has also been shown to be applicable to the teaching of Risk Assessment within Engineering, and theoretically, it can be applied to any discipline that requires its students to work in real world settings.

This research identifies and provides evidence of benefits of mobile learning: firstly, mobile learning can promote independent learning; secondly, that structured prompts delivered *in-situ* by means of an interactive app promotes critical thinking in understanding of context for design.

The research also presents further evidence regarding the benefits of contextual evaluations of mobile applications in discovering issues that tend to be missed in lab evaluations.

In addition, this research suggests guidelines for implementing a mobile application for situated learning activities in HE.

Finally, this research provides insights into:

- What makes contextual mobile apps effective in teaching HCI students how to assess context in design.
- Challenges associated with mobile learning application evaluation.

1.3 Thesis Structure

This thesis consists of eight chapters. The first three chapters review the literature in mobile learning and designing mobile learning apps. The next three chapters present the methodology and analysis of the results. The concluding chapter provides discussions and future work. Below is a brief overview of the content of each chapter.

Chapter Two presents the literature on mobile learning. It looks at the motivation for implementing mobile learning, the use of mobile devices in education and the pedagogical theories related to this research.

Chapter Three discusses the challenges faced when implementing mobile learning, reviews the design requirements for mobile learning and investigates the literature on the evaluation of mobile learning and on usability both in general, and specifically for mobile learning.

Chapter Four discusses the development of the contextual mobile learning app (sLearn) produced for this research. The development proceeded in four phases, following the User-Centred Design Process (UCD). This chapter explains the methodologies and work done for the first two phases of the development cycle: the requirements and contextual inquiry and the theoretical framework development.

Chapter Five discusses the last two phases of the development: the design and prototyping of the sLearn mobile app and the evaluations and usability studies conducted as part of the iterative design approach.

Chapter Six explains the testing methodologies used in evaluating the effectiveness of the framework. It explains in detail the methods used in all studies conducted as part of this thesis: the HCI, User Experience (UX), In-context evaluation, and Engineering.

Chapter Seven discusses the results and analysis of testing explained in chapter six, it provides a categorised discussion of issues discovered from all the studies to answer the research questions, and delivers guidelines for implementing a mobile application for situated learning activities in HE.

Chapter Eight provides the conclusion, an evaluation of the research, a statement of the research contribution and an identification of future work to be carried out.

1.4 Publications

Journal:

- A. Alnuaim A., Caleb-Solly, P. and Perry, C., (2014). Evaluating the effectiveness of a Mobile Location-based Intervention for Improving Human-Computer Interaction Students' Understanding of Context for Design. *International Journal of Mobile Human-Computer Interaction (IJMHCI)*. 6 (3), pp. 16-31.

Book:

- B. Alnuaim, A., Caleb-Solly, P. and Perry, C. (2014). A mobile location-based situated learning framework for supporting critical thinking – A

requirements analysis study. In: Sampson, D.G., Ifenthaler, D., Spector, J.M. and Isaias, P., eds. (2014) *Digital Systems for Open Access to Formal and Informal Learning*. Springer. ISBN 978-3-319-02263-5

Conference:

- C. Alnuaim A., Caleb-Solly, P. and Perry, C., 2012. Location-Based Mobile Learning for Higher Education Students – Developing an Application to Support Critical Thinking. *In the Proceedings of the 11th World Conference on Mobile and Contextual Learning (mLearn12)*. Helsinki, Finland, October 16-18.

- D. Alnuaim A., Caleb-Solly, P. and Perry, C., 2012. A Mobile Location-Based Situated Learning Framework for Supporting Critical Thinking – A Requirements Analysis Study. *In the Proceedings of the IADIS International Conference Cognition and Exploratory Learning in Digital Age (CELDA 2012)*. Madrid, Spain, October 19-21, p. 163-170.

- E. Alnuaim A., Caleb-Solly, P. and Perry, C., 2014, Enhancing Student Learning of Human-Computer Interaction using a Contextual Mobile Application. [In Preparation]

2 Chapter Two: Mobile Learning and Pedagogy

In the past two decades, education has been significantly affected by evolving technologies. Firstly Computer-based teaching and learning, then online and electronic learning (e-learning), and more recently mobile and ubiquitous learning (m- and u- learning). This has changed many activities undertaken by students and has enhanced their experience. Mobile learning is thought of in terms of the use of mobile device such as PDAs, smartphones, tablet PCs, and mobile phones. The mobility of these devices opened opportunities in education for both teachers and students/learners. It endorsed learning at anytime anywhere. Thus, it is not restricted to a particular physical space such as schools and universities. This motivated research on various activities that could be carried out with mobile devices in education to illustrate their benefits and observe their drawbacks.

In this chapter, a literature review of the current state of the art is surveyed. It starts with the debate on the digital natives, examines in greater detail various definitions of mobile learning, the motivation behind implementing it in education, and then considers pedagogical aspects of mobile learning.

2.1 Learners and Technology

Living in an era of advanced technologies, many engage with the new technologies available, leading to a new classification: Prensky (2001) has divided the population into 'digital natives' and 'digital immigrants'. People born between 1980 and 1994 are immersed in technology in their everyday lives and are thus termed 'digital natives'. However, those born prior to 1980 are 'digital immigrants' who tend to have fewer previously learnt technological skills and need actively to learn these, unlike their younger counterparts.

Another related term the 'millennial' (Howe & Strauss, 2000) identifies particularly those who socially interact with their peers, wish to be connected, and prefer collaborative learning (Raines, 2002; Oblinger & Oblinger, 2005). This generation of students interacts and connects through Facebook, Twitter, mobile phones, and emails. This has led to a debate on whether firstly the 'digital native' generation exists and secondly on how educational institutions might consider the potential of adapting learning technologies to this generation's advantage (Bennett *et al.*, 2008).

Nagler and Ebner (2009, p.7) found that 'digital natives' or the 'net generation' "...exists if we think in terms of basic communication tools like e-mail or instant messaging. Writing an email, participating in different chat rooms or contributing to a discussion forum is part of a student's everyday life". Kennedy *et al.* (2008) noted, however, that being in the net generation does not mean being able to use technology deliberately to enhance the learning experience at university.

These studies and more all came to similar conclusions, that being in the 'digital native' generation does not explain the context and ways in which technologies are being employed. Thus, in order to understand how and why 'digital natives' use the technology, more investigation is required. A more recent study conducted by Margaryan *et al.* (2011) came to the same conclusions. Students still prefer the "conventional, passive and linear forms of learning and teaching" (p.439). While Margaryan *et al.* (2011) agree that students' experience using some technologies may exceed that of their lecturers in terms of time spent and direct face to face engagement, they argue that their awareness of the usage of technologies in learning is

restricted by their understanding of the “potential affordances and application of these tools and by their narrow expectations of learning in higher education. Students have limited understanding of what tools they could adopt and how to support their own learning” (p.439).

It is thus unwise to ask educational institutions to make a dramatic change in their teaching and learning methods relying on this generation’s daily use of technology. While some educational institutions may prefer to use traditional methods, others may need to make changes to accommodate new technologies. Bates *et al.* (2011) argue that implementing technology in teaching and learning is essential and educational institutions need to consider investing in technology.

According to Thomas (2005, p.1), “...pervasive learning is about using the technology that a learner has at hand to create relevant and meaningful learning situations, that a learner authors himself, in a location that the learner finds meaningful and relevant”. This suggests that technology has provided the learner with more opportunities for personalised and contextual learning. Such pervasive learning has influenced many researchers in educational technologies to further investigate m-learning. However, creating mobile learning applications should support and exploit students’ new ways of interacting and communicating. The next section discusses in detail the debate on the definition of mobile learning.

2.2 A Debate on Definition

Since the introduction of the term ‘mobile learning’ more than a decade ago, there has been debate on its exact definition. Many researchers, such as

Traxler (2007), were eager to show that m-learning is not a reduced version of e-learning (Belshaw, 2011). According to Traxler (2007, p.14), mobile technologies change the settings for the learning and the delivery method. This can be defined as “just-in-time, just-enough, and just-for-me”.

According to Winters (2007) there are four perspectives in which research applies to mobile learning:

1- Technocentric: where technology is their main concern and mobile learning means using mobile devices in learning such as using mobile phones, PDAs, tablet PCs in learning. For example, Sharples' *et al.* (2002) and Traxler's (2005) emphasised at first the mobility of the device as offering the defining features of mobile learning. However, emphasis soon shifted from the mobility of the device to that of the learner, as shown in point 2 below.

2- Relationship to e-learning: mobile learning here is an extension to e-learning that uses mobile devices. Traxler (2005) commented on this perspective and that the technocentric/e-learning definitions aim to show that mobile learning is a portable version of e-learning, which emphasises the technical issues.

3- Challenging formal education: mobile learning is seen in relation to traditional learning, perceived by some as taking over traditional classroom learning. Quinn (2011) provides an example of this, defining mobile learning as not “...putting e-learning courses on a phone...” Rather he suggests that: “...you should not think about mLearning as delivery of courses. mLearning is about augmenting our learning—and our performance. This includes a role in

formal learning and, occasionally can be the delivery mechanism for a full learning solution, but the real opportunity is augmenting learning and performance, not learning delivery” (Quinn, 2011, p.17). The idea that augmentation is fundamental to mobile learning was first argued by Metcalf (2006).

4- Learner-centred: this concentrates on the mobility of the individual learner, which takes advantage of the technologies. O’Malley *et al.* (2003, p.6) shifted their perception from the device to the learner, defining it as “Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies” (O’Malley *et al.*, 2003; Vavoula *et al.*, 2004).

According to Belshaw (2011) the focus has shifted from the mobile technology to its use in aiding learning on the move. As, Woodill (2011, p.12) acknowledges that there is a shift in the perception of mobile learning, “Ten years ago, mobile learning was about displaying e-learning on a small screen”. He argues that it opens the horizon for learners to learn in ‘anywhere anytime’ manner and accessing information when needed. Walker (2007) emphasises that mobile learning is not only about the technology but also about the ability to learn in different contexts.

Other researchers attempt to provide a set of criteria to determine whether mobile learning is indeed mobile learning. For example, Lee and Lee (2008)

claim that it must be situated, learner-driven and spontaneous, customised, connected, and flexible.

The above discussion of how m-learning is perceived, shows how its definition can dramatically gain new dimensions as the technology advances. In terms of Winter's (2007) classification, this research might be considered as learner-centred, challenging formal education. Moreover, Lee and Lee's (2008) criterion-based definition seems to be in line with the purpose of this research emphasizing a number of characteristics that shape mobile learning. Traxler's definition argues that mobile learning can provide learners with the opportunity to participate in an augmented activity on the move. These characteristics were taken into consideration in developing the framework at the centre of this study discussed in 4.2.

2.3 Drivers Behind Mobile Learning

Many argue for the significance of mobile technologies in learning per se, while others argue that learners are motivated to use mobile technologies in learning for a number of factors discussed below (Jones *et al.*, 2007).

According to Jones *et al.* (2007) and Jones *et al.* (2006) there are six motivating factors behind the use of mobile devices in learning: Control, ownership and appropriation, fun, communication, learning-in-context, and continuity between contexts.

Jones *et al.* (2006) argue that experienced mobile users will have a high level of motivation to use different settings of the device to acquire knowledge and extend their learning activities. In addition, using mobile devices motivates informal learning in which learners might change tasks to suit different contexts (Jones *et al.*, 2006). Furthermore, mobile learning can enhance and enrich the

outdoor learning experience. According to Dillon *et al.* (2006, p. 107) research has shown that learning outdoors can help learners develop their knowledge and add meaningful and valuable experience if the activity was “...properly conceived, adequately planned, well taught and effectively followed up”.

Researchers, such as Kukulska-Hulme and Traxler (2005), Rogers *et al.* (2005), and Ryu and Parsons (2008), argue that the significance of mobile learning lies in the learner’s ability to be immersed in situations in which learning really arises.

Ryu and Parsons (2008) argue that mobile learning can successfully integrate with and aid student’s learning experience allowing students to benefit significantly from any contextual help provided. Kukulska-Hulme (2010) argues that mobile learning helps learners in fulfilling their personal needs. Learners are motivated by the very fact that they are using their own mobile devices.

Others encourage the use of mobile learning not only for the delivery of learning material, but also for the promotion of collaborative learning, administration of assessment, and supplementation of support and knowledge (Brown and Metcalf, 2008). Quinn (2011) defines four areas in which mobile devices can contribute to learning, Quinn’s four C’s of mobile learning are: capturing information, accessing content in the form of media, communicating with others, and the ability to compute responses.

Furthermore, Elias (2011) argues that mobile learning opens a number of opportunities to learners:

- Although the cost is generally an issue for some, mobile devices can be cheaper than many desktops and laptops. However, accessing the network may still be problematic issue.
- The possibility of accessing and creating multimedia.
- The possibility of continuous learning support.

The factors discussed above which motivate the implementation of mobile learning all apply to this research, namely: the opportunities afforded for learning in context, communication and collaboration, accessing content in the form of media, continuous learning support, control, contextual help for students, and capturing information. Having identified benefits of mobile learning that are relevant to this study, the next section discusses the pedagogical theories in mobile learning related to research of this thesis.

2.4 Pedagogical Aspects in Mobile Learning

Taylor *et al.* (2006) claimed that many pedagogical theories failed to capture the distinctive character of mobile learning. This was due to the lack of expansion to accommodate learning outside the classroom environment, which is personally regulated and motivated. The concentration was on learning through a teacher in the classroom environment.

However, learning theories can be applied to mobile technologies to add a different dimension to the experiences. Naismith *et al.* (2004) looked at various learning theories in which mobile technologies could be used to create theoretical based mobile learning. They have identified six theories: Behaviourist, Constructive, Situated, lifelong and informal, collaborative, and learning and teaching support.

Table 1 An Activity-based categorisation of mobile technologies and learning (Naismith *et al.*, 2004)

Themes	Key Theorist	Activities
Behaviourist learning	Skinner, Pavlov	<ul style="list-style-type: none"> • Drill and feedback • Classroom response systems
Constructive learning	Piaget, Bruner, Papert	Participatory simulations
Situated learning	Lave, Brown	Problem and case-based learning Context awareness
Lifelong and informal learning	Vygotsky	Mobile computer-supported collaborative learning (MCSCL)
Collaborative learning	Eraut	Supporting intentional and accidental learning episodes Personal organisation
Learning and teaching support	N/A	Support for administrative duties (e.g. attendance)

The following sections will discuss the theories related to this research.

2.4.1 Situated learning

Lave and Wenger (1991) came up with the situated learning paradigm, that the situation in which learning occurs has a great effect on learners. They argue that learning must not be abstract and out of context. Learning is situated and takes place in the context, activity, and culture in which it occurs as a “legitimate peripheral participation” process. However, Lave and Wenger (1991) emphasise social communication and interaction as being significant part of situated learning. Learning should be presented in an authentic setting supporting knowledge exchange between learners (Naismith *et al.*, 2004). Other researchers support the idea of ‘apprenticeship’. Brown *et al.* (1989) suggest that teachers or instructors should create authentic contexts for students to learn. Moreover, Holzinger *et al.* (2005) describe situated learning as a blend of constructivistic and cognitivistic methods, where the situation plays a significant part in the learning construction process.

Defining the key characteristics of situated learning can differ between disciplines and technologies (Yusoff *et al.*, 2010). When designing situated learning using the mix reality technology, Yusoff *et al.* (2010) outline three main elements: Authentic context, authentic activity/task, and users’ collaboration. Lunce (2006), in designing situated learning using simulation, defines four concepts: a specific context that impacts learning must be defined, peer-based interactions and collaboration between students must take place, knowledge is tacit, and tools must be used to accomplish real-time objectives.

Herrington *et al.* ’s (2000) elements for situated learning using multimedia and online learning are: Authentic contexts and activities, access to expert

performances and the modeling of processes, multiple roles and perspectives, collaborative construction of knowledge, coaching and scaffolding, reflection to enable abstractions to be formed, articulation to enable tacit knowledge to be made explicit, and integrated authentic assessment.

While situated learning has several benefits, we should be aware of the limitations of the claims as discussed by Anderson *et al.* (1996) who note that pragmatic aspects such as students' time constraints and logistics of scheduling activities can result in a division of labour, which can mean that not all students gain the same experience and benefit.

In summary there seems to be a general agreement that although the technologies differ, they all agree on the authenticity of both contexts, activities, and collaboration of learners as key principles of situated learning.

Situated learning has a number of strands in which mobile technologies can play an important role: Context- and location- aware learning, inquiry-based learning, and problem-based learning.

It is important that students are immersed in real-world situations in which they will be working, in order to maximise their learning and knowledge of the issues in the real world, helping to make them more proficient and innovative as designers.

2.4.2 Context-aware and location-based learning

Context-aware location-based computing has attracted researchers' interest in the past decade. It aims to promote a flowing interaction between human and technology (Barkhuus and Dey, 2003) and to collect information from the

surroundings of the user to provide an understanding of what is currently happening (Naismith *et al.*, 2004). Abowd *et al.* (1999, p.3) have defined context, as “Context is 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”. Besides, Brown *et al.* (2010, p.4) defines context as “...the formal or informal setting in which a situation occurs; it can include many aspects or dimensions, such as location, time (year/month/day), personal and social activity, resources, and goals and task structures of groups and individuals”. The above two definitions of context lead to the same understanding although the latter is clearer and gives a better understanding. Barkhuus and Dey (2003) define three levels of context-aware applications depending on the interactivity with the user.

1. Personalization: the user determines the way the application behaves in a particular situation.
2. Active context-aware: this is an application that changes the content independently, based of the sensor data.
3. Passive context-aware: the application presents the changed context, sensor data, to the user and lets him/her take control of the decision on the application behaviour.

The research into context-aware mobile learning is still growing with the growth of the technology. The advances in sensing technologies give us the ability to create more novel learning environments for learners. Novel systems can detect the learning behaviour of students in an authentic context and provide the appropriate learning activities and material (Chiou *et al.*, 2010).

Many studies have been conducted in this area while many context-aware systems have been developed in different areas. However, context-aware mobile learning has been the focus for museums and tours in providing information based on the person's location (Park *et al.*, 2007; Reynolds *et al.*, 2010; Chiou *et al.*, 2010; Costabile *et al.*, 2008; Hsu and Liao, 2011).

Chu *et al.* (2010) developed a location-aware mobile learning system for a natural science course for primary students. The system uses RFID tags on plants as the sensing technology. This system guides students to a particular plant in order to ask questions and compare similar plants. They argue that the system promotes students' interest in natural science and improves their learning and achievements. Since we are interested in location- and context-based mobile learning, Chu *et al.*'s (2010) findings seem to be interesting and provide an example of evaluation. However, results of studies designed as experiments that divides students into two groups, experiment and control groups, should be treated with caution. It should not be applied when the activity is being assessed due to the fact that students in the control group do not have the same opportunity as the experimental group. Thus, it is unfair that their work be assessed equally.

2.4.3 Inquiry-based learning and Problem based learning

In inquiry-based learning, students are given problems that are similar to real world problems to explore, observe, investigate and solve (Feletti, 1993; Shih *et al.*, 2010). Inquiry-based learning is known for the social interaction between learners and their ownership and self-regulation of the learning (Lim, 2004). In Problem-based learning (PBL), students are challenged with ill-defined, ill-structured, and open-ended problems that develop their critical

thinking skills (Boud and Feletti, 1997). Main characteristics of PBL are that: (1) students work in a collaborative group, (2) teachers are "facilitators" of learning, (3) the problems do not assess the skill; but help develop it, (4) the performance is assessed, (5) the problem is ill-defined; students gather data, observe the problem and find a solution (Stepian and Gallagher, 1993). Students are encouraged to identify what they already know, the area of knowledge they need to know, and plans on how to solve the problem (Naismith *et al.*, 2004).

Since a real world situation is an important factor in both inquiry-based and PBL, mobile technologies can play an important role in giving students the support they need. Shih *et al.* (2010) developed a mobile learning activity to guide primary students' learning in a historic site for a social science course. They claim that students' achievements' have risen by 10% and students were enthusiastic as 90.6% strongly agree that using the PDA as a guide is more interesting. Also, they claim that the system helped in lowering the cognitive load of students with low achievements but no significant change was shown with middle and high achieving students. However, Shih *et al.* (2010) believe that the system can be extended to other courses and other aspects of learning such as critical thinking. Many university courses require students to go investigate real world situations to obtain a better understanding of how things are in reality. These activities might demand evaluation and critical thinking. Therefore, it is interesting to investigate a mobile learning activity that promotes critical thinking in HE students. This gave the idea of investigating to what extent a situated learning activity

assisted by a mobile device can trigger critical thinking and evaluation in HE students.

2.4.4 Collaborative learning

There was a move towards social and collaborative learning back in the early 90s most closely connected to Vygotsky's (1980) socio-cultural psychology (O'Malley et al, 2003). Pask (1976) produced the conversation theory, in which learning happens when conversations occur between systems of knowledge. These systems could be humans or interactive technologies. In both theories, mobile technologies contribute effectively to promote collaboration and communication (Naismith *et al.*, 2004). Social interaction and discussions with peers lead to group members changing their understanding or constructing new knowledge which results in improving the higher order thinking skills (HOTS) (Ma, 2009). Mobile learning, as a collaborative learning tool, has been under research to prove that it can enrich interactions between students. Much of the computer-supported collaborative (CSCL) learning can be applied to the mobile-supported collaborative learning (MSCL). With the fast emergence of smartphones and mobile applications, students can easily setup group chats and discussions, exchange images, videos and clips through many of the mobile applications in the market, all of which enhance collaborative learning. Many researchers have investigated the use of technology to enhance their students' collaborative learning. Ma (2009) conducted a study to understand the effect of CSCL in fostering the high order thinking skills. It was concluded that there was a positive relation between quality of the social interaction and the development of HOTS. Ractham and Firpo (2011) used Facebook as a learning resource for an MIS

course for first year students to collaborate and learn from one another. They found that each student, on average, wrote 34 posts, where the most used feature was commenting. This shows that Facebook has provided a lively medium for students to communicate with each other and with the lecturer. Other researchers have come to the same conclusion, that using Web 2.0 tools encourages and fosters collaboration and sharing (Halic *et al.*, 2010; PIFARRÉ *et al.*, 2013; Leelathakul and Chaipah, 2013).

2.4.5 Lifelong and Informal learning

Informal learning is not a new term. It has been around for a while since Dewey described any learning that happens outside the school as ‘informal learning’ (Dewey, 1997). Informal learning could either happen intentionally or accidentally. This can occur intentionally, through prepared projects (Tough, 1971), or accidentally, through reading a paper, talking to someone, or even watching TV (Eraut, 2000). Studies have shown that most adults learning informally without recognising the process (Tough, 1971). However, the focus on informal learning and the discussions concerning it arose when e-learning came into context. **Error! Reference source not found.** gives examples of formal and informal learning with regards to planning a learning activity.

Table 2 Types of Formal and Informal Learning (So *et al.*, 2008)

Out of Class	Intended learning out of Class	Unintended learning out of Class
	Field trip to a museum which is part of the curriculum	Using mobile phones to capture photographs and video clips of animal behaviors in a zoo and share them with friends, driven by self-interest

In Class	Intended learning in class Reading digital textbooks on a Tablet PC	Unintended learning in class Teachable moments, not planned by teachers
	Intended	Unintended

Rohs (2008) carried out a study on experts in the field of informal learning, e-learning, and higher education, to elicit criteria that helps to define informal e-learning.

According to Rohs (2008) an e-learning is defined informal if:

1. The learning environment is technological, non pedagogic, and situated.
2. The learning is self-motivated, self-regulated, and collaborative.
3. The learning has no time limit, it can occur in an anytime anywhere manner.

Cook *et al.* (2008) argue that informal learning can be linked to formal learning, they state that ‘...being part of a continuum or a multi-dimensional clustering of informal and formal learning activities rather than positioned in an either-or relationship’ (p.4). They suggest that mobile devices can bridge the gap between formal and informal learning.

Therefore, this research can be regarded as having elements from both formal and informal learning, which can be bridged via the use of the mobile smartphone.

2.5 HCI Teaching

Human-computer Interaction studies the way people interact with computers in a particular context and evaluates the extent to which these computer-based systems are, or are not, designed for successful interaction (Benyon, 2010).

Students taking HCI modules usually learn about the role of the task and the context for which the interface will be used, the various interface design constraints and trade-offs and the way the human-computer interaction is affected, as well as the relationship between the interaction and the context of use. They are required to know the potential users of the systems and their goals in order to create a system that is effective, efficient, and intuitive. In addition, they learn about user-centred design methods that require the involvement of the user in the whole process of the system development cycle. This deep understanding of the needs and requirements of the users leads to iterative prototyping and evaluation (Strong *et al.*, 1994). According to McDonagh and Thomas (2010) applying empathic design strategies when designing aids in developing a product that pleases the user. Thus, immersing students into real world environments to gather requirements could generate empathy and thus designing a product that related to the users' needs.

To facilitate this, the PACT (People, Activities, Context, and Technology) framework is sometimes used to prompt students to consider specific categories in their analysis. The elements of the framework are described by Benyon (2010):

1. People: they differ physically, psychologically, and in terms of their knowledge of technology.

2. Activities: they differ in terms of temporal aspects (response time, frequency of the activity, time pressure and peaks), cooperation, complexity, and safety-criticality.
3. Contexts: the different environments in which the activities take place encompass the organisational and social context and the physical environment.
4. Technologies: these should reflect the specific issues identified in considering the previous elements. Features include input, output, communication, and content.

However, it should be noted that teaching interaction design is a challenging task (Sas and Dix, 2007). Starting from the design process in providing the students with a specific problem and communicating the appropriate feedback (Sas and Dix, 2007). It is highly significant to bridge the gap between theory and practice (Churchill *et al.*, 2013). Thus, immersing students into real world environment is a crucial part of HCI teaching as discussed earlier. Nevertheless, the challenge occurs in the providing students with the problem specification. It is significant that a balance between the level of detail and a room for exploration is achieved (Sas and Dix, 2007). This is a challenge that is acknowledged by the educators. According to Edwards *et al.* (2006) students studying HCI are usually computer science students who are in favor of clear right or wrong answers and tend to struggle handling less structured tasks which is the nature of HCI (Edwards *et al.*, 2006; Sas and Dix, 2007). Hence educators are constantly trying to identify new approaches to teaching

HCI through exploring the use of technologies in teaching as discussed below.

2.5.1 Uses of technology in HCI teaching

HCI lecturers have been using technology in teaching, or e-learning, for more than a decade. Whether they have used Virtual Learning Environments (VLEs) (Chalk, 2002; Debevc *et al.*, 2008), Wiki-Webs (Brereton *et al.*, 2003), blogging (MacColl *et al.*, 2005), web lectures (Day and Foley, 2006), ePortfolios (Kabicher *et al.*, 2008) or MOOCs (Dix, 2012; Klemmer, 2014).

Wang and Karlström (2012) provided undergraduate Interaction Design (ID) students with iPads that have six productivity apps and six design apps preinstalled. It was intended to aid them in their learning activities. The researchers' aim was to understand the affordances of tablets in the ID learning context. Students, in groups of four, were required to submit a graphic design task every week for the duration of four weeks. Wang and Karlström (2012) found that the iPad had promoted informal learning activities, daily activities such as sending emails, personal use, collaboration, and multimodal interaction. Above all, they argue that collecting data initiated by the student and interacting with the environment was more important than the usage of the context-aware technology. Although this study has shown positive results in using iPads for ID students, some students were concerned about theft and felt uncomfortable taking the iPads in public places such as the subway. This could be an issue when it comes to deploying iPads to aid students' learning outside the classroom. Not all students own a tablet and borrowing a tablet from the university to be used in public places may put extra pressure on students having to worry about keeping it safe.

As mentioned earlier, previous research into the use of mobile devices and apps have focused on in-class learning. Hence, exploring the effectiveness of mobile location-based apps in aiding students' understanding of context for design is at the centre of this thesis.

2.6 Critical Thinking and Reflection

Many teachers and lecturers are keen to improve critical thinking skills of their students rather than putting all their effort into delivering content only. However, some promote these skills through teaching the content while others do it explicitly (Fisher, 2001).

2.6.1 Definition

The question that arises now is, what is critical thinking? There are several definitions for critical thinking; some of which are from the early days of Dewey (1933). However, Dewey did refer to his definition as a definition of 'reflection', and this will be discussed in a later section.

A popular definition that has been used widely is by Robert Ennis; he stated that critical thinking is "...reasonable, reflective thinking that is focused on deciding what to believe or what to do" (Ennis, 1993, p.180).

Another definition was by Scriven and Paul (1987); they defined it in more detail as "...the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action". This

definition shows a clear relation to Bloom's taxonomy, as it relates critical thinking to the three upper levels of the taxonomy: analysis, synthesis, and evaluation (Duron *et al.*, 2006).

The two definitions above agree that a decision and an action need to be made. This shows that critical thinking leads to decision making.

2.6.2 Critical thinking skills

According to Fisher (2001, p.8) there are a number of skills that create critical thinking. To become a critical thinker a person must learn to:

- “Identify elements in a reasoned case, especially reasons and conclusions.
- Identify and evaluate assumptions.
- Clarify and interpret expressions and ideas.
- Judge the acceptability and credibility of claims.
- Evaluate different arguments.
- Analyse, evaluate, and produce explanations.
- Analyse, evaluate, and make decisions.
- Draw inferences.
- Produce arguments.”

2.6.3 Reflection

Reflection is an every day activity done by people either consciously or subconsciously. According to Moon (2001) people normally reflect on something in order to have a better understanding of it, and usually there is a purpose for this reflection.

Moon (1999, p.2) defines it thus: “Reflection is a form of mental processing - like a form of thinking – that we use to fulfil a purpose or to achieve some anticipated outcome. It is applied to relatively complicated or unstructured ideas for which there is not an obvious solution and is largely based on the further processing of knowledge and understanding and possibly emotions that we already possess.”

Moon’s definition shows that people, when reflecting, could use their own previous ideas and perceptions, adding new information, to produce the outcome for the intend reason.

In addition, Dewey had his own definition of reflection, which he related as to the thinking process. He stated that reflection is an: “Active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends” (Dewey 1933, p. 118)

Below is an input/output model of reflection, as perceived by Moon (2001):

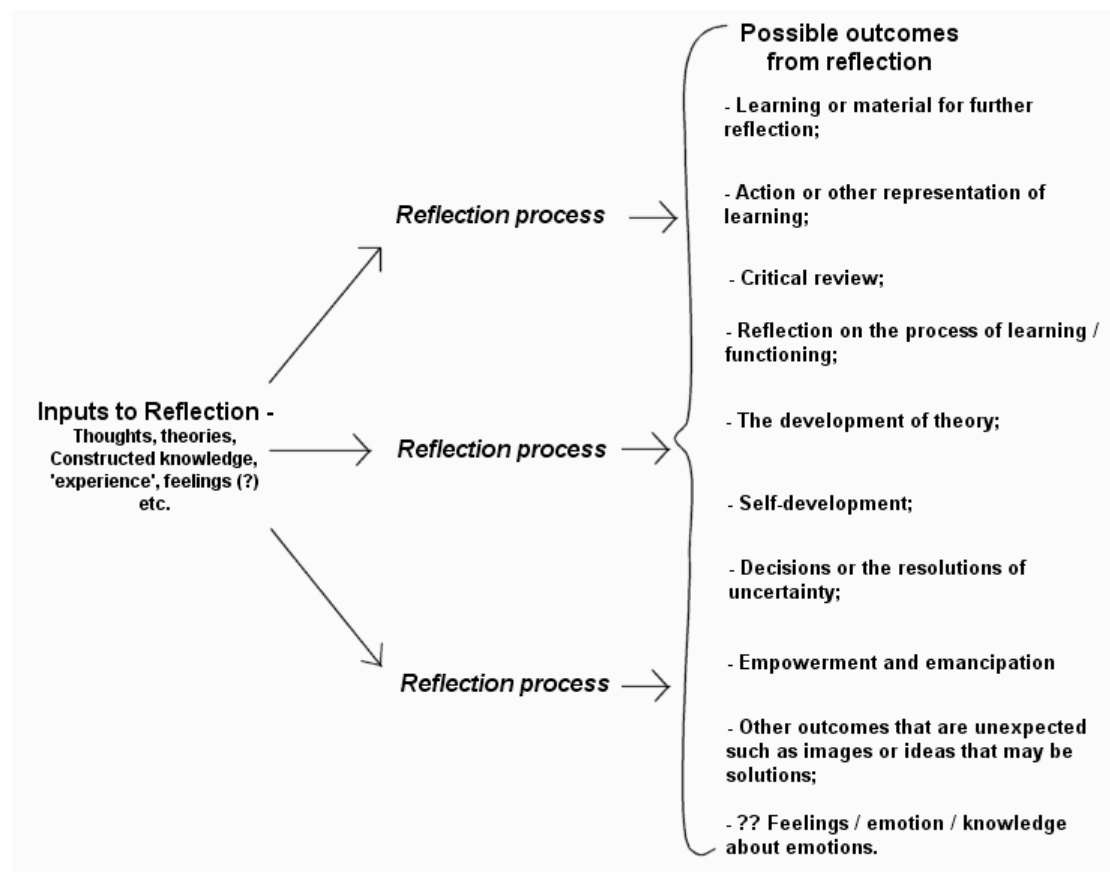


Figure 3 Input/output model of reflection (Source: Moon, 2001, p.5, Used with author's permission)

There are a number of activities that can be added to a curriculum to promote reflection. Moon (2001) has provided some useful examples of learning activities such as: Learning Journals, Portfolios, and Peer- or self-assessment, to name but a few.

2.6.4 Assessment of critical thinking and reflection

Since there are a number of skills that contribute to critical thinking, the assessment of it should reflect the application of these skills. It is very important to set the criteria of any assignment beforehand, regardless of whether it relies on critical thinking, reflection, or any other skill. These criteria

are what students will be assessed against and they should be clearly defined and known to students.

In fact, there are many sheets and rubrics that have been created to assess the student's critical thinking skills. These could be used to guide the assessment and help students understand where they stand. Moon (2001) believes that there are no definite criteria for assessing reflection. This is because people can have different purposes for reflection and thus different outcomes. The criteria should be developed according to the discipline, the purpose of the assignment, and the group of students.

The criteria for assessing students' critical thinking and reflection for the HCI version is shown in 6.1.1.

2.7 Students and Staff perceptions' of mobile learning

Yau and Joy (2009) interviewed 37 university students on their views of the use of mobile devices in learning. The study showed that 30% of the students are motivated to using mobile devices in learning, 43% of students would use them but not in anytime anywhere manner, and 27% of students stated that it would not be useful to them to use mobile devices in learning.

The 27% of students unwilling students to use a mobile device in learning might be due to the fact that many people lack the psychological motivation to be involved in mobile learning, according to Wang and Higgins (2005).

Also, Fisher *et al.* (2007) conducted a survey on students and academic staff, from the School of Computing, after having used Tablet PCs in their teaching and learning for a couple of months. Their study showed that 80% of lecturers agreed that using tablet PCs have enhanced their teaching experience and had improved the procedure of storing the teaching material. Furthermore,

94% of students think that it has improved the quality of their learning experience. While only 46% think that it promotes collaboration, 90% agree that the removal of the tablet PCs will have a negative effect on their performance. However, given the fact that the students and lecturers are from the school of computing, this might have a huge impact on the positive results. Furthermore, the researchers have only selected key responses from the survey for both staff and students.

Pollara and Broussard (2011) reviewed 18 mobile learning studies between the years 2006 and 2010, selecting only those studies with an explicit research design and methodology. These studies showed that, in general, mobile learning has a positive impact on students leading to an increase in their interest and achievements.

These results add to the motivation for implementing mobile learning in aiding students' understanding while learning in-situ.

2.8 Conclusion

This chapter has discussed the literature behind mobile learning, definition, and motivation. Moreover, the pedagogical theories that are related to mobile learning were reviewed in depth giving examples of various applications. From the above literature, this research favours the two approaches identified by Winter (2007) learner-centred and challenging the classifications of formal education , in which mobile learning can provide students with opportunities that can augment their learning on the move. It also agrees with Traxler (2009) that mobile learning can provide the opportunity for promoting students' learning in-situ. Therefore, this research mainly follows Lave and Wenger's (1991) situated learning theory covering the pedagogical aspect of

the project and incorporating both collaborative and informal learning. Furthermore, Lee and Lee's (2008) characteristics of mobile learning are in line with this research; this research promotes situated, personalised, learner-driven, flexible, and connected experience. Although mobile devices have been integrated successfully into education by different disciplines, there is still little research on the use of mobile learning in HCI. This adds to the motivation of understanding the effectiveness of this technology for students in this field and in similar situations. This chapter has discussed critical thinking and reflection, identifying Scriven and Paul's (1987) definition of critical thinking as the appropriate one since it shows a clear relation to Bloom's taxonomy, which is in at the heart of the activity the students- in the HCI study- were required to do. This activity is explained in detail in 6.1.1. Above all, the assessment criteria for critical thinking skills for this study were developed according to the needs of this discipline. Considering Moon's (2001) argument that people can have different purposes for reflection and thus different outcomes, hence there are no definite criteria for assessing reflection. The next chapter explores the literature of designing mobile learning.

3 Chapter Three: Designing Mobile Learning

This chapter explores the challenges of mobile learning, reviews literature concerning the design, evaluations and usability of mobile applications in general and mobile learning applications in particular. This will aid the choice of the proper design framework, help understand the importance of conducting proper mobile usability evaluations and help define an appropriate evaluation methodology for this research.

Before going into designing mobile learning, it should be clear that mobile learning interactions is reinforced by Mobile HCI (Botha *et al.*, 2010). Mobile HCI is defined by Love (2005, p.2) as:

“The study of the relationship (interaction) between people and mobile computing systems and applications that they use on a daily basis [...] HCI is concerned with investigating the relationship between people and computer systems and applications [...] We are concerned with understanding the users, their various capabilities and expectations and how these can be taken into consideration in the mobile systems or application design”.

This definition is in line with the interest of this thesis, the design and evaluation of mobile application for learning in-situ. The following section discusses the challenges presented by the implementation of mobile learning.

3.1 Mobile Learning Challenges

There are educational, technological, design, evaluation, and ethical challenges that must be taken into consideration when opting for mobile learning. In this section each of the above challenges is discussed.

3.1.1 Technological Challenges

The key technological challenges that must be considered are (Vavoula and Sharples, 2009; Elias, 2011):

- Limited, poor, or unreliable connectivity can sometimes in some places be an issue. This means that learners can sometimes struggle to get connected and access the information they need.
- Diversity of operating systems. The current most popular are Apple's iOS, Google's Android, Microsoft's Windows Mobile, and BlackBerry's BlackBerry 10.
- Diversity of mobile devices, there are many manufacturers and models of mobile devices out there.
- When using mobile phones as the medium, relatively small screens can limit the content that can be delivered, limited input methods can, in some cases, limit the learner's capabilities (Shudong and Higgins, 2005).
- The battery in mobile devices normally suffer short battery life, especially when multi-tasking,.

The above technological issues should be taken into consideration, as much as possible, when designing a mobile learning activity.

3.1.2 Educational Challenges

Naismith *et al.*, (2004) argue that one of the biggest challenges was to deliver learning into a seamless daily routine using mobile technologies without learners noticing that they are learning. While this may be true of young learners such as school children with difficulty in engaging, adult or university

students need to be self-aware with independent learning skills (Meyer *et al.*, 2008). They need to reflect on what and how they learn.

Adapting to students' learning styles could cause something of a challenge to educators. Traxler (2007) discusses the fact that learning styles would affect the way mobile learning is conceptualised. He argues that different learners may adopt different learning styles in various times and places. Thus mobile learning needs to adapt to students' needs by meeting a number of criteria:

- Personalised learning: learners are diverse and individual, which means that learning should be developed and delivered with these issues in mind.
- Situated learning: learning takes place in a real world context.
- Authentic learning: learning includes real world problems and projects that would interest learners to get involved.

Furthermore, Vavoula and Sharples (2009) consider the decision of whether mobile learning is a formal or informal type of learning challenge. They argue that a learning experience could have both elements of formal and informal learning. An example they outlined was students visiting a museum with their school, where a museum is considered an informal setting and school is formal.

Thus, when deciding to 'go mobile', educators need to define the learning style that will be supported and the purpose of the application. For this research, the main pedagogical theory is Lave and Wenger's (1991) situated learning theory, having elements from both collaborative and informal learning, where the purpose of the application is to provide students with

contextual information (Ryu and Parsons, 2008), to help them in understanding the situation they are currently in.

Willingness to engage and motivation of HE students is a topic that has been researched since the 1980s (Zepke and Leach, 2010). Indeed, researchers are constantly trying to identify new ways of motivating HE students (Kuh *et al.*, 2008; Kuh, 2009; Chen *et al.*, 2010; Manuguerra, and Petocz, 2011). Some researchers have argued that the introduction of technology enhanced learning has increased the number of engaged students (Manuguerra and Petocz, 2011; Junco *et al.*, 2013). However, there are still a number of students who tend to be less engaged with academic life due to institutional and non-institutional factors such as family, friends, health and employment (Zepke *et al.*, 2010). This could be one of the challenges faced when deploying a new technology enhanced learning (TEL) intervention in higher education.

3.1.3 Ethical Challenges

When using context-aware or location-aware services, learners need to be assured that their privacy is not compromised (Wishart, 2010). However, referring back to the discussion above about informal learning where educators are not certain of what learning activities are carried out, it is sometimes difficult to know in advance what data researchers are looking for. Therefore, getting an informed consent on something that is not clear is a major challenge (Vavoula and Sharples, 2009; Wishart, 2009).

Wishart (2009) created a framework consisting of the ethical issues for a researcher or an educator to take in consideration. The framework consists of a table of key ethical issues in mobile learning intersecting with fundamental

ethical principles. According to Wishart (2010), it is sometimes difficult to meet all principles for a given issue. Thus, an agreement between the researcher and the learner can be made regarding that key issue.

3.1.4 Design Challenges

Designing for mobile learning is one of the biggest challenges, whether it is designing the activity or the system. Quinn (2011, p.133) states: “If you don’t get the design right, it doesn’t matter how you implement it”. Designing is challenging, from gathering requirements to prototyping. Once again, technology plays a major role in the designing phase. Designers must take into consideration the technological elements of the device they are designing for, or whether they are designing for multiple devices and/or multiple platforms (Elias, 2011). The size of the screen is one of the significant issues when designing a mobile application. Moreover, since smartphones are portable, the mobility of the device and the user should be considered when designing (Huang, 2009). Furthermore, understanding the context in which the mobile learning application will be used has a significant implication on the design of the application (Kukulka-Hulme, 2007; Savio and Braiterman, 2007; Cherubini and Oliver, 2009). This is discussed further in 3.2.

However, since mobile learning is fairly new and innovative, some researchers felt it was necessary for mobile learning to have its own design requirements framework, which differs from established eLearning frameworks (Parsons *et al.*, 2007; Economides, 2007; Liu *et al.*, 2008). A number of design requirements frameworks will be discussed later in detail in 3.2.1.

In designing a mobile learning activity, educators should take into account all elements of students' needs. As discussed in 3.1.2, the design should allow for personalisation and authenticity. More discussion on designing for mobile learning will follow in section 3.2.

3.1.5 Evaluation Challenges

Evaluating mobile learning poses a significant challenge, from evaluating the application itself to evaluating the outcomes and learning. According to Vavoula and Sharples (2009), '...capturing learning context and learning across context' is one of the main challenges of evaluating mobile learning. Yet, this is one of the main characteristics of mobile learning. Evaluation becomes more problematic when learning occurs in an informal setting where sometimes the learners are not known in advance and/or the objectives are not clearly defined (Vavoula and Sharples, 2009). Furthermore, assessing the students' achievements and learning progress is difficult in an informal setting. The learners themselves may initiate many learning experiences and thus, it can be difficult to assess and monitor process and progress, especially when multiple contexts and technologies are involved (Vavoula and Sharples, 2009). Other challenges arise from the effect of the surrounding environment including interruptions and variable contexts (Billi *et al.*, 2010). This is discussed further in this chapter.

There are ways in which learning can be tracked and analysed, such as adding logs or tracking mechanisms to the system. However, this directly leads us to another significant challenge that should not be ignored: the ethical aspects of mobile learning discussed earlier. Furthermore, following

from the point discussed earlier in 3.1.2, the lack of motivation of HE students, could influence the ability to conduct a full evaluation of any new TEL innovation in HE. If some students are not willing to try something new, not willing to engage or participate in a study, this will challenge researchers in evaluating such an intervention.

3.2 Contexts for Mobile Learning

According to MacLean and Scott (2007, 2011 p.187) learning design is "...the process of designing effective learning experiences for a variety of contexts: in the classroom or laboratory, in the field, online and via standalone packages using a range of media". This means that for a learning experience to be effective, the design should go through a number of procedures that accommodate a particular context. As discussed in section 3.1.4, designing mobile learning can pose many challenges. These challenges start from designing the mobile learning activity itself to designing the mobile learning application. From the early stages of data gathering the designer should bear the user, his/her aims or tasks, and the context of use in mind in order to outline how the user interface (UI) should be designed (de Sá *et al.*, 2008; de Sá and Carriço, 2011, Harrison *et al.*, 2013). When designing a mobile application the context is crucial to understand (Savio and Braiterman, 2007; Cherubini and Oliver, 2009). The context of use, in this thesis, is regarded as any aspect of the physical and social environment surrounding the user when using the mobile application and any interaction that occurs with people or objects.

Savio and Braiterman (2007) have created a context model, shown below, for mobile interaction design that consists of the overlapping spheres that surround the mobile users. The model highlights different factors that potentially influence the use of a mobile application such as culture, environment, activities, goals, and tasks. However, not all factors occur in all situations. Rogers *et al.* (2011) recommend that designers visit the contexts in which a mobile app will be used, in order to appreciate the significance of these factors and to take them into account in their design.



Figure 4 The Context of Mobile Interaction (Source: Savio and Braiterman, 2007, p.2, this work is licensed under the Creative Commons Attribution 2.5 License. To view a copy of this license, visit www.creativecommons.org/licenses/by/2.5/)

From the discussion above and looking at people nowadays, they live in two overlapping spheres: physical and digital. It is difficult to control these spheres, however, providing students with learning opportunities within the interactions of those two spheres should be a significant objective when designing mobile learning. In other words, the learning content should suit the current environment of the learner.

The section below discusses a number of frameworks that have been developed to accommodate these issues.

3.2.1 Requirements frameworks for designing mobile learning

Many researchers in the field have discussed general requirements for mobile learning (Sharples *et al.*, 2005; Parsons *et al.*, 2007; Economides, 2007; Liu *et al.*, 2008). They argue that mobile learning is similar but different from e-learning and so e-learning frameworks cannot be applied to it. This has led various researchers to developing frameworks to support the design and development of mobile learning applications. Below, a number of frameworks developed by different researchers will be presented.

Parsons *et al.* (2007) developed a design requirements framework for mobile learning applications. They argue that when designing a mobile learning application three main areas must be taken under consideration:

1. Generic Mobile issues

There are a number of issues concerning mobile environments.

- Understanding the mobility issue. What is mobile in this context?
Is it the learner, the device, the service, or all?

- The user's role in the environment. Is the user a learner or an instructor?
- The UI: the mobile devices are known for their relatively small screens, short battery life and limited input methods.
- The media types involved should not distract the learner from the intended learning objective.
- The socialisation support available

2. Mobile learning contexts

There are six dimensions regarding the mobile learning context (Wang, 2004 cited in Parsons et al., 2007):

- Identity: the identity of the mobile user.
- The Learner: it is important to consider the learner. As learning attitudes differ from one another.
- Activities: individual activities carried out by learners.
- Collaboration: a feature of M-learning that it supports collaborative activities.
- Spatio-temporal: The awareness of location or/and time.
- The facility: mobile devices, smartphones, PDAs, etc.

3. Learning objectives and experiences

- Improving skills and developing new skills will need a number of learning experiences which include:
 1. Organised content.
 2. Goals and objectives.

3. Outcomes and feedback.
 4. Representation or story.
- Acquiring team and social skills need these learning experiences:
 1. Conflict, competition, challenge, and opposition
 2. Social interaction to build collaborative learning.

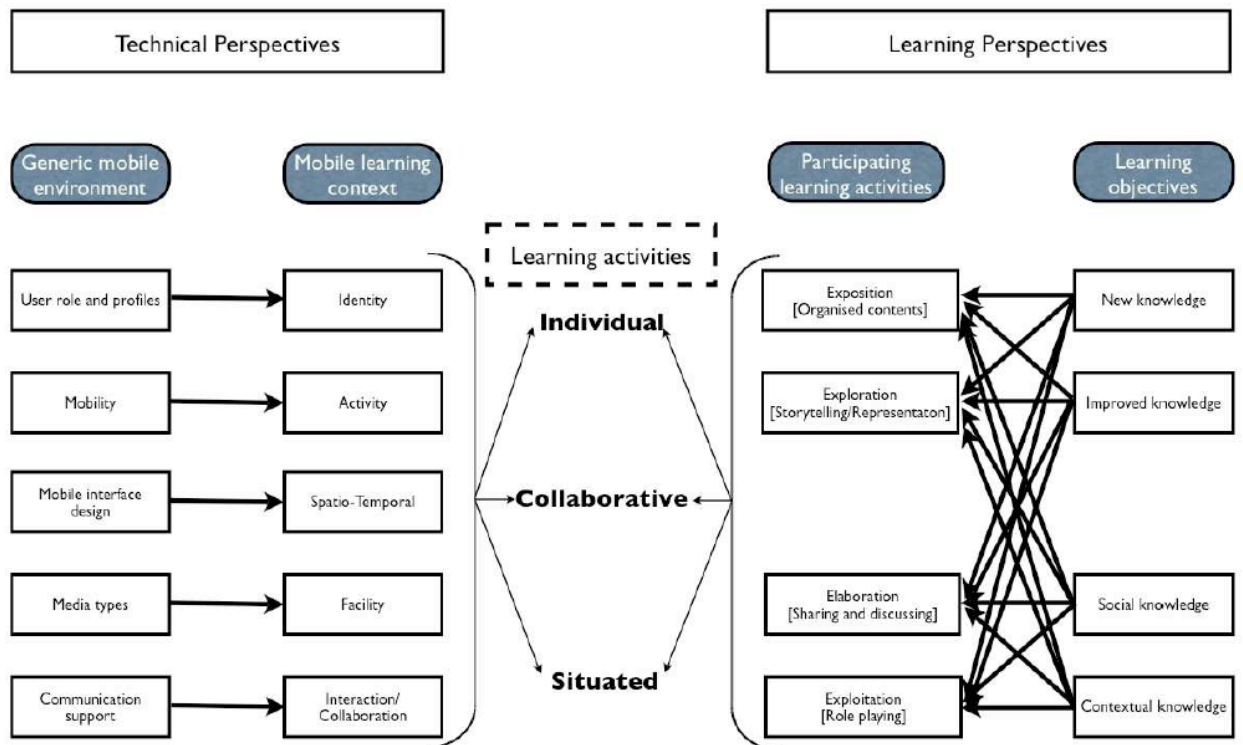


Figure 5 A framework for M-learning design requirements (Source: Ryu and Parsons, 2008, p.12, Used with authors' permission)

Economides (2007) presented four dimensions for mobile learning requirements.

1. Pedagogical
 - (a) Learning Theories.
 - (b) Instructional Design Models.
 - (c) Content Quality.
 - (d) Content Comprehensiveness and completeness

- (e) Content Presentation.
- (f) Content Organisation
- (g) Student Support and Feedback.
- (h) Control.

2. Socio-Cultural

- (a) Acceptability.
- (b) Social Interaction methods.
- (c) Sociability.
- (d) Attitude.
- (e) Visibility and Observability.
- (f) Trust, Privacy, and Intellectual Property.
- (g) Fashion.

3. Economical

- (a) Cost and Economic Feasibility.
- (b) Cost-Effectiveness,
- (c) Service Level Agreement.

4. Technical

- (a) UI.
- (b) Functionality.
- (c) Awareness.
- (d) Adaptation.
- (e) Reliability and Maintainability.

(f) Efficiency and Performance.

(g) Connectivity.

(h) Security.

Although the requirements covered by Economides' framework all apply, some are obvious and are not required for the design of mobile learning.

Other mobile learning design frameworks were developed by Mohammad *et al.* (2007) and Liu *et al.* (2008). Mohammad *et al.* (2007) extended their e-learning framework to create a mobile learning framework by adapting a couple of dimensions to suit the mobile learning environment. The dimensions discussed are mobile device, user, connectivity, and context. These analyse the users' characteristics, learning strategies, technologies within the device, and connectivity speed and cost. Liu *et al.* (2008) argued that mobile learning activity design is the core of their framework. They take into account four areas: (1) Requirement and Constraints analysis, (2) Mobile Learning Scenario Design, (3) Technology Environment Design, and (4) Learner Support Service Design. See figure 3 below:

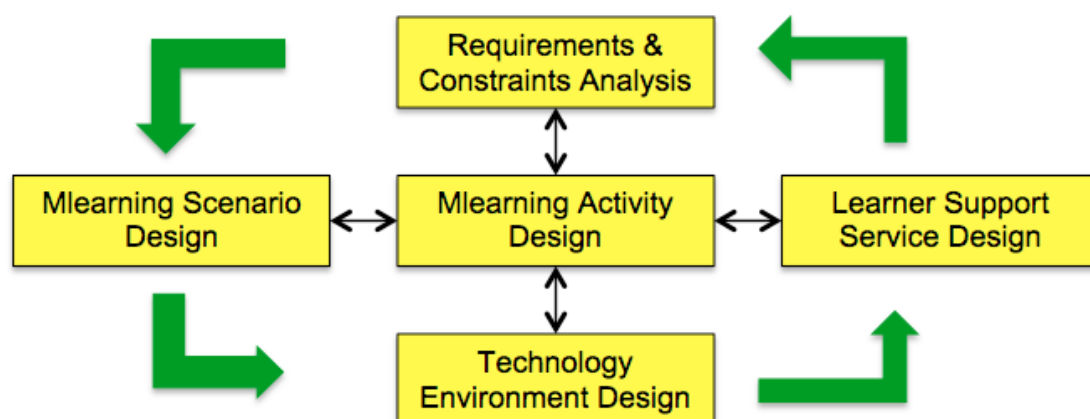


Figure 6 Design Framework for mobile learning (Source:Liu *et al.*, 2008, p.185, © 2011 IEEE)

The frameworks discussed above share many dimensions. Although some are more detailed and require more emphasis on certain areas, they all agree on the general concept that the user, the technology, the environment, and the learning activity should be at the centre of any mobile learning design.

When talking about design principles, Herrington *et al.* (2009) outlined a number of characteristics that should be taken into account when designing a mobile learning activity for higher education students:

1. Real world relevance: Mobile learning should be applied to authentic settings.
2. Mobile contexts: Learners are on the go or ubiquitous.
3. Explore: Students have been familiarised with the technology.
4. Blended: The activity is blended, mobile and non-mobile technologies are in use.
5. Whenever: The use of mobile is 'spontaneously'; it can be used 'whenever' needed.
6. Wherever: The use of mobile is informal; it can be used 'wherever' the learner is.
7. Whomsoever: The use of mobile learning can accommodate collaborative and non-collaborative learning.
8. Affordances: Profit from the affordances of mobile technologies
9. Personalisation: Students are able to use the personal devices.
10. Mediation: Mobile learning 'mediates' knowledge.
11. Produce: Mobile learning 'produces' knowledge.

For the purposes of this research, Ryu and Parsons' (2008) framework was chosen to analyse the initial design requirements for the mobile learning

activity. This was primarily because of the way the framework was designed, addressing both technical perspectives and learning perspectives. It is vital to have a clear understanding of the different design requirements and the relationships between them. In addition, this framework addresses the learning activities that this research is most interested in: situated, collaborative, and individual learning activities. Other frameworks discussed above were not chosen due to the fact they were either limited or too detailed.

3.3 Evaluating Mobile Applications

Requirements' gathering is usually the starting point when designing a system. However, evaluating prototype designs adds to the understanding of the target users and their interaction with the application, leading to an iterative process of editing the design. Bowser *et al.* (2013) found that treating participants, of an evaluation study as co-designers, would enable them to criticise the design more freely.

When it comes to evaluating a mobile app, the context of use plays a significant role which must not be ignored (Savio and Braiterman, 2007; de Sá *et al.*, 2008; Cherubini and Oliver, 2009; Harrison *et al.*, 2013). Many researchers in the field of usability evaluation favour conducting evaluations in the field rather than isolated laboratories (Tsiaousis and Giaglis, 2010; Korn and Zander, 2010; Larsen *et al.*, 2011). They argue that many of the contextual factors that influence the user's performance such as noise, interruptions, multitasking and lighting conditions are not available in laboratory settings. Thus, many usability problems may not otherwise be discovered. Lab evaluations will discover interface issues and problems;

however, it will not reveal issues relating to the actual use of the app and these may be missed (Larsen *et al.*, 2011, Sun and May, 2013).

Kaikkonen *et al.* (2005) conducted a study to understand if there were any differences in identifying usability problems when testing in a laboratory or in the field. They found that the same number of problems was identified in both settings. However, Kaikkonen *et al.* (2005) emphasise the need for more studies to validate their results. Moreover, they argue that laboratory evaluation of some applications that provide location information in particular may miss some usability aspects. Tsiaousis and Giaglis (2010) conducted a study of 64 mobile website participants and found that the lighting, the proximity of nearby people, the motion of nearby objects/people and the environmental sounds significantly affected the effectiveness and efficiency in the using of the mobile website. Lemmela *et al.* (2008) conducted mobile evaluations of a messaging application for two contexts (in a car and walking) that concluded that context has an influence on the user's preferences in the usage of modalities and interaction strategies and backs up the argument that conducting evaluations in-situ does help to identify a wider range of issues, as context influences usage. Korn and Zander's (2010) walkshop study, in which they assess the usability by walking in-situ, found a number of usability issues that were not discovered in the lab. These are related to 'data input under stress' as well as receiving interesting discussion and reflection from the participant which they think is a result of interacting with the environment.

A recent study by Sun and May (2013), supporting an earlier study by Kaikkonen (2005), found similar numbers of usability issues in both lab and field evaluations. However, there were essential differences in the issues

identified between both the settings. The issues discovered in the lab were mostly interface problems, while issues in the field were mainly about the mobile 'use' and were influenced by environment. Participants in the lab were less engaged, and participants in the field were found to be more critical. However, they concluded that the field evaluation was difficult to control, as the event distracted some participants, forgetting they were taking part in the study and needing prompting.

The context model constructed by Savio and Braiterman (2007) shown in 3.2 gives a good framework when planning the evaluation of the mobile application. It shows the different elements that could have an effect on the usability of a mobile system.

However, in the case of this research, the evaluation takes two forms:

1. Evaluating the learning experience.
2. Evaluating the design, usability, and user experience of the mobile application.

The deployment and evaluation of mobile learning interventions is a growing research area, particularly in higher education. Researchers are still investigating best practice. Evaluating the effectiveness of mobile location-based learning is fraught with difficulties, as discussed earlier in 3.1.5. In order to ensure a rigorous approach to this research, current approaches for evaluation were investigated.

Vavoula and Sharples (2009) defined a now well-established approach (Ahmed & Parsons, 2012) for evaluating mobile learning. They developed a three-level framework for evaluating mobile learning:

1. The Micro level examines two aspects: the individual activities of the users (learners) and the usability of the technology used.
2. The Meso level examines two aspects: the whole learning experience and how well the learning experience links with other activities.
3. The Macro level examines the impact of the new innovation on (a) the established teaching and learning practice and (b) on the educational institution.

Their framework is shown below:

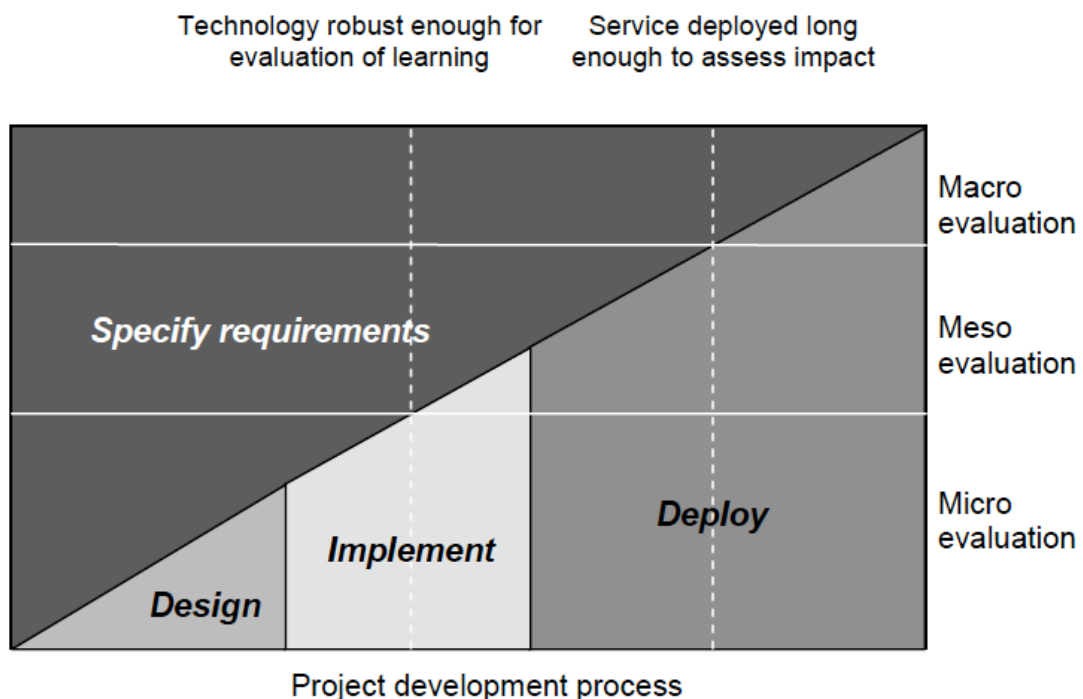


Figure 7 Three level evaluation framework (Source: Vavoula and Sharples, 2009, Copyright, IGI Global. Reprinted with permission of the publisher)

When this current research first began, the Macro level evaluating the long-term impact of the new innovation on the established teaching and learning practice and institutions (Vavoula and Sharples, 2009) was considered to be beyond its scope. However, it was decided later that the Macro level could be incorporated in this research by deployment of the contextual learning model in several modules. This is discussed in detail later in chapter four.

Other evaluation frameworks were investigated (Economides and Nikolaou, 2008; Taylor, 2004; Traxler & Kukulska-Hulme, 2005). Taylor's (2004) evaluation framework is a task-centred approach concentrating on 'pedagogical soundness' to evaluate mobile learning against the user's goals. Economides and Nikolaou (2008) have developed a three-area evaluation framework (Usability, Technical, Functional) for evaluating handheld devices for mobile learning. However, this framework is only interested in the characteristics of the handheld device. It does not relate to any pedagogical aspects and, thus, is not an appropriate framework for evaluating the whole mobile learning experience. Furthermore, the strength of mobile learning occurs in the ability of the learners to use their own handheld devices in learning; hence, many aspects of this framework are not appropriate.

3.4 Usability

According to the ISO 9241 definition of usability, it is: "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, 2009). Nielsen considers usability as a 'quality attribute' that examines how easy it is to use a UI and the ability to 'improve the ease-of-use' of an application in the life cycle of the design (Nielsen, 2012). He defines five main aspects of a usable system that should be borne in mind during the design process:

- Learnability: focuses on whether it is easy to complete basic tasks when interacting with a system for the first time.
- Efficiency: focuses on how fast users can complete tasks when using a system that they have already used.

- Memorability: focuses on how easy is it to remember how to use the system when returning to it after some time.
- Error: focuses on the number of mistakes users make when interacting with a system, how easy is it to correct these mistakes, and their severity.
- Satisfaction: focuses on users' perceptions of using the system.

It is important to differentiate between learnability and efficiency. The first measures the ease-of-use when doing the tasks for the first time. On the other hand, efficiency is only measured when the users have had experience using the system.

Usability testing can help to identify problems and help make improvements in the early stages of design and as such is a significant part of any software development cycle that can be cost effective when implemented in a timely manner (Nielsen, 1993).

Harrison *et al.*, (2013) have designed a usability model, PACMAD (People At the Centre of Mobile Application Development). They argue that their model tackles the limitations of existing usability models when applied to mobile devices. This model identifies three elements that influence the usability of a mobile application: User, Task, and Context of use. They argue that these three elements should be taken into consideration when designing a usable system. This argument supports the earlier discussion in 3.2. Within the PACMAD there are seven usability attributes: Effectiveness, Efficiency, Satisfaction, Learnability, Memorability, Errors and Cognitive load. These attributes were combined from both the models of the ISO with Neilson adding a new attribute, the cognitive load.

As mentioned earlier usability evaluations can be conducted either in a laboratory setting or in the field (in-situ). Holzinger (2005) has classified usability evaluations thus:

1. Evaluations without end-users or inspection methods: Heuristic evaluations, Cognitive walkthroughs, and Action analysis.
2. Evaluations without end-users or test methods: Thinking aloud, Field observations, and Questionnaires.

The next section will explain and discuss each of the above methods in detail.

3.5 Evaluation and Usability Methods

This section will explain the usability methods in Holzinger's (2005) classification that are relevant to this research.

3.5.1 Inspection Methods

Heuristic evaluations are usability evaluations that help identify usability problems of the UI of tested software. They are performed by a number of specialists in the field, to maximize the number of problems to be found, using a set of principles or "heuristics" (Nielsen, 1993). They can be time effective as it does not involve recruiting participants, however, the results might miss some key problems, as the evaluators are not the end-users (Trivedi and Khanum, 2012).

Cognitive walkthroughs, like the heuristic evaluations, are performed by experts in the field. They perform, or "walkthrough" a set of tasks, one task at a time, simulating the user's behaviour. The evaluator will try to understand cognitive issues, how the user would explore the system to learn about it. It

will try to find design problems that might make a particular part of the system hard to learn. It is quick and cost effective where design problems can be found in the early stages of the development phase. However, it only concentrates on the ease of learning attribute of usability (Wharton *et al.*, 1994).

3.5.2 Test Methods

'Think aloud' involves asking the user to verbalise his/her thoughts whenever they are struggling while using the system. The practitioner should not interfere with the user nor interrupt their thoughts (Nielsen, 1993).

Nielsen (2012) argues that the most significant advantage of this method is that it offers a way to understand the users' perceptions of the system and the design. A redesign should be performed when the users misinterpret the tested design. Other advantages are that it is: cheap, robust, flexible, convincing, and easy to learn. However, think aloud has its drawbacks. To Nielsen (2012) the main drawback is that it does not provide thorough statistics. Others are: it can be difficult for some people to speak their minds articulately and clearly; their statements can be filtered, thus biasing user behaviour (Nielsen, 2012).

Field observations involve attending the users' workplace and observing their usage. The observer should not interfere with the natural environment in which the user is interacting with the system. The user should not feel the attendance of the observer nor should he/she notice the observer taking notes; this might make the user uncomfortable and would affect the way the user interacts. Holzinger (2005) claims that this is the simplest method of all usability methods.

Questionnaires measure the users' perception of the system and the design. They are indirect usability measures that should be designed by specialists in the field (Holzinger, 2005). There are a number of ready usability questionnaires that have been developed by experts SUS (Brooke, 1996), CSUQ (Lewis, 1995), QUIS (Chin *et al.*, 1988), to name but a few.

Each of the usability testing methods discussed above has its drawbacks. Applying one test method would probably only discover a limited number of issues, especially if the sample size of participants is low. However, applying a mixture of these approaches would probably strengthen one another, maximise the validity of the results obtained, and more usability issues would be discovered.

3.6 User Experience

User experience (UX) is a fast growing research area within the HCI community. Law *et al* (2009) have argued that it was challenging for researchers to agree on a definition due to its being an overwhelmingly rich concept; many researchers have attempted to define UX from as early as the 90s when Alben (1996) stated that: *"UX covers all the aspects of how people use an interactive product – the way it feels in their hands, how well they understand how it works, how they feel about it while they are using it, how well it serves their purposes, how well it fits into the context in which they are using it, and how well it contributes to the quality of their lives"*. From this definition UX emphasises the user's emotions and satisfaction using the interactive system in a particular context. Other researchers such as Forlizzi and Ford (2000) have identified elements that influence the user experience in a user-product interaction: user, product, context of use, and social and

cultural factors. Also, the ISO 9241 defines UX as "...a person's perceptions and responses that result from the use or anticipated use of a product, system or service" (ISO, 2009).

A study by Law *et al.* (2009), conducted on 275 researchers and practitioners from academia and industry to gain a common definition, concluded that UX is: 'dynamic, context-dependent, and subjective'.

In this sense, this research is interested in understanding the effect of the environment on the user's experience of using a mobile location-based application for learning in-situ.

3.7 Evaluations in-Situ

As mentioned earlier, some usability evaluations are conducted in-situ. The context could have a significant effect on the usability of any application, especially mobile applications that are meant to be used on the move. The context was defined by a number of researchers (Abowd *et al.*, 1999; Schilit *et al.*, 1994; Brown *et al.* 2010). However, when usability is the main issue, Trivedi and Khanum (2012) argue, "Context is anything which has an effect on the human behaviour". The ISO's 9421 definition of usability mentioned earlier stresses the fact that the usability of a system does not only depend on the features of the system but on the situations in which this system is used. "The Context of Use consists of the users, tasks and equipment (hardware, software and materials), and the physical and social environments in which a product is used" (ISO, 2009). This definition of a usability evaluation in context seems to be in line with the interest of this research in understanding the effect of context on the usability of a mobile learning application for situated learning.

3.7.1 Physical Context

The physical context, or environment, is the natural location of the users when using the evaluated system and what is surrounding them (Trivedi and Khanum, 2012). Lighting and noise levels can all have an effect on the usability (Maguire, 2001b). For mobile phones, the location is not static. Thus, it might be challenging to evaluate applications that could be used in various contexts. However, it is necessary to evaluate the app in these contexts to get a better understanding of the environment's effect on the usability and the user experience. Researchers were interested in the influence of the physical environment on the usability of a system (Kaikkonen *et al.*, 2005; Tsiaousis and Giaglis, 2010). They all concluded that the physical context has influenced the results of their usability evaluations.

3.7.2 Social Context

Social interactions are a part of our everyday life. Therefore, these would normally occur when a person is using his/her mobile app and would have a significant effect on the usability and the user experience of the application (Jones and Marsden, 2006). Examples of social interactions may be interruptions when using the application. These interruptions could be long, such as when running into a friend and getting a phone call or they could be brief, as in answering a quick question from a colleague. Whatever the interruption, it should not have a negative effect on the usability of the application. Although some researchers have shown interest in the influence of the social context on the usability of a system, Trivedi and Khanum (2012) argue that research in this area is inadequate.

This research is interested in understanding whether the social context influences the user’s experience of a mobile location-based application for learning in-situ.

3.8 Pedagogical Evaluation

When designing a mobile learning application to be usable, it is not only the interface or the technical aspects that are supposed to be usable but also the pedagogical content and design. Pedagogical usability evaluation investigates how a mobile learning application supports students’ learning in a particular or various contexts. It is related to the utility of the pedagogical application (Hadjerrouit, 2010). According to Kukulska-Hulme (2007), it is crucial to add elements of pedagogical usability when evaluating mobile learning applications. She argues that incorporating this raises the importance of looking at the relationship between pedagogical design and usability issues. Moreover, some pedagogical usability aspects could be influenced by the discipline. When understanding pedagogical usability the following should be addressed: the learning content, the learner’s needs, the learning experience, process, and outcomes (Kukulska-Hulme, 2007).

There needs to be a well-defined set of metrics and measurements to conduct a pedagogical usability evaluation study.

Ivanc *et al.* (2012) have provided a table of general pedagogical usability metrics, shown in Table 3.

Table 3 Pedagogical usability metrics adapted from Ivanc *et al.* (2012)

Metric	Measuring questions
Instruction	Are the app’s instructions clear?
Suitability of learning content	Is the content suitable for supporting the learner?
Structure of learning content	How organised is the learning content

	in supporting learning?
Tasks	To what extent did performing the application's task help in achieving the learning objectives?
Personalisation	Does the application provide means of personalisation?
Collaborative learning	Does the application support collaborative learning?
Learner control	Does the application provide means of learner's control?
Motivation	To what extent does the application motivate students to develop new ideas?

3.9 Operational concepts

This section will describe the operational concepts as they are used in this thesis.

Critical thinking: is regarded in this thesis as the ability to analyze and synthesize information gathered by observations and generated by reflection and/or communication.

Context: "...the formal or informal setting in which a situation occurs; it can include many aspects or dimensions, such as location, time (year/month/day), personal and social activity, resources, and goals and task structures of groups and individuals" (Brown *et al.*, 2010, p.4.).

Learning Model: the collection of activities performed by the teachers and the students in the teaching and learning process. Starting from teachers setting objectives, in-class teaching, setting coursework, and evaluating against objectives, to students performing tasks with or without the intervention and submitting their coursework.

Framework: the theoretical framework of the contextual mobile application developed in this thesis.

User-centred design: is the approach used in this thesis to develop the mobile application in which the stakeholders are actively involved in the iterative design cycle to assure that it serves their best interest.

Novice user: is a new user, with no experience, of an operating system or a particular smartphone.

Activity: is the task/s the students' are required to perform in order to stimulate learning.

3.10 Conclusion

It was significant to understand and survey the literature of designing for mobile learning and the challenges that could be faced when implementing mobile learning in a curriculum. It is crucial to take such challenges into consideration when designing a mobile learning activity. The ideal situation is to have the mobile learning app available for the majority of operating systems. However, due to the time constraints of this research, only one operating system has been chosen. A number of design frameworks were investigated to find the appropriate one to use in this research. Herrington *et al.*'s (2009) design principles provide detailed guidelines for integrating mobile learning in HE. These guidelines are useful to take into consideration when designing the framework used in this thesis. Furthermore, Ryu and Parsons (2008) framework was chosen to analyse the initial design requirements for the mobile learning activity. This was primarily because of the way the framework was designed, addressing both technical perspectives and learning perspectives.

This chapter has discussed the relevant literature of mobile evaluation and usability. Many researchers argued that the context of use should be taken into consideration when planning an evaluation study (Savio and Braiterman, 2007; Tsiaousis and Giaglis, 2008; de Sá *et al.*, 2008; Cherubini and Oliver, 2009; Harrison *et al.*, 2013). For an evaluation study to be successful, it is crucial to have an understanding of the factors that might have an influence on the results and to predefine the appropriate evaluation criteria. A number of usability questionnaire tools were examined. The System Usability Scale (SUS) (Brooke, 1996) has been found to be a “highly robust and versatile tool” (Bangor *et al.*, 2008, p.574) as well as quick and easy to implement. Above all, Vavoula and Sharples’s (2009) defined a now well-established approach (Ahmed & Parsons, 2012) for evaluating mobile learning.

This research focuses on how mobile application should be designed to support students’ learning in-situ. In order to do so, pedagogical evaluation should be considered. This evaluates the learning aspects of the mobile application and would help in understanding the effectiveness of the app in its learning context. Moreover, the user experience has been a popular research area with the HCI. This research is interested in understanding whether the environment influences the user experience of the proposed mobile app. The next chapter starts by outlining the research objectives and explaining the process of the development of the contextual mobile learning framework.

4 Chapter Four: Development of a contextual mobile learning Model

The aim of this research was to investigate firstly, a blended learning model for students in higher education using mobile technology for situated learning, and secondly, the process of designing a mobile learning app within this blended learning model.

In order to proceed with this aim, a number of objectives have been identified see 1.1.2. The first objective was to construct and demonstrate a prototype for a pedagogical activity assisted by a mobile device to facilitate independent study skills. To achieve this, there needs to be an example and a sample to be treated as the target users in order to develop a relevant mobile application and test it. Hence, The initial situated learning activity has been developed for undergraduates enrolled in the Human-Computer Interaction (HCI) module in the Department of Computer Science and Creative Technologies at the University of the West of England. Lecturers of HCI normally look for ways to expose their students to real world environments, similar to those in which they will eventually be designing, to maximise their ability to identify opportunities for innovation. Hence, the HCI module is a good choice to test the contextual mobile learning model.

The development process has been identified in phases. These Phases were derived according to the User-Centred Design Process (UCD) in the field of HCI. In UCD the user is involved in the whole process of the software development cycle to ensure that the design meets the needs of the user and produce a usable system (Maguire, 2001). The phases for this study were as follows: Phase 1: Requirements and Contextual inquiry Phase 2: Theoretical

Framework Development. Phase 3: System Design and Prototyping. Phase 4: System Evaluation and usability studies.

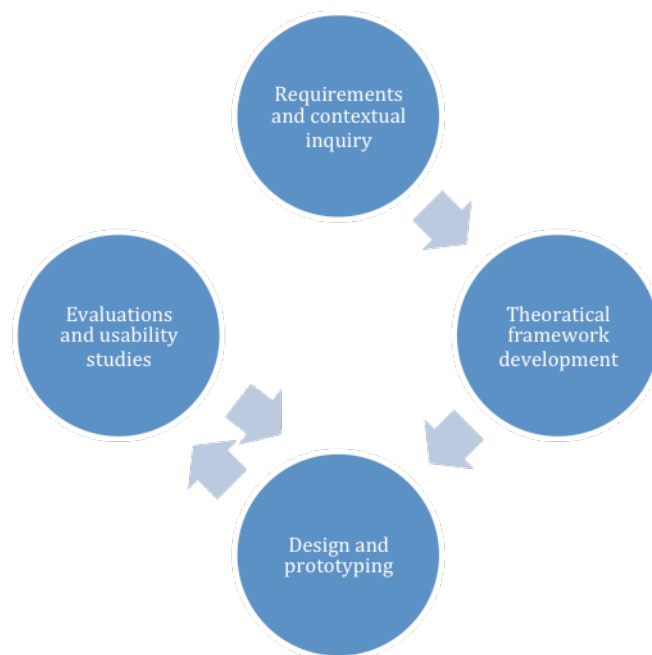


Figure 8 Iterative Development Process

This research was conducted to have a better understating of issues that might occur when deploying a mobile application in a situated learning context for HCI student. As this research involved testing with students, university ethics approval was gained. The literature review of mobile learning, applications and technologies, and educational theories as discussed in Chapters 2 and 3 gave a comprehensive knowledge of the current state of the art. This knowledge has helped in shaping the design and trigger ideas for the app and the approach for integrating it as part of a blended learning experience.

This chapter explains and discusses the first two phases of the development process: the requirements and the theoretical framework. Below are figures of the overall iterative design activities and a detailed timeline of activities

conducted as part of the whole iterative development process explained in this and the following chapter.

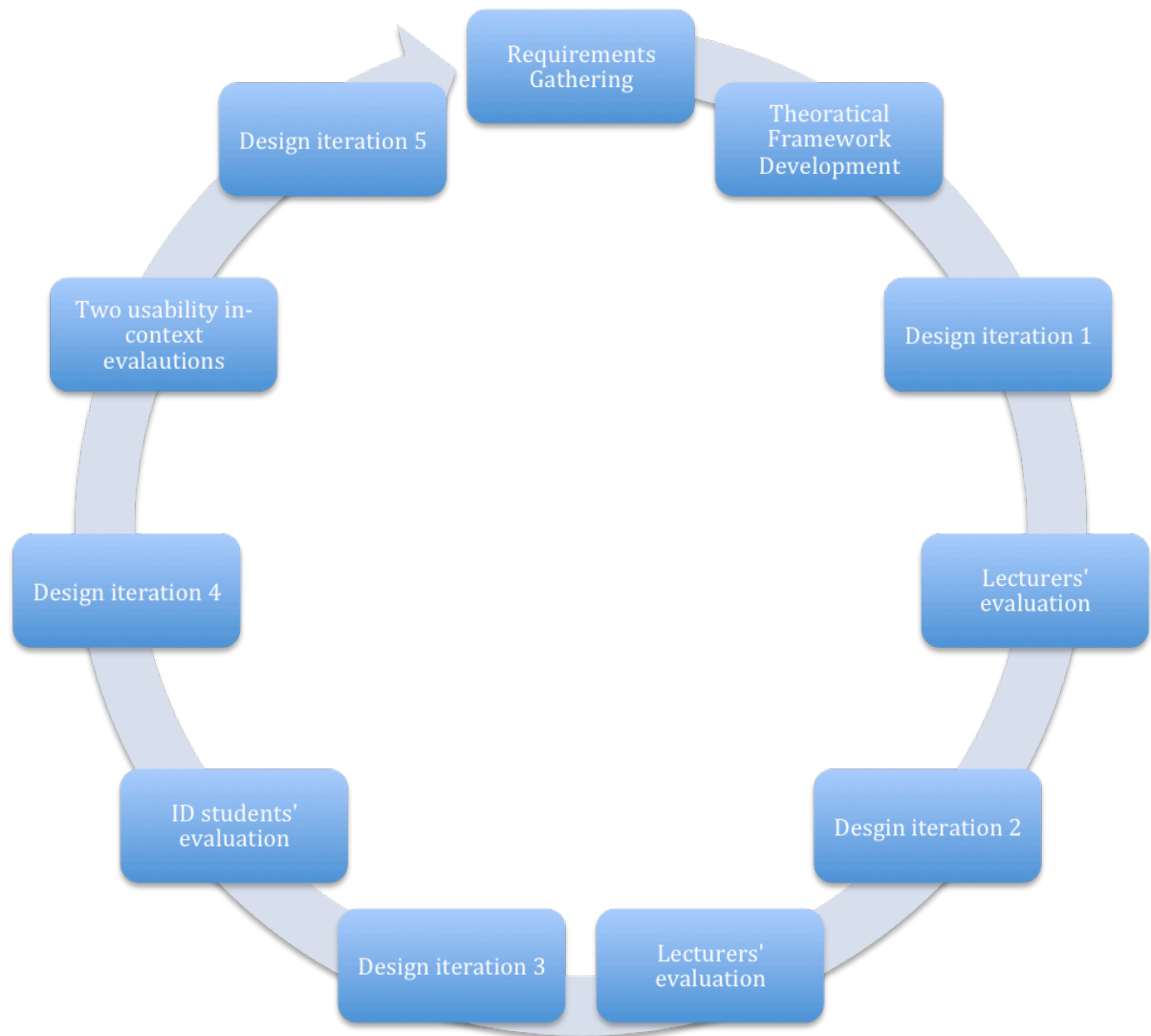


Figure 9 Detailed activities within the iterative development process

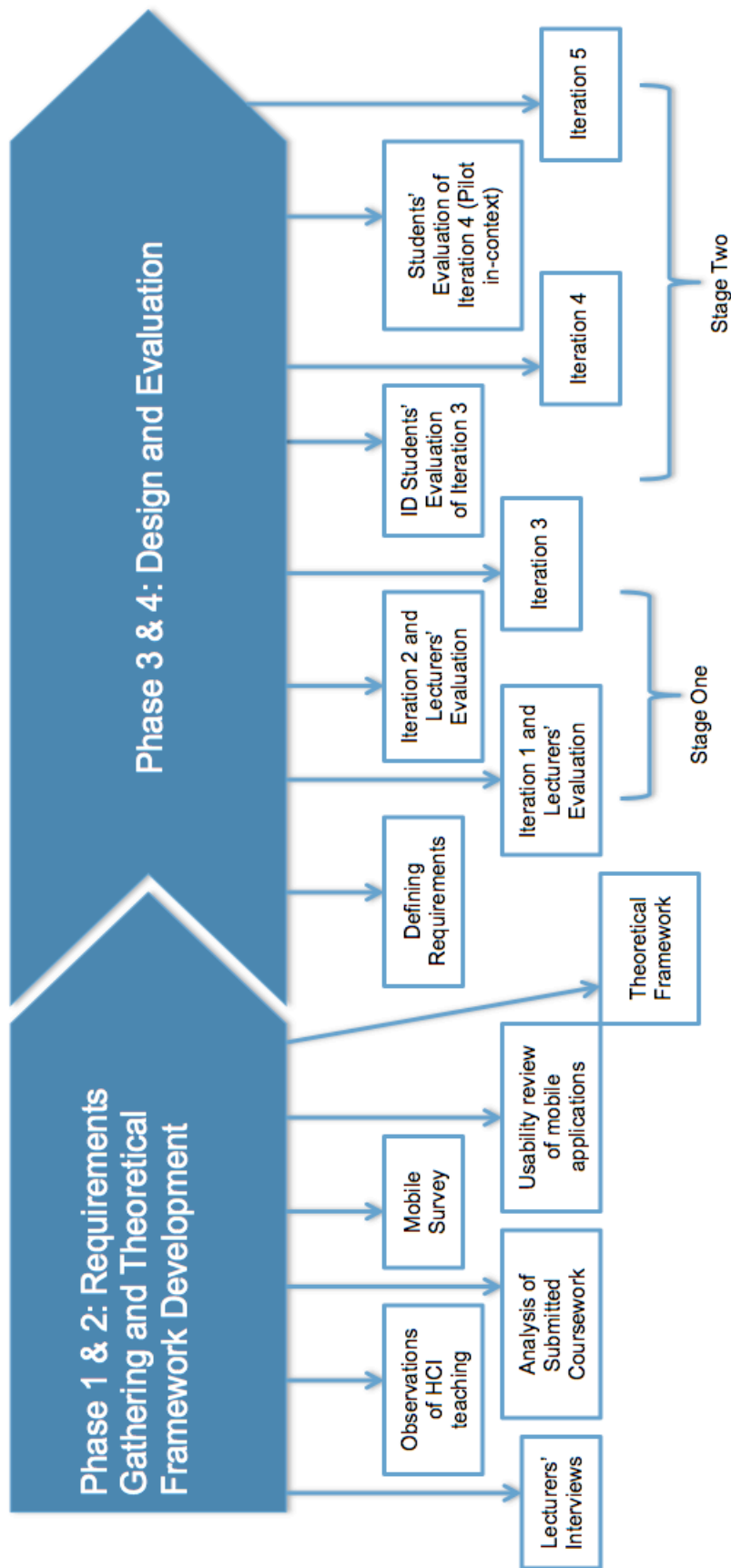


Figure 10 Development timeline showing the different activities that involved the stakeholders

4.1 Phase One: Requirements and Contextual inquiry

Requirements' gathering is an essential part of UCD strategy within the field of HCI. Contextual inquiry (Holtzblatt and Beyer, 2013) is crucial to establish a deep understanding of the current situation, to thoroughly identify the user needs, to identify the functional and non-functional requirements of the application, and to know how the proposed application could aid in overcoming the current difficulties. Moreover, requirements gathering can be seen as method of exploratory research. The problem being investigated has not been precisely described (Shields and Rangarjan, 2013). In order to do so and to develop the theoretical framework, phase two of this research, the following mixed methods were undertaken in the academic year 2011/2012. The findings of all the methods discussed below were triangulated. Triangulation of the results of the mixed methods avoids the limitation or bias that might occur in any of the single methods. Thus, it supports the resulting findings (Adams and Cox, 2008).

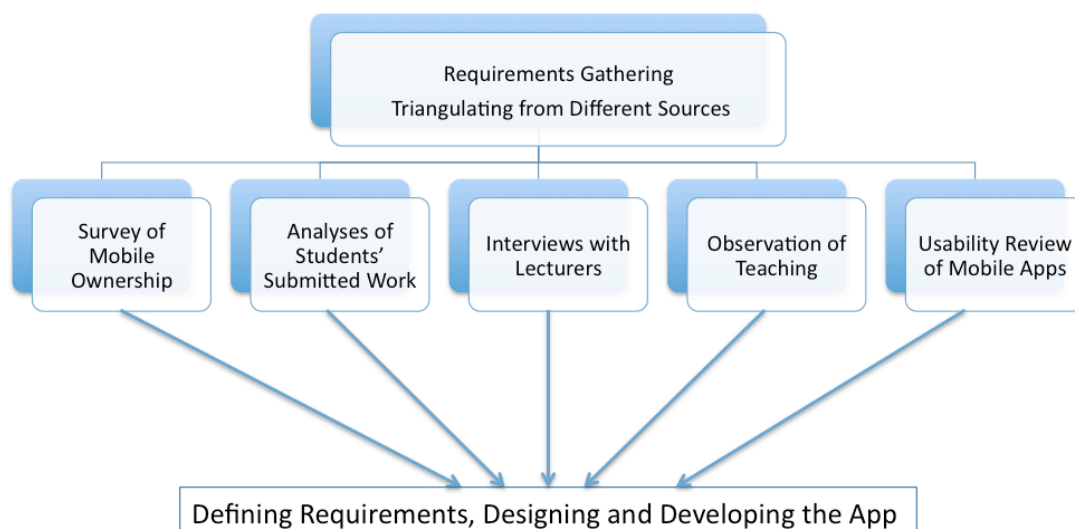


Figure 11 Requirements and Contextual Inquiry mixed methods

4.1.1 Interviews

Interviews are significant in gathering requirements and understanding the needs of the users (Lazar *et al.*, 2010). In-depth interviews are one of the methods used in understanding a problem that has not been precisely described (Shields and Rangarjan, 2013). Cohen *et al.* (2007, p. 349) describe an interview as “a flexible tool for data collection, enabling multi-sensory channels to be used: verbal, non-verbal, spoken, and heard. The order of the interview might be controlled while still giving space for spontaneity, and the interviewer can press not only for complete answers but also about complex and deep issues.” Interviews have different methods such as: structured, semi-structured, and unstructured. A Structured interview has a precise, fixed agenda with specific questions that are asked to all of the interviewees. However, there should be some flexibility especially when participants start to give an answer for a latter question (Adams and Cox, 2008). An Unstructured interview is where the interviewer does not have a pre-determined agenda and questions are asked to the interviewees depending on the given responses. A Semi-structured interview is a mix of both unstructured and structured interviewing. These three methods usually take place on a one-to-one basis with an interviewer and an interviewee. The group interviewing method involves an interviewer interviewing a number of participants in a group. In this situation, responses of one participant may trigger inspirations and/or responses from another participant, possibly leading to a flowing discussion from different participants, which can provide same, similar, different views on the proposed topic (Taylor *et al.*, 2002; Cohen *et al.*, 2007).

It was crucial to explore and understand the lecturers' point of view about various issues regarding their HCI module. Hence, an exploratory interview study methodology was chosen.

The aim was to explore the following issues with the lecturers teaching the HCI module:

1. Their current practice of teaching students, especially concerning the PACT framework has been explained to them,
2. Their current approach to explaining assignment to students,
3. The students' current practice in completing the assignment, the difficulties they encounter, and the reasons behind these difficulties from the lecturers' point of view, and
4. What they would hope this intervention would achieve.

A series of unstructured interviews with two lecturers teaching the HCI module were carried out. This was a significant part in the requirements gathering as it highlighted the functionalities of the application that's needed to be considered when designing and developing. Furthermore, the context of use is significant and plays an effective role when gathering data (de Sá *et al.*, 2008). Thus, since this phase of the research is regarded as contextual, one of the interviews took place at the environment in which the mobile app would be used. The following sections present the findings of the interviews.

4.1.1.1 In-class teaching

In the HCI module, students learn about how people undertake activities in context using technologies. They apply the PACT framework, explained in 2.5, to analyse situations in order for them to design interactive systems Benyon (2010). The lecturers explain the PACT framework in detail to

students giving them specific examples to clarify the concept. These include scenarios such as (a) a female student using her smartphone to send a text message whilst on a moving bus, when she is seated, when she is standing holding on to a bag and an overhead strap for balance, and when the bus is extremely crowded, and (b) an elderly woman setting her burglar alarm which is located in a dimly lit passageway, with situations where the elderly woman has different age-related conditions. These example scenarios are formulated to support the students in understanding the elements of the framework. Photographs are shown to provide students with a realistic view of the physical environment and the students are encouraged to discuss the issues and draw on their own experiences where appropriate. However, the weakness is that the students are not able to immerse themselves in the actual environment to get a tangible understanding of the constraints, and therefore fail to develop empathy for the users.

4.1.1.2 *Practical learning activity*

As explained above about the current model of teaching, this learning thus needs to be reinforced by practical activities. Thus, as part of one of their assignment activities, students are required to conduct a requirements study for the design of a new technology. In the past this has included the design of a university information kiosk and a digital guide for a music festival. This year students were asked to consider the design of a self-service checkout for use in a cafeteria. As part of their work for this module, students were required to design a graphical user interface (GUI) for a touch-screen based kiosk. In order to do so they were required to conduct requirements gathering and analysis to produce a set of artefacts such as a PACT analysis, personas and

scenarios, and a set of functional and non-functional requirements. A crucial part of this requirement gathering process is to carry a thorough analysis of the current situation where the proposed kiosk will be installed. To conduct the analysis, number of activities such as observations of the OneZone cafeteria (Main University Cafeteria at UWE) at various times, to consider their own experiences, as well as to conduct short interviews with at least 3 stakeholders. The requirements gathering process involves exploring opportunities for a technological intervention, ensuring that the solution developed will suit the particular situation/users. The emphasis is thus on gaining a really deep understanding of the people involved, their activities and the context thus generate empathy. The student designer needs to consider the question: 'what are the opportunities, constraints and barriers within the situation that need to be addressed?'

Students were then required to present their findings as a mind-map/, ensuring that there were clear links between the People, Activities and Context elements and the Technologies considered. They needed to explain in separate paragraphs and in relation to each element of the PACT framework, why the points that they had noted were of significance.

This was explained to the students in class and described on their coursework assignment specification alongside the marking criteria.

4.1.1.3 *The students' current practice of the assignment from the lecturers' point of view*

It is crucial to investigate the lecturers' understanding of the students' current practice, the difficulties they encounter, and the reasons behind it from their point of view. Lecturers' assessment of the work gives them the impression

that some students get distracted by the environment and sometimes forget the main purpose of their assignment. From their experience, students miss out key details when carrying out their analysis, leading to a disconnected analysis, especially between the elements of PACT. Also, students tend to forget that 'people undertake activities in context using technology'; as a result they fail to consider the implications of what they have identified for each of the elements, People, Activities, and Context, in relation to the Technology. They thus miss the purpose of their assignment, to analyse the situation and consider technologies that reflect peoples' needs when carrying out certain activities in a particular context. In some cases, students fail fully to engage with, or appreciate the relevance of going to the location at all, and complete the activity in a rushed manner with little or no reflection.

4.1.1.4 *The lecturers' view of the intervention*

Sending students out into real-world environments with a brief to be evaluative and analytical, without the presence of a teacher, can lead to a superficial and frustrating experience, especially for students with beginning levels of analysis and limited critical thinking skills. Therefore, having a mobile application that could assist in carrying these activities could help resolving issues faced by students discussed in the requirements gathering phase of this research.

The lecturers want this mobile application to assist students when carrying out their analysis. They want it to provide students with prompts when they are at the location. These prompts should address the students' weaknesses already identified by the lecturers and also from the analysis of the previous

students' assignments, discussed later. The lecturers suggest that the students should be able to capture images using the application, take notes, and track their own progress.

4.1.2 Observations of teaching

In addition to the interviews with the lecturers, observation of teaching was conducted over two lectures, which consist of four hours of teaching covering the topics of the assignment. This gave a better understanding of the current practice. Attending HCI lectures was a crucial part of the research to get an insight into how students engage with the lectures and what question they might raise about the PACT framework and the assignment. In addition, observing the collaboration forum on Blackboard was very useful in gaining more knowledge of the students' queries and concerns and the feedback given by the lecturer. The students concern was about the elements of PACT and the relationship between the different elements. This raised significant questions that needed resolving. To what extent is it crucial to encourage students to use the PACT elements correctly? Is it a tool for bringing to light many factors or do we value it as a categorisation tool? It was important get back to the lecturers to discuss those two issues. It was agreed that we should remind students of the PACT elements without putting undue emphasis on categorisation.

4.1.3 Survey of Mobile ownership

A survey was conducted to give a clearer picture of student ownership and use of smartphones in the locale of this research. This survey aimed to: (A investigate the University students' ownership and usage of smartphones, (B explore the potential of using mobile smartphone devices for learning. The

results from the survey have helped in making some of the choices such as the operating system and locative media. The survey questions can be found in Appendix (A).

Subjects

88 students have filled out an online questionnaire about their ownership and practice of mobile phones, of which 58 undergraduate students aged between (17-30) and 30 postgraduate students aged between (22- 50). Of the 88, 60 were males while 28 were females. The questionnaire was distributed to them through the students' union or through the lecturers of the HCI module in October 2011.

Materials and Procedure

The questionnaire consisted of 15 questions divided between three sections. Five demographic questions about their age, gender, faculty, and course; 6 questions about their mobile device' make, model, operating system and data usage; 4 questions about privacy issues, GPS usage, and whether they were prepared to share their location with peers and lecturers; and an optional open ended question for any further comments.

4.1.3.1 Survey Analysis

The analysis of the survey results is presented along with a discussion of the implications of results on the research.

4.1.3.2 Mobile Devices' ownership

Upon analysing the questionnaire, it was found that the two major operating systems for smartphones used by students were Android and iOS. 31.8% of students owned an Android based mobile phone while 26.4% owned an iOS

Apple iPhone. However, 23% of the students were not sure what operating system is running on their phones. Table 4 shows the distribution of the operating systems.

Table 4 Operating Systems

What Operating system is running on your device?

	Frequency	Percentage
iOS	23	26.1
Android	28	31.8
Blackberry	14	15.9
Symbian	2	2.3
I don't know	21	23.9
Total	88	100.0

4.1.3.3 Data Usage

When asked about their data usage, 58.9% of the students have a data contract while 40.2% do not. Of 58.9% whom own a data contract 90.2% think that their data allowance is adequate.

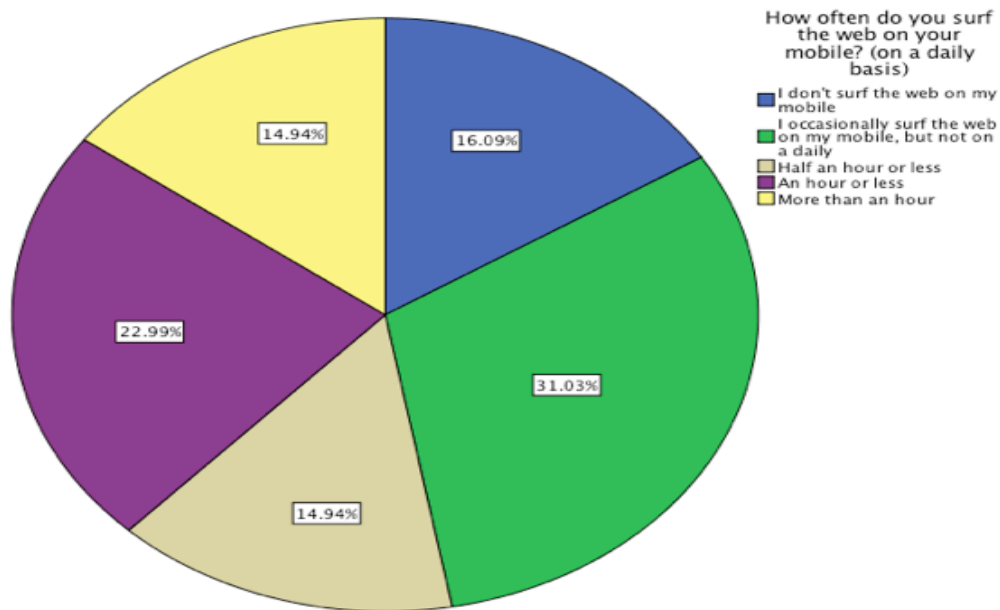


Figure 12 Daily web surfing

4.1.3.4 Privacy Issues

This part was crucial to understand the students' current practice regarding GPS enabled applications and whether they were ready to share their location with their fellow students and lecturers. The survey showed that 73.2% of students do not use GPS-Based location applications, such as Foursquare (Foursquare Labs, 2013). When asked about the reason behind not using it, 50.8% said they never needed to, 42.4% said because they liked their privacy and 15.3% were not interested in social networks. However, of the 26.8% of students that use GPS based application only 26.1% use it openly while 65.2% limit the access to friends and family. When asked whether they were be prepared use GPS-Based location applications for learning purposes (with fellow students and/or lecturers)? I.e.: an activity which requires you to reveal your location to students and/or lecturers through the application to exchange and share knowledge on a particular assignment. 42% agreed that they would

use such an application, sharing location information with both students and lecturers, 12.3% said they would share with students only, 8.6% said they would share with lecturers only while 37% indicated that they would not like to share their location data. When asked about the reason behind it, 66.6% were worried about privacy while 33.3% did not see the relevance of using such an application in learning.

4.1.3.5 Statistical Analysis of Privacy Issues

To know whether there was a significant difference between the mean responses of the sample due to faculty, course, type of study, age, and gender, non-parametric tests were applied as the data does not follow the normal distribution. The Kruskal-Wallis Test was used between three or more groups of data while the Mann and Whitney Test was used between two sets of data.

A Kruskal-Wallis Test found that there were no statistically significant differences in the response of respondents of the privacy issues questions due to their faculty, the course, and their age as the potential value (Sig.) for all areas was greater than the significance level (0.05).

Moreover, the Mann and Whitney Test found that there were no statistically significant differences in the response of respondents to the privacy issues questions due to their type of study (Undergraduate or Postgraduate). However, when looking at the gender, there was a statistically significant difference in their answer to last question of the privacy issues (Would you be prepared use GPS-Based location applications for learning purposes) depending on their gender. The potential value (Sig.) was $0.045 < 0.05$. Table 5 shows the mean ranks.

Table 5 Mean ranks for (Gender)

	Gender:	N	Mean Rank
Would you be prepared use GPS-Based location apps for learning	Male	60	41.01
	Female	28	51.98
	Total	88	

4.1.3.6 Discussion

The analysis of this questionnaire shows that the two preferred operating systems were iOS and Android. The Android has a slightly higher preference with a percentage of 31.8% compared to 26.4% for iOS. This finding has influenced the choice of which operating system should be used when implementing the application for this research. The analysis showed, as well, that students care about their privacy and would not easily compromise it. A high percentage of 73.2% are not using location based social application where 42.4% pointed out that privacy was the reason for not using such applications. What's more, only 42% of students said they would be prepared to use a location based social application for learning purposes. This finding is especially of interest as it has influenced the choices for functionality and design of the application of this study.

4.1.4 Previous Submitted Coursework

In order to have a better understanding of the issues lecturers have described in the interview, in which the students face when doing the activity, an analysis of submitted coursework by students from the year 2011/2012 and feedback from lecturers on the work was conducted. This has given a better

understanding of the weak points in students' work and the areas in which support is most needed.

Undergraduate students in their second year enrolled in the HCI module were required to submit a portfolio of small assignments. 47 out of 48 students submitted this part of their portfolio. The work of these students was looked at carefully and analysed. Each student's work was separately scrutinised to identify his/her weaknesses and any good practice. It is crucial to know how common a particular issue is among the students to gain an understanding of whether that issue needs to be considered when designing and developing the application. The analysis was verified by checking its correspondence with written feedback from the lectures on each aspect of their work.

To anonymise the students, each was given a number from 1 to 47 and the occurrence of each issue counted in each assignment. Table 6 shows the issues identified and occurrences.

Table 6 Issues and occurrences

Issue ID	Issues	Total number of students
A	No clear links of the issues discussed in P, A, and C with Technologies.	17
B	Some issues were not related to the right element of PACT.	11
C	No real consideration of the human factors.	10
D	Issues were general and not mainly context related.	6
E	No links of the issues discussed in P, A, and C with Technologies.	8
F	Gave the issue with the solution rather than putting the solution under Technologies and	10

	linking it with PAC.	
G	Need more thoughtful consideration of the context	5
H	Need to address issues found under each PACT element.	3
I	Technology issues could be expanded.	3
J	Linking should be more explicit.	6
K	Need to find solutions to current problems not eliminate ideas because of that problem.	2
L	Need to think about and address issue from observations, experience.	1
M	Need to identify issues under each P, A, C, and then see what T can allow for the proposed self-checkout not for the cafeteria.	4
N	Need to consider human factors in more depth.	4

In Table 6 we can see that 36% of the students had difficulties linking the characteristics of the people, activities, and context identified to technologies. In other words they should have identified the technologies that would serve the characteristics of the people carrying out certain activities in that particular context. Furthermore, 23% of them had issues with understanding the PACT framework itself. However, it should be noted that the lecturers had not put a great deal of emphasis on this, as mentioned in 4.1.2. It is clearly important to consider the people who will be using the technology; nevertheless, 21% of students did not give this much attention. The chart below shows each issue with the corresponding percentage of students to whom this applies.

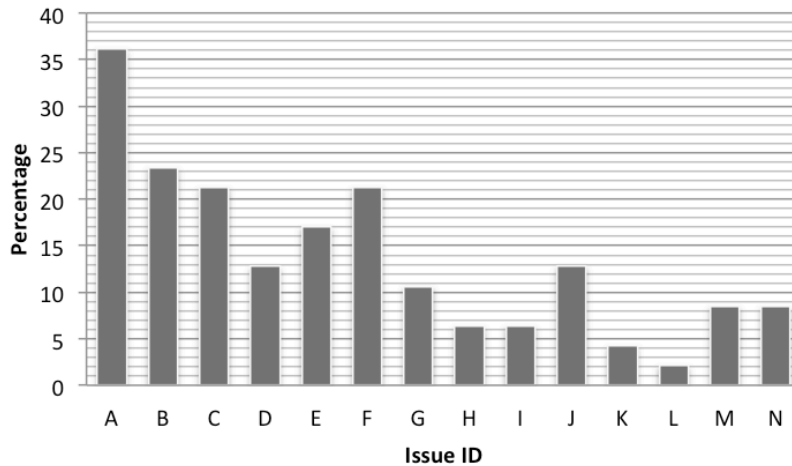


Figure 13 Percentages of the occurrences of issues

4.1.5 Focus Group

The aim of this focus group was to understand the students' experience doing their coursework, to highlight the issues they had and the difficulties they faced when conducting their requirements' gathering, and to get their insights about how they think a mobile app would help them overcome these issues.

Five students showed their interests in attending the focus group. Hence, a Doodle (2007) page was created to schedule a time the suits all five participants.

Four participants agreed on a time for the focus group. However, due to other commitments they were not able to attend and could not reschedule. Thus, no data was gathered from this method.

4.1.6 Usability review of mobile applications

It is crucial to understand the usability issues that might be face when interacting with the mobile application. Hence, a review of mobile applications was conducted. This review gave an understanding of what usability issues

students might encounter when using such an app, and how the educational features should be configured given any constraints of the technology.

Examining a range of apps and designs, see Appendix I, has highlighted the following issues, which have been consolidated into four different categories.

People:

The main users of our app will be higher education students. However, students still vary. They might have:

1. Physical differences such as size of hands and impairments (visual, hand and finger movement).
2. Psychological differences such as learning style preferences, different capacity for remembering things, varying levels of stress and frustration.

Activities:

Since the app is meant to be used in-situ, there are number of aspects that should be considered:

1. Temporal Aspects: The app will be used at different times of the day where the environment could be busy or quiet. Interruption is likely to occur and the student should be able to return to same point pre interruption. The app's response time should be adequate.
2. Cooperation and Complexity: The app is meant to be used by one student; however, the content may be shared and so should be easy to access for all students. Contribution of data in any shared space should be clearly attributed to the student who made the submission.
3. Content: To solve the issues that were identified in Table 6, the content should be considered carefully to address these weaknesses,

the text and images should be clear, should provide the ability to take photos, and write notes.

Context:

1. Physical Environment: the app could be used indoors or outdoors, in different light and weather conditions.
2. Social Context: Students may prefer to be in pairs or groups and the environment might be crowded and noisy.
3. Organisational Context: When looking at what the app might provide regarding the educational institution, it should not add to the lecturers' workload, it should improve students' knowledge and learning, and it should be cost effective from a teaching resource perspective.

Technologies:

Now that we have identified the above, it is crucial to associate them with proper technologies.

1. Input:

- a) Touchscreen: clear and adequately sized buttons to cater for the physical differences.
- b) Text: ability to type in notes and observation and allow editing, mistakes that might happen due to interruption or busy environment.
- c) Images: The ability to capture photos using the integrated camera on the smartphone.

2. Output:

- a) Text: Must be of a good size, with hints written in language that supports different abilities.

- b) Images: Should coordinate with the appropriate notes.
 - c) Auditory: Must be kept to a minimal due to the environment.
3. Communication: fast response time, Internet connectivity, allow for service interruption and provide feedback as appropriate.

4.1.7 Phase One Findings

This section will explain the insights gained so far. It also explains how these were translated into design features. As discussed earlier, the findings of the contextual methods used above were triangulated to support and reinforce the findings of this phase and ensure all aspects were covered.

Students lose focus on the purpose of tasks when away from classroom. They may get distracted by their surroundings and miss out key elements. So a key feature of this mobile application could be to remind students of the purpose of their learning and to support their progression through the activities in a personalised manner.

When students reach a pre-specified location, the application should display a detailed map identifying the various sub-locations and containing either text and/or images. These prompts could be designed to aid them in widening their perspectives, in developing their own ideas and in critical evaluation. The text notes could vary from simple instructions and prompts, to questions, and in some cases to links that will open a quiz webpage; the particular content would depend on the specific aspect that the lecturer would want the students to focus on.

It is important to encourage students to think of issues beyond their own experiences and perspectives. Providing students with functionality to share comments, ideas and perhaps stories if desired, may enable them to benefit

from their peers' knowledge and different perspectives. Adding a collaborative learning aspect to the activity, students will be able to share their comments with their lecturers and fellow students.

Students have varying levels of ability when it comes to design thinking, and they work at different rates. A mobile application such as this provides opportunity for personalised learning, these include paced progression, checklists to give a sense of achievement and motivation, and structured disclosure, based on the students' level of interaction with the application.

Some students have been found to struggle in analysing their findings and specifically in using their findings to develop new ideas. Prompting them with probing questions that challenge their assumptions or get them to explore other methods of requirements gathering, beyond observation, could help them identify innovative opportunities. This approach could also address the problem of their failing to identify appropriate technologies for the specific characteristics identified in the earlier analysis.

4.2 Phase Two: Theoretical Framework Development

The focus of this phase was on developing a theoretical framework of the project based on the findings of the previous phase, the requirements' gathering, and an intense literature review. The literature survey revealed the current state of research in the related areas which prevented repeating findings. It helped in identifying the gaps in knowledge and gave a better understanding of how this framework could fill in these gaps.

Since one of purposes of HCI education is to build future designers, future designers should be exposed to real world situations. Thus, the situated

learning paradigm (Lave and Wenger, 1991), discussed earlier in 2.4.1, is the appropriate theory for this research.

In order to build the requirement framework, a number of existing general frameworks have been examined to choose the most relevant one for this research. I have chosen the work of Ryu and Parsons (2008) as an appropriate framework for developing the design requirements' framework. This was primary because of the way the framework was structured addressing both technical perspectives and learning perspectives as described in section 3.2.1. It is vital to have a clear understanding of the design requirements and the relationships between them. In addition, this framework addresses the learning activities that this research is most interested in, situated, collaborative, and individual learning activities. A careful consideration was taken when designing the actual activity for this research. It was significant to try to incorporate all characteristics of mobile learning identified in the literature. Lee and Lee (2008) defined mobile learning as being situated, learner-centred and spontaneous, customised, connected, and flexible. The proposed mobile application allows students to learn in situ at their preferred time, giving them the ability to observe and note, connecting them with their peers, and giving them some prompts. The given notes are there to guide but not limit. The figure below shows the design framework for the mobile learning activity in this research.

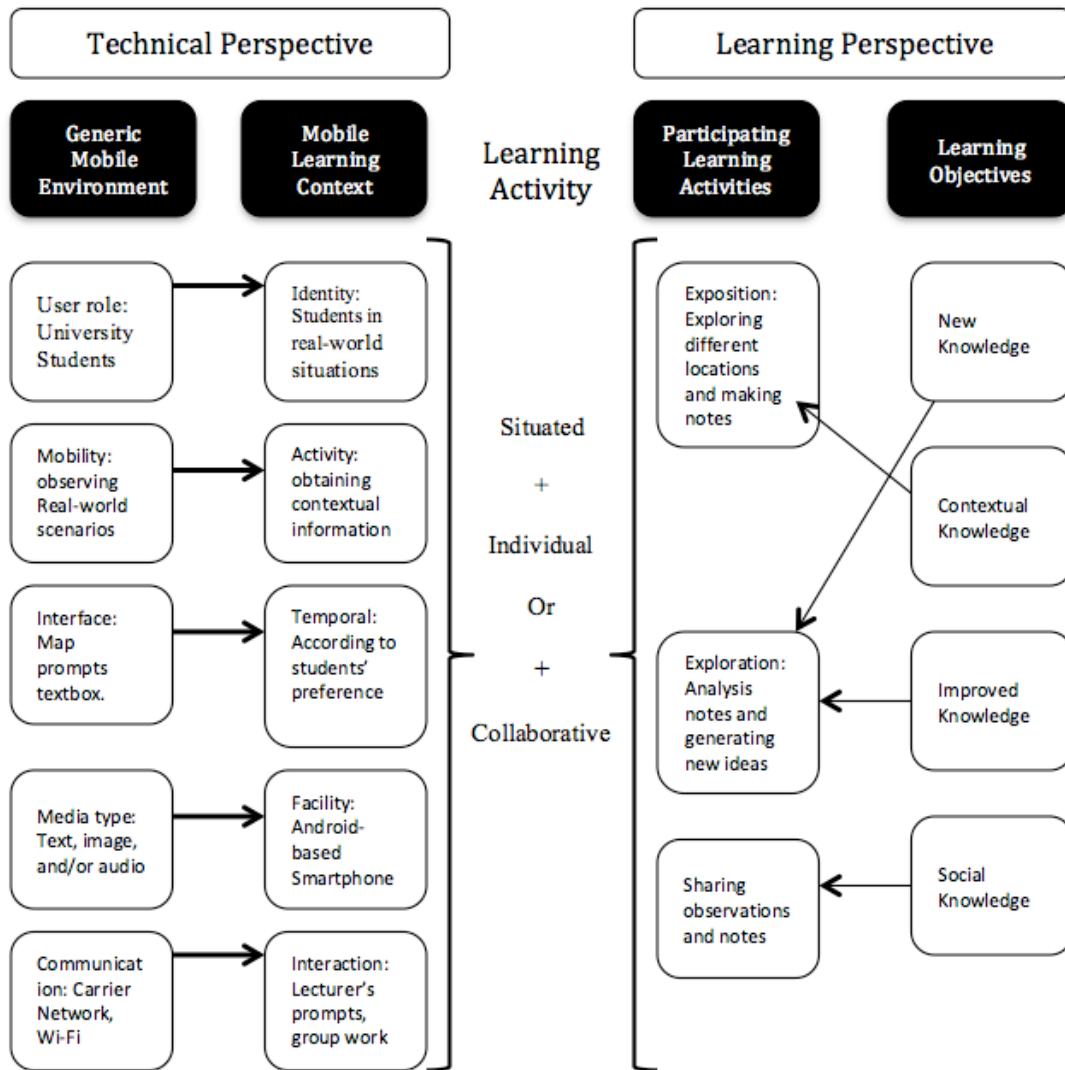


Figure 14 sLearn's Activity Design Framework

As the above framework shows, this activity is designed for undergraduate HCI students investigating real world situations. The sLearn application will be developed initially for Android-based smartphones where the interface needs to provide the student with a map and/or images of the area investigated, hints from lecturers, and textboxes to save his/her notes. Students will visit the area at different times based on their preference. The mobile communication method would be either the carrier network or Wi-Fi if available. Having special hints for each location provides students with contextual knowledge. Having the ability to type in their observations will allow

them to analyse their notes at a later time and generate new ideas, which would mean improved knowledge. Moreover, having the ability to share their observations with their peers allows for social knowledge. The above explanation has incorporated Herrington *et al.*'s (2009) mobile design principles discussed in 3.2.1.

Many modules require students to investigate real-world scenarios, so this framework needs to be flexible to enable deployment in other similar learning contexts. Table 7 describes the situated learning activity of this research. This analysis is related to the design framework shown above and has been derived from Parsons *et al.*'s (2007) analysis of previous projects.

Table 7 Analysis of situated learning Activity using sLearn

Objectives	Learning Experience	Learning Context	
<p>Individual Learning (Improving Skills) Observations and Investigations, Reflection, and Analysis</p> <p>Collaborative Learning Communicating ideas, Consolidating</p>	<p>Organised content: <i>For different locations, different things to look for and observe/investigate</i></p> <p>Outcome and feedback: <i>Notes observations/investigation saved and shared if desired</i></p> <p>Goals and Objectives: <i>To observe/investigate real world scenarios To analyse what was observed To discuss and reflect on findings</i></p> <p>Conflict, competition, Challenge, opposition: <i>Discussing the analysis and finding</i></p> <p>Social interaction: <i>Peer/group forum to consolidate findings</i></p>	<p>Identity: <i>HE students (under/post graduate)</i></p> <p>Activity: <i>To go to predefined location and carry out observation/investigation activities and collecting data to further analysis and discussion</i></p> <p>Spatial-temporal: <i>Predefined location, at a time of students' preference</i></p> <p>Facility: <i>Smartphone Application. Initially Android-based smartphone</i></p>	<p>User roles: <i>Students observing/investigating, collecting information</i></p> <p>Mobility: <i>Smartphone</i></p> <p>Interface design: <i>Photo of the location, lecturer's prompts/hints, capturing images, taking notes, collaboration support.</i></p> <p>Media: <i>Images/texts</i></p> <p>Communication: <i>Cellular data, Wi-Fi</i></p>

		Collaboration: <i>Lecturer's prompts/questions, going with peers</i>	
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It is important to consider carefully the types of prompts to be provided to the users of this mobile application, higher education students. At this level prompts should only give some hints to the students regarding what they should look for and observe or investigate. They should be able to develop their own understanding of the situation and develop their own insights. These expectations should be clearly explained to students prior to the activity.

It is envisaged that providing students with a mobile application with structured guidance will be particularly helpful for students who need additional support in analysing a situation in a logical manner. Being able to have this structured support available outside of a classroom will open access to their formal learning in an informal setting, which they can complete at their own pace. Enabling students access to their peers' notes and observations should also help in consolidating their knowledge with the expertise of other students with different perspectives and attention to detail, also encouraging collaborative learning. As discussed in the literature, this was proven helpful to students in a number of studies (Ractham and Firpo, 2011; Leelathakul and Chaipah, 2013).

4.3 Conclusion

This chapter has given the rationale behind the importance of situated learning for HCI students. Application focused research into mobile situated learning in higher education is rapidly growing. This research has potential to add to the understanding of how mobile applications can assist students

learning in-situ and to develop analysis and critical thinking skills. In order to develop applications of this type, the development of the sLearn application was divided into four phases: requirements and contextual inquiry, theoretical framework development, design and prototyping, and evaluations. It is important to consider the issues associated with the learning experience from a range of perspectives. This chapter discussed the interviews conducted with the lecturers of the HCI module, observation of the teaching process, both face to face and via discussion forums, mobile ownership survey, usability review of mobile applications, and the analysis the students' submitted assignments, as a part of phase one; this data has highlighted the specific difficulties that students encounter, and thus helped establish the functional and non-functional requirements to be considered when designing and developing the mobile application explained in the following chapter. Also, the theoretical framework was derived and explained in detail. The following chapter will continue with the remaining phases of the development process.

5 Chapter Five: The Design and Evaluation of a contextual situated mobile learning app (sLearn)

In this research, an iterative design and prototyping approach was followed. Conceptual design enables the translation of requirements into a conceptual model. A conceptual model is “a high-level description of how a system is organised and operates” (Johnson and Henderson, 2002 cited in Rogers *et al.*, 2011).

Prototyping is an effective way to discuss design ideas with stakeholders. It is well recognised that it helps in testing technical feasibility, understanding requirements, testing and evaluating, and assuring design compatibility (Rogers *et al.*, 2011). The iterative design and prototyping approach is a cyclic process of defining requirements, designing, coding, and testing.

This proposed system has been designed for smartphones, providing students with structured support as they learn about their subjects in a real-world context. When students reach a pre-specified location, the application will display a detailed map identifying the various sub-locations, which contains either text and/or images provided by their lecturer. These prompts are designed to aid them in widening their perspectives, developing their own ideas and in critical evaluation. The text notes will vary from simple words to questions, and in some cases they could be to links that will open a quiz webpage; the particular content depending on the specific aspect that the lecturer would want the students to focus on. Furthermore, to add a collaborative learning aspect to the activity, students will be able to post their comments for their lecturers and fellow students to take note of.

Designing a mobile application to be used by students in context is not as straightforward as it may seem. Many elements have either direct or indirect influence; students' different learning styles and preferences (Traxler, 2009), the context's various elements and its effect, and the nature of the content delivered. The design of sLearn was developed in two main stages. Stage one involved initial designs and evaluations from lecturers of the HCI module and expert review; stage two involved evaluations and redesign of two working prototypes.

As this research was following an iterative approach, testing was performed on early prototypes of the system. This has included paper prototypes that tested early concept through to working prototypes in-situ. Conducting a valid evaluation of mobile technologies presents a range of challenges in the field. This research was exploring a range of methods and it was envisaged that the use mixed methods will aid in identifying most of the possible issues.

During the cycle of the design and development of sLearn, a number of evaluations were conducted with the various stakeholders to ensure that their needs were met. Other methods for usability studies were also employed such as observations, interviews, and questionnaires methods. A set of appropriate usability criteria has been identified for the usability evaluation studies. This chapter will first present the defined requirements then the iterative design process followed.

5.1 Defining Requirements

Following the requirements analysis and theoretical framework development conducted in phase one and two, a better understanding of the situation and what the users' needs was given. It was significant to define the scenario of

use, the initial functional and non-functional requirements of the application, and to describe the application's architecture.

5.1.1 Scenario of use of the app

The scenario for this particular activity as explained in section 4.1.1.2 shows that students are required to conduct an analysis and observations of the users and environment that they will be designing the system to be used in.

The lecturer will explain the assignment to the students and will inform them of the availability of a mobile application (sLearn) for them to use in that context i.e. the environment. The full specification of the assignment will be available to students via Blackboard. Students will have the freedom of either going on their own or with their peers.

A typical scenario of use of the app from the students' perspective comprises the following steps: downloading the app on to a smartphone, going to the location in which they are required to conduct the analysis and starting the sLearn app. The app would need to include a detailed map of the whole location and various sub-locations which the student needs to investigate. The student would start by choosing one of the sub-locations where he/she would be provided with a number of prompts or questions that he/she would need to consider in regards to that particular sub-location. The student would then record his/her observations by typing notes into the app. The student would also have an option of taking photos to support his/her findings, and sharing these findings with peers. The student could choose to investigate another sub-location whenever he/she desires.

Scenario B: two students will go together sharing the application. They will look at the prompts on the app for hints, will write their notes, and will share what they have found with the rest of the group members.

A Hierarchical task analysis (HTA) (Kirwan and Ainsworth, 1992) was used to define the structure/process of usage of the app – Figure15 below describes the hierarchic usage of sLearn.

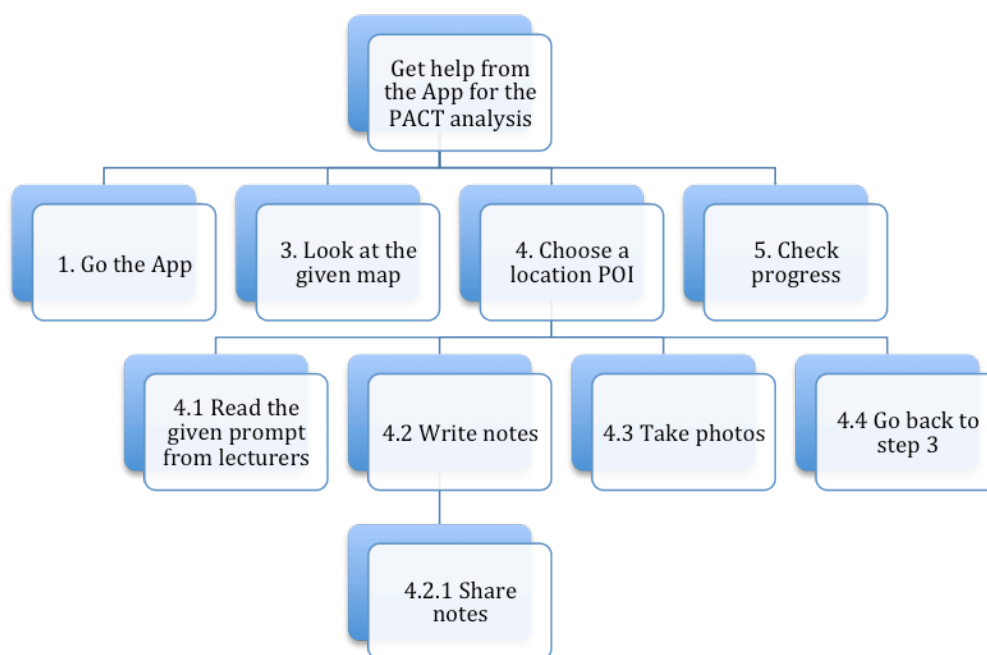


Figure15:Hierarchical Task Diagram for using the app

The flowchart in Figure 16 shows the flow of activities the students will follow when using this application.

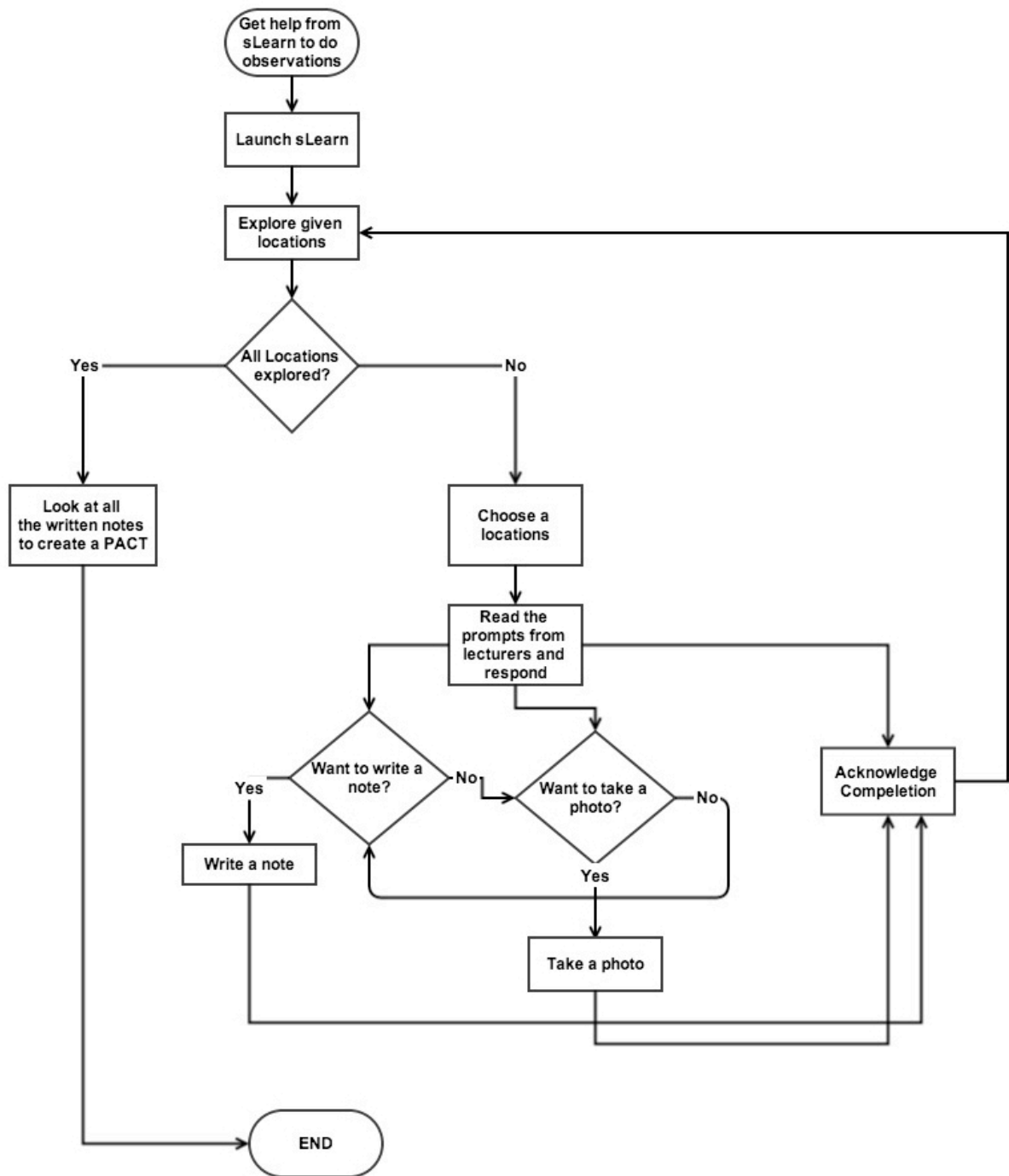


Figure 16: sLearn's Flowchart

5.1.2 Functional and Non-Functional Requirements

Drawing from the findings of phase one, the requirements gathering, explained in chapter four, the functional and non-functional requirements of the application were defined. Table 8 and Table 9 show these requirements:

Table 8: Functional Requirements

<i>Requirement Number</i>	<i>Description</i>
<i>F1</i>	<i>The user should be able to choose different locations to check the prompts.</i>
<i>F1.1</i>	<i>The user should be able to read the prompt(s) associated with the chosen location.</i>
<i>F2</i>	<i>The user should be able to write their own comments in response to each prompt within each location.</i>
<i>F2.1</i>	<i>The user should be able to share their comments.</i>
<i>F3</i>	<i>The user should be able to capture images.</i>
<i>F4</i>	<i>The user should be able to get back to the main map.</i>
<i>F5</i>	<i>The user should be able to get back to the same point when interrupted by a call, text, etc.</i>
<i>F6</i>	<i>The system should allow the user to know which prompts within each location he/she had already visited/observed.</i>
<i>F7</i>	<i>The system should calculate the time spent on each location.</i>
<i>F8</i>	<i>The system should provide the user with data to track his/her progress.</i>

Table 9: Non-Functional Requirements

<i>Requirement Number</i>	<i>Description</i>
<i>N1</i>	<i>The system should be easy to learn.</i>
<i>N2</i>	<i>The system should be intuitive.</i>
<i>N3</i>	<i>The buttons should be of a good size.</i>
<i>N4</i>	<i>The images should have high contrasting colours.</i>
<i>N5</i>	<i>The system should be light to give fast responses.</i>

The above are the initial requirements defined, as this research is adopting a user-centred approach, these requirements might be refined when testing and evaluating the design and/or the prototype.

5.1.3 System Architecture

To support this functionality, the sLearn app was designed to consist of three main components:

- (1) Learning/checklist repository: where learning material, prompts and questions from lecturers are stored.
- (2) User/student's performance/progress: the student's progress is stored here. How much time s/he spends on each location, number task/prompts/questions completed, and student's notes.

- (3) Facility for sharing: a web-based forum within the app for sharing their notes and comments on their peers' notes.

Figure 17 illustrates a rich picture of the system's architecture.

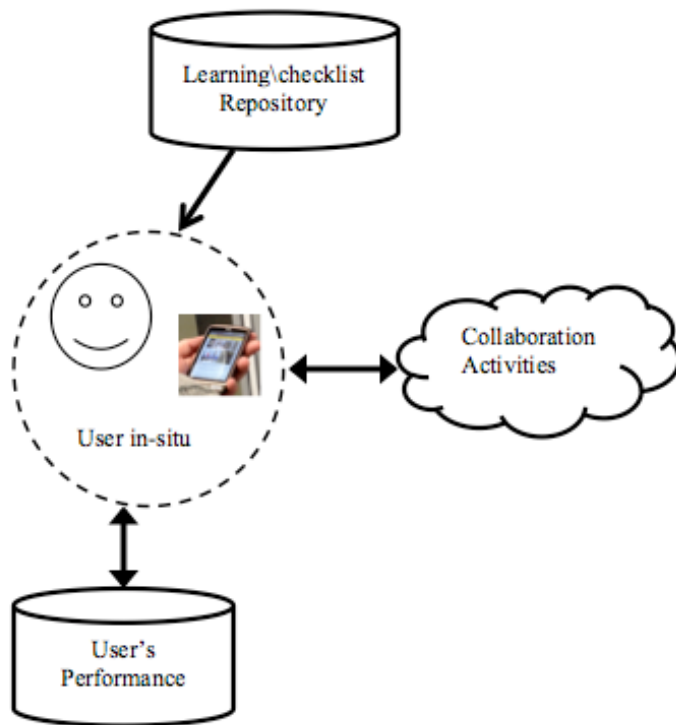


Figure 17 System Architecture

The initial design activities described have led to the development of the prototypes of this mobile application. A number of iterations were created for this application up to date. This application was developed using MIT App Inventor (Google Research, 2012) to create an Android-based mobile application.

5.2 Prototype Design and Evaluation Iterations

Designing a contextual mobile learning application requires consideration of a number of issues. These include students' different learning styles and preferences, the location's characteristics and its physical and psychological

effect on the user, as well as the appropriateness of the location-specific content.

An iterative design process was adopted. As part of this a series of prototypes were created, starting from conceptual wireframes to functional apps. Comprehensive user-based usability studies helped to identify and address numerous usability issues prior to deployment.

The development of sLearn went through five iterations before the prototype was used by HCI students to support their work. The first three design iterations of this prototype were each modified following the lecturers' feedback and suggestions. Once the lecturers were satisfied with the third design, it was crucial to get feedback and evaluation from people out of the circle of this research. The first step to try and identify obvious design issues is to carry out usability testing. The iterations were grouped into two main stages as described below.

5.2.1 Stage One

This stage involved three iterative design cycles of sLearn, each of which was evaluated by the lecturers involved in the teaching of the HCI course, following an expert heuristic evaluation. It was important to evaluate the initial designs with the lecturers and consider them as co-designers to ensure that it was what they had envisaged and that the content was appropriate to the students' learning needs.

Below are descriptions of the iterations of stage one.

5.2.1.1 *Iteration One and Evaluation*

The first design was a simple application showing the concept behind this project. It consisted of two screens:

The first, the home screen, shows a map of the area with pins on particular locations. The user would touch one of the pins to go to this location's screen. The location's screen shows a closer picture of this location, two buttons to take notes and take photos, and a paragraph of given prompts (questions) from lecturers.

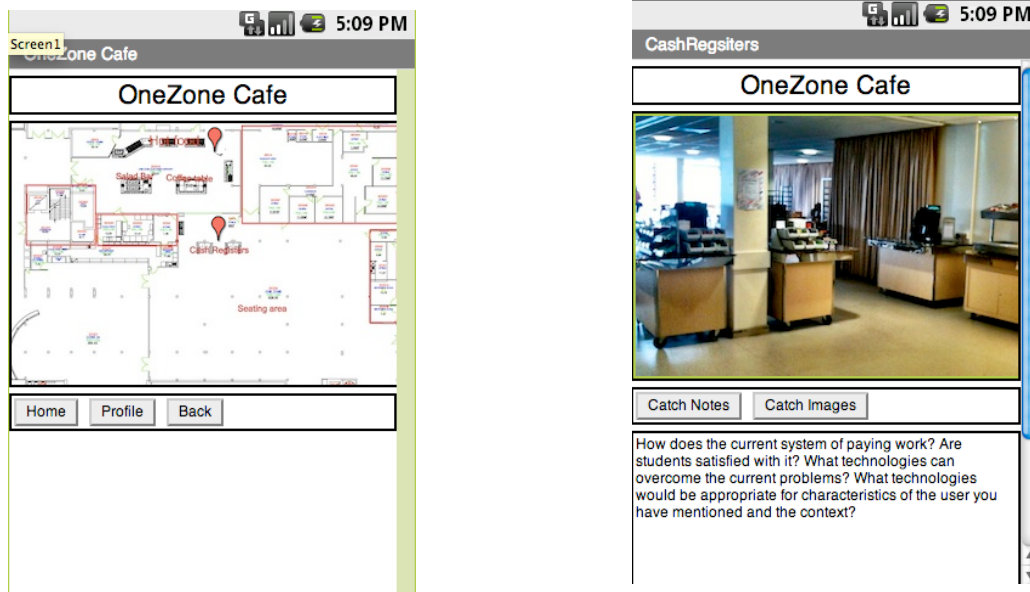


Figure 18: Iteration One

The main concern with this prototype is that the prompts were in a paragraph style, which would be difficult to read by the users especially when they are in a busy environment. This is not a practical design and it could cause confusion and frustration and thus, users might be put off using the application. Prompts should be easy to read, users should be able to know in an easy and quick manner which ones they have not yet read. Moreover, at the time of development, App Inventor did not allow having navigation on the map. The users will not be able to touch on the pins on the map to navigate to the location's screen. Therefore, an alternative approach should take place.

5.2.1.2 Iteration Two and Evaluation

This iteration fixes the design problems from the first iteration regarding:

- a) The navigation to locations on the home screen. Under the map, images of pins were added along with the name of that location. As soon as the app is launched, the user will receive a message telling them to press on the pins under the map in order to navigate.
- b) The display of the prompts. Each prompt is now displayed by itself followed by a checkbox which the user ticks when he/she has read and acted upon this prompt.
- c) A button for note taking was added. This allows the users to take notes on a screen that resembles a notepad.



Figure 19: Iteration Two

It was first considered making all prompts invisible but the first one. When the user ticks the first checkbox indicating that he/she has completed it, the second prompt appears and so on. However, when discussing this with the lecturers it was decided not to go for this method for a number of reasons:

Firstly, the control would be removed from the user. He/she would not be able to choose which prompt to start with depending on their needs. Secondly, if

he/she was not able to act upon this prompt, he/she would not be able to try and understand the others, as they are invisible. Thus, the system was not supportive and thus not usable.

5.2.1.3 *Iteration Three*

This iteration adds a textbox under each prompt to allow the user to type in their comments in the same screen. This allows for:

- (a) Easy access to notes.
- (b) Linking the note with the prompt. When the user sees the prompt when typing, it reminds him/her of what he/she is noting.

Since having added for each prompt a checkbox and textbox, this made each screen longer because each of these three contents were in a separate line. The design had to be modified to overcome this issue, and therefore the checkbox was moved to be next to the textbox. A button to save notes was then added next to each textbox to save the note of this particular textbox.

The first version of the working prototype was finalised. It consisted of:

1. Home screen: Showing a map of the area with pins indicating specific locations that the students needed to visit. Pressing on a pin enables the user to display the screen for that particular location.
2. Location screens: These show a picture of the specific location; a navigation bar to save the notes, take extra notes, and take photos; prompts from the lecturers with prompts on possible aspects to explore for each location; and text boxes under each prompt for students to type in their observations.
3. Extra Notes screen: This allows the user to type in and save more observations and notes.

4. Help and Profile screen. The Profile screen provides the student with a summary of the time spent on each location and number of prompts they have considered in each location.

The figure below shows screenshots of the final prototype at the end of stage one.

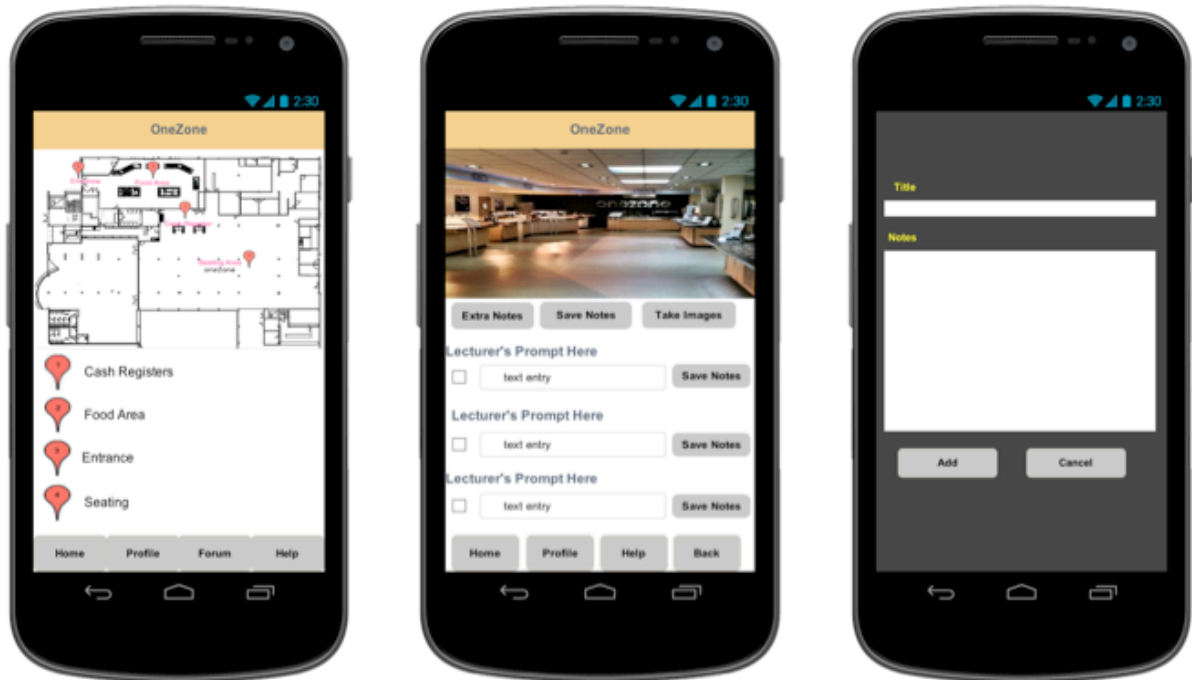


Figure 20 Iteration three

Once the lecturers were satisfied with the design and content of this prototype, further evaluative comments from students were elicited, both in a laboratory setting and in the environment in which the app was designed to be used. This resulted in two iterations conducted as cooperative usability evaluation studies (Rogers *et al.*, 2011), which involved observing students use the app in situ. The main aim of these evaluations was to ensure that the interface was easy to learn and use in a real world environment.

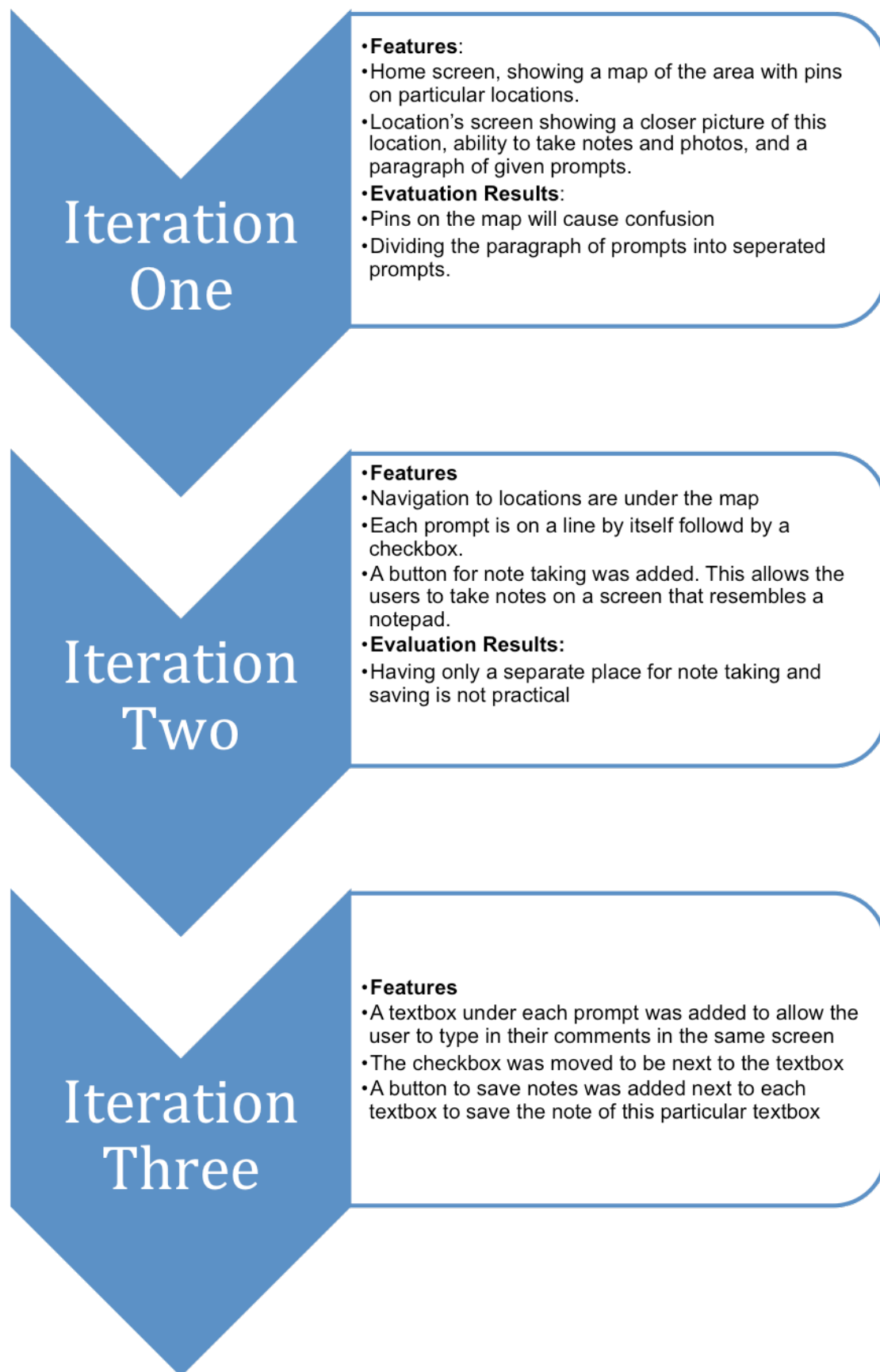


Figure 21 Stage One Iterations Stage Two

Having developed an initial working prototype, it was possible to begin the next stage of field trials.

5.2.2 Stage Two

This stage involved evaluating the last iteration from stage one with student participants as part of the user-centred design approach.

5.2.2.1 Evaluation One

The aim of this was to evaluate the app by people out of the scope of the research, students in particular. The objectives of the evaluation were:

- To discover usability problems in this application.
- To discover whether there was any ambiguity or aspects that might cause confusion to users.

The first evaluation of this stage was performed by third year Web Design undergraduate students enrolled in the Interaction Design (ID) module as a part of a class activity for learning how to evaluate a mobile app. They were chosen for two main reasons. Firstly, they were enrolled in the ID module, which makes them interested in evaluation and usability testing. Secondly, all but one took the HCI module the year before, which means they had experience doing the coursework and thus understood the purpose of the application. There were nine students in total, eight males and one female.

The process was as follows:

1. The concept of the learning model and the pedagogic basis of the app were explained to the students.
2. sLearn's requirements were explained.
3. The students were divided into three groups of twos and a group of three.

4. To help them conduct a cooperative evaluation of the sLearn app as part of their class activity, each group allocated roles for each person in their group, a facilitator, an observer and a 'user' and identified tasks for the 'user' to perform using the sLearn app.
5. The groups went to the University's café to conduct the evaluation in the real environment.
6. When the evaluation was completed, they returned to the classroom to form a focus group to discuss their findings.

This evaluation study was designed to enable the students to be both evaluators and users, enabling usability issues and misconceptions to be identified without bias from the design team.

5.2.2.2 Findings of Evaluation One for Stage Two

As explained, this was the first usability evaluation conducted on the first working prototype. This study was a valuable one as it had discovered a number of usability issues that might not be known otherwise. The students were engaged as they were performing the tasks and identifying flaws and misconceptions that might make the user confused.

As they performed this evaluation in groups, it was useful to share their findings and discussion in a focus group. All the tasks that the students had been asked to accomplish were put up on the screen and we went through them one by one, asking what problems they had had while doing this task, and what usability issues they had identified.

Under each task numbered below are the issues students raised in the focus group.

1. Choose a Location to explore

- Poor affordance of pins
 - Instructions were not clear, too quick – user control and freedom
 - Should there be an imposed structure – support and help
 - The feedback in response to selection was missing
2. Read the desired prompts and check the ones that you have done
 - Relationship between check-box and inserting text was unclear
 - Ambiguous instruction – the word ‘check’
 3. Write down a note for one of the prompts and save it
 - Size of the textbox – affords limited writing
 - Utility of the check box was unclear
 - Sequence of actions
 - Feedback on button relates to action rather than execution of function
 4. Write Extra notes for the whole location and save it
 - Visibility of system status – notes existing not shown
 - Having two different places for notes creates confusion
 5. Go back to the home page
 - Navigation is not consistent with expectations – match between system and real world
 6. Check your Profile
 - Potential to improve visualisation of information

The above points have met the two objectives on the usability problems and confusion aspects of the application. It is clear that there should be some work done on this iteration of the prototype before it goes into trial with real

users. The invaluable input from this study was acted upon immediately addressing almost all issues as much as possible.

Furthermore, some students commented on the pedagogical usability of the app, reflecting on the past experience:

"It makes it clear having a guide on each section. I had some trouble last year".

"Makes the whole process a lot easier".

"It is easier. Like filling out a form. We focus on what to observe".

These comments from students who have experienced doing this coursework gave an assurance that sLearn is progressing in the right direction in which it is aiming to support the students' learning in-situ and provide them with structural help.

The explanation of the development of the forth iteration below shows what should be done to solve these issues.

Although this study has raised many usability problems, there are still areas in which this research is interested in discovering that were not covered. Thus more in depth evaluations were needed.

5.2.2.3 *Iteration Four*

This iteration was a crucial one as it responded to the finding of the first usability study performed by the ID students as discussed above. The changes were:

- The notifier that instructs the user to press on the pins to navigate to a location's screen was changed from a note that disappears after a couple of seconds to a fixed note that requires an action from the user to disappear. The user can set it to 'Do not show again'.

- The language of the written instructions was changed to remove any ambiguity.
- The location and size of the textbox were changed. Instead of having a small textbox for each prompt, one large textbox at the bottom under the prompts was created.
- A feedback is given to the user when he/she saves the notes.
- The Extra Notes button that takes the user to a notepad screen was removed. Having a notepad within the app created some confusion for the students and we have decided that the textbox for taking notes under the prompts on each location's screen is enough.
- The middle navigation bar was removed and the 'Take Photos' button was put next to Save Notes under the textbox.

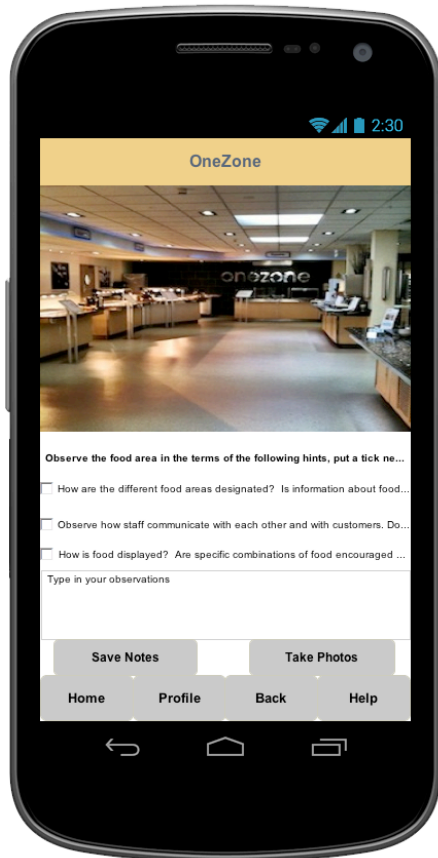


Figure 22: Location's screen of iteration four

However, There was an issue that could not be modified due to the restrictions and limitation of App Inventor: the way the pins are laid out and pressed.

We have therefore conducted a second usability test to evaluate the changes made in this evaluation.

5.2.2.4 Evaluation Two

A second evaluation was conducted before real users are given the application to use. It was considered important to carry out an evaluation on the new iteration that reflected the issues identified in the first evaluation explained above. This evaluation was conducted to make sure that the actions taken regarding the issues identified in the evaluation above were the

appropriate ones, to discover more issues, and to understand the effects of context on the usability of the application. Above all, it was significant to have a pilot study for the main in-situ evaluation study discussed later in the testing part of this thesis. According to Adams and Cox (2008, p. 25): “Initial, small-scale studies (pilots) help to identify how questions are likely to be interpreted. It is important to seriously consider any research issue that occur at this point and use them to improve your questionnaire design or interview techniques”.

The objectives for this evaluation were:

- To discover more usability issues and misconceptions.
- To understand the effects of the context on the usability of this application.
- To understand the user experience using the app in the real environment.

Two cooperative usability evaluations were conducted with two female students, in their third year of a computing course, who volunteered to participate. The cooperative evaluation provided an opportunity to gain more understanding of the usability issues of using the mobile application in context. The influence of the environment on their approach to using the sLearn app was noted in particular. As discussed earlier, the context of use plays a significant role which must not be ignored when it comes to evaluating a mobile app (Savio and Braiterman, 2007; Cherubini and Oliver, 2009).

Each participant was asked to use sLearn in the same university café as the previous group. They were asked to ‘think aloud’ as they completed a set of tasks. The facilitator (This author) followed and observed the participants as they used the app in the café and took notes. Once the participants had

completed all tasks, they were asked demographic questions about their mobile ownership and experience with smartphone. They were then interviewed about their experience. The evaluation plan can be found in Appendix (B).

The interview questions were:

1. How would you describe your experience of using the app – how did it feel?
2. What are the three things you like least about the app?
3. What can be improved in the app to overcome these issues?
4. If you could make one significant change to this app, what change would you make?

5.2.2.5 Findings of Evaluation Two (Pilot in-context Evaluation)

Observations:

Both participants completed their tasks without any critical errors. However, both had difficulties navigating from the main screen when choosing a location to explore. Participant one at first pressed on the pins on the map to navigate then tried the pins under the map. Participant two was pressing the word, the name of the location, next to the pin under the map rather than the pin itself.

Interviews:

The interview was semi-structured meaning that answers from participants could prompt new questions. Both participants were happy with the experience of using sLearn. They agreed that the environment had no effect on their experience and it was easy to use in that context.

However, what they wanted to be added to the app was: more instruction, especially since they were both novice Android users, and press able pins on the map.

Discussion

Looking at the observation, post-task questions and the interview, the results from the study suggest that users might still get confused when using the home screen of this application to navigate to a particular location. The way this screen is designed calls in their previous knowledge and conception of a 'pin' on a map. They are used to the idea of touching the pin to get more information or even navigate. However, since the version of App Inventor, at the time of developing this application, does not support creating a map on an image to act as navigator, it was decided that the whole concept of pins should be removed from the design to prevent this misconception and any frustrations that might occur and put students off using this application.

This pilot study gave a taste of how in-situ evaluations should be conducted. There are a number of issues that should be considered carefully when conducting the main in-situ evaluation later. Participants should be informed clearly of what is expected of them, the observer should be careful not to influence the participant when using sLearn in the environment. Conducting a general usability in-situ on its own was not enough. It is crucial to evaluate both general usability and pedagogy. In other words, participants of the main in-situ evaluation should act as the real users of the sLearn in order to understand the effectiveness and efficiency.

5.2.2.6 Iteration Five

This iteration followed the results of the evaluation conducted above. The issue of having pins on the map that do not allow navigation was still causing confusion. The user will directly touch on the pins to navigate or find more information. This led to the decision of removing any image of pins in the design to eliminate such confusion.

In this iteration, the collaboration part of this activity was added. A Button for posting the notes to a blog was added at each location's screen. This allows peers within each group to share their notes with their group members and allow for online distance discussion. Screen shots of the code and the lecturer's prompts can be found in Appendix (C).

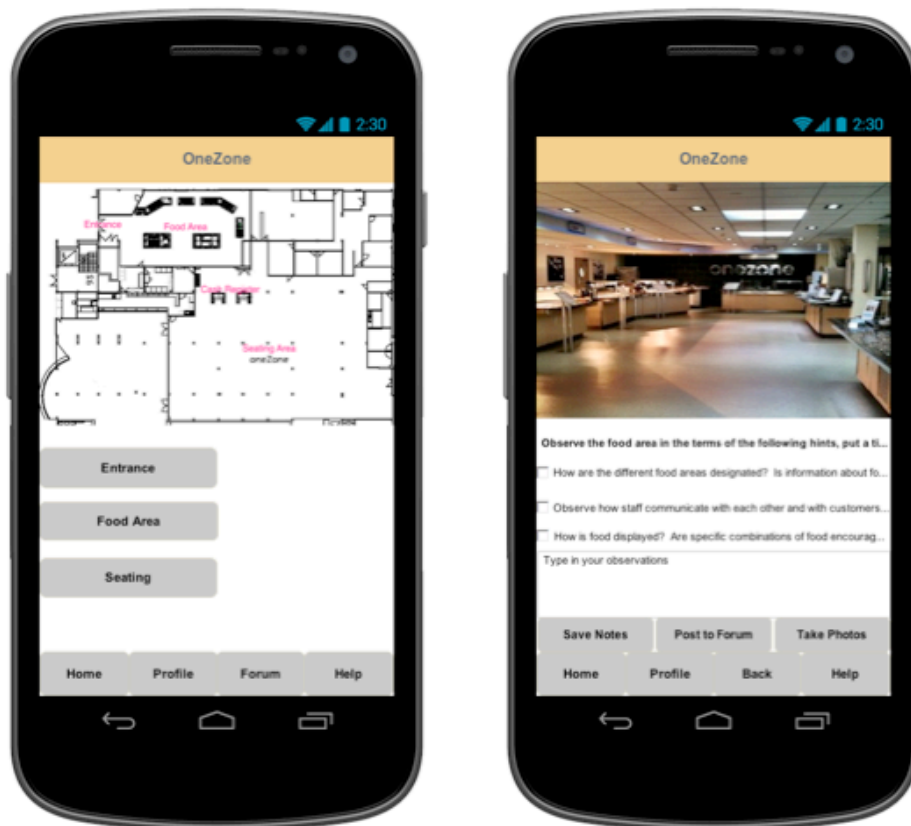


Figure 23: Iteration Five

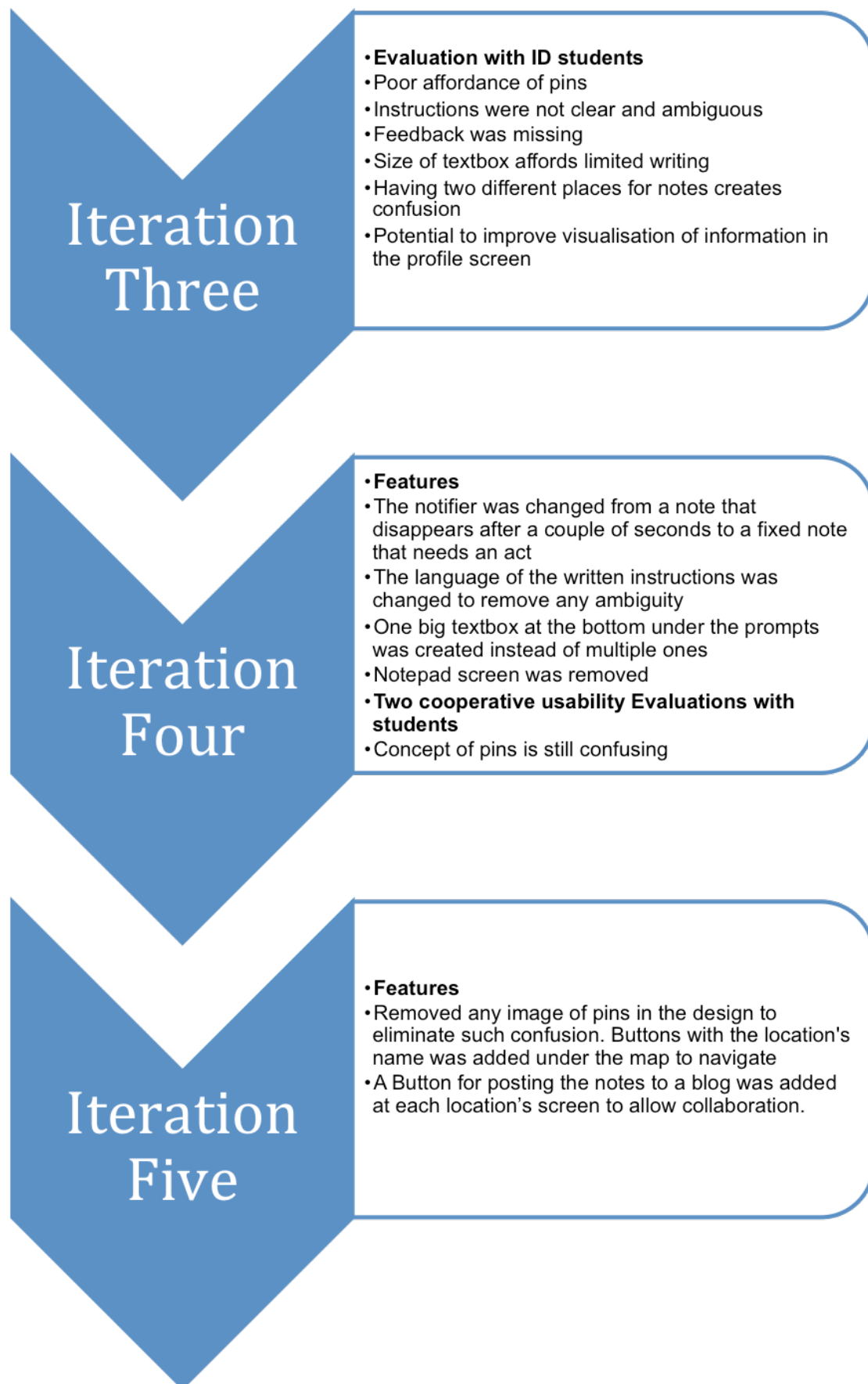


Figure 24 Stage two iterations

5.3 Conclusion

This chapter discussed the third and fourth phase of the development process, designing and prototyping the sLearn app. As pointed out in chapter four, a UCD process was followed in deriving the phases of this research. Therefore, this phase followed an iterative design approach for the design and evaluation of the contextual mobile application intended to support students in a design task as part of their HCI coursework. The aim was to find the optimal design to help students learn effectively in-situ.

The design and evaluations went into two main stages. Stage one involved three design iterations that were all modified following the reviews of the lecturers. The third design iteration was implemented into the first working prototype that was evaluated by ID students. Further modifications were carried out to create the fourth design iteration, which was then evaluated as a pilot in-situ evaluation. The findings of both evaluations have revealed a number of usability issues and misconceptions when using sLearn. These needed to be dealt with before testing the app with real users, which resulted in a redesign of sLearn into the fifth iteration. The app is now ready to go into the testing phase of this thesis and be tested by the HCI students, explained and discussed in the following chapter.

6 Chapter Six: Testing the contextual mobile learning model

Following the development of the sLearn app, the next stage was deployment, whose target user group were HCI students. The main research question for this study was to understand the effectiveness of mobile learning in providing students with the necessary guidance in a situated learning activity without the physical presence of a tutor or lecturer. In order to extend the scope of the study, it was decided to test this app with two more student cohorts. Deployment two: students enrolled in the User Experience (UX) module and deployment three: Engineering students. The full profile of the cohorts is explained later in the chapter. Moreover, as it was important to understand the influence of the context of the use on the user experience, an in-context evaluation of the app was also conducted.

This chapter starts by fully explaining the methodology followed in the deployment of sLearn with the HCI students, the methodology followed for the in-situ evaluations, and the methodology followed for the other two versions of deployment. The findings and results of all the deployments are discussed in Chapter 7. Figure 25 summarises all the activities conducted:

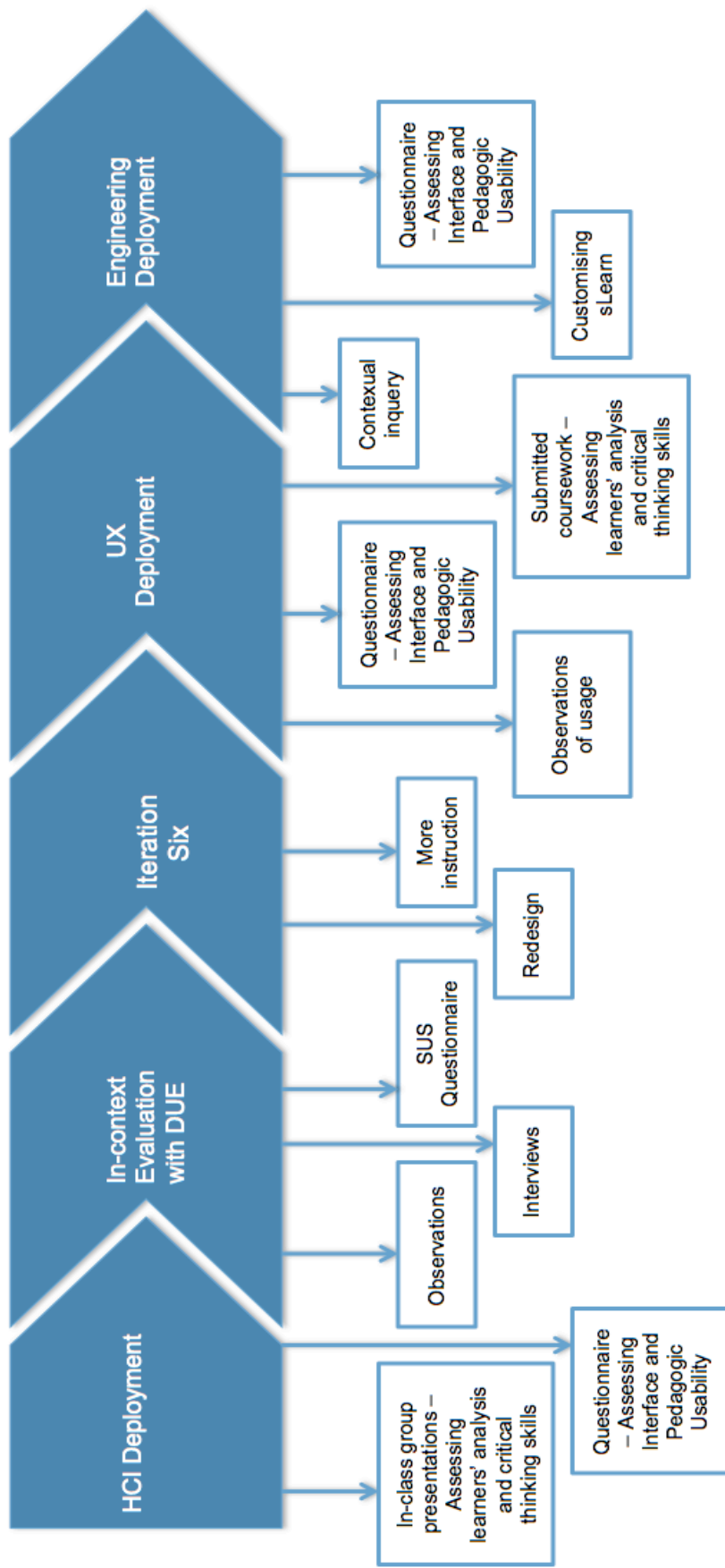


Figure 25 Testing timeline

6.1 Deployment One: HCI Students

The main aim was to evaluate the effectiveness of sLearn and to understand to what extent a contextual mobile app can improve HCI students' understanding of context for design. To pursue this aim, this evaluation was conducted with the intended users of sLearn, that is, the students enrolled in the HCI module. This group was the main sample that was chosen to test the contextual situated mobile learning model and thus were the target of the requirements phase.

6.1.1 Assignment specification

The specific assignment to which this study relates was slightly modified from the previous academic year 2011/2012. For the academic year 2012/2013, it involved designing a GUI for a touch-screen based kiosk to be installed in the University's Onezone Refectory to offer support to students and staff, helping them make the right meal choices. The right choice can relate to specific goals that individuals can set (target calories, 5-a-day, proportions of proteins and carbohydrates), or support for specific dietary needs (diabetes, allergies, food intolerances).

The assignment was structured as a group project involving three or four students, where the initial work consisted of requirements gathering and analysis to produce a set of artefacts such as a PACT analysis (the observation work necessary to complete this would now be supported by the app), personas and scenarios, and a set of functional and non-functional requirements. The assignment deliverable was an in-class presentation of their work.

Students were required to present their findings as a mind-map, ensuring that there were clear links between the People, Activities and Context elements and the Technologies considered. They were required to go on to explain and discuss why the points that they had noted were of significance and they were then expected to define a set of requirements, based on their research, and to design prototypes. This was explained to the students in class and described on their coursework assignment specification that included clear marking criteria. The marking criteria for observational work (supported by the sLearn app) in the assignment was written by the lecturers and divided into two categories. These related to assessing the ability for detailed and insightful observation, and critical thinking demonstrated by analysing the significance of the observation and translating this into requirements:

1. Ability for detailed and insightful observations were assessed by considering:
 - a) The depth and scope of the observations, marks awarded between 1-6 (1= Only superficial 6= Very Thorough)
 - b) How well the observations were translated into insights and whether the insights went beyond the obvious, marks awarded between 1-4 (1= Lacking depth and detail 4= Went beyond the relatively obvious, and included depth and detail)
2. Ability for critical thinking was assessed by considering:
 - a) How well they translated the collected data into a PACT, marks awarded between 1-6 (1= The translations lacked depth 6= Went beyond the relatively obvious, and included depth and detail)

- b) How well they translated the collected data into functional requirements, marks awarded between 1-6 (1= The translations lacked depth 6= Went beyond the relatively obvious, and included depth and detail)
- c) How well they translated the collected data into non-functional requirements, marks awarded between 1-6 (1= The translations lacked depth 6= Went beyond the relatively obvious, and included depth and detail)

The marks corresponding to the relative weighting given to each of the criteria above, 1a and 2(a, b, c) are more highly weighted.

Figure 26 shows the contextual blended learning model implemented for the HCI module.

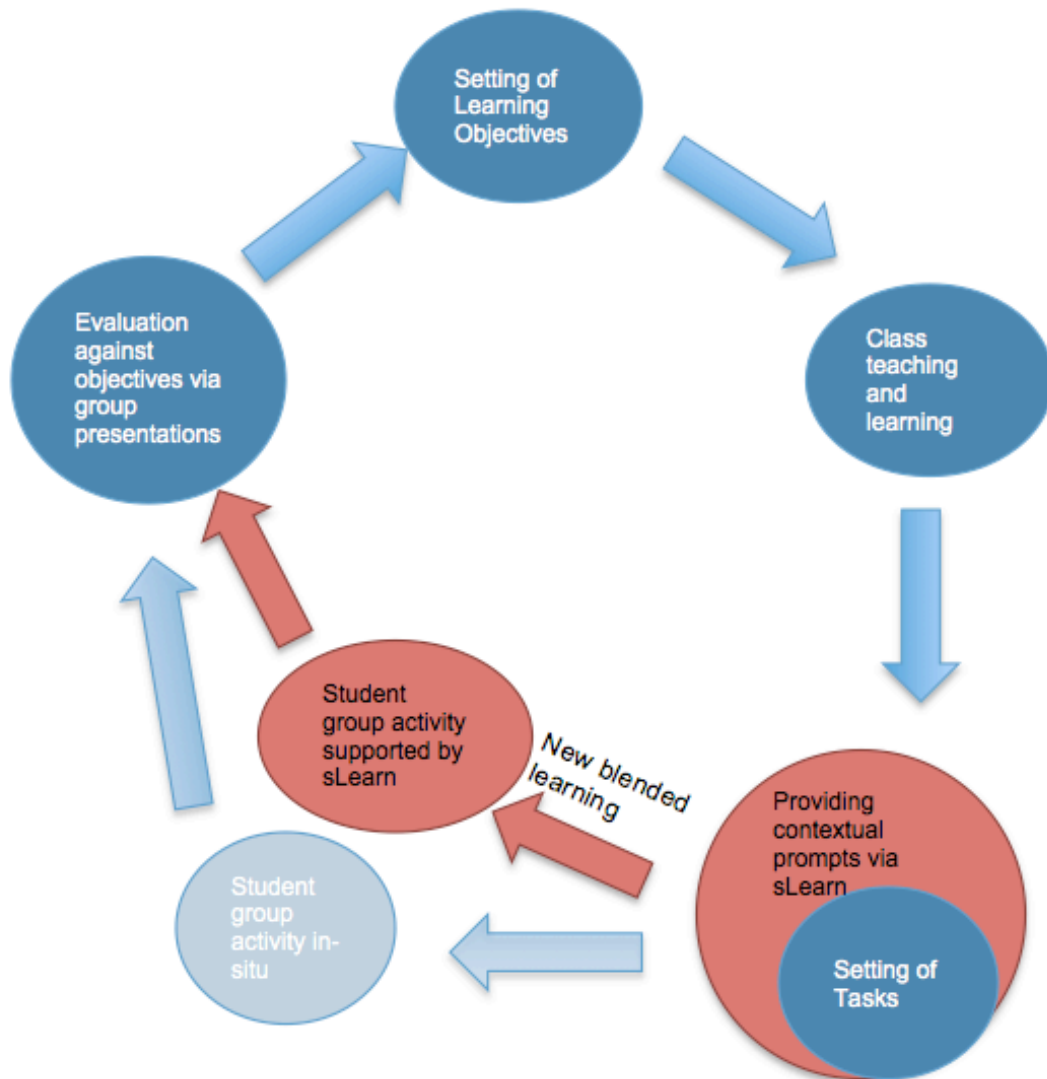


Figure 26 Contextual blended learning model for the HCI module

6.1.2 Evaluation Design

Vavoula and Sharples’s (2009) three-level framework for evaluating mobile learning, discussed earlier in 3.3, provides a useful structure which was used to define the different elements of the evaluation in this evaluation. Table 10 provides a summary of the different elements. For this deployment, only the Micro and Meso levels have been deployed, this is because the Macro level evaluates the long-term impact of the new innovation on the established teaching and learning practice and institutions, which is beyond the scope of this study.

Table 10 HCI's evaluation methodologies

M3 Evaluation Level	Evaluation Aspect	Evaluation Method
Micro	1- Interface usability 2- Pedagogical usability	1- SUS questionnaire 2- sLearn questionnaire
Meso	1- Learner's analysis and critical thinking skills	1- Students' presentations 1- Lecturers' Criteria

To strengthen the findings and generate a multi-perspective overview of the effectiveness of the intervention, it was crucial to draw on a range of resources. These included the coursework (students' presentation and slides as described earlier), the students' evaluation of the sLearn app and feedback and marks from the lecturers' on the assessed work. This mixed method was chosen since it was not possible to divide the students into control group and experiential group as in the evaluation of Chu *et al.* (2010) because this coursework is assessed as discussed in 2.4.2.

It was decided not to carry out any in-depth usability evaluations of the students using the app, to ensure that they would not be distracted by being observed, which might affect the ecological validity of the study. However, it was crucial to gain their views on the usability of this application. The System Usability Scale (SUS) (Brooke, 1996) was chosen to measure the usability of sLearn. Additionally, it was important to understand the students' perspective of how the sLearn app supported their learning, referred to as pedagogical usability (Kukulska-Hulme, 2007; Hadjerrouit, 2010). The pedagogic usability was measured using statements adapted from a set of metrics defined by

Ivanc *et al.* (2012), discussed in 3.8, to suit the nature and context of the mobile learning application.

The SUS statements used were:

1. I think that I would like to use this app frequently
2. I found the app unnecessarily complex
3. I thought the app was easy to use
4. I think that I would need the support of a technical person to be able to use this app
5. I found the various functions in this app were well integrated
6. I thought there was too much inconsistency in this app
7. I would imagine that most people would learn to use this app very quickly
8. I found the app very cumbersome (awkward) to use
9. I felt very confident using the app
10. I needed to learn a lot of things before I could get going with this app

A 5-point Likert scale ranging from Strongly Disagree to Strongly Agree was used and the responses were converted to numbers and calculated according to the SUS scoring formula.

To assess the pedagogic usability, the statements shown in Table 11 were used with a Strongly Disagree (1) -to-Strongly Agree (5) Likert scale, together with an additional 'Not Applicable' option.

Table 11 Pedagogic Usability Question Results

Statements
The app helped me in my observation
The app gave me hints on what to look for
The app helped me organise my ideas
It was helpful to have a space for note taking
The app helped our group members to share ideas and notes
The Forum (Blog) within the app was useful
It was useful to track my progress through Profile
The app helped me develop ideas for PACT

6.1.3 Participant and deployment details

There were 55 students enrolled in the HCI module, seven females and 48 males. The standard practice for the coursework assignment was maintained which involved allowing the students to form self-selecting groups of 3 or 4. This resulted in 17 groups; however, only 16 groups presented their work. Due to the self-selection process, the students retained control over how the work for the assignment was distributed amongst individual group members.

All students had access to the assignment specification through the Virtual Learning Environment, Blackboard. Two weeks prior to the presentations, the lecturers notified students that they had access to an Android mobile app called sLearn that they could download and use when doing this assignment. Students without access to an Android based smartphone could borrow one from the lecturers. This was made clear via announcements in class and on Blackboard.

Students were introduced to the app at a lecture, where the concept was explained to them, and each screen was shown and explained. Three groups borrowed the university's HTC desire phones, ten groups used their own phones, while three groups neither borrowed nor used their own.

Two weeks later students were required to present their findings in class where their presentations were video recorded.

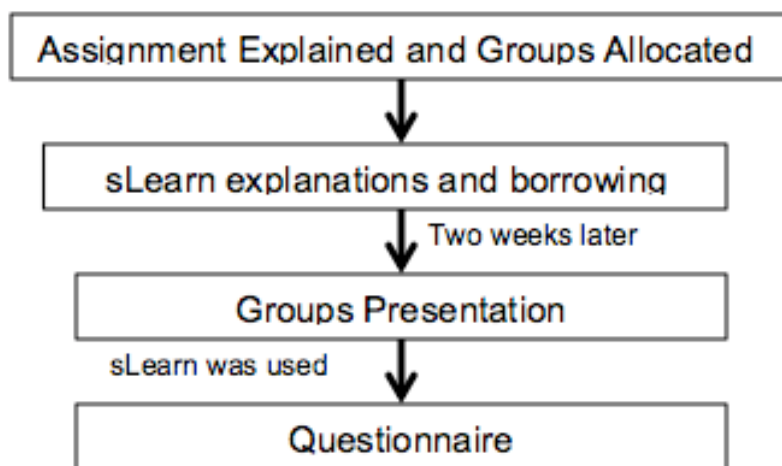


Figure 27 HCI's Deployment Methodology

Once the lecturers had finished marking students presentations a post-intervention discussion was crucial to understand what lecturers thought of the intervention and whether it had a positive influence on students' results.

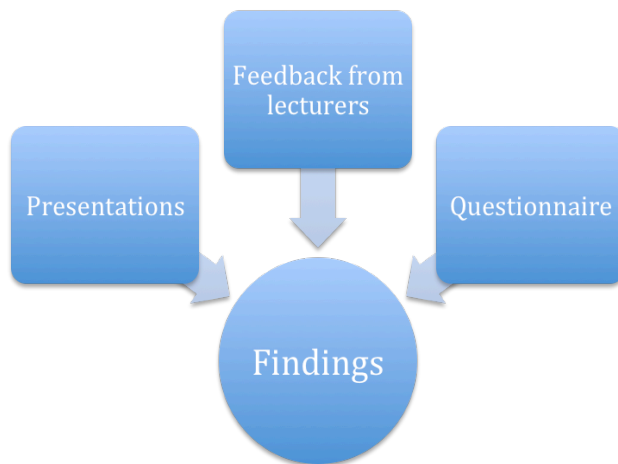


Figure 28 HCI's Evaluation Methods

6.2 In-Context Evaluation

To accurately assess the use and value of this mobile learning app for higher education students, it was necessary to conduct *in-situ* evaluations in the environment of its intended users. Moreover, it is critical to understand what might influence the usability and the user experience of this app in such a busy environment. However, since the content in the app was designed for an assignment for the HCI students, and in order to assess the app as a whole, general and pedagogical usability, the participants of this evaluation needed to be familiar with the material and concept of this assignment. This was crucial since it was not possible to perform any in-depth usability evaluations and follow up focus group with the HCI students, the end-users, as discussed in 6.1.2. Hence, postgraduate students doing their MSc IT degree in the university, enrolled in the 'Designing the User Experience' (DUE) module, were chosen as participants of this evaluation. In this module, they learn many topics such as Usability, User Experience, Design Principles, Identifying

Needs and Requirements, and Prototyping, to name but a few. This makes them familiar with concepts of HCI.

6.2.1 Participants and Evaluation Design

Seven out of 30 students participated in the evaluation, five males and two females. However, many showed their interest but, due to the timing of the study, they were not able to fit it in their busy schedule. Although the response rate was only 13.3% of DUE students, Nielson argues that 85% of usability problems will be identified by as few as five participants (Nielson, 2000).

An online scheduling page was created using doodle with three one-hour slots three or four days a week, that covers the busy lunch time of the University's main café, over the period of three weeks. Students were sent the link to the online schedule to choose the times that suited them best. Students were then contacted with a time and a location to meet.

Five evaluations were conducted with one participant at a time. One evaluation was conducted with two participants at the same time to evaluate the experience of using the app in context with a peer. However, it was noted that having two participants using the app together for the first time meant that that one student had a negative influence on the other, affecting the usability evaluation. Therefore, it was decided to continue the rest as one-to-one evaluations.

Each participant signed a consent form and the purpose of the application, what the HCI students were supposed to do and the tasks he/she was expected to perform, were explained. Three evaluation techniques were used: observation, interview, and an SUS questionnaire to gain a comprehensive understanding of the usability and user experience of the app.

Participants were encouraged to ‘Think Aloud’ when using the app and to speak what was on their minds when they looked confused. All participants used the app in the intended environment, the University’s main café, performing the tasks while they were on the move. Once all tasks had been done, an interview took place to follow up what was observed during the activity and understand the participants’ experience using sLearn. The interview was semi-structured as some questions triggered others, arising from observations during the activity that needed some explanations. The interview questions prepared beforehand were divided into two categories:

- User Experience and Design:
 1. How does it feel using the app in general?
 2. How does it feel using the app in that context?
 3. Are any aspects of the interface confusing?
 4. What is your opinion of how information is organized on a particular location screen?
 5. Is there anything that could have helped make the experience easier?
 6. What would you like to see changed in the appearance of the app?

- Pedagogical Usability
 1. Has the app helped in your observation?
 2. Were the hints provided helpful?
 3. Has the app helped you develop ideas?
 4. Has the app helped you organise ideas?

Table 12 summarises the approach followed. However, the evaluation plan and consent form can be found in appendix (D, E).

Table 12 In-Context evaluation methodologies

M3 Evaluation Level	Evaluation Aspect	Evaluation Method
Micro	1- Interface Usability 2- Context-of-use	1- SUS questionnaire 2- Think Aloud,

	on usability	Observations, and interview
	3- Pedagogical usability	3- Interview

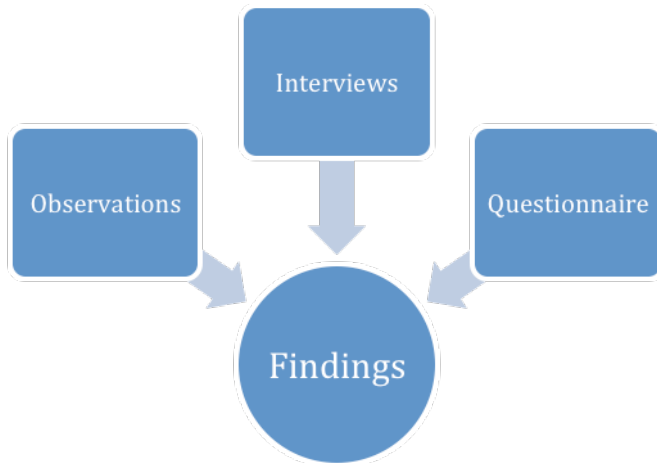


Figure 29 DUE's Evaluation Methods

6.3 Deployment Two: User Experience (UX) Students

The deployment of sLearn in this phase has been with different undergraduate student cohorts enrolled in the User Experience (UX) module. This module contributes towards a BSc in Digital Media and was delivered via a three-hour lecture. However, there are only 22 students enrolled in the module. This year's assignment was divided into eight mini exercises. The best six of these contribute towards the final assignment mark. sLearn supports exercise one, which is very similar to that discussed in the HCI case study. However, there were a number of differences:

1. Each student did the assignment individually.
2. The assignment was delivered via online submission for the lecturer to mark, as no presentations were required.

3. The deliverables were: (A) a PACT Mind-map, (B) a discussion for each element of the PACT showing its significance in terms of opportunities, constraints and barriers.

Students were asked to visit the environment, OneZone, on at least two different occasions, to experience it when it was both quiet and busy.

The marking criteria were as follows:

1. Ability for detailed and insightful observations were assessed by considering:
 - a) The depth and scope of the observations, marks awarded between 1-3 (1= Only superficial 3= Very Thorough)
 - b) How well the observations were translated into insights and whether the insights went beyond the obvious, marks awarded between 1-4 (1= Lacking depth and detail 4= Went beyond the relatively obvious, and included depth and detail)
1. Ability for critical thinking was assessed by considering:
 - c) How well they translated the collected data into a PACT, marks awarded between 1-3 (1= The translations lacked depth 3= Went beyond the relatively obvious, and included depth and detail).

Figure 30 shows the contextual blended learning model implemented for the UX module.

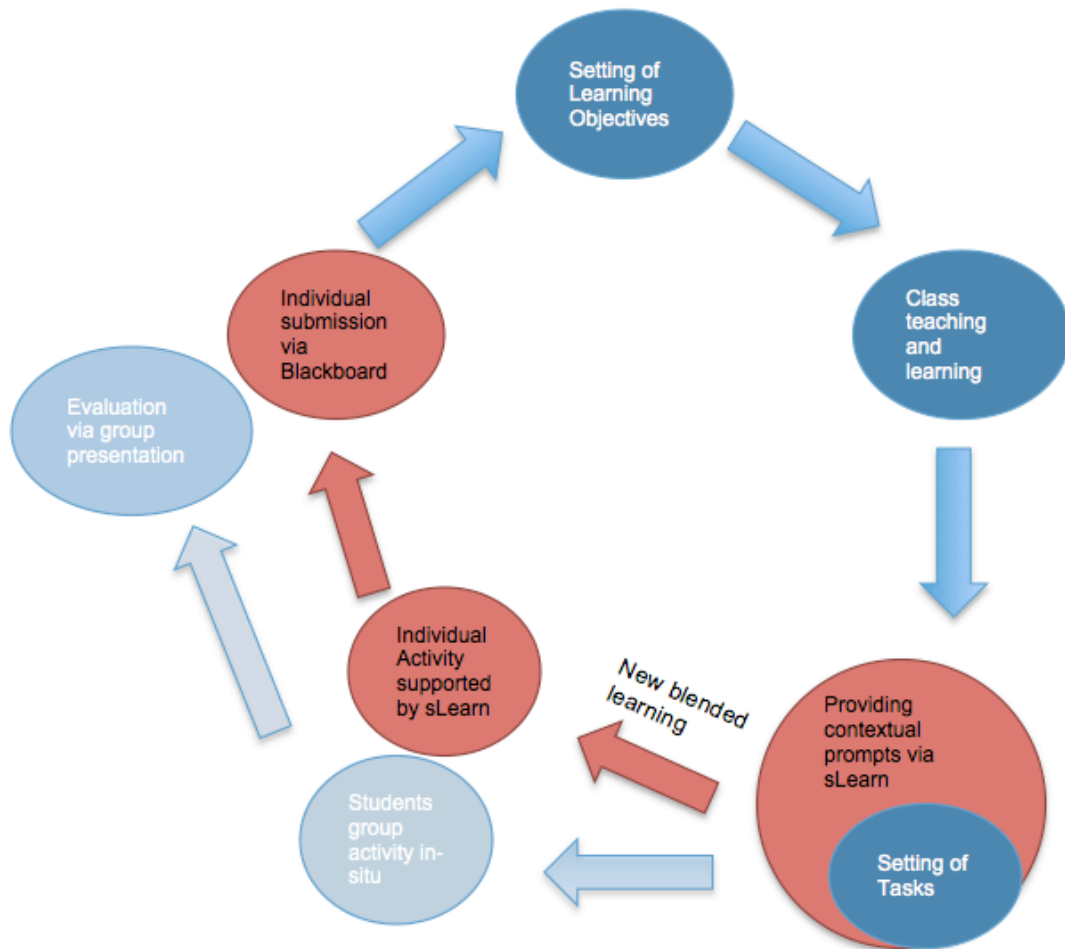


Figure 30 Contextual blended learning model for the UX module

6.3.1 Evaluation Design

The aim of this study was to:

- Evaluate the model with more students.
- Understand students' perception on the usability and pedagogical usability of sLearn.
- Understand whether the changes of assignment had influenced the students' achievement.

There were seven females and fifteen males in this module. In addition to having access to the assignment specification through Blackboard, students were briefed about the assignment in a normal scheduled lecture. They were

allowed to do the observations in pairs, due to limited phone availability, but were reminded that their analysis and work should be done individually. An online questionnaire was created for them to fill when they had finished their observations and had created their PACT analysis. The questionnaire was similar to that given in the previous deployment with a slight change. The first sentence of the SUS questionnaire was modified to 'I think that I would like to use this app or a similar app whenever available for this sort of learning'. The reason for this modification is explained in 7.1.2.

The pedagogical usability part of the questionnaire was modified as well to reflect the change made to the app.

Table 13 Evaluation Design for UX

M3 Evaluation Level	Evaluation Aspect	Evaluation Method
Micro	1- Interface usability 2- Pedagogical usability	1- SUS questionnaire 2- sLearn questionnaire 3- Observation
Meso	1- Learner's analysis and critical thinking skills	1- Lecturers' Criteria

Table 14 Pedagogical usability statements

Statement
The app helped me in my observation
The app gave me hints on what to look for
The app helped me organise my ideas
It was helpful to have a space for note taking under each hint
It was helpful to have textbox for extra observations and notes

The app helped in sharing ideas and notes
The Forum (Blog) within the app was useful
It was useful to track my progress through Profile
The app helped me develop ideas for PACT

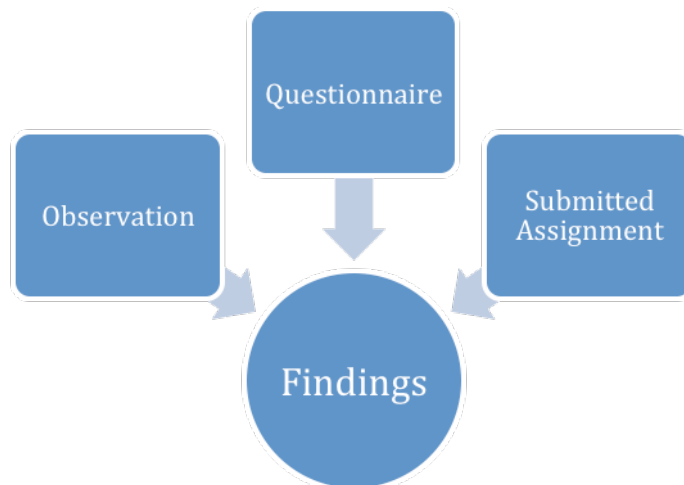


Figure 31 UX's Evaluation methodology

6.4 Deployment Three:Engineering Students

sLearn is an app to support students' learning when conducting course-related activities in-situ. Therefore, it is necessary to demonstrate that this model is not only for the HCI or UX students, but that it could be used by different courses outside the computing field. Thus, in order to prepare engineering students for their real life occupation, lecturers are encouraged to apply the situated learning theory by visiting authentic sites to support their students' understanding of the field (Galloway, 2007). They visit construction sights, bridges, roads, and river docks, to name but a few. There are various risks that could be faced when a person is in such a location. Thus, it is important for future engineers to know how to conduct a 'risk assessment'. According to the Health and Safety Executive (2013) "Risk assessment is simply a careful examination of what, in your work, could cause harm to

people, so that you can weigh up whether you have taken enough precautions or should do more to prevent harm”.

However, for this study, the purpose was to suggest that this model is applicable to different disciplines. The evaluation design for this study was concerned with the ‘Micro’ level of the evaluation framework.

6.4.1 Contextual Inquiry

In order to understand the activities that the students are required to perform and to have a better understanding of the situation, a contextual inquiry similar to the one done in the HCI case study was conducted. This included lecturers’ interviews and observation of a similar activity.

A number of unstructured interviews were carried out with programme leaders of the Civil and River and Coastal Engineering courses. It was necessary to consider:

- The activity and the students.
- sLearn’s Role

The concept of sLearn was described and the HCI version of sLearn was demonstrated to them.

6.4.1.1 *The Activity and Students*

The activity was designed for the induction week level one for students enrolled in both Civil Engineering and River and Coastal Engineering. During this week, they go on a field trip to the Bristol Docks to carry out a number of activities such as producing a set of engineering sketches of particular structures. However, before doing any of the activities they are required to conduct a risk assessment. Hence, sLearn would be used to support this risk assessment. The students go in groups to undertake the required activities

and are given a time and a point of meeting. The lecturers described the students who enrol in those two courses as usually being engaged and committed.

6.4.1.2 *sLearn's Role*

SLearn is intended to support the students in conducting a thorough risk assessment. The lecturers feel that having the ability to conduct the risk assessment using a mobile application would aid the students in many ways. They feel that typing in on a mobile application could be easier in that context than pen and paper. In addition, providing students with structured hints would help in identifying potential hazards. Furthermore, having the ability to take photos of the identified hazards would enhance their assessment.

6.4.1.3 *Observation of a similar activity*

To have a clearer picture of how the field trip is run, a similar field trip was observed. This was a field trip for a group of sixth formers students doing very similar activities that would be undertaken in the induction week with the level-one undergraduate students. However, in this case the risk assessment was already completed and given to the students. When arriving at the location the students were briefed. They were split into groups and were asked to read carefully through the risk assessment sheet that was handed to them prior to performing any activity. They were then allowed to go and perform engineering sketches of a particular bridge and given a time to meet.

6.4.2 Customising sLearn's content

In order for sLearn to support the activity, the content needed to be modified. The lecturers of any module are the best source of the suitable content for

their students. They know their students' strengths and weaknesses and thus, deliver the appropriate content that would help augment their students' learning. In the case of the HCI, the content was derived from weaknesses and strengths of the students that were known through the contextual inquiry approach in addition to what the lecturers thought would best support their students. However, in this case study, since this area is completely different from HCI and since the purpose of this study is to show that sLearn can be used in various contexts, the main source for the content of sLearn for this study was intended to come from the lecturers. One problem was that the lecturers were under pressure due to various unconnected engagements. This meant that they were not able to provide the content of sLearn for this study. Hence, the content was created from the risk assessment sheets that were given to the sixth form students as explained in 6.4.1.3. Thus, it might not reflect the weaknesses and the difficulties they encounter when learning *in-situ*, which might have affected the main goal of sLearn: supporting students when learning *in-situ*. This is shown in some of the results of the deployment in 7.5.1.

6.4.3 Deploying sLearn in the Engineering Context

Participants

As described earlier, this study was for students enrolled in two undergraduate engineering courses: Civil Engineering and River and Coastal Engineering. They were required to carry out a number of non-assessed activities on a field trip in the induction week of their first year at the University of the West of England.

Evaluation Design

Students were asked to self-divide themselves into groups of five, where each group would have students from the two different courses: Civil Engineering and River and Coastal Engineering. Seven groups came to the field trip, where they were told that there was an app to help them conduct one of the activities. Students were informed that they could use their own mobile phones if they had an Android-based smartphone. They were told that there were five HTC desire smartphones to borrow, and they were asked for a volunteer from five different groups. Five students came forward; each was given one HTC with the sLearn app preinstalled. However, two other groups did not have access to sLearn; either they did not have access to an Android-based smartphone or they did not volunteer. The concept of sLearn was explained to them. Other group members were told that they could download the app if they had an Android-based smartphone. The five students were handed a paper questionnaire to fill in after the activity.

Questionnaire

The questionnaire handed to the students was similar to the one given to the HCI and UX students; it had two parts: System Usability Scale (SUS) and Pedagogical usability statements. There were slight changes to the pedagogical usability to reflect their activity.

The Pedagogical statements were as follows:

1. The app helped in conducting the risk assessment.
2. The app gave me hints on what to look for.
3. The app helped me organise ideas.
4. The photos in the app were useful.

5. Using the app as a group encouraged us to share ideas.

Table 15 Evaluation design for Engineering

M3 Evaluation Level	Evaluation Aspect	Evaluation Method
Micro	3- Interface usability 4- Pedagogical usability	4- SUS questionnaire 5- sLearn questionnaire

Nonetheless, if this model shows to be generalizable, this would mean that the 'Macro' level of the M3 evaluation framework (Vavoula and Sharples, 2009) was deployed and that the contextual blended model had an impact on the traditional teaching and learning practice. An educational institution might consider making such an app available to various courses.

6.5 Methods of Analysis

This section discusses the methods used for analysing both the qualitative and quantitative data collected from all deployments. Issues regarding the reliability and validity of these methods are also discussed.

6.5.1 Qualitative data

The data was generated from interviews, observations, and analysis of students' submitted work as shown in Figure 25. The data from the interviews was analysed via assigning codes and themes as described by Miles *et al.* (2014). It was decided that the Content Data Analysis method would be used to allow patterns to emerge from the interview data. This process included grouping together the responses from participants for each interview question to enable themes to emerge from the grouped responses. The themes were then given appropriate names that related to the discussed issue. This

qualitative data analysis method is commonly used for evaluating interview transcripts (Cohen *et al.*, 2007). Narrative description (Miles *et al.*, 2014) was used to present the results.

In-depth content analysis of coursework submitted by students was used to discover what issues students tended to discover while conducting their observations; the frequency with which particular issues occurred in the work was also noted. The Descriptive Coding method (Miles *et al.*, 2014) was used to summarize issues identified in the students' work. This analysis was conducted in addition to the application of the marking scheme used to allocate marks given by the lecturers to enable a more detailed analysis of the work.

6.5.2 Quantitative data

Quantitative data was generated from the questionnaires given to students from the HCI, UX, DUE, and Engineering modules. The purpose of these questionnaires was to evaluate the usability of the app interface and pedagogical usability of the sLearn app from the students' point of view. The questionnaire for each deployment is explained in the evaluation design section of each deployment (see sections 6.1.2, 6.2.1, 6.3.1, and 6.4.3). The data gathered from the questionnaire included, students' self-diagnosis of their level of Android expertise, SUS results to measure the usability of sLearn, and pedagogical usability statements. The pedagogical usability questions were different for each deployment as they related directly to the coursework assignment and specific changes in the design of the sLearn app resulting from the in-context evaluations. The SUS part of the questionnaire

was analysed using the specific formula that generates a usability score for each participant (Brooke, 1996). The average for each pedagogical usability statement was calculated to show the mean score. Additional analysis was conducted to understand the effect of the level of expertise of using Androids on pedagogical usability. To ensure a large sample size for the analysis, the HCI and UX questionnaire responses were merged, bringing the total number of respondents to 38. A cross-tab using a Chi-square test was performed to find out if there were statistically significant differences in responses between students who were “expert” and “non-expert” Android users.

6.5.3 Research Validity

To ensure the ecological validity of the results, it was crucial that the research methods aided in answering the research questions.

As the contextual blended learning model for the HCI module was new, it was not possible to use a previous cohort’s results for comparison. Also, it was not possible to easily create control groups for the assessed work in the cohort, as it could create an unfair advantage for the student who had the assistance of the app. The approach adopted was therefore to compare performance of work supported by the app, with other elements of the assignment work completed without the support of the app. The use of Vavoula and Sharples’s framework (see sections 3.3, 6.1.2, and 6.3.1) helped to distinguish benefits of the app from different perspectives. The use of established metrics for usability and pedagogic utility strengthened the reliability of the evaluations considering the effectiveness of the app design and perceived benefits.

The findings were further verified by triangulating results from the analysis of Groups' presentations, questionnaire, and lecturers' discussion and feedback to students.

It should be pointed out that there was an attempt to gather more data regarding HCI students' perspectives and experiences of using the app, and develop a deeper understanding of reasons why some groups chose not to use it, via a focus group. However, due to a lack of engagement of the students to participate in a focus group, this could not be organised.

However as part of the DUE evaluation study, a more in-depth understanding of the use of sLearn app was possible. All evaluation aspects were considered to ensure that a maximum number of issues influencing use and experience were discovered. Choosing participants that had similar profiles to the actual end-users was necessary for an assessment of the app as whole. Observing the participants interact with the app in the intended environments and allowing them to communicate their feelings via the 'Think Aloud' method provided insights into the user experience. Additionally, conducting an interview to follow up the observations was a very important part of this evaluation study. According to Taylor *et al.* (2002): "Interviews can provide rich data and give considerable insight into perceptions and attitudes. Misperceptions or misunderstandings about what is being asked can be recognised and dealt with at the time. The interviewee has the opportunity to express opinions important to them, clarify ideas and feel that these are valued. The interview can be a learning process for both interviewer and interviewee". Adding the SUS questionnaire aided in understanding the

participants' views on the usability of the app. Furthermore, triangulating the results of these methods helped maximise the validity of the study.

The UX and Engineering deployments were conducted to further understand the effectiveness of sLearn as described in 6.3.1 and 6.4. However, the way the lecturers designed the assignment influenced the evaluation design and results as discussed later in 7.4, 7.4.5, and 7.5.

6.6 Conclusion

This chapter explained the research methodologies used to answer the main research questions and how the sLearn framework was tested with three different student cohorts: HCI, UX, and Engineering. The main studies were the HCI and UX, while the Engineering study was conducted to address the generalizability of the contextual blended learning model. Another crucial study was conducted to understand the effects of the environment on the user experience of sLearn. This was conducted with Masters level students enrolled on the DUE module. For an app such as this, conducting *in-situ* evaluations is vital. It is not only the user's interaction with the app interface that is important to evaluate, but also the effect of the environment surrounding him/her on the usability of the app and how it affects his/her ability to observe and analyse. The next chapter will discuss the results and analysis of each of the studies.

7 Chapter Seven: Results and Analysis

This chapter presents the results and analysis of all the studies conducted as part of this research. The results of the main study, for which the app was specifically designed, are presented first, followed by the results of the in-context evaluation and the UX deployment. Lastly, the deployment with engineering students is presented.

7.1 Deployment One: HCI Results

The fifth iteration of sLearn was used by the target user group for whom it was initially designed, the HCI students. The results and analysis for this evaluation which was conducted as described in 6.1.2 are presented below.

7.1.1 In-class group presentations – Assessing learners’ analysis and critical thinking skills

Sixteen groups presented their work in class over two days. All presentations were video recorded and groups also submitted a CD of the presentation slides and materials. Thirteen groups used the sLearn app for their assignment, out of which 3 groups borrowed the HTC smartphones and the ten others used their own. Three groups chose not to use sLearn.

Table 16 and Table 17 present the marks given to groups for their presentations based on the marking criteria discussed in 6.1.1. Two lecturers first independently marked all presentations; a moderation process followed this where a single mark was agreed based on a discussion and review of the presentation videos.

Table 16 HCI students' Coursework Allocated Marks- sLearn used

Group ID (Total Number of students) (sLearn users)	Depth and scope of observations	Translation of observations into insights	Translation of data into PACT	Translation of data into functional requirements	Translation of data into non- functional requirements	Marks for app supported elements	Overall marks for all the assignment elements
	1= Only superficial 6= Very Thorough	1= Lacking depth and detail 4= Went beyond the relatively obvious, and include depth and detail	1= The translations lacks depth 6= Went beyond the relatively obvious, and include depth and detail			Average = 77.32%	Average = 66.15%
A (4) (1)	3	2.5	2.5	5.5	5.5	67.8%	46%
B (4) (2)	5.5	3	6	5	3	80.3%	65%
C (3) (1)	6	4	6	6	6	100%	74%
D (3) (3)	3	2.5	3	4	5	62.5%	69%
E (4) (1)	5	3	5	5	5	82.14%	71%
F (4) (4)	6	4	5.5	6	6	98.2%	79%
G (3) (1)	(Not Presented) 0	(Not Presented) 0	6	6	3	53.57%	51%
H (3) (2)	6	4	6	6	6	100%	92%
I (3) (2)	5	3.5	5	3.5	0	60.7%	64%
J (3) (1)	4.5	(Not Presented) 0	5.5	6	6	78.57%	73%
K (3) (2)	4	2.5	4.5	4.5	3	66%	68%
L (3) (2)	5	3	5	6	2	75%	57%
M (2) (1)	3	3	4.5	6	6	80.35%	51%
Total number of Students who used sLearn	23						

Table 17 HCI's Coursework Allocated Marks- sLearn not used

Group ID	Depth and scope of observations	Translation of observations into insights	Translation of data into PACT	Translation of data into functional requirements	Translation of data into non-functional	Marks for app supported elements	Overall marks for all the assignment elements
	1= Only superficial 6= Very Thorough	1= Lacking depth and detail 4= Went beyond the relatively obvious, and include depth and detail	1= The translations lacks depth 6= Went beyond the relatively obvious, and include depth and detail			Average = 39.83%	Average = 47.33%
N	4.5	2.5	3.5	2.5	2.5	55.3%	53%
O	0	0	2.5	3	5	37.5%	58%
P	0	0	3.5	2	2	26.7%	31%

Table 16 shows that most groups did very well in their assignment. The average class mark for this cohort for the elements that were supported by use of the app is 77.32%, which is above the cohort average mark for the assignment as a whole, which is 66.15%. It is interesting to also note that the 3 groups receiving below 60% overall (Groups A, L and M), were the ones who seemed to have benefitted most from the use of the app. This is of particular interest because this app aims to aid students with less developed levels of analysis and critical thinking. Note that even if a group claimed to use the app, no marks were awarded to those who did not show any evidence of the assessed elements in their presentation (Groups G and J). Table 17 shows that the three groups (N, O, and P) who chose not to use the app received relatively low marks. However, since the number of groups that chose not to use the app is much smaller than the number of groups that used

the app, it was hard to build concrete conclusions, as this is likely to relate to their low engagement with the module in general.

The following sections show the detailed scrutiny of the students' work, which suggests a positive effect of sLearn on their performance. Below, each marking criterion is considered in turn and the extracts from students work demonstrate ways in which the criteria are met.

7.1.1.1 *Extracts from students work showing of depth and scope of observations*

The highlighted extracts in blue show how sLearn has influenced their observation. These highlighted extracts relate to prompts provided by the lecturers in sLearn which show how the students' were able to benefit from the prompts in widening their observations. It also shows the depth of their observations in relation to the given prompts where some students went beyond the obvious. The full list of prompts can be found in Appendix C.

Group B's work:

*"From our findings we found with **the entrance** that one of the doors wasn't open which would be a massive problem on a busy time such as lunchtime if there was a big queue waiting for their meals. We also found **other people can easily get in and out** at the time we were at the refectory but can be improved by **opening both doors**. There was also an important notice on the door showing that the onezone only accepts cash which made clear to the people using the refectory what payment method should be used. We also had to consider with our healthy eating system if we have a monitoring system then it has to be cash only.*

*Also the lines were unorganized, since **the counters are split into sections**. It also had a **good variety of food**. It was also clean and **staff was on help** all the time which made the customers more comfortable. In the environmental*

context for the customer, temperature of the room was warm and had dim lights which we will explain later on. Also *people look around and hesitated which section to go to*. They had a *variety of menu stands* to help make their decision. Once they made their choices, they ordered their meals”

“The *food area was split into sections: traditional, theatre, express*. Also *information about the food is available* on the stands provided next to each section. They had many varieties: such as *gluten free, hall, vegetarian, etc*. *The staff are prepared to give info to the students* and the food is displayed to the users fully, and in great details: *very appetising*. With the *seating area* we found users are offered *the cutlery* when they have to pay for their meals. No sign is shown to indicate the cutlery location, drinking waters are given in bottles, and they have to find the machine which houses them. Also it was *crowded in the seating area*. And most users were mostly in groups when getting food and eating they moved at their own pace. There was evidence of food wastage on the trays and they ate at their own pace, not rushed.”

The above extract demonstrates very detailed observation from group B showing how well they have considered various elements in the surrounding environment of the cafeteria that might influence the newly designed system.

Extracts from group C’s work:

“We conducted an observation of the OneZone refectory at two separate times (morning/lunchtime) and noted a couple of key things;

- *Students often knew exactly what they wanted before they even entered the refectory*, meaning they just walked in, picked up their items and proceeded through in a quick fashion. This is likely due to being regulars.
- *Staff seem willing to help* however when it gets busier there is a lot less room for that.
- *Most people who are eating in groups use the seating area*, whereas most who are on their own buy something they can leave with.”

Extracts from group L's work:

"A higher amount of customers seem to be returning customers and know more or less what they want. The different areas are decently well designated, and actual navigation seems to not be a big problem."

"What (sic) appear to be new customers read the signs, though it seems people are a little bit uncomfortable standing and reading, and some just go for the obvious option without understanding all the options. Returning customers have either already read the signs, or they don't care so much what is on them."

"There was a queue, and some people were looking at the salad bar and sandwiches. It was still easy to navigate, but people needed to check where they were going, or there might have been minor collisions."

"There is a distinct lack of nutritional value, though there is a colour guide (traffic lights) to indicate just how bad the cooked food is, and how often a particular food should be eaten. It's sort of encouraging having more healthy things with your fry-up, like tomato, instead of something less healthy (bacon). Though the item price is about the same, so even if a person is interested in more nutritional food, it seems like you are being screwed by choosing the tomato."

All the above extracts from the three different groups show that the students have conducted a thorough observation of the cafeteria. A great level of depth and detail was considered. It would seem that sLearn had an effect on the thoroughness of their observation. This was shown through their use of similar words to those provided by the lecturers in the prompts and extending their observation beyond the prompts. Prompts were carefully selected by the lecturers in order to overcome the difficulties the students' encounter when doing such a coursework as discussed in 4.1.1. It can be noted that the observations vary from a group to another; this might be due to the fact that some groups have visited the cafeteria more than once, as advised by their

lecturers, and were able to gather more thorough data. More extracts can be found in Appendix (J).

7.1.1.2 Extracts from students' work: Translation of data into PACT demonstrating critical thinking and synthesis

Group B's work:

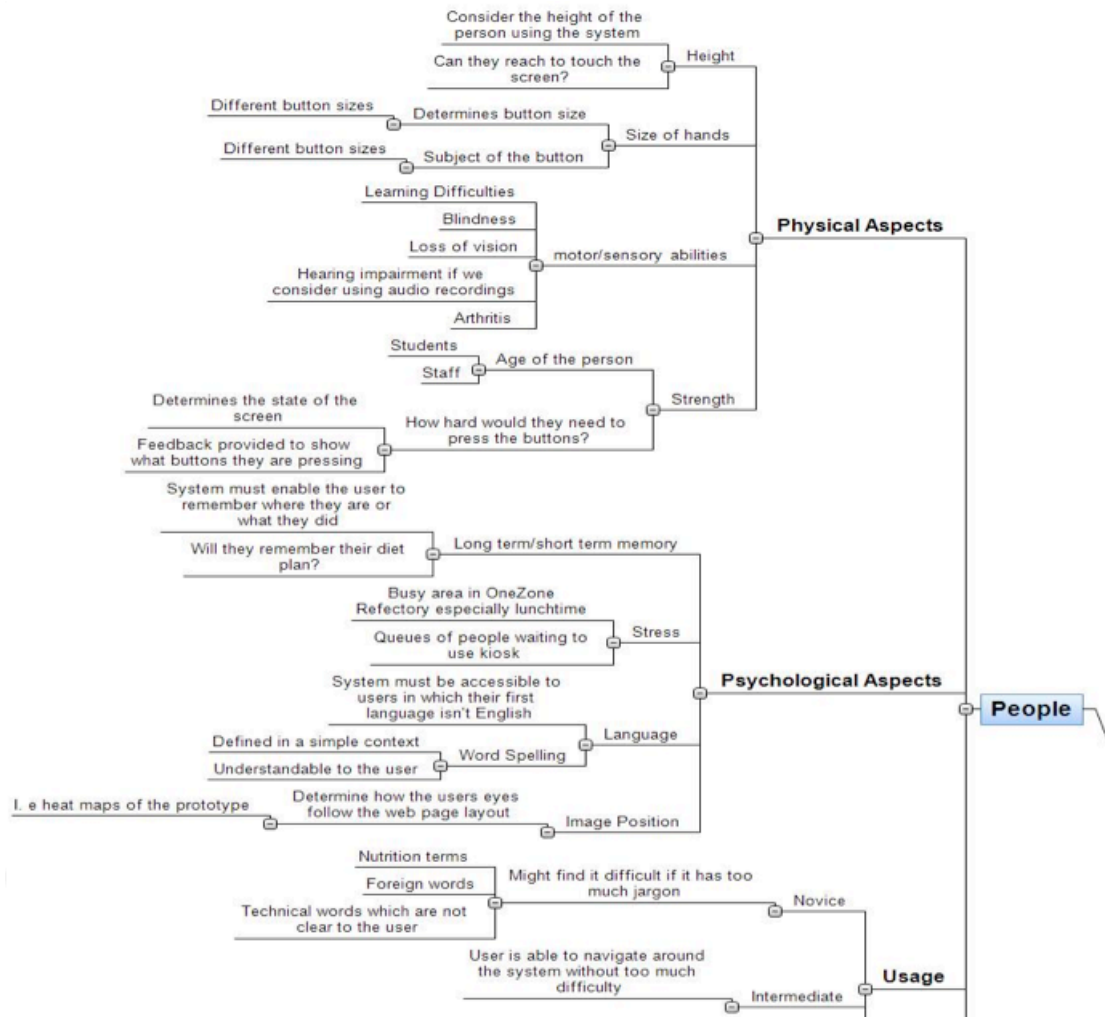


Figure 32 Group B's PACT part 1

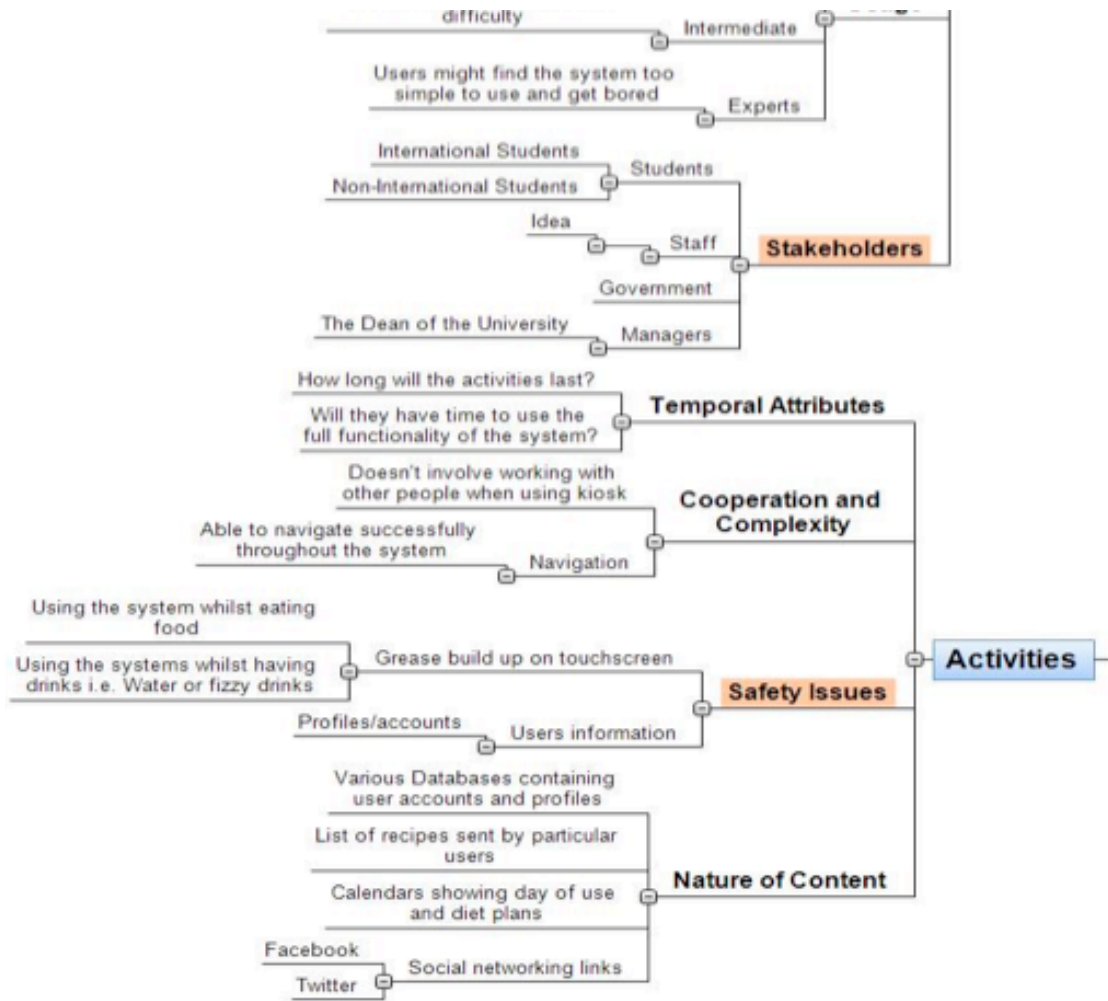


Figure 33 Group B's PACT part 2

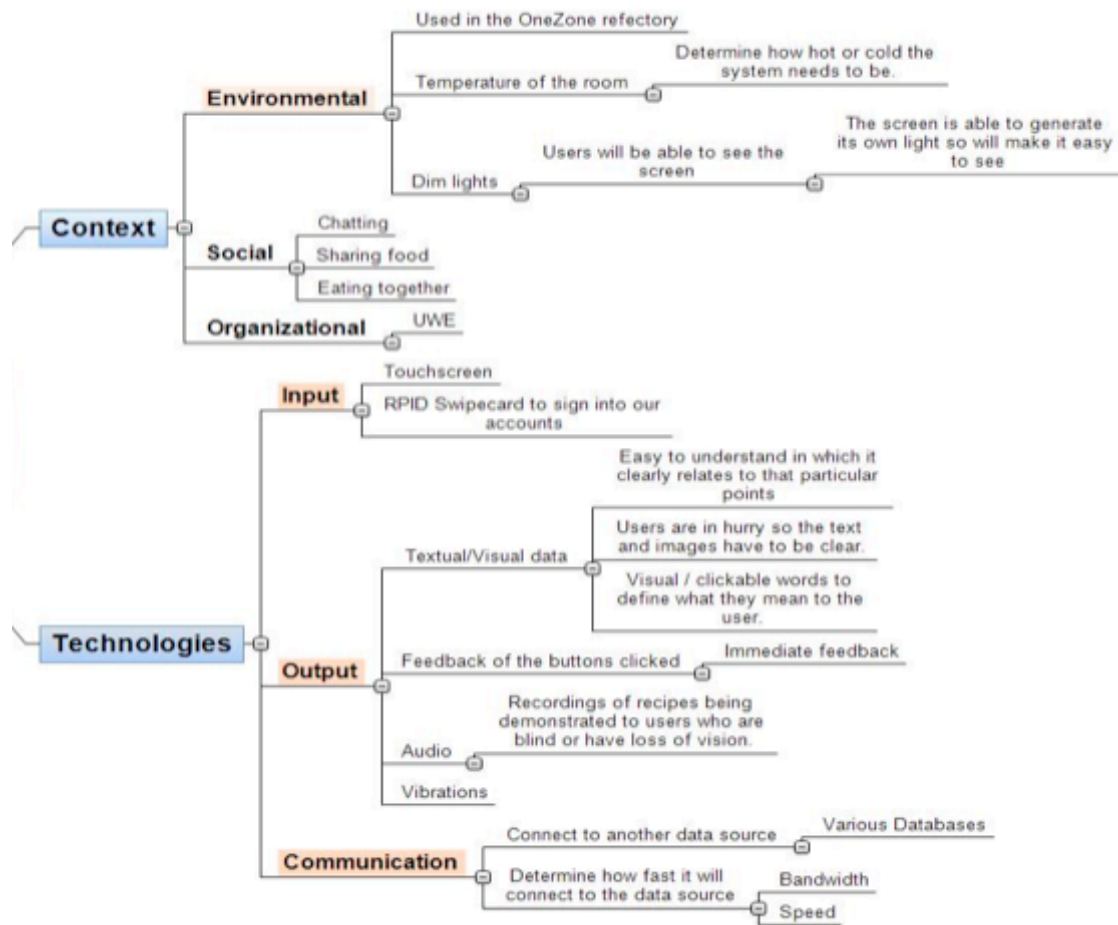


Figure 34 Group B's PACT part 3

Group C's work:

Person	Activity	Context	Technology
Often know what they want before entering.	Ordering food is undertaken every day by a lot of people (temporal).	Gets very busy/hectic around lunchtime.	Touch screen input
Varying shapes and sizes.			Wheelchair accessible
Some with disabilities	Ordering food is often rushed.	Most people move in groups.	LCD screen output shouldn't be a problem in the refectory.
Some very stressed	Likely to get interrupted by friends talking or other distractions.	Noisy in the busier hours.	Sound should not be key.
For the most part intelligent		Might be carrying books/ other items	

Figure 35 Group C's PACT

Group L's work:

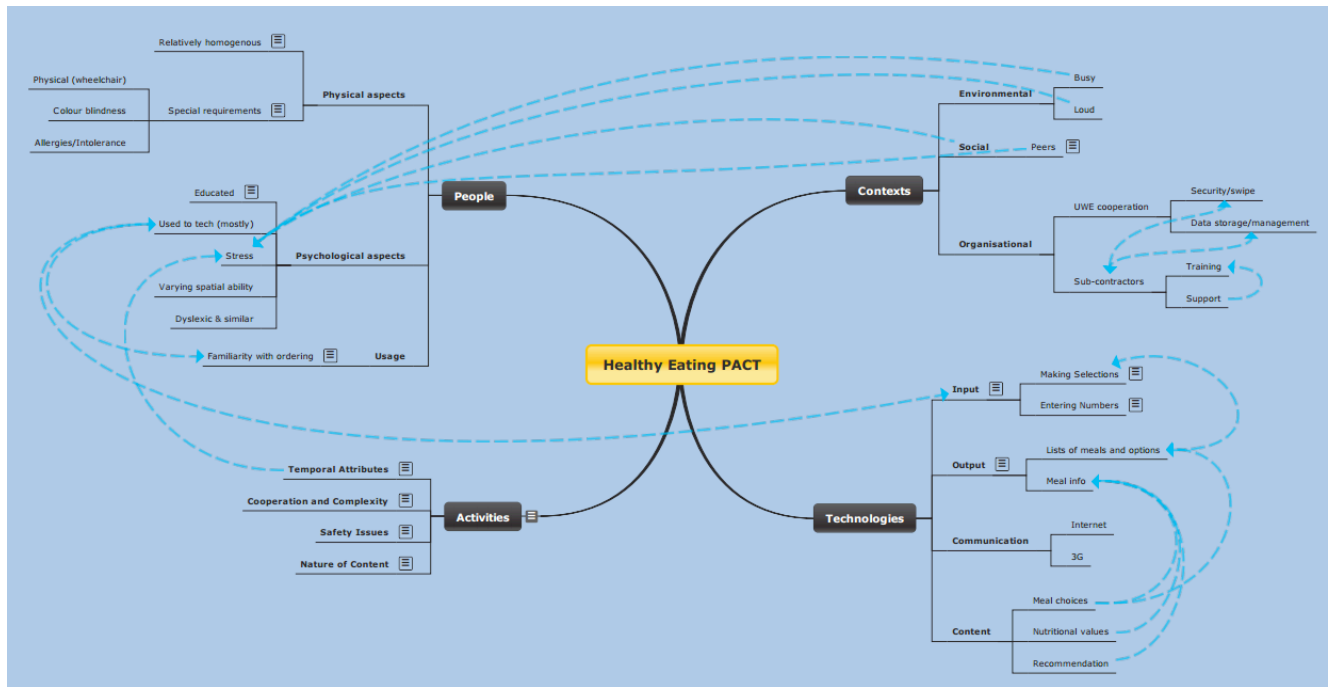


Figure 36 Group L's PACT

Group G's work

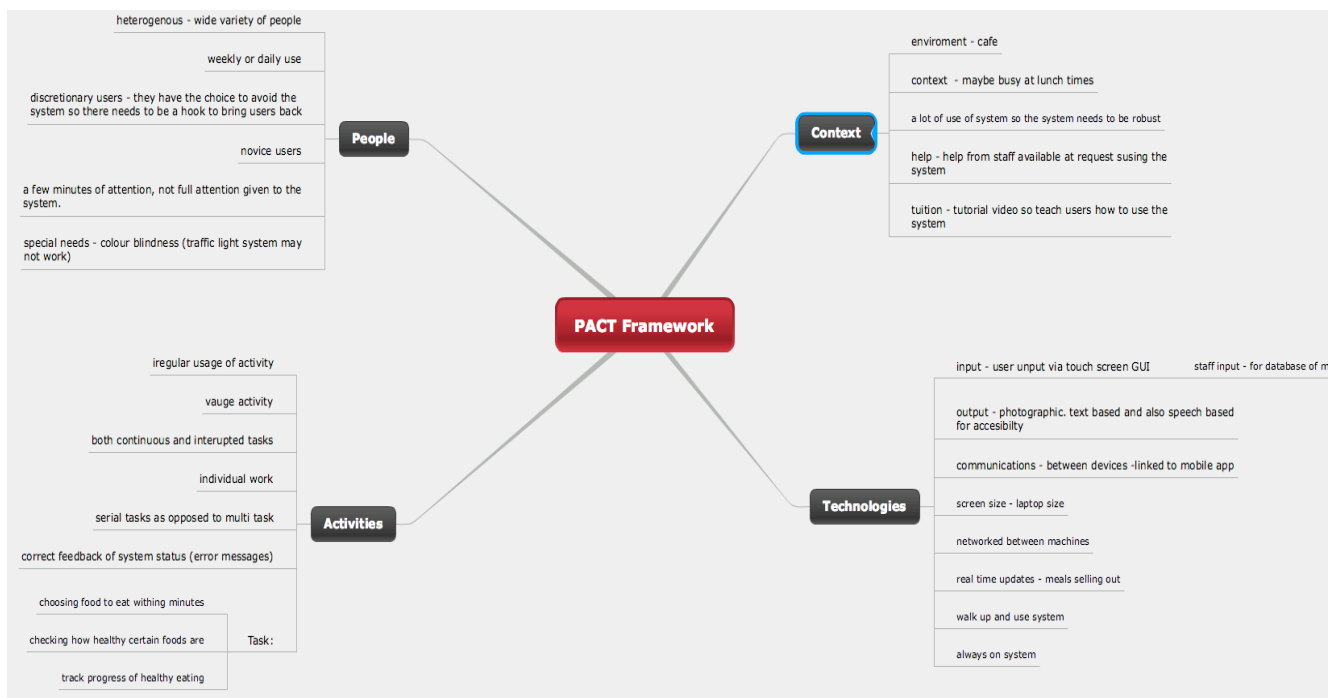


Figure 37 Group G's PACT

Group J's work

PACT Analysis

People

Main groups: students, lecturers and staff ages 18-45,

General traits: well educated, competent with technology's

Special Consideration: the disabled, vision impaired, size of insta.

Activities

Preliminary activities: interacting with the system, swiping RFID swipe card

Frequency: frequently, peaks twice a day.

Specific Activities: search system for refined information, diets , nutrition, browse menus and order food



Figure 38 Group J's PACT

PACT Analysis

Context

Physically: will take place indoors, potential users may be carrying debilitating objects

Socially: may happen in groups, more likely as individuals

Organisationally: context providing information about nutrition, dieting and general good health.

Technologies

Preliminary activities: interacting with the system, swiping RFID swipe card

Frequency: frequently, peaks twice a day.

Specific Activities: search system for refined information, diets , nutrition, browse menus and order food, retain an online profile.

Figure 39 Group J's PACT part 2

The students of group B have systematically reviewed aspects of OneZone, guided by sLearn to produce a PACT analysis. This has led them to note, for example, the need to accommodate visibility issues that might arise from the user's impaired vision, or from the dim lighting in the refectory. The ability to analyse the current system and to draw inferences from this analysis to identify requirements that are not immediately obvious (for example the benefit of audio recipes as a feature of the new system), demonstrate critical thinking skills previously noted by Fisher (2001) and listed in 2.6.2.

Although the translation of the data into PACT for groups (C, G, L, J), was not as detailed as group B, it still shows a high level of depth and detail where the students were able to analyse and synthesise the data collected, thus demonstrating critical thinking as defined by Scriven and Paul (1987). This was clearly shown in their presentation where they were able to clarify and interpret their expressions and ideas.

7.1.1.3 *Extracts from students' work: Translation of data into functional and non-functional requirements demonstrating critical thinking and synthesis*

Group A's work:

System Specifications

Functional Requirements

- Ability for users to set and update personal goals based on their individual needs.
 - Target calories
 - 5 a day
 - Dietary requirements
- Visual weight loss features (Charts etc.)
- Cloud Storage accessible from personal myUWE web site.
 - Ability to add data from home
 - Smart phone app compatible
- Use student ID card to log onto system (RFID technology), and pay via credit system managed online.
 - printed collection coupon.
- Optional visual view for people with optical impairments (high contrast).
- Optional audio voice over for people with optical impairments.
- Multiple language support linked with ID card to auto switch when logged on.



Non-Functional Requirements

- Sealed from elements design. (Splash/Dust proof)
- Tough scratch resistant screen.
- Regular system maintenance
- Disabled user friendly. (Separate kiosk – set at lower height)
- Coupon printer.
- Uniform layout throughout

GUI Guidelines

- APPLE-People make specific finger movements, called gestures, to operate the unique Multi-Touch interface of iOS devices. For example, people tap a button to activate it, flick or drag to scroll a long list, or pinch open to zoom in on an image. The Multi-Touch interface gives people a sense of immediate connection with their devices and enhances their sense of direct manipulation of onscreen objects. Familiarity is a key requirement to implement into a Food kiosk system which users can feel comfortable using and allow for repeated use.
- ANDROID - The user interface guideline is far stricter which allows more application freedom. As far as aspects regarding the colour scheme, font, layout and format of elements must relate to both the One zone café as well as UWE as a brand.

Figure 40 Group A's requirements

Group F's work:

Requirements

Functional

- Offer support in helping students & staff make the right meal choices.
 - Set & update goals & needs
 - Select options, choices & recommendations
 - Enable students to place orders
 - Use online credits to pay for their meals & be able to receive a collection token

Non-Functional

Data

- User Profiles
- Nutrition/dietary Information
- OneZone Menu- prices, calories

Environmental requirements or context of use

- **Physical:** Placed in a well lit area, non-reflective screen, height adjustable
- **Social:** Multilingual Language, user-friendly, enter reviews, accessibility
- **Organisational:** Training, maintenance/updates, user support (help button)
- **Technical:** Swipe card technology, printer, security

User

- Busy students/staff wanting to improve their healthy eating
- System to be used on a weekly basis
- Familiar with touch screen technologies

Usability

- Memorable- Consistent & Intuitive layout/navigation (repeated steps)
- Learnability- User-friendly interface, icons
- Effectiveness-Traffic light system, motivating

Figure 41 Group F's requirements

Group H's work:



Figure 42 Group H's requirements

Group L's work:

Functional Requirements:

Account services:

- Ability to create account with student ID in order to save information.
- Form for user to enter their needs & goals
- A recommendations page catered to the user's needs/goals.
- Language and visual preferences
- Ability to save and retrieve menus.

Generic services

- List of all food served in the Onezone, split up into meals (Breakfast, Lunch, etc.)
- A basic page for each food type containing important nutrition information (Carbs, calories, suggested serving, etc.)
- Allergy/intolerance information, with warning symbols for common allergies. (Such as nuts).
- Search function
- Opening hours of Onezone

Non-functional requirements:

- Administration (Keeping the software up to date)
- Security and privacy.
- Location of the HEIS

Group M's work:

Data Requirements

Must Have

- User information - must have database of users and their personal information along with their personal calorie information and any dietary requirements.
- Nutritional information - must have nutritional information about each meal that can be ordered.
- Menu data - must have a menu database which contains all the meals and prices.
- Payment data - This is the tokens that the user gets when ordering a meal. This needs to be connected to

Should Have

- Calorie information - should have a database of foods with calories & nutrition information which the user can use to create meals that they have eaten for the calorie calculator.
- Graphs of data - should be able to display the data as a graph to show the users calories / 5-a-day over time.

Could Have

- Store card information - this means the user only has to enter their card information once when buying tokens using the system. The downside to this is the database could get hacked and lots of students card info could get stolen. It doesn't take that long to enter in your card number each time. They might use a chip and pin device which would make paying safe and fast.

Figure 43 Group M's Requirements

Functional Requirements

Must Have

- Login - The system needs a login page so that users can login to their own page and get information about the food they have eaten and get personalised recommended meals.
- Order meals (menu) - The system needs to be able to let the user order meals and get a token to hand over at the onezone.
- Information on meals
 - Calories - Each meal should have calorie information which can be added to your total daily calories when you order the meal.
 - number of your 5-a-day - It should say how many of your 5 a day is in the meal.
 - Nutritional information - It should give nutritional information about the meal which will include energy, fat, salt and protein.
 - allergy information - It should give allergy information saying if it contains - or contains traces of - nuts, gluten and dairy.
 - vegetarian/vegan information - It should also give information if its suitable for vegetarians or vegans.

Should Have

- Calorie Calculator - The system could include a calorie calculator which would calculate how many calories you are getting each day.
 - Food - It would calculate food by the user entering in what food they have eaten.
 - Exercise - Users could enter how much calories they have lost from exercise to get a more accurate calculation of the calories.

Could Have

- Online website or phone app to update calories and information - The system could have an mobile app version or a browser version which means users don't have to go to the system to update their meals and other information, they can do it on the go or at home.

Figure 44 Group M's Requirements part 2

Although the requirements may differ from one group to another, they all show a high level of detail and consideration of various requirements. For example, group F has identified the need for the system to be placed in a well-lit area translating their observation into a requirement.

7.1.2 In-depth content analysis of students' work

Having considered how thoroughly students conducted their observations and PACT analyses, this additional analysis considers what issues students tend to notice and analyse, and whether any patterns emerge. Tables 18, 19, and 20 display the themes that have emerged from the in-depth content data analysis of the students' work. As explained in 6.5.1 the video recordings of the students' presentations were scrutinized to pick up patterns in the students' observations and analysis. Similar ideas were coded and grouped depending on the aspect, be it a 'people', 'context', 'activity', or a 'technology'

factor. This shows how students were able to observe and analyse data according to the PACT framework. This analysis should be of a particular interest to the HCI lecturers to help them understand what issues students tend to take into consideration and what issues most students tend to miss.

Table 18 Content Analysis of Students' work (The context)

The context	Groups
Doors (Entrance space)	B, D, H, I
Cash Only	B
Counters are split into sections	B, D, I, L
The lines were unorganized	B
Room temperature was warm	B
Lighting	B, E, C, H, F, K, M
Information about the food is available to some degree	B, D, H, J, L
Environment was also clean	B
Cutlery location	B, C, H, L
Busy (noisy)	B, C, F, G, I, J, L, M
Greasy environment	C, E
Traffic light system	D, E, F, G, H, I, L, M

Table 19 Content Analysis of Students' work (The people and Activities)

The People and Activities	Groups
Staff's Help	B, C, E, H, L
Customers mostly regulars	B, C, D, H, L, M
Some people look around and	B, D, H, L

hesitated	
People were mostly in groups	B, C, D, H, J, L
They moved at their own pace	B, D
International students	B, E, F, G, I, J, K, L, M
Psychological Aspects (Stress)	B, A, C, F, I, L, M
Physical Aspects (Disabilities)	B, A, C, E, F, G, I, J, K, L, M
Carrying Book, Bags	C, E, J
Rushed	C, F, H, D

Table 20 Content Analysis of Students' work (Technology)

Technology and problem solving	Groups
Cash only system	A, B
Touchscreen	B, C, F, G, J, K, L, M
Swipe card	A, B, F, G, J
Textual or visual data	B, M, F, H, K, L
Accommodate various students' backgrounds	B, F, E, J, K, M
Accommodate various technological abilities	A, B, C, F, G, J, K, L, M
Accommodate various physical abilities	B, C, E, F, G, H, J, K, M
Intuitive	C, B, E, F, G, H, J, K, M
Controlled sound (Busy environment)	C, M
Sanitary issues	C, H, E
App available for smartphones	E, F, G, K, M

System has to be in a well-lit area	B, E, C, F, H, K, M
-------------------------------------	---------------------

It can be seen from Table 18 that there are a number of ‘people’ issues that were noted by various groups such as being stressed or being international students. This has then led the students to identify appropriate technological solutions, providing an intuitive system that accommodates various students’ background. Another issue discovered was the need for the system to be placed in a well-lit area. On the other hand not many students noticed that the accepted method of payment in the OneZone is cash only and thus the system might have to adjust to that. Although this was a fairly observed issue missed by the students, it might be that many students did not think it was a crucial one. It could be simply that others did not notice it while it might, nevertheless, be an important one.

Many of these issues are specific to this particular coursework; lecturers could determine the pattern of weaknesses of the students and adapt the app to provide helpful prompts.

7.1.3 Questionnaire – Assessing Interface and Pedagogic Usability

As stated earlier, since groups were self-selecting, students had the freedom to decide which activities were undertaken by each group member. Some groups decided that not all members should go to the OneZone Café to conduct observations using the sLearn app. Therefore, only the students who conducted the observations were in a position to answer the questionnaire. Thus, only 23 students filled in and returned the paper questionnaire. Of these 23, 83% were expert touchscreen users. 39% of the 23 were expert Android

users, 35% were intermediate (have little experience), and 26% novice Android users.

The mean SUS score based on all the responses was 69; this is above the average SUS score. According to Bangor *et al.* (2008), this score falls within the high marginal scores of SUS scores. However, it was noticed that many students might have misinterpreted the first statement of the SUS questionnaire, 'I think that I would like to use this app frequently'. This may explain why many either disagreed or were neutral. Students perhaps felt that they did not need to use this application anymore as they had already submitted their assignment. The statement should have been modified to 'I think that I would like to use this app or a similar app whenever available for this sort of learning.'

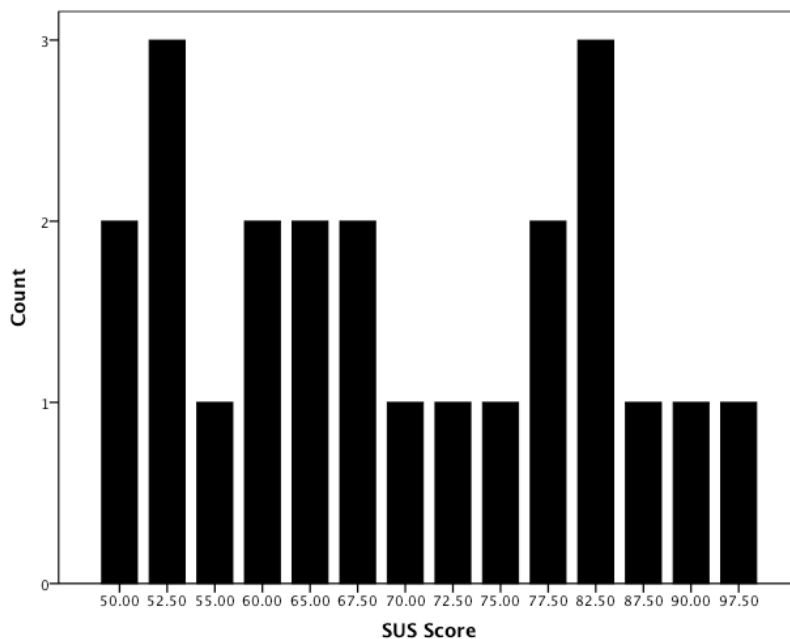


Figure 45 HCI's SUS Scores

Table 21 shows the mean response to each of the statements for the pedagogic usability part of the questionnaire.

Table 21 HCI's Pedagogic Usability Question Results

Statements	Mean	
	N	Scores
The app helped me in my observation	23	4.17
The app gave me hints on what to look for	22	4.36
The app helped me organise my ideas	22	4.18
It was helpful to have a space for note taking	23	2.43
The app helped our group members to share ideas and notes	23	3.74
The Forum (Blog) within the app was useful	18	3.00
It was useful to track my progress through Profile	21	3.71
The app helped me develop ideas for PACT	22	4.36

When N is less than 23, it indicates that some students had chosen 'Not Applicable' for this statement. On six of the eight pedagogic usability metrics, the mean scores are above 3, indicating that in regards to these aspects the students feel that they have benefitted from sLearn when doing their activity. The lower score for the statement on note taking might relate to the awkwardness of typing notes on a small device; this needs to be further investigated. Although a number of researchers found that blogs were effective for learning (Halic *et al.*, 2010; PIFARRÉ *et al.*, 2013), the mean score of the usefulness of the blog, in this study, was 3.00. This is likely to be due to the fact that the collaboration part was excluded from the objectives of the teaching model. This feature requires attention and further investigation.

The questionnaire had an optional space asking what features they would wish to see in the app. The following are extracts of the comments received:

A: *“A help button for users who are stuck or have never used the app before. Also training to make you understand the Android all together mainly by explanation from users or video tutorials”*

B: *“iOS Version. A few more physical images of onezone”*

C: *“Record audio notes. Bit awkward to type lots of notes on mobile.”*

D: *“iOS support, I wound up using an emulator. Otherwise it was very helpful. Thank you :)”*

E: *“Interactive functions such as tutorials for people who don't know how to use the app- some usability functions e.g. change of font options.”*

F: *“The app could have a function to upload notes and pictures to blackboard so they can be retrieved easier as the email function keeps failing.”*

G: *“Upload feature became a problem for us as we were unable to upload notes or the pictures we took to blackboard”*

H: *“No extra features”*

As this part of the questionnaire was optional, only eight students filled it in. However, this suggests that these students felt the potential of sLearn and wanted to take it to another level.

The two main issues raised the need for more help by providing video tutorials and providing an iOS version of sLearn. Although there is a help button explaining various elements of the app and the app was explained to students in a lecture, students felt the need for tutorials. This is perhaps mainly due to the fact that they are not familiar with Android or HTC phones and possibly did not attend the lecture. This leads to the second issue of providing sLearn on

multiple platforms to accommodate personalisation. However, since sLearn has shown its potential and students requested that it become available to other platforms, sLearn should be developed to run on multiple platforms when further deployed in higher education institutes.

Another problem reported was that with uploading notes via email. This functionality had failed with two of the three groups that borrowed an HTC from the university. By the time they tried to use this functionality, the phone's system needed updating and the mail function did not work properly. This was not an issue with the third phone and with the groups that used their own phone. Using an unfamiliar phone and not knowing how to solve a problem, such as that described above, would certainly result in a frustrated user. This has raised some questions of how being a novice user of a phone would affect the usability and user experience of an application and what issues, not app related, the user might face that would influence the user experience. These aspects are further investigated and discussed in 7.2.1.

7.1.4 Discussion

As discussed earlier in 3.1.5, it is a challenging task to find an objective way to evidence that the app improves the quality of students' observations, and that it facilitates deeper analysis and critical thinking. It was decided to assess this by defining and applying clear marking criteria to a specified piece of work that was completed with the support of the app. While it is problematic to compare different cohorts, the overall high achievement of this group stands out in terms of their work being thorough, and consisting of a high level of depth and detail. Based on quantitative results, overall engagement with the observational requirements activity, as well as the quality of the students'

insights and requirements emerging as a consequence of their observations supported by the use of the sLearn, indicates that the app has had an effective impact on student learning. In regards to the blended learning model, facilitating empathy was an objective. The approach used in immersing the student in real environments can help them view the situation from the perspective of the user, hence helping them to generate empathy as discussed in 2.5. As a result of being provided with contextual prompts when carrying out close observation, it was noted that they develop shared understanding and become more aware and appreciative of issues that are faced by the user. Extracts of student works can be found in appendix (G).

There are numerous challenges in designing and evaluating mobile learning within this context. As with any intervention, the outcomes are often due to a complex set of interacting factors. These include group dynamics, particularly in a group activity such as this, ownership of mobile devices, as well as willingness and motivation to engage or try something new, intrinsic ability, the novelty value of the app, and the usability of the interface versus the helpfulness of the content. Trialling an app such as this on a cohort of students outside of a controlled assessment can result in only those who are highly engaged in participating. Also as discussed by Anderson *et al.* (1996), and noted in observing usage of the app, a number of groups divided the work between group members, which resulted in some not having a first hand experience of the context. Gaining objective results, which are ecologically valid, means that it is not possible to easily create control groups for assessed work as it could create an unfair advantage to one of the groups. The

approach adopted here, assessing performance on work supported by the app, against other elements of the assignment work, is promising.

The use of Vavoula and Sharples's framework helped to distinguish benefits from different perspectives. The use of established metrics for usability and pedagogic utility has provided additional strength for the approach, in terms of effectiveness of the app design and perceived benefits. Engaging students in this process of evaluation of the app could also encourage them to consider the use of other apps or tools for tracking progress and facilitating a methodical approach to learning. It would be interesting to follow-up on whether the use of an app in one context, encourages students to seek out other learning apps of their own volition.

Another significant issue that has emerged from this deployment is considering the appropriate level of support and prompting that which should be included in the app. The design of the content of the app, whereby the guidance is just enough to prompt thinking, without inhibiting independent thinking, can be a difficult balance to achieve. Do we want to give higher education students highly prescriptive instructions at this level? To what extent are instructions truly necessary and do they risk jeopardising the independent learning expected of HE students? These are important questions to debate, particularly when considering whether the purpose of such apps is to develop learning skills or augment learning. This debate is acknowledged in the research community as discussed in 2.5. Many students struggle handling less structured tasks, which is especially true for computer science students who are used to right or wrong answers (Edwards *et al.*, 2006). It should be clear to students that this app will act as a preliminary

guide only. The hints and prompts provided should be viewed as the beginning of a thread and they should aim to identify issues beyond the obvious and the predictable. However, more instructions on how to use such an app should be available at the start.

7.2 In-Context Evaluation

The fifth iteration was used to understand the influence of the context of use on the user experience of sLearn. This evaluation was conducted with masters students enrolled in the DUE module as described in 6.2.1.

7.2.1 Observations Results

It was important that the presence of the evaluator did not influence the participant in any way. The participants were reminded to think aloud when they seemed hesitant. However, whenever a participant asked what he/she should do, they were asked to do what they thought was right. All participants were freely moving around. One participant received a call while using the app which did not affect his usage as he went back to the app as soon as he had finished. Some got really engaged and went to members of staff and asked some questions.

Table 22 shows the issues that were observed when the students were using the app in this study.

Table 22 In-context observation issues

	Error or Hesitance						
Participant ID	A: Hesitation or confusion in general	B: Did not scroll to find the text box	C: Did not know how to post to forum	D: Confused whether to save the notes first or post then save	E: Did not know how to remove the keyboard	F: Did not tick the checkbox after acting upon the hint	G: Conscious that staff will notice that he/she is not here for buying

							food
1 (2 participants at once)	At the beginning			✘			
2		✘		✘	✘		✘
3					✘		
4	At the beginning			✘		✘	
5	At the beginning				✘		✘
6							
No of participants	3	1	0	3	3	1	2

The table showed the issues that occurred while observing the students interacting with sLearn in the OneZone café. The three main issues recurring were issues A, D, and E. Nevertheless, it can be argued that the first two issues relate to participants' anxiousness about making a mistake even though they were told that it was acceptable to make mistakes. Issue E relates to the fact that they were novice HTC users. However, it should be pointed out that issues A and E might be a result of using an HTC for the first time. This fact has significant impact on the user experience of sLearn. Not knowing how to remove the keyboard away from the screen creates frustration and thus a negative experience, as noted during observation of the students. This situation might have occurred with some of the students in the HCI deployment where 64% of the students were non-expert Android users. This raises the question of whether it is more appropriate to show the novice

participants various functionalities of the actual phone prior to the evaluation of the app, thus ensuring that their experience is not affected by external factors (the non-related app features).



Figure 46 A student observing the entrance and the food area of the cafeteria

7.2.2 Interviews

The main themes of the interview were general usability and pedagogical usability, and contextual influences. The emerging findings of these interviews will be presented accordingly.

Theme One: General usability

Finding 1. Instructions: more explicit instructions should be available to students at the beginning. The reason behind some participants being confused or hesitant is the lack of instructions, as participants described. Although some instructions were on each location's screen and a help screen was provided, this was not enough nor practical for them.

Finding 2. Redesign: all participants prefer that under each prompt there should be a text box to write their notes and observations. This will make their notes more organised. It is easier to look at the prompt and write rather than scroll up and down in a busy environment. According to the participants this helps in giving specific answers and avoids clustering of information.

Theme Two: Pedagogical Usability

Finding 1. Helpful and Supportive app: All participants agreed that the sLearn has helped them in their observation. The prompts were supportive and sLearn helped them organise ideas. However, some would prefer each prompt to only contain one prompt/question.

Theme Three: The Context

Finding 1. Personality and self-consciousness: Most participants felt comfortable using sLearn in its intended environment. They were moving, observing and writing down their notes with ease. 28.57% of the participants did not feel comfortable looking around at people and writing on the phone. One participant would have preferred there to be a voice recorder within sLearn to record his notes and observation and to later enter them as text. This confirms that the social context does influence the user experience discussed in 3.7.2. Another participant commented on the small size of the screen and size of the keyboard, which is a known issue in mobile phones as discussed in 3.1.1 and 3.1.4. He said that he would be more comfortable if he could use a tablet for this type of application.

7.2.3 Questionnaire

As with the HCI deployment, the participants of this study filled the SUS questionnaire. The only difference was that the first statement was modified to

“I think that I would like to use this app or a similar app whenever available for this sort of learning”. This was done to avoid any misunderstanding, which might have happened with the HCI students.

All seven students filled in the questionnaire. Of these, 57.14% were expert Android users, while 42.85% were either novice users or have little experience.

The figure below shows the SUS scored by each of the participants.

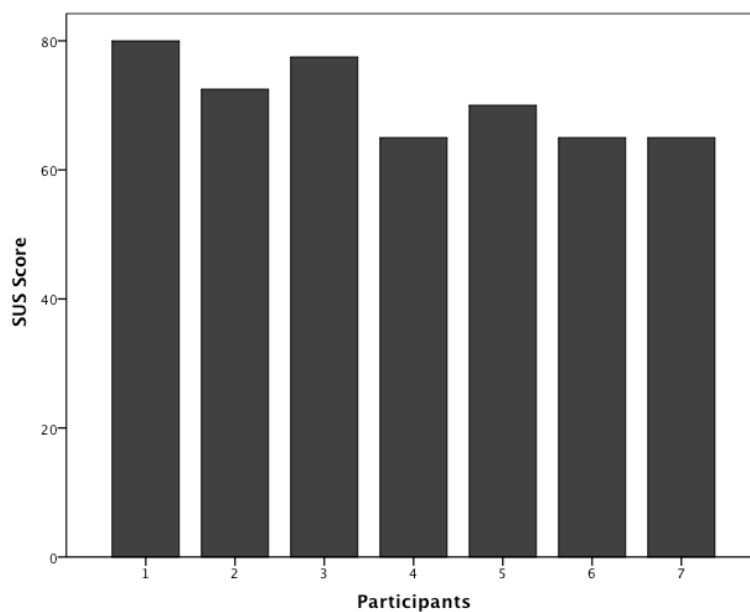


Figure 47 DUE's SUS Scores

The SUS score for the whole group was 70.7, which is higher than the average score of 68. According to Bangor *et al.* (2008) this score falls within the Acceptable scores of SUS scores. This score is slightly higher than the one obtained in the HCI's case study.

7.2.4 Discussion

Earlier, the difference between field and lab evaluations was discussed. Kaikkonen *et al.*'s (2005) study found that there were no differences between

lab and field evaluations in the number of usability problems identified. However, since this app is to be mainly used in a specific environment, conducting in-situ evaluations will highlight issues that will most likely be missed in the lab. It is not only the user's interaction being investigated, but also the effect of the environment surrounding him/her on the usability of the app, the user experience, and how it affects his/her ability to observe and analyse.

While observing the participants using the app, it was noted that their learning styles and personality had an influence on how they perceived it. Although most of them were not affected by the people around them and moved freely, some were rather uncomfortable observing, typing and taking photos. Some were very engaged and went to ask members of staff at the café some questions. This observation of users supports the study by Lemmela *et al.* (2008), mentioned in the literature, that context has an influence on the user's preferences in the usage of modalities and interaction strategies. However, it should be pointed out that in Lemmela *et al.*'s study, the users did not prefer the speech input when in a walking environment, while in this study some students felt it would be beneficial to have a speech input. This shows the importance of considering the context of use and the users' preference when designing. This supports the argument of Wang and Karlström (2012), discussed earlier in 2.5.1, that multimodal interaction was significant to ID students when they were using the iPads outdoors.

Additionally, all participants were spatially aware while using the app, as none of them bumped into people or objects around. Moreover, The overall experience of the participants was satisfying.

These findings have significant implications for research in this field and confirm the claims and findings by Korn and Zander (2010) and Tsiaousis and Giaglis (2010). Conducting evaluations in context does lead to the discovery of issues that could not be discovered when evaluating in a lab due to social and physical interactions. If this evaluation was in lab, the user might not feel the way she/he felt while using the app *in-situ* and thus, the need for multimodal interaction, for example, would not have been identified. Furthermore, they might not have felt the need for a separate textbox under each prompt in an isolated lab. When designing mobile applications for situated learning purposes it is best to consider the users, or participants with a similar profile, as co-designers, as discussed in 3.3. Their needs should be met, as far as possible, to receive the maximum benefit from the app, even when this means trading-off a design principle. This can be especially true in a university context where many students are international and might not feel confident.

Furthermore, the issues discovered from the observations show that being a novice user of a particular phone would certainly influence the results of the user experience of the app. Participants might come across some issues that are not app related, such as the removing of the keyboard, which would result in frustration if they did not know how to solve it. It would be beneficial to demonstrate some of the phone's main functionality to novice participants to ensure that any difficulties that they might encounter are related to the app rather than the phone.

7.3 sLearn Iteration Six

As discussed in the section above, there were a number of issues that needed consideration before carrying out a new trial with different student cohorts. The two main changes that were inserted in this iteration were: more instructions and more textboxes.

7.3.1 Redesign

Students felt the need for a textbox under each of the prompts given to them. They argued that this would make the ideas more organised. Since sLearn is supposed to augment their learning, it was necessary to reflect on this particular comment. However, having only a textbox under each prompt would limit thinking and jeopardises their independent learning. Thus, It was agreed to add one last textbox at the end of the screen to allow extra observations and notes. The figure below shows the modification made.

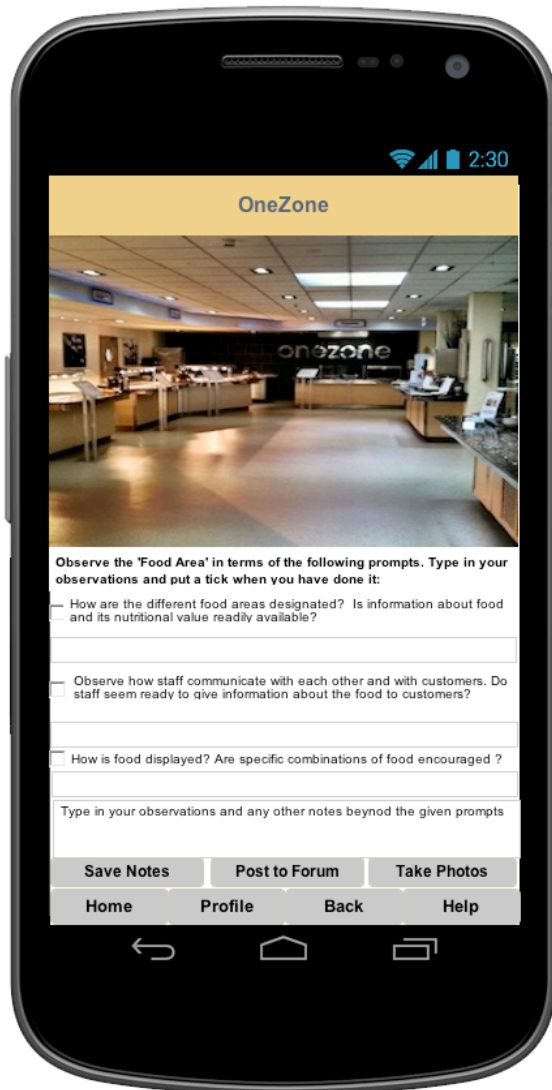


Figure 48 More Textboxes added to each location

7.3.2 Clearer Instructions

As discussed earlier, students' felt they needed more instructions. However, when it comes to university students many questions arise regarding the level, detail and necessity of the given instructions as discussed in 7.1.4. It was decided to make the instructions regarding the purpose of sLearn clearer to students. Below is a figure showing the modified instructions.

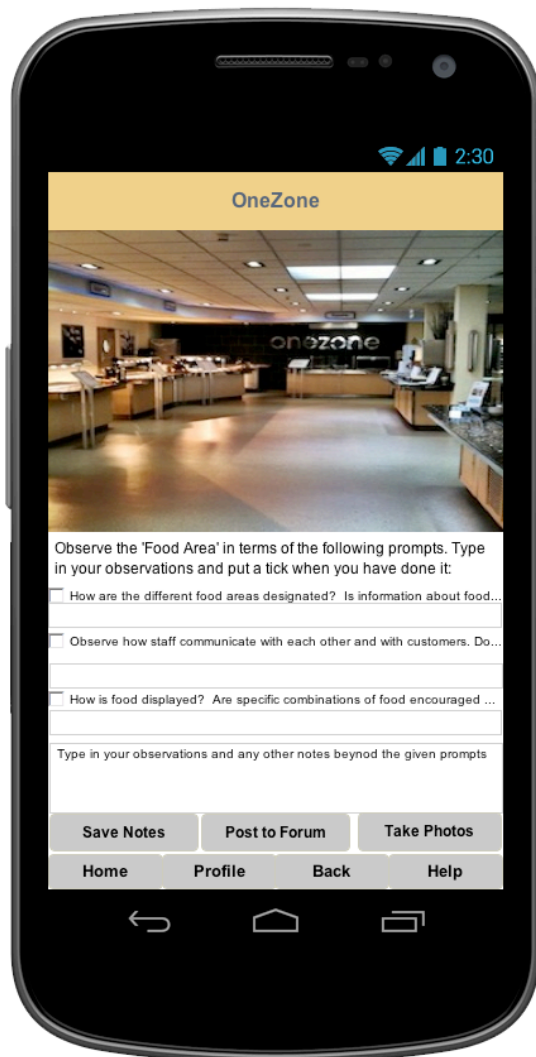


Figure 49 Clearer instruction on what to do in each location

Figure 49 gives the student a hint that this big textbox at the end is for further observations, advising them not to limit their thinking to the prompts given above. This should remind them that the prompts within the app are only a guide and they should look for issues beyond what is provided to them.

7.4 Deployment Two: UX Results

As with the first deployment, this study involved different assessment and evaluations methods to support and reinforce the findings of this deployment.

The results for each method are analysed and explained separately below. Once all results were analysed, they were all triangulated into findings.

7.4.1 Observations of usage

As with the HCI deployment, conducting an *in-situ* evaluation of sLearn was not a good choice in this context. Some students might not feel comfortable being watched performing the coursework's task as this might affect the quality of their observations and thus the quality of their coursework. However, as this module had a three-hour lecture, the lecturer allowed the students to go to OneZone to start their data gathering as a class activity. In this session, only 20 students attended, although the lecturer had informed the students about the intended activity before the session. There were six available Android-based smartphones to be borrowed. Six pairs borrowed the university's phones while four pairs used their own android-based phones/tablet. The students with the borrowed phones were allowed to keep the phone with them for further observations.

It was a good opportunity to observe the actual students using sLearn in the context it was designed for as the lecturer and the author accompanied students to the cafe. Since it was past lunchtime, the cafe was quiet. Allowing the students to carry out the observations during a timetabled session gave the opportunity to observe how they engaged with sLearn without affecting the actual purpose of the activity.

This observation did not appear to interfere with their work as we did not make any close observations and thus they did not feel our presence. None of the students came and asked any questions, either about sLearn or about the activity. All students were moving freely in the café, acting on the prompts

given in sLearn, and looked engaged. Figure 50 and Figure 50 show the students using sLearn.



Figure 50 UX Students interacting with sLearn

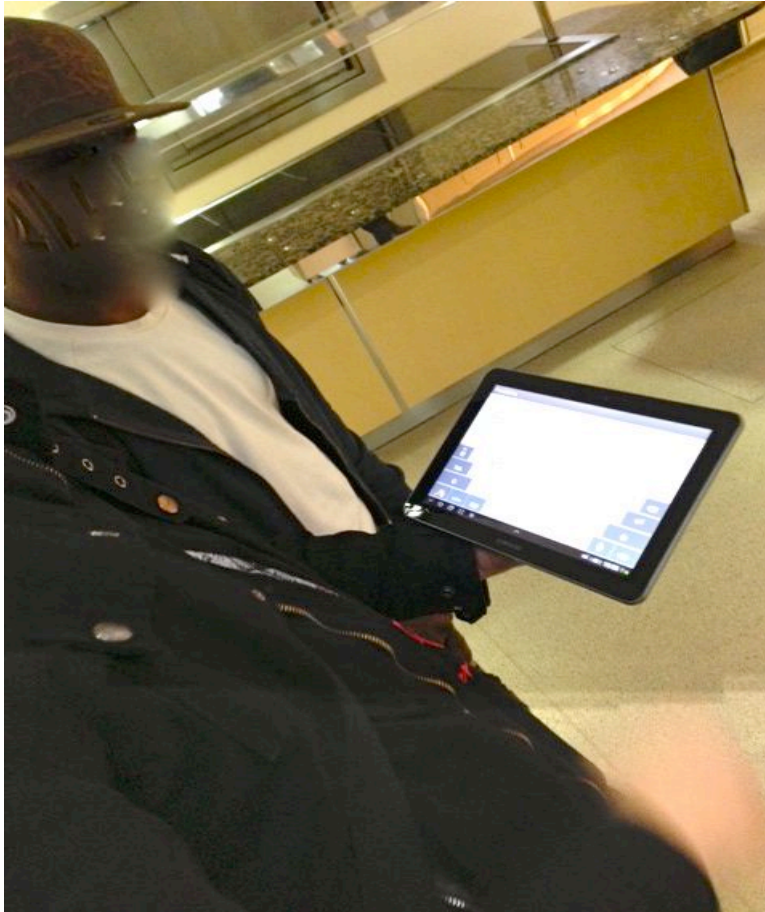


Figure 51 UX students interacting with sLearn on their tablet

7.4.2 Questionnaire

The link to the questionnaire was given to students by the lecturer and was available through Blackboard from three weeks after their first use of sLearn until the submission deadline of the assignment. Fifteen out of 22 students filled the online questionnaire, a response rate of 68%.

The questionnaire had two parts: SUS and Pedagogical usability.

The mean SUS score based on all the responses was 71, which is higher than the average score of 68. According to Bangor *et al.* (2008) this score falls within the acceptable scores of SUS scores. This score is higher than the one

obtained in the previous trial with the HCI students. Below is a figure showing the SUS scores obtained and the frequency of each score.

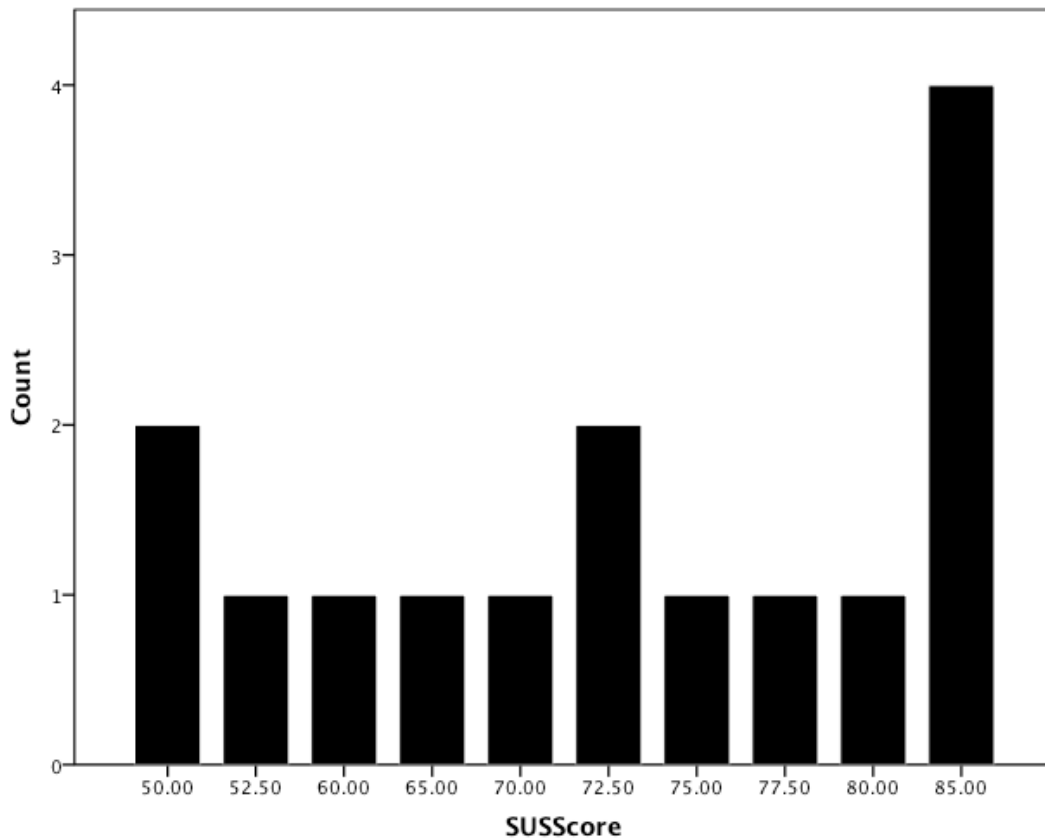


Figure 52 UX SUS Scores

Table 23 shows the mean response to each of the statements for the pedagogic usability part of the questionnaire.

Table 23 UX's Pedagogical Usability Results

Statement	N	Mean
The app helped me in my observation	15	4.27
The app gave me hints on what to look for	15	4.07
The app helped me organise my ideas	15	3.93
It was helpful to have a space for note taking under each hint	15	4.40

It was helpful to have textbox for extra observations and notes	15	4.33
The app helped in sharing ideas and notes	15	3.67
The Forum (Blog) within the app was useful	15	3.33
It was useful to track my progress through Profile	15	3.53
The app helped me develop ideas for PACT	15	3.93

From Table 23 it is clear that all nine pedagogic usability metrics were above the average of three, indicating that in regards to these aspects the students feel that they have benefitted from sLearn when doing their activity. Changing the design by adding textboxes under each prompt has made a significant change. In the previous iteration the average score for the benefit of the single textbox was below average having a score of 2.43. UX students felt that having a space for note taking under each hint was helpful giving it an average of 4.40; they also thought that having an extra textbox for note taking was helpful giving it an average of 4.33. This design trade-off following the HCI deployment and the DUE in-situ evaluation appeared to have improved the pedagogical usability of sLearn.

7.4.3 Submitted Coursework

Twenty students submitted this exercise via blackboard. The submitted work has been marked and analysed. Because some students shared a phone when conducting the observation, they both were given a pair number. To

distinguish the work of the individuals, each student was assigned a unique ID (combination of the pair number and a letter). Table 24 shows the details of the marks given to each student and the overall mark.

Table 24 UX's coursework mark allocation

Student ID	Phone ownership	Observations 1-3 1= Only superficial 3= Very Thorough	PACT 1-3 1= The translations lacks depth 3= Went beyond the relatively obvious, and include depth and detail	Insights 1-4 1= Lacking depth and detail 4= Went beyond the relatively obvious, and include depth and detail	Overall Mark
1A	N	2	1.5	2	55%
1B	N	2	2.5	3.5	80%
2A	Y	2.5	2	1.5	60%
2B	Y	2.5	Not submitted	1	35%
3A	Y	2.5	1	1.5	45%
3B	Y	0.5	2	0	25%
4A	Y	3	2.5	4	95%
4B	Y	2	1.5	3.5	70%
5A	N	1.5	2	1.5	50%
5B	N	2	1	2	50%
7A	Y	1.5	1	1	35%
7B	Y	1	Not submitted	Not discussed	10%
8A	N	2.5	1.5	2	60%
8B	N	3	2	3	80%
10A	N	3	2.5	3	85%
10B	N	2	1.5	1	45%
11A	N	3	3	4	100%
11B	N	2.5	3	3	85%
12	Y	3	2.5	2	75%
13	Y	2.5	2	1.5	60%
Average class mark					60%

The table shows that 55% of the students got the average, a merit, or a higher mark. Of the 55%, 40% of the students got distinction. The 45% that got a below average mark have done well in the observations part of the exercise. This might indicate that in this group sLearn has helped them discover and identify elements of the environment, however, the issues that prevented

them from getting high marks were translating these into insight and/or PACT as in students (3A, 5A, 10B). As discussed previously in the deployment of the HCI in 7.1.1, sLearn is aimed at students with less developed skills. The question remains, had sLearn not been available, would they have been able to pass this assignment?

The table shows that three students (2B, 7A, 7B) have failed this assignment. Although they claimed they had used sLearn to support their work, the evidence was not strong. This can be related to various reasons discussed below.

7.4.4 Discussion

As explained in the observation section, the students seemed engaged the first time they used sLearn during the class activity. No issues or uncertainty were raised either during this activity or afterwards. This can be seen as well from the results of the questionnaire where the SUS score was 71 and all pedagogical metrics were above average. Although the average mark received by the whole class was a merit, there were still a number of students who did not do well. It is very challenging to understand the exact reasons for this. However, there are a number of factors that might have had an influence, which need to be addressed. This exercise was a part of eight exercise submissions, where only six were chosen for the final mark, and therefore some students might not have put all their efforts into this one. Another influence may have been the fact that, this time, it was an individual piece of work, and also the fact that the students submitted their work electronically and did not present their work before the lecturers. Lastly, it could be that some only conducted the observations once, as part of the class activity

discussed in 7.4.1 and did not conduct further observations when the refectory was busy, as advised by the lecturer. It could be that all these factors or only some influenced their performance. Furthermore, when it comes to higher education, students are expected to be self-motivated and independent learners. Lecturers pointed out that students with lower marks were not engaged and seemed to be less motivated.

7.4.5 Comparison between HCI and UX deployments

In the HCI deployment, having a group project did not allow all students to benefit from sLearn, since many had chosen to distribute tasks among group members and thus some groups decided that only one or two group members should do this task. This has led to a debate on the appropriate approach that should be implemented for such an activity. Does making this activity an individual activity allow all students to experience the various tasks? Would this mean all students would benefit from the app and thus would provide an in-depth analysis and greater critical thinking? To begin to answer these questions the UX study was conducted.

The way the UX assignment was designed, as an individual-based assignment, was to address some of the issues that arose in the HCI study. However, as shown in 7.4.3, although 90% of the students did well in the observation part of their assignment, this was not the case in the PACT and Insight elements of the assignment for 45% of the students. This indicates that the app helped them in carrying out their observations but these students did not provide in-depth and detailed translations into PACT and insights. The questions that emerge from this are: is this as a result of the format of the submission? Or is it because they have worked individually? Or the fact that

this cohort of students was not motivated, as described by the lecturer? It is very difficult to know the exact element that affected their performance, yet this might be identified by conducting more studies where the assignment could be exactly as deployed by the HCI study, with all group members being encouraged to conduct the observation using sLearn.

Another factor to consider is that the assessment mode might have made a difference. In the HCI study, students presented their work before the lecturers and verbally communicated their ideas, which might have allowed for better results. In contrast, in the UX study, the students submitted their written work electronically. In this type of assignment, presentations seem to be helpful for students who might find it difficult to express their ideas and insight by writing. This can be especially true for international students.

Table 25 A comparison between HCI and UX

Elements	HCI	UX
Number of students	55	22
Type of Assignment	Group work (16 Groups)	Individual Work
Number of sLearn users	13 groups (23 students)	20
Type of Submission	In- Class Presentation	Online submission
Average Mark	77.32%	60%

Table 25 summarises the deployments in the HCI and UX studies. Although there were known issues in both deployments, sLearn has been shown to be effective in augmenting the students' learning *in-situ*. The results are promising and it is envisaged that integrating this contextual blended learning

model in teaching will provide students with the necessary guidance and aid in improving many students' HOTS when learning *in-situ*.

7.4.6 Reliability of questionnaires

A Cronbach's Alpha (Cronbach, 1951) reliability test was performed on the two main questionnaires, the HCI and UX. The following tables show the corrected item-total correlation for each statement.

Table 26 HCI's questionnaire reliability test

Statement	Corrected Item-Total Correlation
The app helped me in my observation	0.524
The app gave me hints on what to look for	0.137
The app helped me organise my ideas	-0.055
It was helpful to have a space for note taking	-0.666
The app helped our group members to share ideas and notes	0.358
The Forum (Blog) within the app was useful	0.430
It was useful to track my progress through Profile	0.260
The app helped me develop ideas for PACT	0.448

Table 27 UX questionnaire reliability test

Statement	Corrected Item-Total Correlation
[The app helped me in my observation]	0.518

[The app gave me hints on what to look for]	0.584
[The app helped me organise my ideas]	0.788
[It was helpful to have a space for note taking under each hint]	0.497
[It was helpful to have textbox for extra observations and notes]	0.398
[The app helped our group members to share ideas and notes]	0.279
[The Forum (Blog) within the app was useful]	0.407
[It was useful to track my progress through Profile]	0.535
[The app helped me develop ideas for PACT]	0.694

The study was limited in terms of sample size due to the difficulty of recruiting participants overwhelmed with the demands of the academic semester, as discussed in detail in section 8.3. Therefore, having an appropriate corrected item-total correlation value (Tavakol and Dennick, 2011) for most statements in table 26 and 27, provides the necessary support for the reliability of the questionnaires as tools to collect data.

7.4.7 Level of Android expertise

To understand whether the level of Android expertise has any effect on the students' responses with respect to the pedagogical usability, a cross-tab Chi-square test was performed as described in 6.5.2.

Table 28 Level of expertise

Statement	Skill	Not Applicable	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total
The app helped me in my observation	Expert	-	1	2	0	6	6	15
	Non-Expert	-	0	1	3	10	9	23
	Total	-	1	3	3	16	15	38
The app gave me	Expert	1	-	1	0	7	6	15
	Non-	0	-	1	3	9	10	23

hints on what to look for	Expert							
	Total	1	-	2	3	16	16	38
The app helped me organise my ideas	Expert	1	-	0	6	4	4	15
	Non-Expert	0	-	1	3	12	7	23
	Total	1	-	1	9	16	11	38
It was useful to track my progress through Profile	Expert	2	0	1	4	6	2	15
	Non-Expert	1	2	1	5	12	2	23
	Total	3	2	2	9	18	4	38
The app helped me develop ideas for PACT	Expert	0	-	2	3	3	7	15
	Non-Expert	1	-	0	1	13	8	23
	Total	1	-	2	4	16	15	38

The Chi-square test, for Table 28, found that there were no statistically significant differences in the response of students to pedagogical usability depending on their level of Android expertise as the potential value (Sig.) for all the statements was greater than the significance level (0.05). However it was decided to analyse the positive responses for each of the questions on an individual basis as shown in Table 29.

Table 29 Students' positive responses percentages

Statement	Skill	Agree	Strongly Agree	Total	Percentage
The app helped me in my observation	Expert	6	6	12/15	80
	Non-Expert	10	9	19/23	82.61
	Total	16	15	31/38	81.58
The app gave me hints on what to look for	Expert	7	6	13/15	86.66
	Non-Expert	9	10	19/23	82.61
	Total	16	16	32/38	84.21
The app helped me organise my ideas	Expert	4	4	8/15	53.33
	Non-Expert	12	7	19/23	82.61
	Total	16	11	27/38	71.05

It was useful to track my progress through Profile	Expert	6	2	8/15	53.33
	Non-Expert	12	2	14/23	60.8
	Total	18	4	32/38	84.21
The app helped me develop ideas for PACT	Expert	3	7	10/15	66.66
	Non-Expert	13	8	21/23	91.3
	Total	16	15	31/38	81.58

Looking at Table 29, it can be noted that a high percentage of both expert and non-expert students have agreed to most aspects of sLearn’s pedagogical usability. However, it can be noted that for the statements “The app helped me organise my ideas” and “The app helped me develop ideas for PACT”, which reflects the higher order thinking skills, non-expert users were more positive than experts. This is an interesting finding that needs further research.

It would have been interesting to explore the impact of specific mobile device ownership, and of the consequent additional personalisation of the learning experience. However, no data on ownership of specific devices was collected. This is a factor to be considered in future research.

7.5 Deployment Three: Engineering Results

As explained earlier, the purpose of this deployment was to explore the extent to which this model can be used by disciplines other than computing.

7.5.1 Deployment Results

Five questionnaires were returned. As with previous studies, the mean SUS score was calculated. The mean score was 86; according to Bangor *et al.*

(2008) this score falls within the acceptable excellent SUS score range. Below is a graph showing the individual SUS scores for each of the five participants.

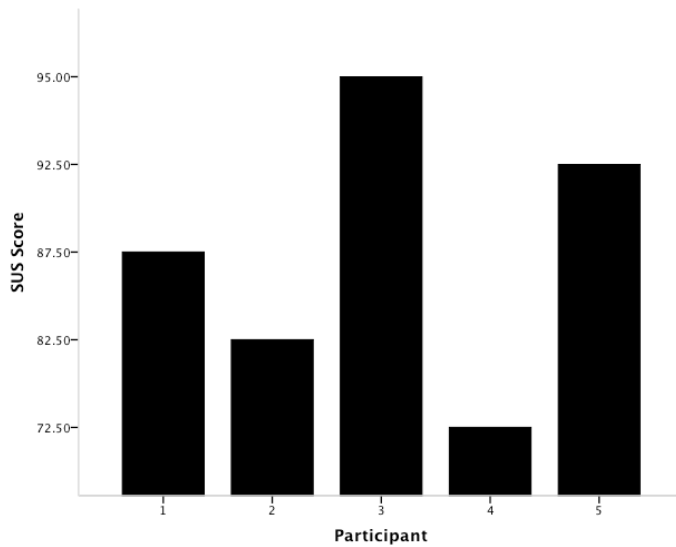


Figure 53 Engineering's Individual SUS scores

From the above graph it can be noted that the lowest score 72.5, is regarded according to Bangor *et al.* (2008), in the acceptable good SUS score ranges. It is important to point out that all five participants were either expert or intermediate users of Android- based smartphones.

Below are the mean scores of the pedagogical usability of sLearn

Table 30 Engineering's pedagogical usability

Statements	N	Mean
The app helped in conducting the risk assessment	5	3.60
The app gave me hints on what to look for	5	3.80
The app helped me organise ideas	5	4.00
The photos in the app were useful	5	2.80
Using the app as a group encouraged us to share ideas	5	4.40

Statements	N	Mean
The app helped in conducting the risk assessment	5	3.60
The app gave me hints on what to look for	5	3.80
The app helped me organise ideas	5	4.00
The photos in the app were useful	5	2.80
Using the app as a group encouraged us to share ideas	5	4.40

On all but one of the five pedagogic usability metrics, the mean scores are above 3, indicating that in regards to these aspects the students feel that they have benefitted from sLearn when doing their activity. The lower score for the statement on photos provided relates to what was mentioned earlier: that the content was merely created from what was understood about risk assessment. Thus, it might not have supported them in the way sLearn was intended to. One of students wrote a comment that it would have been useful if there had been a brief description of each risk.

7.5.2 Discussion

Although this is small sample and the participants were familiar with Androids, the SUS score raises a question. Has the fact that these students were not of a computing background influenced their judgement of the usability of sLearn? In other words, does being from a computing background, especially HCI, influence the HCI's students' judgment of sLearn when acting as usability evaluators?

These two questions cannot be answered without further investigation by widening the use of sLearn on larger numbers of students from both computing and non-computing backgrounds. Moreover, sLearn is intended to support students' learning and promote observations. However, without the careful consideration of the content provided, sLearn would not serve its purposes. This was clearly the case in this study where the content was inadequate. Students have given a high usability score to sLearn and they have agreed that it helped organise their ideas. Nevertheless, they were not really sure that it had either given them hints on what to look for or if it really had helped in conducting the risk assessment. As one student observed, a brief description of each of the risks provided would have been helpful.

When conducting this study, one of the lecturers pointed out that since this is an induction week for first year undergraduates, it is not expected that they will conduct a perfect risk assessment. This means that they need contextual prompts which itself supports the finding that the content is crucial. It reinforces the finding that the lecturers of a module are the best source of the content of sLearn that supports their students in doing the activities they created for them.

7.6 Discussion of all evaluations conducted

The results of the individual evaluations were considered as a whole, then they were grouped into three main overlapping categories relating to:

- (1) Design and GUI of the app,
- (2) Usability, User experience and Students' Perspectives, and
- (3) Designing and deploying a Blended Learning Model.

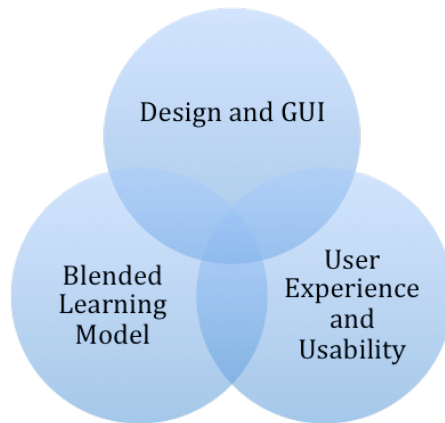


Figure 54 Categorising Findings

These are presented in relation to the first and second research questions stated in chapter 1. The third question will be answered at the end of the discussion.

7.6.1 Design and GUI

Interface design trade-offs

Designers usually need to take decisions that involve some form of design trade-offs. However, it is crucial that these trade-offs are in the users' best interest. The small size of the mobile screen has always been regarded as a drawback when implementing mobile learning (Vavoula and Sharples, 2009; Elias, 2011). This limitation led to considerable debate regarding the design of the textboxes in the location screens of the app. This was one of the issues that kept on recurring in all evaluations. Small textboxes resulted in students writing fewer notes, the space available seemingly impacting on the perceived scope of their observations. However, having one big textbox at the end of the screen was not suitable when using sLearn in the given context. Participants preferred that under each prompt a text box was available to write their notes of observations. They expressed the view that this would make their notes

more organized. They argued that it is easier to look at the prompts and write rather than keep scrolling up and down to refer back to the prompts. A text box associated with each prompt helped them to give specific answers and enabled each aspect to be addressed separately which made it easier for them to check that they had covered all issues. Having a text box under each prompt would probably limit their observation, analysis and thus their critical thinking. Including a large textbox at the end for additional observations and notes to solve this issue was considered. However, this creates a design problem in that the user would need to continuously scroll back and forth. Excessive scrolling would be cumbersome given that the activity involves observations in an area that could be very busy, resulting in users having to look away from the screen often. However, having made this choice and testing it proved that this was a good one. Students in the UX study agreed that having both a text box under each prompt and large one at the end has helped.

The evaluations also revealed that the graphical representation adopted for the placement of the location pins had poor affordance. Participants were drawing on their previous knowledge of a 'pin' on a map and were used to the idea of touching the pin to get more information or even navigate. However, due to the small screen size and lack of indoor navigation, the pins did not provide the expected functionality. This resulted in unnecessary confusion and frustration for the users.

7.6.2 Usability, User Experience and Students' Perspective

Issues discussed here relate to students' experience using sLearn in general and in-context. Of the 50 returned questionnaires, 72% of participants felt that

it was easy using sLearn in its intended environment. However, there were some issues identified that need further consideration:

Personalities and Confidence

Level of confidence influences how people interact with systems, and their experience of these. In this context, confidence relates to level of expertise of using smartphones and feeling self-conscious in using them in a public place.

It was noted the level of confidence in regards to both these factors influenced the participants' experience of using sLearn in context, and how usable they found it. Students who were less experienced with touchscreens on smartphones were not as confident as expert users, and so this has influenced their satisfaction of the experience. This discussion takes us back to the digital native debate in 2.1 which shows that being a digital native does not mean being able to use technology deliberately (Kennedy *et al.*, 2008).

From observations of the participants using the app and from the questionnaire feedback, it was noted that their learning styles and personality also had an influence on how they perceived the app. Although most of the students were not affected by people around them and moved freely, 5.7% of participants did not feel comfortable with the process of observing, walking around, typing on the phone, and taking photos. They were conscious that people might not like being observed. They preferred to have a voice recorder or speech input functionality within the app so that the use of the mobile would feel more natural.

The following is an extract from an interview with one of the participants about this matter:

“Using the app itself was good. Using in that environment was ‘almost not good’ (sic). I needed to type and look at people at the same time. It looks too

obvious standing around, looking at people and taking pictures. Having a voice memo would solve this for me, it's like I am making a phone call"

This comment from the students exemplifies how context can affect a person's preference for the interaction modality. Different contexts of use will seem to change what modality the user prefers to use. For example in the Lemmela *et al.* (2008) study the users did not prefer speech input when walking, while in this study some students' felt it would be beneficial. This reminds us again of the importance of providing flexibility in terms of offering multimodal interactivity. This is also supported by the research of Wang and Karlström (2012), which showed that multimodal interaction was significant to the ID students when they were using the iPads outdoors.

The results from the quantitative evaluations, the SUS score, indicate that the app is above average in terms of usability. For the whole group of HCI students the SUS score was 69. The SUS scores for the whole group of DUE and UX students were 70.7 and 71 respectively. Furthermore, the SUS score for the Engineering was 86, surprisingly higher than all three scores. When combining all SUS scores together, the SUS score becomes 74.12, which is, according to Bangor *et al.* (2008), regarded as a good acceptable score.

7.6.3 Blended Learning Model

The discussion below answers the first research question: **How effective is mobile learning in providing students with the necessary guidance in a situated learning activity without the physical presence of a tutor/lecturer?**

The motivation behind sLearn is to augment students' learning and assist them in conducting contextual inquiry. As well as assessing its effectiveness

as a tool to augment learning in achieving its aim, it was significant to consider how successfully it was integrated into a blended learning model.

Overall, students found that sLearn supported their work. Below are comments from three students, from stage two evaluations, relating to the pedagogical usability of the app, where they reflect on their past experience:

“It makes it clear having a guide on each section. I had some trouble last year”.

“Makes the whole process lot easier”.

“It is easier. Like filling out a form. We focus on what to observe”.

This is supported by the assessment of the HCI students’ work. The average class mark for this cohort for the elements that were supported by use of the app is 77.32%, which is above the cohort average mark, 66.15%, for the assignment as a whole. Based on quantitative results, overall improved engagement with the observational activity, as well as the quality of the students’ insights and requirements identified, indicate that the use of sLearn has had an effective impact in augmenting student learning and improving their critical thinking skills and synthesis as discussed in 7.1.1.1 and 7.1.1.2 and 7.1.1.3.

Collating results from all the evaluations conducted, apart from the engineering, 88.8% of the participants agreed that the sLearn had helped them in their observation. 91% agreed that the provided hints were helpful and 73.33% agreed that sLearn had helped them organise their ideas.

Pragmatic issues when deploying a mobile learning app in a blended learning environment

Below are the pragmatic issues discovered addressing the second research question ‘What are the pragmatic issues when deploying a mobile learning app in a blended learning environment?’

1. Deciding the appropriate level of support to encourage independent learning

Many students wanted more instructions. Judging the appropriate level of support and amount of prompting to be provided by the app is a contentious issue. The design of the content of the app, whereby the guidance is just enough to prompt thinking, without obstructing independent thinking, is not easy to achieve as discussed in 7.2.4. For the purpose of the HCI and UX activity, students should clearly understand that the app is only an introductory guide. The hints provided are the beginning of the thread of ideas and should aim to identify issues beyond the obvious and the predictable. Since sLearn is aimed at HE students this should be true for all other disciplines. However, more advice explaining this and instructions on how to use such an app should be available at the start and, additionally, as a tutorial available on Blackboard to those who could not attend the lectures in which the utility of the app and its functionality were explained to the students.

2. Students’ Willingness and Motivation to Engage

Willingness, motivation to engage, and to try something new are some of the issues identified in evaluating the effectiveness of the app with HCI and UX students. Trialling an app such as this on a cohort of students outside of a controlled assessment can result in only those who are highly engaged, participating. Higher education students’ engagement is a topic that has been

researched since the 1980s (Zepke and Leach, 2010). As discussed in 3.1.2, some have argued that the introduction of technology enhanced learning has increased the number of engaged students (Manuguerra and Petocz, 2011; Junco, 2013). However, there are still a number of students who tend to be less engaged, especially if the coursework setting is informal and they cannot recognise any tangible gain over competing priorities.

3. Relationship between teaching and assessment within this model

Although using technology has shown to encourage and foster collaboration as discussed in 2.4.4, this was not the case in the HCI study. This is likely to be because there was no emphasis on the collaboration aspect of the assignment and it was not part of the assessment. For different elements of the app to be useful and for the blended teaching model to serve its purposes, teachers should carefully plan the relationship between teaching and assessment. The assessment mode via students' presentation has been shown to be more effective, for this type of coursework, in demonstrating students' higher order thinking skills as shown in the results of the HCI compared to the UX in 7.4.5.

The adaption of sLearn to the engineering courses supported an earlier statement about importance of the app's content. Students and lecturers both viewed sLearn as a potential aid which could be very beneficial. However, students did think that it needed more precise content. This responsibility would seem to lie with the lecturers of the module, as their experience of the module, the designed activity, and of the cohort of students would make them most able to provide the content.

The remaining third research question is: **What evaluation criteria and techniques can be used to evaluate such mobile learning apps?**

Evaluating mobile learning apps is fraught with difficulties; the use of mixed evaluation techniques was necessary to ensure ecologically valid results and to generate a multi-perspective overview of the effectiveness of the intervention. These included the submitted coursework, the students' evaluation of the sLearn app and feedback and marks from the lecturers' on the assessed work. To follow a solid evaluation design, Vavoula and Sharples's (2009) framework was implemented as discussed in 6.1.2 and 6.3.1.

To evaluate this mobile app in terms of design, usability and user experience, this thesis has deployed a range of evaluation techniques. For each of the studies conducted with the HCI, UX, and Engineering students, a System Usability Scale (SUS) questionnaire was handed to students to get their feedback. Additionally, an in-depth, in-context evaluation was conducted with students with a similar profile to that of the HCI and UX students in order to assess the app as a whole, its general and pedagogical usability. To find the maximum number of issues, a range of mixed methods was used. These included: (a) 'Thinking Aloud' and observations, (b) interviews for following up observations, understanding user experience, and pedagogical usability, and (c) SUS questionnaires. This evaluation was crucial since it was not possible to perform any in-depth usability evaluations and follow up focus group with the HCI students. Thus it yielded many interesting findings, as discussed in 7.2.

The results of an evaluation of the effectiveness of an intervention in HE where coursework is part of the assessment should be treated with caution. Dividing the students into control and experiment groups, such as the one used in Chu *et al.* (2010), would mean not providing equal opportunity to all students and therefore would be inherently unfair. Furthermore, the controlled experiments method seems, from the author's experience, to be effective in primary education for two main reasons: (1) the pupils are well known to their teacher and division into groups can result in two similar groups in terms of ability and skill (2) they are more engaged and willing to participate in non-assessed activities.

7.7 Guidelines for implementing a mobile application for situated learning activities in HE

Guidelines for designing and deploying a successful learner-centred mobile learning application experience in higher education are now presented. They are derived from both the literature and the primary research conducted as part of this PhD. An underlying principle is that in order to adequately understand the scope of each of the issues requires regarding stakeholders as co-designers.

The app should:

- **Be accessible from the learner's mobile device- Multi platform compatible:** having an app that can be accessed from the majority of mobile platforms will provide the learner with personalisation, control and ownership. It is his/her own device that is being used. The app is available in an anytime anywhere manner. Students will use devices when they feel

the need to. This factor will also impact on their level of confidence in using the app.

- **Provide Suitable Contextual Content:** The educators defining the content for the app need to ensure that students are prompted to consider all relevant aspects of the environment. This is important as the content provided in the app should be authentic and address students' known weaknesses.
- **Provide Independent Choices:** The learner should feel independent and have the flexibility of choosing what to do and when to do it. Hence, the design of the content and the design in general should reflect this.
- **Provide Multimodal Interaction:** providing multimodal interaction would enable personalisation and customisation, avoid any discomfort for feeling self-conscious about using the app for an extended period in a public space and hence maximise the effectiveness.
- **Provide Collaborative facility:** Provide the learner with connections with peers and/or teachers to share and discuss ideas.
- **Provide Clear Instructions:** The learner should not feel hesitant or uncertain. They should know what the learning objectives of using the app are, how it can support them with their learning task, and what exactly to do with it.

Table 31 Guidelines for designing a mobile app for in-situ activities in HE

Mobile learning characteristic	Guideline
Personalisation	Accessible from the learner's mobile device- Multi platform

	compatible
Authentic and Situated	Suitable Contextual Content
Flexible and learner-driven	Provide Independent Choices
Personalisation and Customised	Multimodal Interaction
Connected	Collaborative facility
Building Confidence	Clear Instructions

7.8 Conclusion

This chapter presented the results of the main evaluation performed as part of this research. The two principal studies were with two different student cohorts, HCI and UX students. One in-context evaluation with DUE students was conducted to understand the effects of the environment on the usability and user experience of sLearn. Finally, one deployment with engineering students was conducted to suggest that sLearn can be generalised to another discipline.

The results obtained from all deployments discussed are promising. Students, in general, have felt that sLearn is useful and has helped them in their coursework. However, each deployment raised a number of issues. The findings of the evaluations, grouped into three main categories, GUI and Design, User Experience and Usability, and Blended learning Model, have significant implications for research in this field and support the claims and findings of other research studies such as Korn and Zander (2010) and Tsiaousis and Giaglis (2010). Conducting evaluations in context helps to

discover issues that could not be discovered when evaluating in a lab that does not expose the users to the influences that they might experience when using the app *in-situ*. As such, given that users might feel differently while using the app *in-situ*, their identification of issues in the lab will lack ecological validity. This is especially true in a university context where students come from different experiences and backgrounds. From a design perspective, it could also mean that the need for certain features, such as multimodal interaction, would be difficult to identify from lab-based studies. The concerns raised in the HCI deployment, in terms of the design of sLearn, were the need for more instructions and the change of the layout of textboxes in the location screens. These were modified in iteration six, as explained in 7.3. There were some issues regarding the deployment in a blended model. Changes were made in the UX deployment to provide individual coursework delivery. While many complex factors influenced outcomes, and it is inappropriate to make general claims regarding the impact of different methods of assessment, there is some evidence that that group work delivered by presentations is the most appropriate approach to help foster the students' higher order thinking skills for this type of activity, as discussed in 7.4.5. Though students should be reminded to get involved in all aspects of the coursework to maximise their benefits, SLearn has been shown to be applicable to more than one discipline: both engineering students and lecturers perceived it to be useful. However, students felt they would benefit to a greater extent if more specific content were provided.

This chapter presented a set of guidelines for educators considering implementing a mobile learning application to aid their students' learning *in-*

situ. These guidelines were derived from the evaluation and testing performed in this research. It is envisaged that if followed, they will address many of the issues and concerns highlighted in this thesis.

8 Chapter Eight: Conclusions and Future Work

This chapter concludes with an evaluation of the research presented in this thesis, identification of contributions to the research, questions that have been raised and areas for future research.

8.1 Evaluation of research

The research was conducted in order to address the following research aim:

To investigate firstly, a blended learning model for students in higher education using mobile technology for situated learning, and secondly, the process of designing a mobile learning app within this blended learning model.

The investigation of this aim was carried out through the literature review, a user-centred iterative design approach, and the evaluation of the model. The main study for this investigation was based on the delivery of the HCI module. Additionally, evaluating mobile learning applications for higher education students is a challenging process as discussed later in 8.2, be it is evaluating the effectiveness of the app, or evaluating the usability and user experience. The extent to which the research has met the aim is evaluated here in relation to the research objectives identified in 1.1.2.

8.1.1 Objective 1

To construct and demonstrate a model for a pedagogical activity assisted by a mobile learning app to facilitate independent study, and reflection and critical thinking in a more structured manner.

A comprehensive requirements gathering and contextual inquiry was conducted to understand the current practice, the difficulties both lecturers and students encounter, and the best approach to construct this blended learning model. Interviews with the lecturers, observation of teaching, reviewing of previously submitted coursework, a survey of mobile ownership, and a mobile usability review were conducted, as explained in chapter 4, to consider the issues associated with the learning experience from a range of perspectives. Issues found were:

- Students lose focus on the purpose of tasks when away from the classroom. They may get distracted by their surroundings and miss out key elements.
- Some students have been found to struggle in analysing their findings and specifically in using their findings to develop new ideas.
- Students care about their privacy and would not easily compromise it.

The above helped in providing the initial framework in 4.6 for the parts of the model supported by the mobile app.

However, the model can only be beneficial to students if lecturers give careful consideration to the content of the mobile app. This was shown clearly in the Engineering deployment.

8.1.2 Objective 2

To carry out and review a user-centred iterative design process for developing the mobile app

This study adopted a user-centred design approach from the early stages of requirements gathering. The stakeholders (lecturers and students) were at its centre to ensure that their needs were properly met. Hence, six iterations of the prototype were developed. The first three iterations were a result of evaluations involving the lecturers. Iteration four followed an evaluation involving Interaction Design students and iteration five followed two cooperative pilot in-context evaluations with two student participants. Iteration six followed the main testing of the mobile app with the end-users and the in-context evaluations with the DUE students.

These evaluations have revealed some interesting findings regarding the user experience and influence of the context of use on the design of a mobile app.

- The graphical representation adopted for the placement of the location pins had poor affordance, explained in 5.2.2.
- For this type of app, students prefer that a textbox space for typing their observations and notes should be placed directly under each given prompt. This would enable them to concentrate directly on the given prompt and not get distracted by the others in such a busy environment. They argued that it is easier to look at the prompts and write rather than keep scrolling up and down to refer back to the prompts. This created a conflict, since having small textboxes under each prompt might implicitly limit their thinking. The decision was to

have a large textbox at the end of the screen for further observations and notes.

- The need for multimodal interaction was one of the findings that were discovered clearly in the in-context evaluation. This was a result of the close observations and follow-up interviews and is related to user experience and self-consciousness, discussed in the following section.

This research has implemented a working prototype to confirm the concept and discover the best design and functionalities for situated learning activities, as part of a contextual mobile learning model for augmenting students' learning. For all students and lecturers to fully benefit from an app such as sLearn, it should be developed to be compatible with the most used operating systems (OS). As mobile learning is all about personalisation, students should be able to download sLearn onto their own phones, whatever OS they are using. Many students were not familiar with the phones that were used in the trial and had some issues that influenced their user experience; hence some of the results were affected as discussed in 0 and 7.2.1. Optimal results would be achieved if the users used the app on their own or one familiar to them. This brings us back to one of the main characteristics of mobile learning, personalisation, as discussed previously.

8.1.3 Objective 3:

To review the user experience and usability of the contextual mobile application prototype.

In-depth understanding was achieved via the main in-context evaluation discussed in chapter 6 and 7. Generally speaking participants felt the mobile app was easy and comfortable to use in its intended environment. However, it was noted that students' personalities and degree of confidence played an important role. In this context, confidence relates to level of expertise of using smartphones and feeling self-conscious using them in a public place. Students who were less experienced with touchscreens or smartphones were not as confident as expert users, and so this has influenced their satisfaction of the experience. The results from the quantitative evaluations, the SUS score, indicate that the app is above average in terms of usability.

8.1.4 Objective 4:

To review students' perceptions of the pedagogical usability provided by the mobile application.

The methodology used was a likert scale questionnaire of adopted pedagogical usability statements that directly relates to use of the app in this learning context.

Overall, students found that the app supported their learning. A high number of students agreed that:

- The mobile app had helped them in their observation.
- It had helped them organise their ideas.
- The provided hints were helpful.

Past students also thought that if they had had this app, doing the coursework would have been easier.

8.2 Research Contributions

The outcome of this research is the design and development of a mobile contextual learning model initially for HCI students, but which can be applied to different disciplines. The model has been shown to be applicable to the teaching of the subjects of HCI and UX. It has also been shown to be applicable to the teaching of Risk Assessment within Engineering, and theoretically, it can be applied to any discipline that requires its students to work in real world settings.

This research identifies and provides evidence of benefits of mobile learning: firstly, mobile learning can promote independent learning; secondly, structured prompts delivered *in-situ* by means of an interactive app promote critical thinking and understanding of context for design. This was clearly shown in the students' coursework results in the HCI deployment analysed in 7.1.1.

The research also provides further evidence of the benefits of contextual evaluations of mobile applications, identified by previous studies, in discovering issues that tend to be missed in lab evaluations as discussed in the results of the in-context evaluation presented in 7.2.

In addition, this research suggests guidelines for implementing a mobile application for situated learning activities in HE. These were derived from mobile learning characteristics reviewed in the literature and the evaluations discussed in this thesis. The full guidelines can be found in 7.7.

Finally, this research provides insights into:

- **What makes contextual mobile apps effective in teaching HCI students how to assess context in design.** As HCI students are still learning how to design, they might not notice crucial issues when conducting contextual inquiry. Providing students with prompts regarding issues that they should take into consideration has helped in making them more empathetic towards the users they are designing for, as discussed in 7.1.3. Having an empathetic attitude can help become better designers as they will be more sensitive to users' needs. Contextual prompts have helped some students to conduct more thorough observations, translating the collected data into insights and the PACT framework, as well as formulating functional and non-functional requirements, thus prompting higher order thinking skills. This was shown in analysis of some of the students' works as discussed in 7.1.1 and 7.1.4.
- **Tackling challenges associated with mobile learning application evaluation in a learning context.** This research has shown the importance of conducting in-context evaluation in discovering user experience and usability issues for mobile applications designed for diverse HE students discussed in 7.2 and 7.6. The use of mixed mobile evaluation methods helped to ensure ecological validity and to overcome the challenges of the lack of willingness of students to participate in the research; difficulty in recruiting participants who would be valid users of this type of app; different levels of confidence and experience; their unfamiliarity with the phones used in the evaluation; and intrinsic differences between cohorts, as discussed in 7.1.4 and

7.2.4 and 7.6. These logistic issues require further consideration by the research community.

8.3 Limitations

In this section, the limitations of the mobile contextual learning model and of research work more generally are considered.

- As discussed earlier, the model can only be beneficial to students if lecturers give careful consideration of the content of the mobile app. This was shown clearly in the Engineering deployment.
- The sample size of the studies. Since the activity for which sLearn was used was specific for a particular module, the number of participants depended solely on the number of students enrolled in the module. This was one of the main reasons for running multiple deployments of sLearn and the particular mixed method approach as described in sections 6.1.2, 6.2.1, 6.3.1, and 6.5.3 Moreover, it was difficult to run extra studies at the same time, due to the time constraints of the academic calendar and the module assessment cycles.
- Furthermore, the evaluation of mobile learning applications for higher education students is a challenging process, be it evaluating the effectiveness of the app, or evaluating the usability and user experience. The challenges found were lack of motivation in the learning process from a group of students who had difficulty in engaging with academic life due a range of well established issues, difficulty in recruiting participants who would be valid users of this type of app, and intrinsic differences between cohorts. These logistical issues require further consideration by the research community.

- The lack of engagement from students has influenced the research design. Students were not willing to participate in further focus groups so it was difficult to completely understand their experience. This has affected the ability to follow-up many of the findings that were discovered from the studies and therefore to fully understand the reasons, for example, why some groups in the HCI did not use sLearn, or why some sLearn users did not think they would like to use this app frequently. This is discussed fully in 7.1.2.
- The design of the questionnaires also limited the study in some respects. As mentioned earlier, it would have been very interesting if a question about the students' ownership of the smartphone device had been included, in order to throw light on the extent to which a feeling of ownership would affect their performance using and experience of the sLearn app.

8.4 Future Work

This section describes future directions for this research. As discussed in the previous section, further development of sLearn to support lecturers should be carried out. Firstly, developing a lecturer's web-based authoring tool would enable lecturers to customise sLearn to any coursework, content, activity, or module they desire. Lecturers would not need to have any programming background to do this. This would enable sLearn to be used by various courses from different disciplines. Lecturers in the fields of computing, engineering, and health and social science have already shown interest in sLearn. Secondly, the authoring tool should be able accommodate various operating systems and make full use of the technical capabilities of the native

platform of the device. It is envisaged that the researcher will endeavor to address these issues as part of future research developments.

Future developments will also include the deployment of the app in a different cultural context. It will be interesting to explore the impact of the different variables such as: class size, degree of respect for authority on the part of the student, ownership of device, and single or mixed sex education. These are factors that may have a bearing on how mobile learning can be effectively integrated into classroom teaching.

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Appendix A: Mobile Ownership Survey

Introduction

This survey is conducted for a PhD research study in the Department of Computer Science and Creative Technologies at Faculty of Environment and Technology, UWE. The survey should take no more than 5-7 minutes.

The survey aims to:

1. Investigate the University students' ownership and usage of smart phones.
2. Explore the potential of using mobile smart phone devices for learning.

The survey is anonymous and the responses that you provide will not be used to identify you as an individual. Your response is of a value to us but you are not required to respond to this survey if you do not wish to. We have disabled the method by which responses can be tracked. You can exit the survey at any time by clicking on the exit link at the top right of each page.

Demographic questions

1- To which faculty do you belong?

- | | |
|--|---|
| <input type="checkbox"/> Faculty of Business and Law | <input type="checkbox"/> Faculty of Creative Arts, Humanities and Education |
| <input type="checkbox"/> Faculty of Environment and Technology | <input type="checkbox"/> Faculty of Health and Life Sciences |

2- You are doing a:

- Undergraduate Course
- Postgraduate Course

3- To which faculty do you belong?

- | | |
|--|---|
| <input type="checkbox"/> Faculty of Business and Law | <input type="checkbox"/> Faculty of Creative Arts, Humanities and Education |
| <input type="checkbox"/> Faculty of Environment and Technology | <input type="checkbox"/> Faculty of Health and Life Sciences |

4- What course are you doing?

5- Gender:

- Female Male

6- Please select your age group:

- 17-21 22-30
 31-40 40+

7- What is the make and model of your mobile phone

8- What operating system is running on you device?

- iOS Android
 Blackberry Symbian
 Windows I don't know

9- Do you have a data contract:

- Yes No

10- If you have answered 'Yes' to question 9, Please specify your monthly allowance:

- 250 MB 500 MB
 750 MB 1 GB
 +1GB

11- Is you data allowance adequate?

- Yes No

12- How often do you surf the web on your mobile? (On a daily basis)

- I don't surf the web on my mobile I occasionally surf the web on my mobile, but not on a daily basis
 Half an hour or less An hour or less
 More than an hour

13- Do you currently use your mobile device for any of the following learning-related activities:

- Accessing lecture notes Checking grades
 Accessing Blackboard Sending emails to lecturers/staff
 finding course information Other (Please Specify)

14- Which of the following tools you currently use for learning purposes?

- | | |
|--|---|
| <input type="checkbox"/> Wikis | <input type="checkbox"/> Discussion boards |
| <input type="checkbox"/> Social Networks (Facebook, Twitter, etc.) | <input type="checkbox"/> Blogs |
| <input type="checkbox"/> Calendars | <input type="checkbox"/> Other (Please Specify) |

15- Which of the following tools would you prefer to access using your mobile device?

- | | |
|--|---|
| <input type="checkbox"/> Wikis | <input type="checkbox"/> Discussion boards |
| <input type="checkbox"/> Social Networks (Facebook, Twitter, etc.) | <input type="checkbox"/> Blogs |
| <input type="checkbox"/> Calendars | <input type="checkbox"/> Course Information |
| <input type="checkbox"/> Student's Management system (MyUWE) | <input type="checkbox"/> Blackboard |
| <input type="checkbox"/> Other (Please Specify) | |

16- Do use GPS-Based location applications, which shares personal information, on your mobile devices such as Gowalla, fourquare, etc.?

- Yes No

17- I currently use GPS-Based location apps on my mobile device:

- | | |
|---|--|
| <input type="checkbox"/> Openly | <input type="checkbox"/> Only limited to well known friends and family |
| <input type="checkbox"/> Other (Please Specify) | |

18- I do not use GPS-Based location apps because:

- | | |
|---|---|
| <input type="checkbox"/> I never needed to | <input type="checkbox"/> I like my privacy |
| <input type="checkbox"/> I am not interested in social networking | <input type="checkbox"/> Other (please specify) |

19- Would you be prepared use GPS-Based location applications for learning purposes (with fellow students and/or lecturers)? i.e.: an activity which requires you to reveal your location to students and/or lecturers through the application to exchange and share knowledge on a particular assignment.

- | | |
|---|--|
| <input type="checkbox"/> Yes with both students and lecturers | <input type="checkbox"/> Yes with lecturers only |
| <input type="checkbox"/> Yes with students only | <input type="checkbox"/> No (Please specify reasons) |

20- If you have any other comments to share, please do use this space. Examples: your experience with your current mobile device, any frustrations, what applications you use often, etc.

Appendix B: Evaluation Plan for Pilot In-situ Evaluation

Aim

The aim of this evaluation is to identify potential design issues of sLearn's mobile app and to understand whether this app is easy to use in context and serves its purposes.

What's being tested?

- Project Prototype: sLearn mobile application.
- Goal of sLearn: To provide the user with the necessary hints/help when conducting a study in situ. Learning in real world context should be beneficial rather than confusing. Learners should be able to gain the knowledge needed and record their notes and findings.

Test objectives

1. To identify navigation errors- failure to locate functions, excessive clicks to complete a task, and failure to follow the recommended screen flow.
2. To identify presentation errors - failure to locate and properly act upon information in screens, selection errors due to labeling ambiguities.
3. Data will be used to judge whether the interface could be regarded as being effective and efficient.
4. Establish a baseline user performance level for comparison in future evaluations.

Methodology

The concept behind this app will be explained to the recruited participants. Each participant will be asked to use this app in context, the environment this app will be used in, and follow a task list. They will be asked to "think aloud" as they complete the tasks.

After they have completed all tasks, participants will be asked to fill out a post-task questionnaire and a post-task interview will take place.

Participants will be required to sign a consent form prior to beginning the test.

Participants

Participants will be:

- University students.
- Interested in usability.

Duration

The whole session should not take more than 40 minutes to complete and is divided as follows:

Pre-test arrangements (5-10 minutes)

- Sign a consent form.
- Explain the activity and tasks to the participants.
- Ask the participant to think aloud.

Tasks (15 minutes)

The participants will start doing the tasks.

Post-task questionnaire (2 minutes)

The participants will be asked to fill out a post-task questionnaire.

Post-task Interview (10 minutes)

- Follow up any particular problems that came up.
- Ask questions about the experience and preference.

Things to note during the observation of the tasks performance:

- Can they figure out what to do at each location?
- Do they understand the hints provided by their lecturers?
- Can they navigate their way around the app?
- Do they look engaged?
- Where do they appear hesitant or confused?
- Are they able to complete the task?

Environment

The test will be carried in the OneZone Café at the same environment the real users will use this app.

Timing

The test will preferably take place between 12-2 pm where the café is at its peak.

Metrics

- Task completion success rates. The task is complete when the participant reaches the stopping criteria.
- Error rates. Critical errors, those that are unresolved during the process of completing the task or produce incorrect outcomes, and non-critical errors, that are recovered from by the participant will be collected.

Goals

The goals of this usability test are as follows:

- All participants successfully completing the task without critical errors.

Aspects of “sLearn” under test

- 1- Choosing a Location to explore

Scenario	You need help in a particular location, so you click on that location.
Stopping criteria	Participant reaches the location's screen.
Correct Path	Participant touches location's name button under the map.
Possible issues	Participant does not know how to navigate to that location. Participant cannot press the button correctly.

2- Reading the desired prompts and ticking when done.

Scenario	You are not sure what to look for, so you start reading the prompts.
Stopping criteria	1- Participant reads the prompts. 2- Participant ticks the ones that he/she have read
Correct Path	Participant ticks the checkbox next to the prompt.
Possible issues	Participant does not understand the purpose of the checkbox.

3- Writing down a note for one of the prompts and saving it.

Scenario	You have some notes you need to save for when you write your report
Stopping criteria	Participant clicks the save button.
Correct Path	1- Participant touches the text box and writes the notes. 2- Participant presses the Save Notes button.
Possible issues	Participant does not press the save button.

4- Posting the notes to the Blog to share

Scenario	You have some notes you need to share with your peers
Stopping criteria	Participant clicks send email and the email is sent
Correct Path	1- Participant clicks the Post to forum button. Either: 2- Participant set up their email for the first time then goes to 3. Or 3- Press the send button in the mail app to send the email.
Possible issues	Participant does not know how to set up their email.

5- Checking the Profile.

Scenario	You need to track your progress
Stopping criteria	Participant reaches the Profile screen
Correct Path	Participant presses the Profile button in the navigation bar.
Possible issues	Participant cannot locate the navigation bar

Post-task questions

Please complete the following tasks and write any additional comments.

1-Choose a Location to explore.

If you have managed to do the task, please choose one of the following:
1- I knew what to do straightaway.
2- It took me a moment to figure out how to do it.
3- It took me a while to figure out how to do it.
4- I did not know how to do it and had to seek for help.
Additional comments about the task: I was looking at and pressing the word rather than the pin.

2- Read the desired prompts and tick the ones that u have done.

If you have managed to do the task, please choose one of the following:
1- I knew what to do straightaway.
2- It took me a moment to figure out how to do it.
3- It took me a while to figure out how to do it.
4- I did not know how to do it and had to seek for help.
Additional comments about the task:

3- Write down a note for one of the prompts and save it.

If you have managed to do the task, please choose one of the following:
1- I knew what to do straightaway.
2- It took me a moment to figure out how to do it.
3- It took me a while to figure out how to do it.
4- I did not know how to do it and had to seek for help.
Additional comments about the task:

--

4- Check your Profile.

If you have managed to do the task, please choose one of the following:
1- I knew what to do straightaway.
2- It took me a moment to figure out how to do it.
3- It took me a while to figure out how to do it.
4- I did not know how to do it and had to seek for help.
Additional comments about the task: I was confused, I thought it will include the notes and the pictures

Post-task Interview

How would you describe your experience of using the app – how did it feel?
What are the three things you like least about the app? What can be improved in the app to overcome these issues?
If you could make one significant change to this app, what change would you make?

Appendix C: Code and Lecturers' Prompts

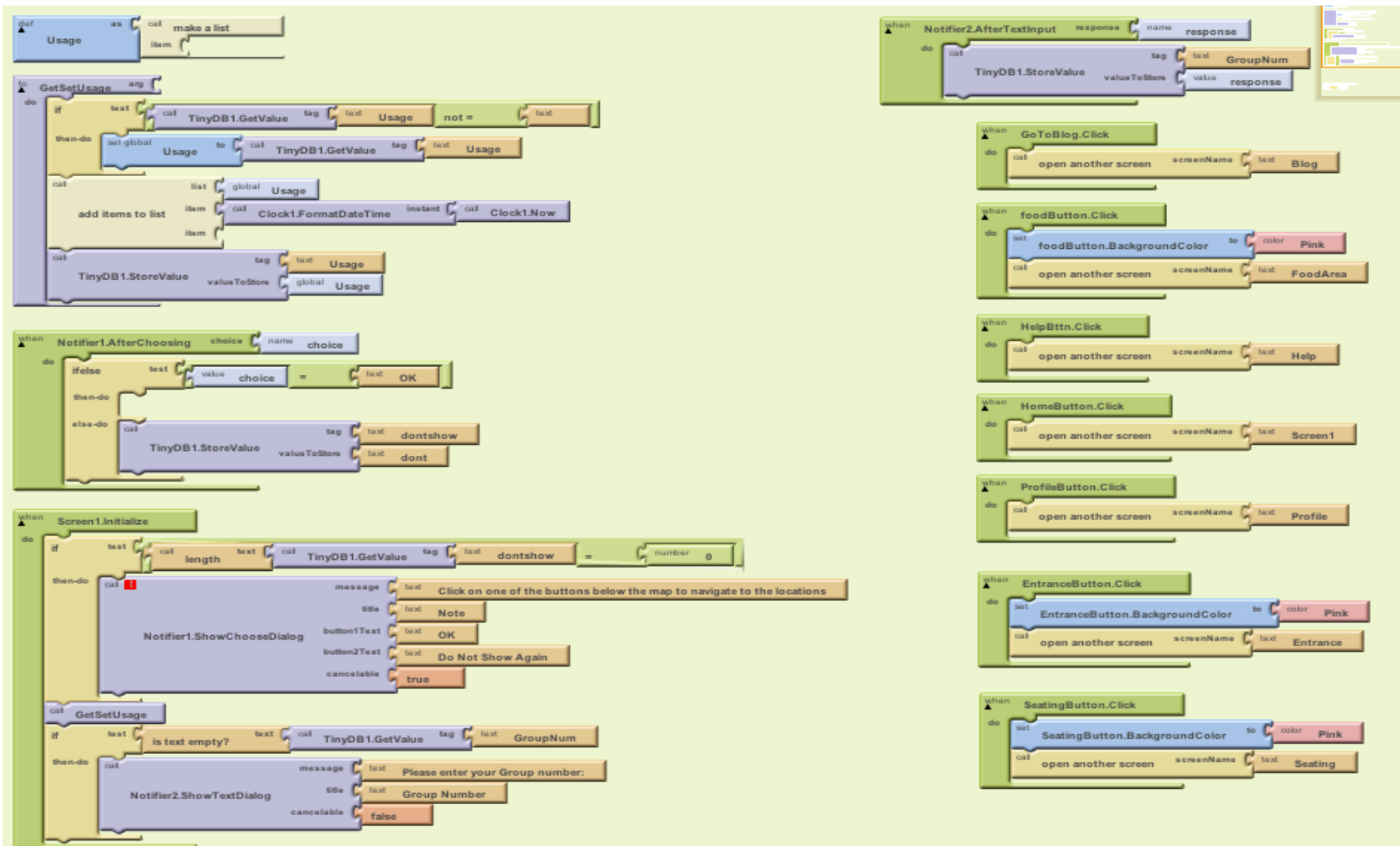


Figure 1 Home screen code

Appendix C: Code and Lecturers' Prompts

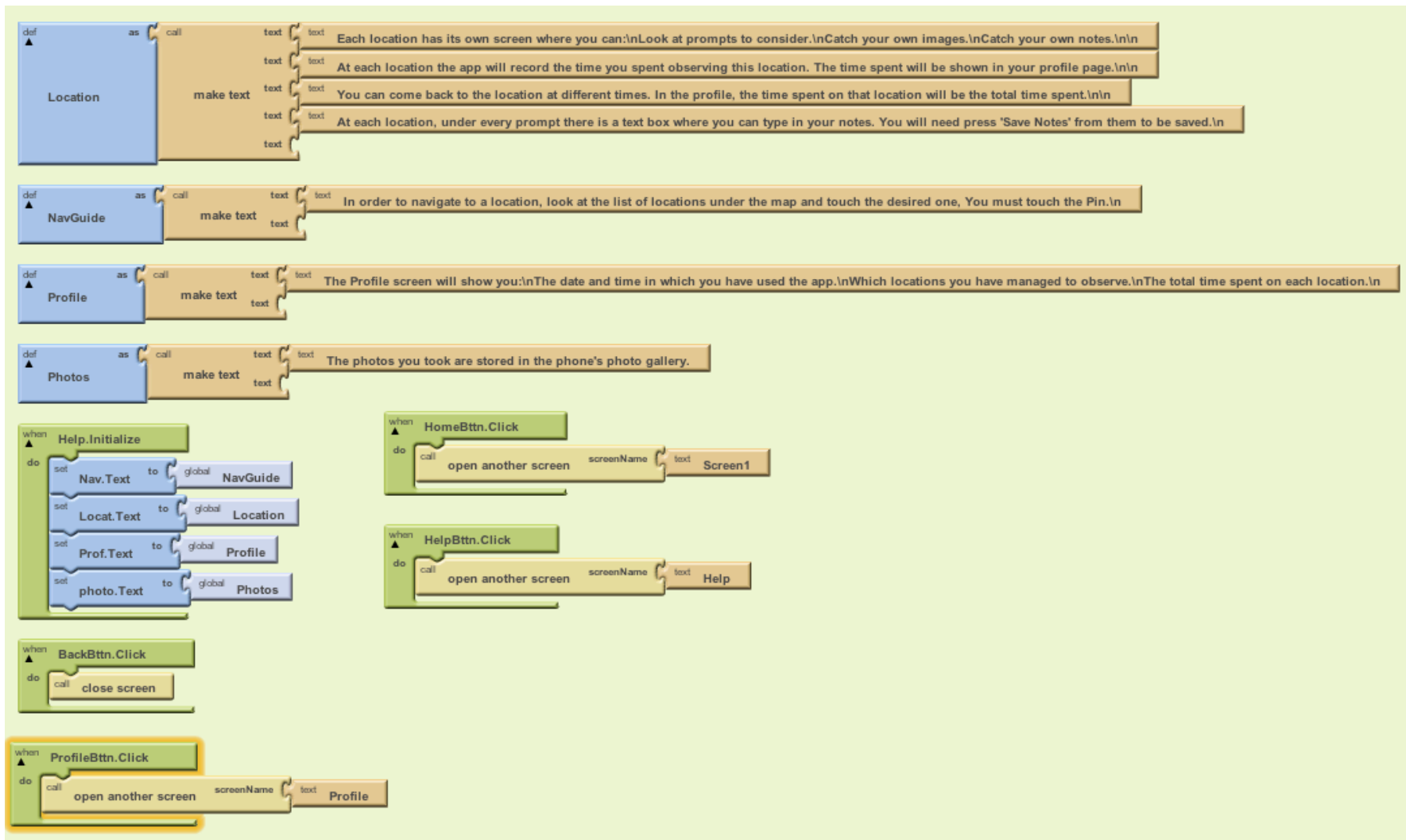


Figure 2 Help screen code

Appendix C: Code and Lecturers' Prompts

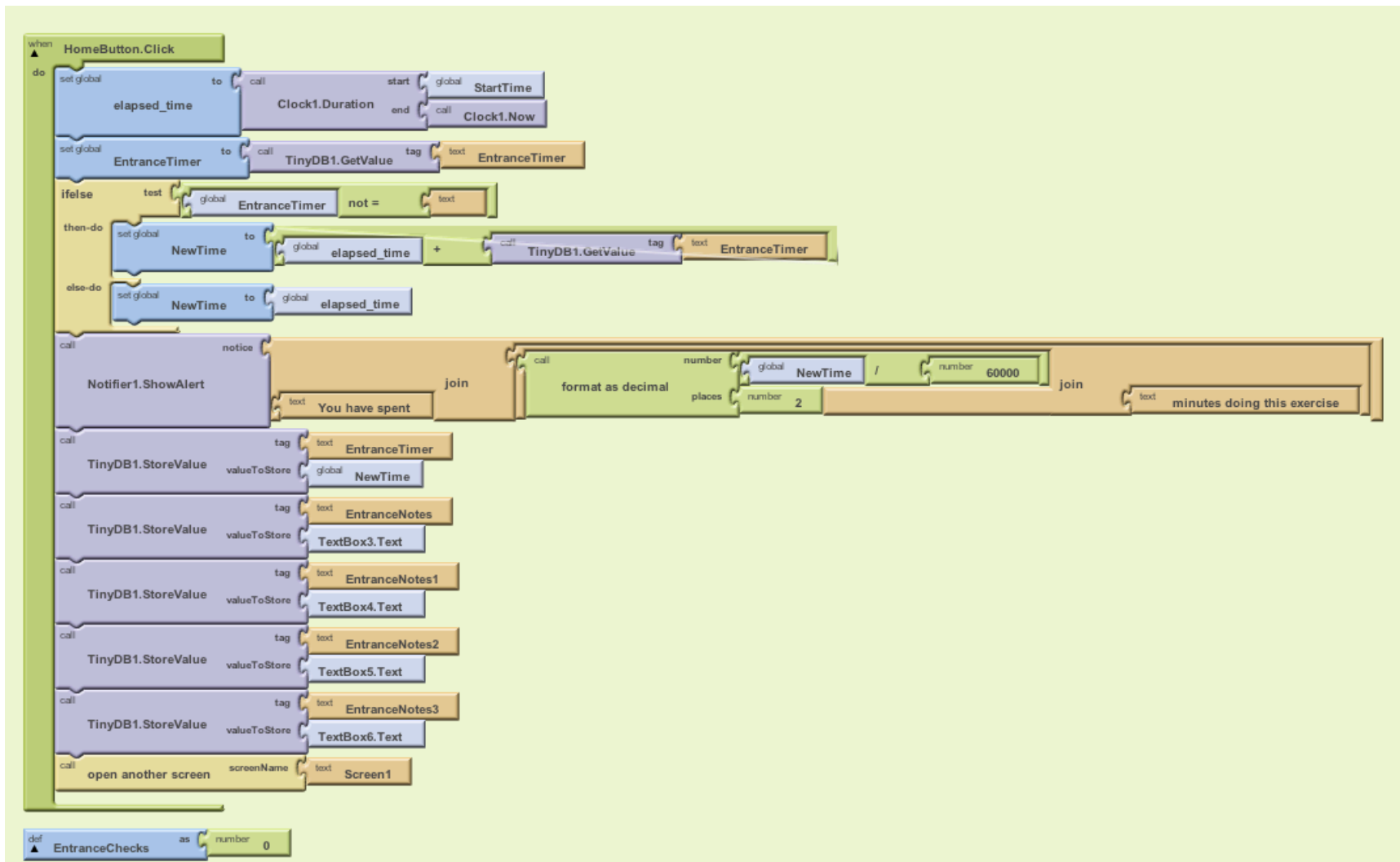


Figure 3 Location screen Code part 1

Appendix C: Code and Lecturers' Prompts

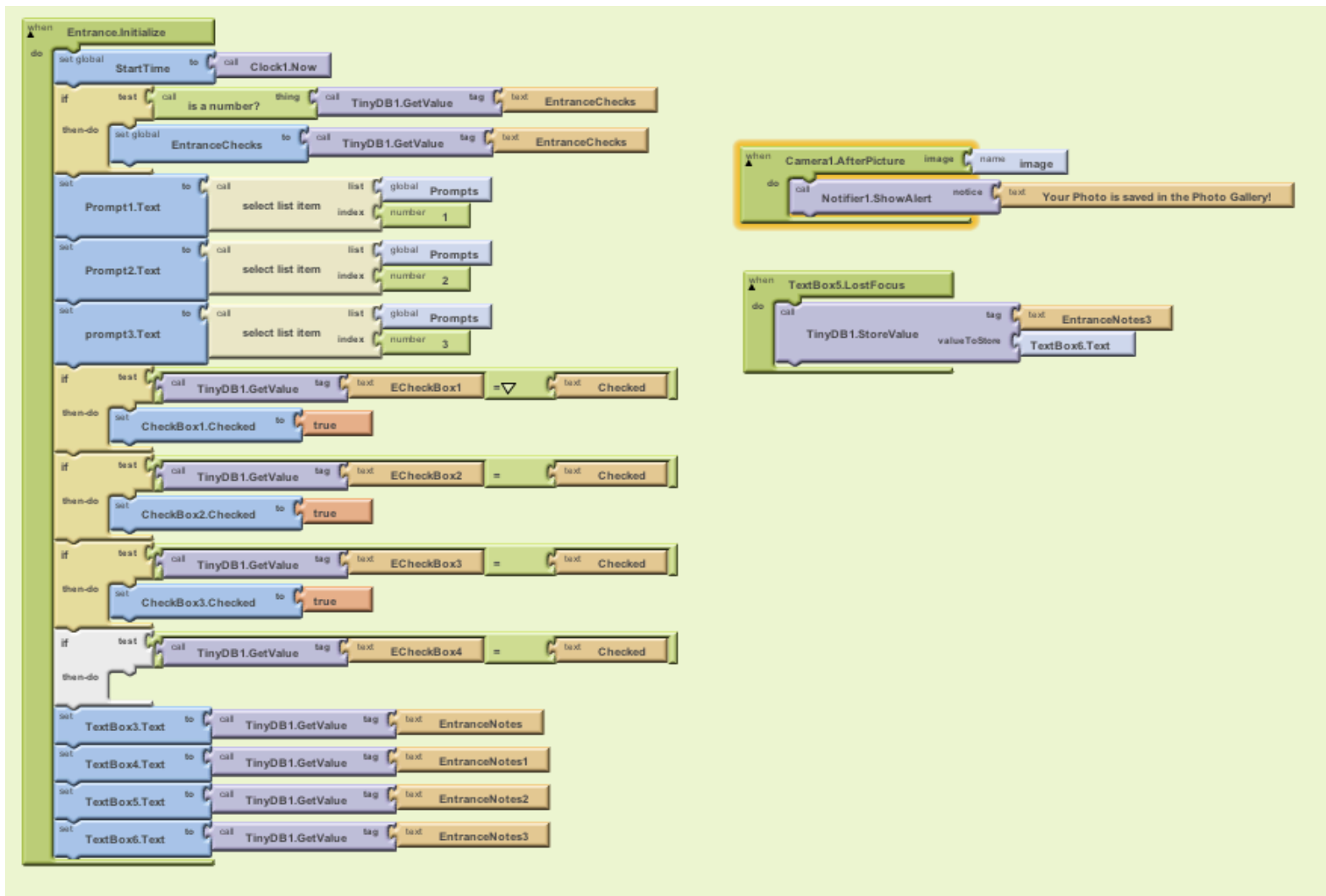


Figure 4 Location screen code part 2

Appendix C: Code and Lecturers' Prompts

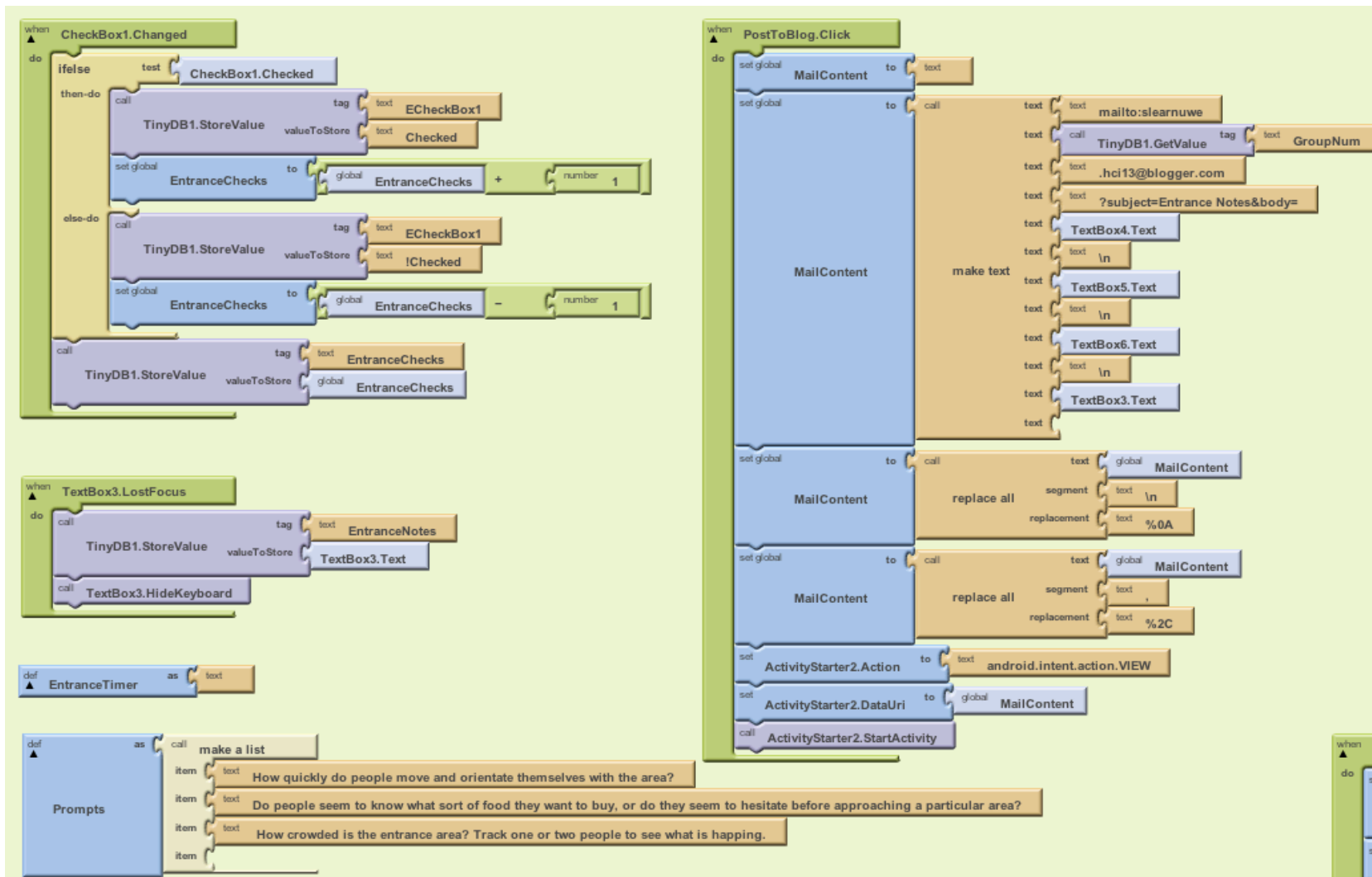


Figure 5 Location code part 3

Appendix C: Code and Lecturers' Prompts

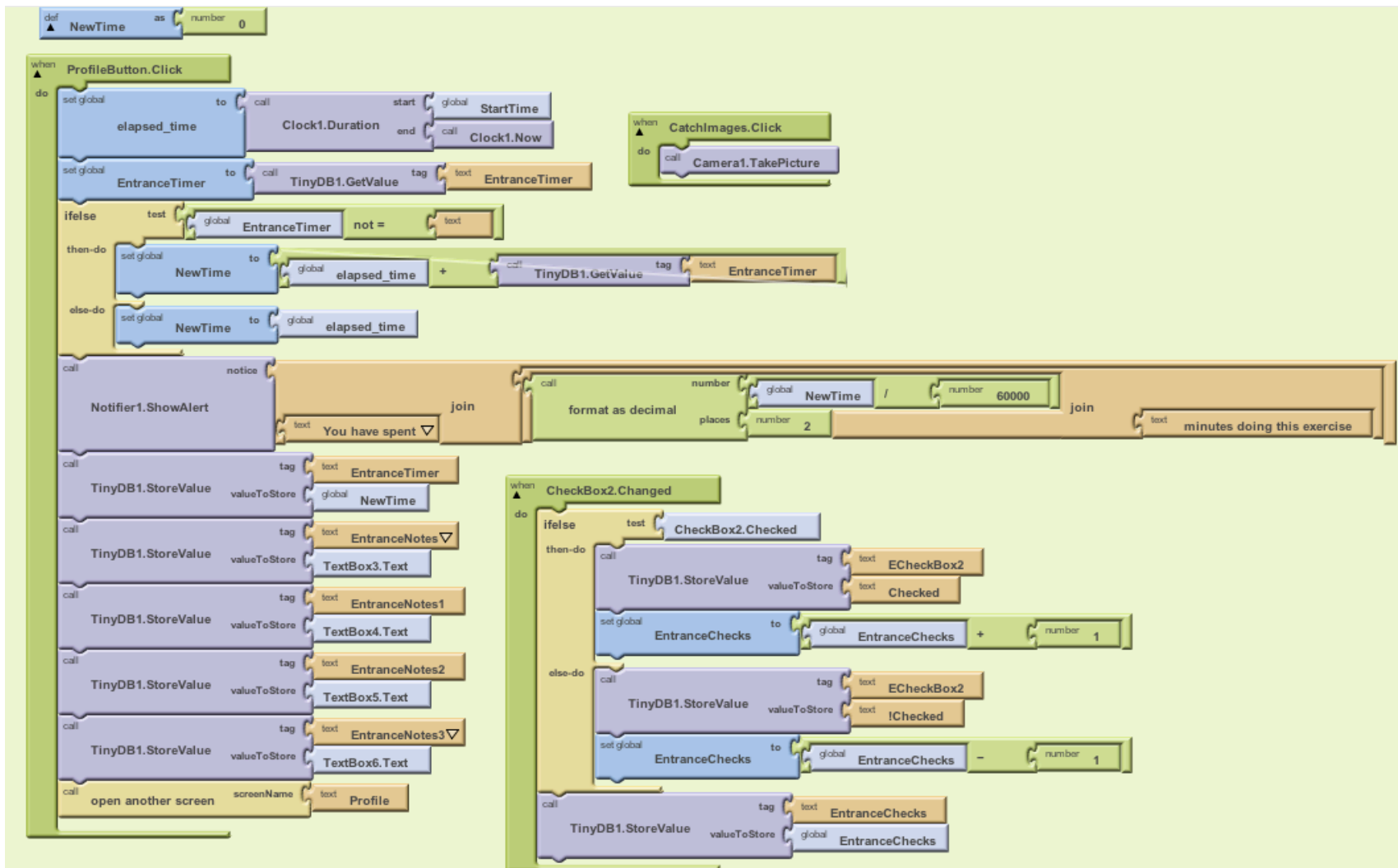


Figure 6 Location screen part 4

Appendix C: Code and Lecturers' Prompts

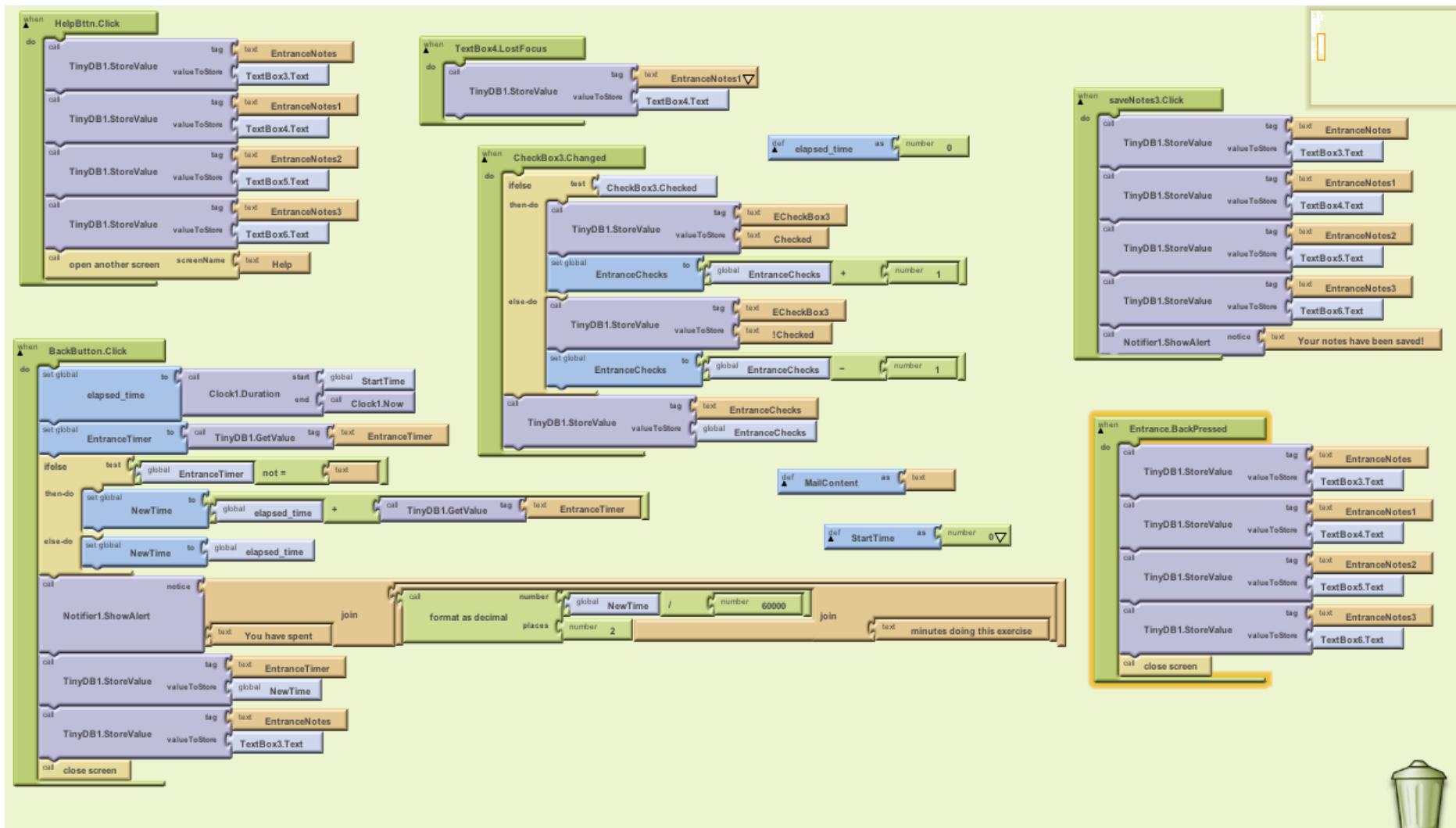


Figure 7 Location screen part 5

Appendix C: Code and Lecturers' Prompts

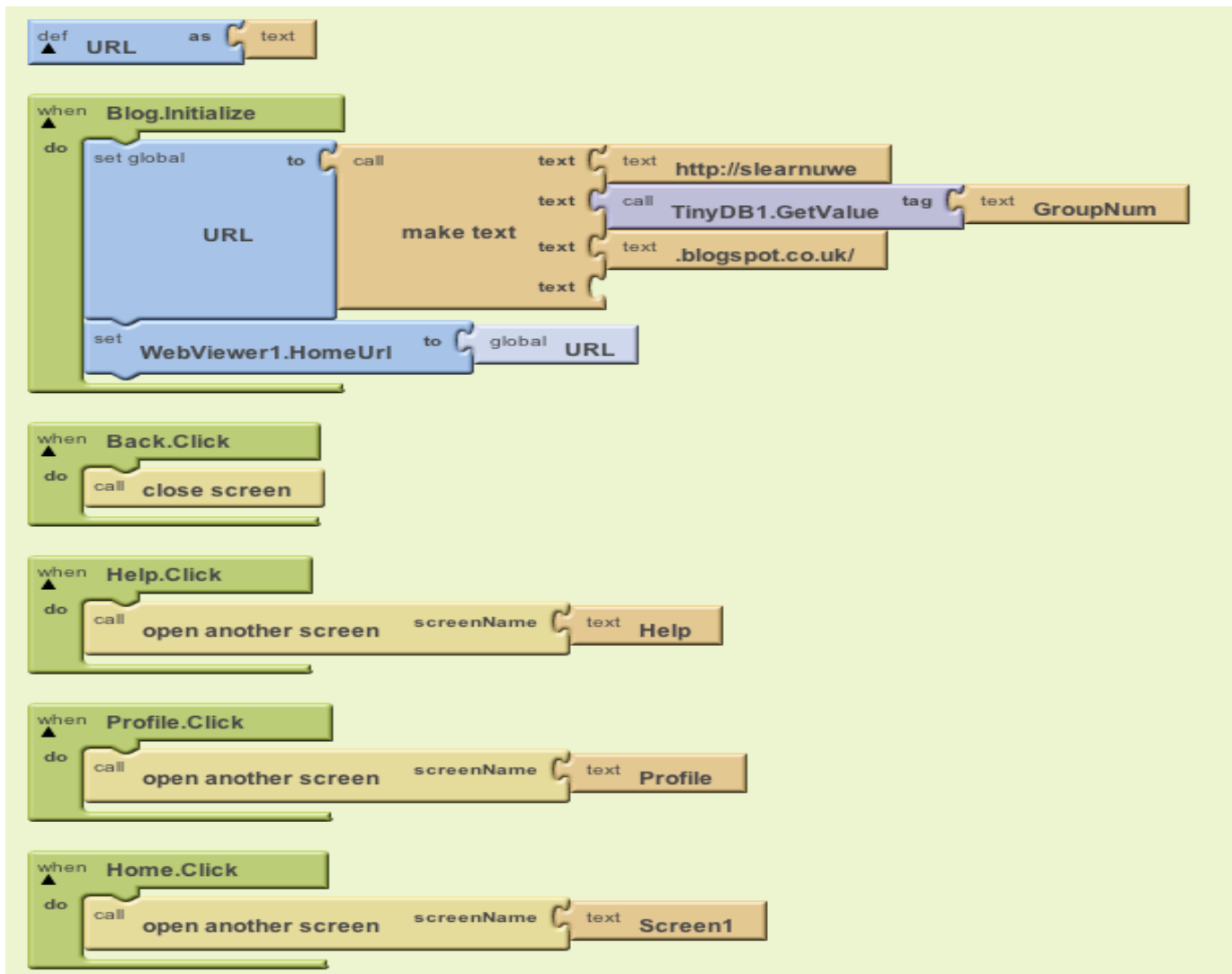


Figure 8 Blog screen code

Appendix C: Code and Lecturers' Prompts

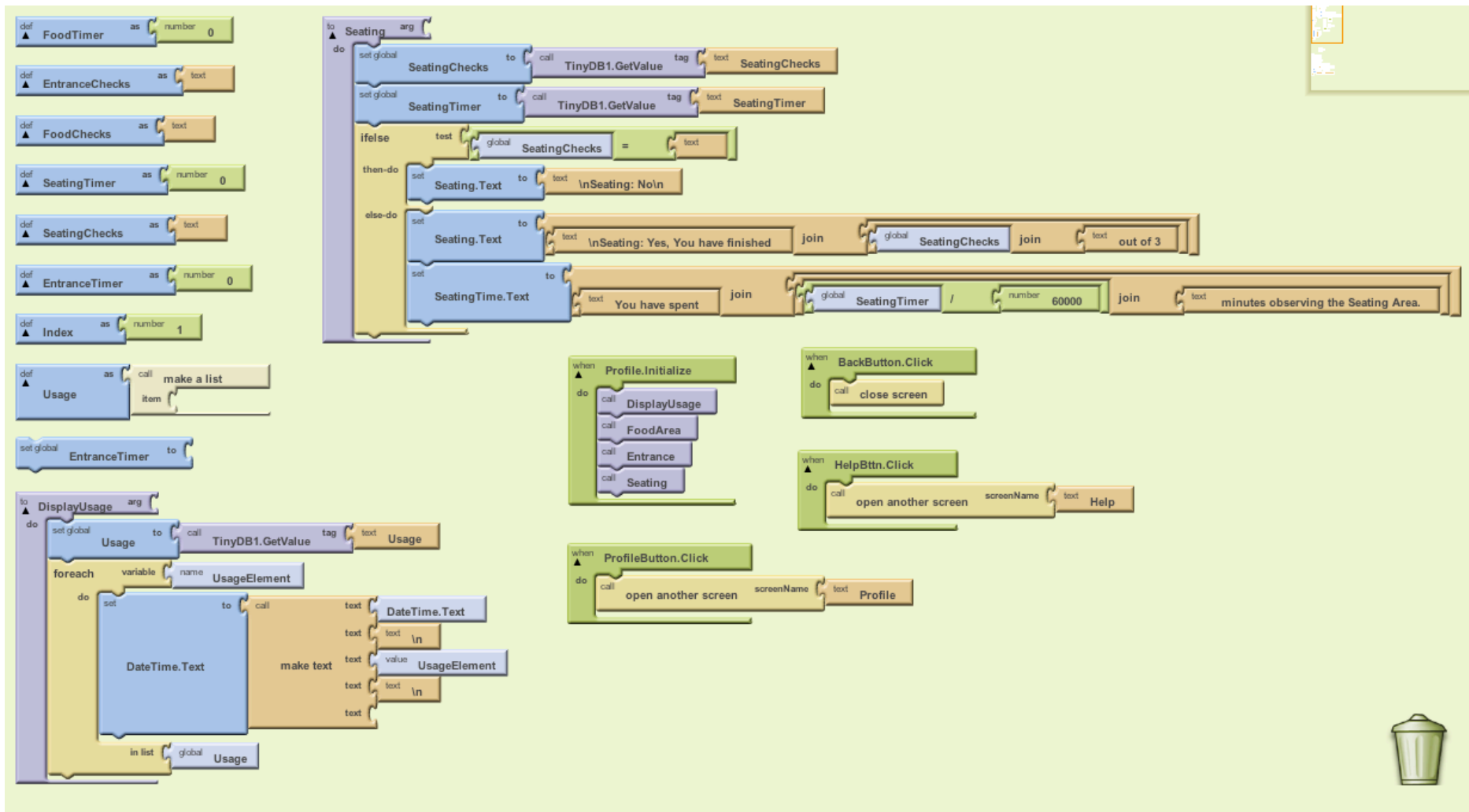


Figure 9 Profile screen code part 1

Appendix C: Code and Lecturers' Prompts

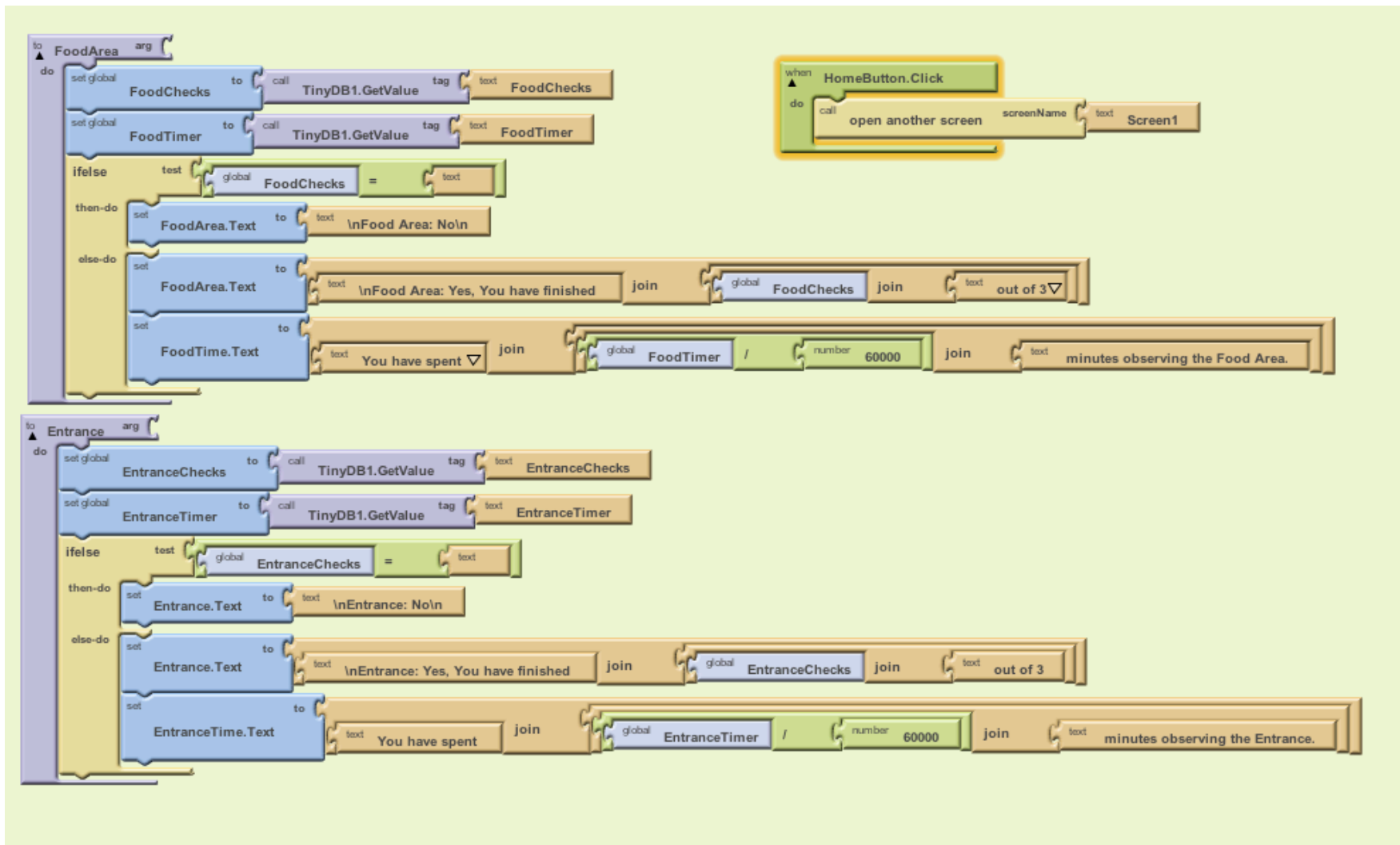


Figure 10 Profile screen part 2

Appendix C: Code and Lecturers' Prompts

Lecturer's Prompts

Location	Prompts
Entrance	<ul style="list-style-type: none">• How quickly do people move and orientate themselves with the area?• Do people seem to know what sort of food they want to buy, or do they seem to hesitate before approaching a particular area?• How crowded is the entrance area? Track one or two people to see what is happening.
Food Area	<ul style="list-style-type: none">• How are the different food areas designated? Is information about food and its nutritional value readily available?• Observe how staff communicate with each other and with customers. Do staff seem ready to give information about the food to customers?• How is food displayed? Are specific combinations of food encouraged or discouraged? Can people choose their portion sizes?
Seating	<ul style="list-style-type: none">• How do they move? Are they mostly in groups or their own? How crowded is the seating area?• Do people seem to eat in a hurried way, or do they take time over their food? Is there evidence of food wastage on the tray trolleys?• Observe one or two people as they enter the seating area. Do they have any difficulties finding cutlery, sauces or drinking water?

Appendix D: Evaluation Plan For In-context Evaluation

This evaluation was presented in sections 6.2 and 7.2 of the thesis.

Aim

The aim of this evaluation is to identify potential design issues of sLearn's mobile app and to understand whether this app is easy to use in context and serves its purposes.

What's being tested?

- Project Prototype: sLearn mobile application.
- Goal of sLearn: To provide the user with the necessary hints/help when conducting a study in situ. Learning in real world context should be beneficial rather than confusing. Learners should be able to gain the knowledge needed and record their notes and findings.

Test objectives

1. To identify navigation errors- failure to locate functions, excessive clicks to complete a task, and failure to follow the recommended screen flow.
2. To identify presentation errors - failure to locate and properly act upon information in screens, selection errors due to labeling ambiguities.
3. Data will be used to judge whether the interface could be regarded as being effective and efficient.
4. Establish a baseline user performance level for comparison in future evaluations.

Methodology

The concept behind this app will be explained to the recruited participants. Each participant will be asked to use this app in context, the environment this app will be used in, and follow a task list. They will be asked to "think aloud" as they complete the tasks.

After they have completed all tasks, participants will be asked to discuss their findings through an interview and to fill out a short questionnaire that would measure the usability of the app.

Participants will be required to sign a consent form prior to beginning the test.

Participants

Participants will be:

- Postgraduate University students.
- Interested in usability.
- Each session will have either 1 or 2 participants.

Duration

The whole session should not take more than one hour to complete and is divided as follows:

Pre-test arrangements (5-10 minutes)

- Sign a consent form.
- Explain the activity and tasks to the participants.
- Ask the participant to think aloud.

Tasks (15-20 minutes)

The participants will start doing the tasks.

Post-task questionnaire (2 minutes)

The participants will be asked to fill out an online questionnaire.

Post-task Interview (15 minutes)

- Follow up any particular problems that came up.
- Ask questions about the experience and preference.

What do I want to learn? What concerns, questions, and goals is the test focusing on? (Interview Questions)

- Can the students use sLearn mobile app effectively and efficiently?
 - How does it feel using the app in general?
 - How does it feel using the app in that context?
 - Are any aspects of the interface confusing?
 - What is your opinion of how information is organized on a particular location screen?
 - Is there anything that could have helped make the experience easier?
 - What would you like to see changed in the appearance of the app?
- Does the app serve its purpose?
 - Has the app helped in your observation?
 - Were the hints provided helpful?
 - Has the app helped you develop ideas?
 - Has the app helped you organise ideas?

Things to note during the observation of the tasks performance:

- Can they figure out what to do at each location?
- Do they understand the hints provided by their lecturers?
- Will they be able to recognise that they are supposed to click the checkbox after they have finished acting upon the hint?
- Can they navigate their way around the app?
- Do they look engaged?
- Where do they appear hesitant or confused?
- Are they able to complete the task?

Environment

The test will be carried in the OneZone Café at the same environment the real users will use this app.

Timing

The test will preferably take place between 12-2 pm where the café is at its peak.

Metrics

- Task completion success rates. The task is complete when the participant reaches the stopping criteria.
- Error rates. Critical errors, those that are unresolved during the process of completing the task or produce incorrect outcomes, and non-critical errors, that are recovered from by the participant will be collected.

Goals

The goals of this usability test are as follows:

- All participants successfully completing the task without critical errors.

Aspects of “sLearn” under test

1- Choosing a Location to explore

Scenario	You need help in a particular location, so you click on that location.
Stopping criteria	Participant reaches the location's screen.
Correct Path	Participant touches location's name button under the map.
Possible issues	Participant does not know how to navigate to that location. Participant cannot press the button correctly.

2- Reading the desired prompts and ticking when done.

Scenario	You are not sure what to look for, so you start reading the prompts.
Stopping criteria	1- Participant reads the prompts. 2- Participant ticks the ones that he/she have read
Correct Path	Participant ticks the checkbox next to the prompt.
Possible issues	Participant does not understand the purpose of the checkbox.

3- Writing down a note for one of the prompts and saving it.

Scenario	You have some notes you need to save for when you write your report
Stopping criteria	Participant clicks the save button.
Correct Path	1- Participant touches the text box and writes the notes. 2- Participant presses the Save Notes button.
Possible issues	Participant does not press the save button.

4- Posting the notes to the Blog to share

Scenario	You have some notes you need to share with your peers
Stopping criteria	Participant clicks send email and the email is sent
Correct Path	1- Participant clicks the Post to forum button. Either: 2- Participant set up their email for the first time then goes to 3. Or 3- Press the send button in the mail app to send the email.
Possible issues	Participant does know how to set up their email.

5- Checking the Profile.

Scenario	You need to track your progress
Stopping criteria	Participant reaches the Profile screen
Correct Path	Participant presses the Profile button in the navigation bar.
Possible issues	Participant cannot locate the navigation bar

Questionnaire

The questionnaire provided to students is the System Usability Scale.

1 = Strongly Disagree

5 = Strongly Agree

Statement	1	2	3	4	5
I think that I would like to use this app or a similar app whenever available for this sort of learning.					
I found the app unnecessarily complex.					
I thought the app was easy to use.					
I think that I would need the support of a technical person to be able to use this app.					
I found the various functions in this app were well integrated.					
I thought there was too much inconsistency in this app.					
I would imagine that most people would learn to use this app very quickly.					
I found the app very cumbersome (awkward) to use.					
I felt very confident using the app.					
I needed to learn a lot of things before I could get going with this app.					

Appendix E: Usability Test Consent Form

Please read and sign this form.

I state that I am over 18 years of age and wish to participate in the evaluation study being conducted by **Abeer Alnuaim**. The purpose of the study is to assess the usability of the sLearn mobile app.

In this usability test:

- I will be asked to perform tasks using this app.
- I will also be asked a few questions before and after I attempt the tasks relating to my previous experience of using smartphones and thoughts regarding the app.
- The evaluators will observe my use of the app and will make notes/audio recordings.

All information will remain strictly confidential. The descriptions and findings will be used to write a report on the usability of sLearn app and help identify possible improvements. At no time will my name or any other identification be used. I understand that I am free to ask questions and can withdraw my consent to the experiment and stop participation at any time.

If I have any questions after today, I can contact **Abeer Alnuaim** at abeer.alnuaim@uwe.ac.uk

I have read and understood the information on this form and had all of my questions answered

Participant's Signature

Date

Evaluator's Signature

Date

Appendix F: HCI & UX Questionnaire

HCI Questionnaire

Gender *

- Female Male

Age Group *

- 17-21
 22-26
 27-31
 31+

Skill Level with Touchscreen Smartphones *

- Novice (Never used one)
 Intermediate (Have used one before)
 Expert (Owned one)

Skill Level with Androids *

- Novice (Never used one)
 Intermediate (Have used one before)
 Expert (Owned one)

The System Usability Scale (SUS) *

Please rate the following statements: 1-Strongly Disagree 5- Strongly agree

	1 Strongly Disagree	2	3	4	5 Strongly Agree
I think that I would like to use this app frequently.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the app unnecessarily complex.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought the app was easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think that I would need the support of a technical person to be able to use this app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the various functions in this app were well integrated.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought there was too	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1 Strongly Disagree	2	3	4	5 Strongly Agree
much inconsistency in this app.					
I would imagine that most people would learn to use this app very quickly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the app very cumbersome (awkward) to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt very confident using the app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I needed to learn a lot of things before I could get going with this app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

SLearn *

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not Applicable
The app helped me in my observation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app gave me hints on what to look for	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app helped me organise my ideas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was helpful to have a space for note taking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app helped our group members to share ideas and notes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Forum (Blog) within the app was useful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was useful to track my progress through Profile	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app helped me develop ideas for PACT	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What features would you wish to see in the app that will be useful?

UX Questionnaire

Gender *

- Female Male

Age Group *

- 17-21
 22-26
 27-31
 31+

Skill Level with Touchscreen Smartphones *

- Novice (Never used one)
 Intermediate (Have used one before)
 Expert (Owned one)

Skill Level with Androids *

- Novice (Never used one)
 Intermediate (Have used one before)
 Expert (Owned one)

The System Usability Scale (SUS) *

Please rate the following statements: 1-Strongly Disagree 5- Strongly agree

	1 Strongly Disagree	2	3	4	5 Strongly Agree
I think that I would like to use this app or a similar app whenever available for this sort of learning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the app unnecessarily complex.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought the app was easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1 Strongly Disagree	2	3	4	5 Strongly Agree
I think that I would need the support of a technical person to be able to use this app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the various functions in this app were well integrated.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought there was too much inconsistency in this app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would imagine that most people would learn to use this app very quickly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the app very cumbersome (awkward) to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt very confident using the app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I needed to learn a lot of things before I could get going with this app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

SLearn *

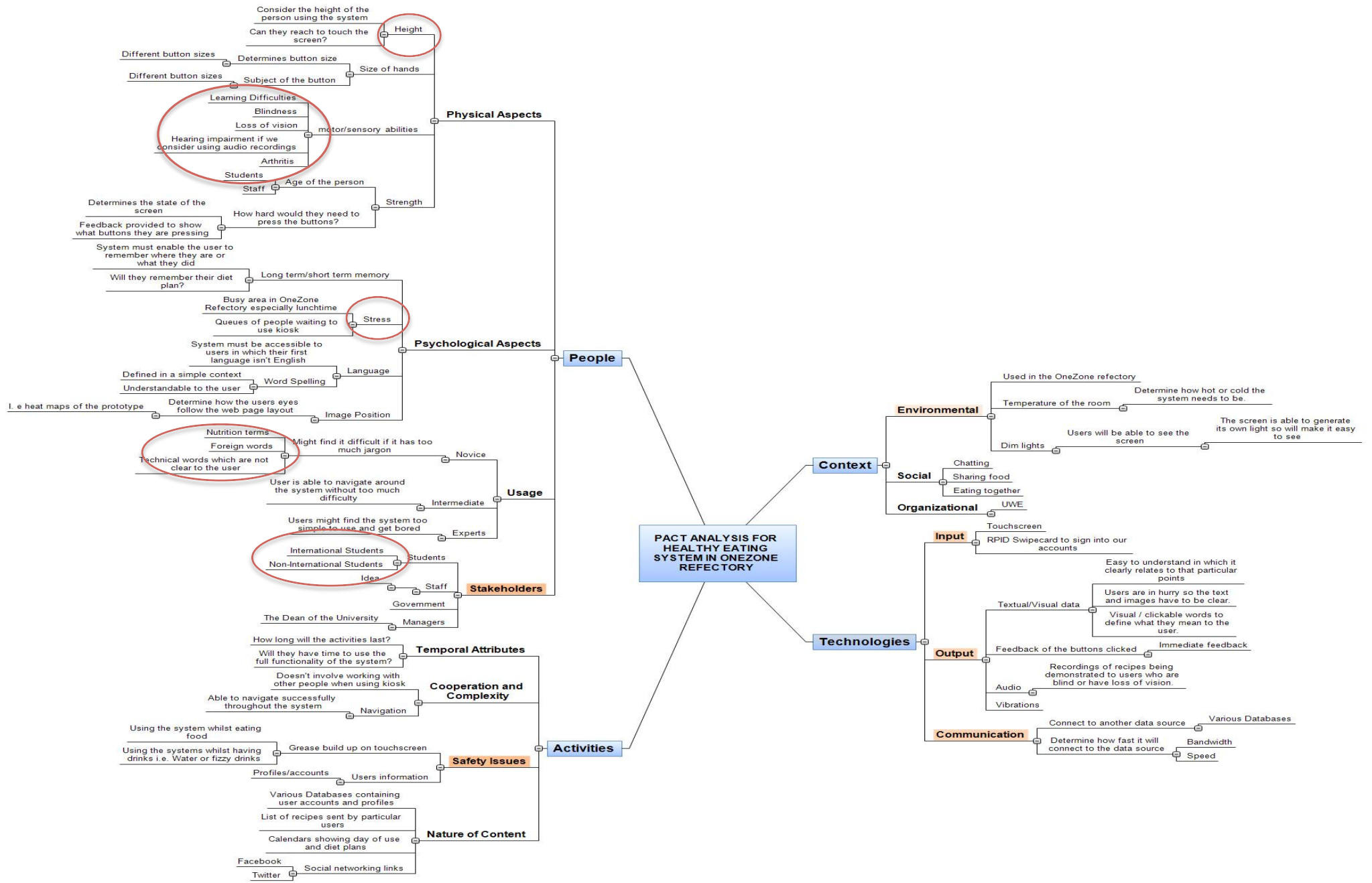
	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not Applicable
The app helped me in my observation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app gave me hints on what to look for	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app helped me organise my ideas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was helpful to have a space for note taking under each hint	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was helpful to have textbox for extra observations and notes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app helped to share ideas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not Applicable
and notes						
The Forum (Blog) within the app was useful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was useful to track my progress through Profile	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app helped me develop ideas for PACT	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What features would you wish to see in the app that will be useful?

Appendix G: Extracts from students' work

Presented below is some students' work that shows the development of empathy they develop shared understanding and become more aware as discussed in 7.1.



PEOPLE

Social Differences

Different Motivations

Some people may want to find lots of information or instructions about the food and other may just want to find one simple thing, such as what time is it

Trust

Some people don't trust machines and devices.

How do we show them that food information in the devices are reliable and trustful.

Psychological Differences

tiredness

Some people can be very tired after long and hard morning.

In the case when the user is tired, he won't be happy to read lots of information about the food.

Clean and simple design with easy to read information should be applied.

Language

For some people English is not their first language and their level of English may vary.

Should the devices offer different languages and what kind of English should be used?

Spatial Ability

Users with bad spatial ability may have a trouble to navigate if the devices will be too complicated. This could be solved by providing good signage and clear directions

Physical Differences

Height

How high should be the devices in the OneZone cafeteria?

wheelchair users

Weight

Should be there a different information in the devices, depending on user weight?

How should the machine or device know the user weight?

Touch

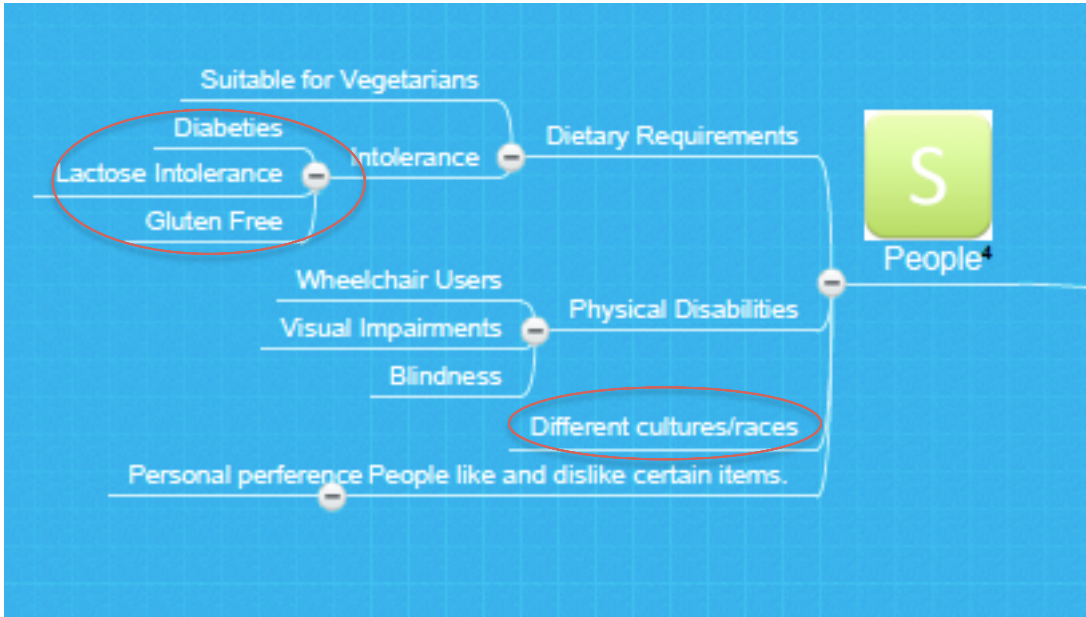
Touch screen could be a problem for users with vision difficulties

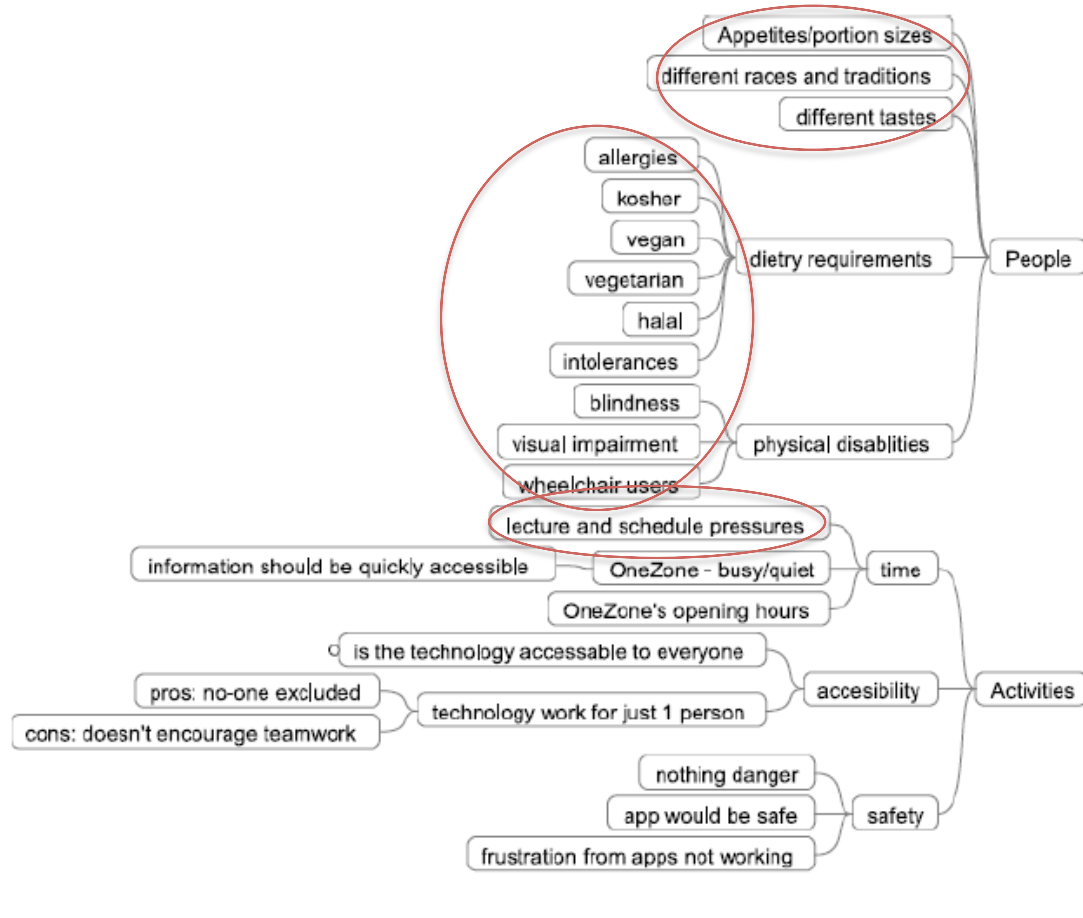
Color blindness

Should the devices systems be in black and white?

Hearing difficulties

Should the devices use sounds to interact with users?





Appendix H: Engineering Questionnaire

Gender *

- Female Male

Age Group *

- 17-21
 22-26
 27-31
 31+

Skill Level with Touchscreen Smartphones *

- Novice (Never used one)
 Intermediate (Have used one before)
 Expert (Owned one)

Skill Level with Androids *

- Novice (Never used one)
 Intermediate (Have used one before)
 Expert (Owned one)

The System Usability Scale (SUS) *

Please rate the following statements: 1-Strongly Disagree 5- Strongly agree

	1 Strongly Disagree	2	3	4	5 Strongly Agree
I think that I would like to use this app or a similar app whenever available for this sort of learning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the app unnecessarily complex.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought the app was easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think that I would need the support of a technical person to be able to use this app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the various functions in this app were well integrated.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought there was too much inconsistency in this app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would imagine that most people would	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1 Strongly Disagree	2	3	4	5 Strongly Agree
learn to use this app very quickly.					
I found the app very cumbersome (awkward) to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt very confident using the app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I needed to learn a lot of things before I could get going with this app.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

SLearn *

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Not Applicable
The app helped in conducting the risk assessment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app gave me hints on what to look for	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The app helped me organise ideas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The photos in the app were useful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using the app as a group encouraged us to share ideas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What features would you wish to see in the app that will be useful?

Appendix I :Evaluating Mobile Application

Gobby:

An application targets non-native English people. It provides explanation of various phrases used in everyday life by English people.



Figure 1

1. Educational Features:

- i) Phrases are categorised see figure 2.
- ii) The meaning of the phrase is explained and an example is provided for illustration see figure 3.
- iii) An option for listening to the phrase to show correct pronunciation see figure 3.
- iv) Each Phrase is given a rate in which where it can be said or to whom 'Chilli rate'. Each rate is properly explained see figure 4.

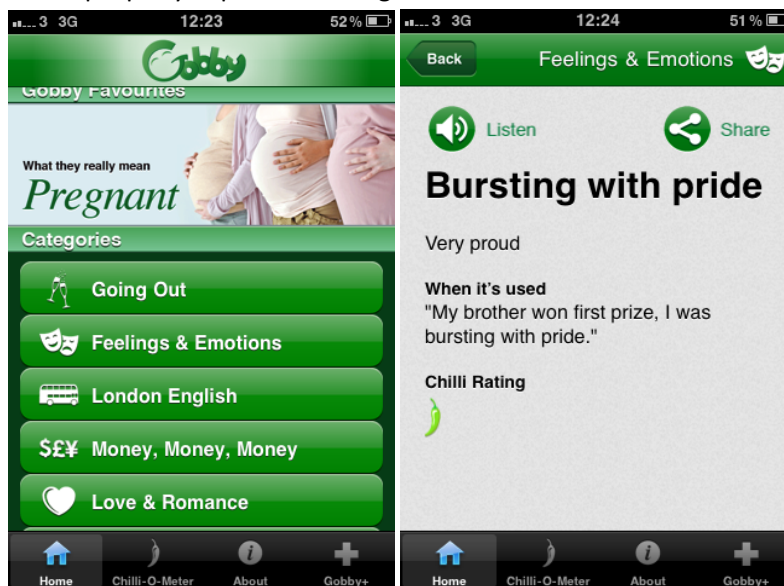


Figure 2

Figure 3



Figure 4

2. Technical Features:

- i) App's favourite are displayed on the main page as a banner with pictures to illustrate the meaning see figure 2.
- ii) Allows users to suggest phrases to be included in next edition see figure 5.
- iii) Gives option to share phrases with others via email or SMS see figure 3. Maybe needs to add twitter & Facebook as options
- iv) Needs a search box to search for phrases when users are not sure which category might it be under.

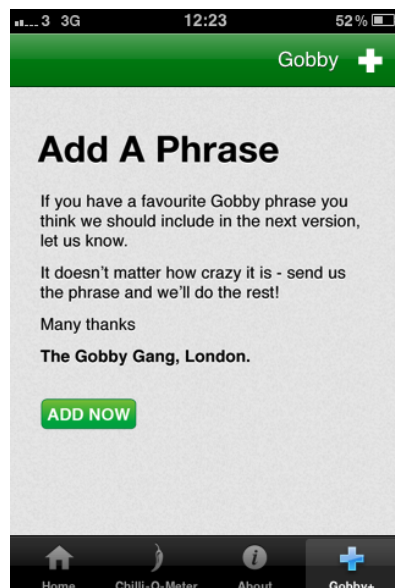


Figure 5

3. Usability Features:

- i) Learnability: it was easy to learn.
- ii) Efficiency: users can be efficient users easily.

- iii) Memorability: it was easy to remember different functions.
- iv) Number of errors: None.
- v) Satisfaction: the design satisfies the needs.

Our Story:

An application created by the Open University. It targets Young children and Mothers to create stories of the child.



Figure 6

1. Educational Features:
 - i) Create a story from the child's own background.
 - ii) Can promote reading by engaging children with stories they are familiar with.
 - iii) An example has been included to illustrate the use of the app.

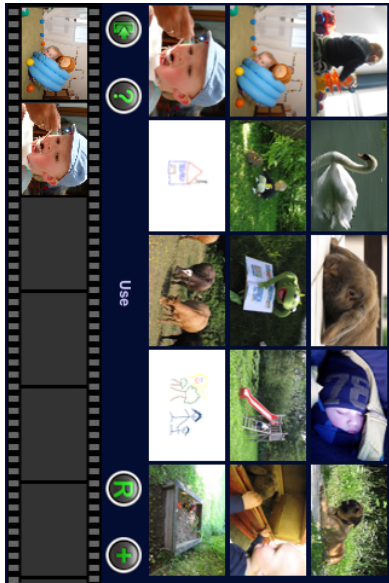


Figure 7



Figure 8

2. Technical Features:

- i) Allows multimedia through the ability to add text, audio, and images.
- ii) Navigation system is not very clear.
- iii) Allows users edit pictures, audio, and the images.
- iv) Allows users to save 10 storyboards.
- v) Provides information on how to use the app, which in this case is handy but boring.

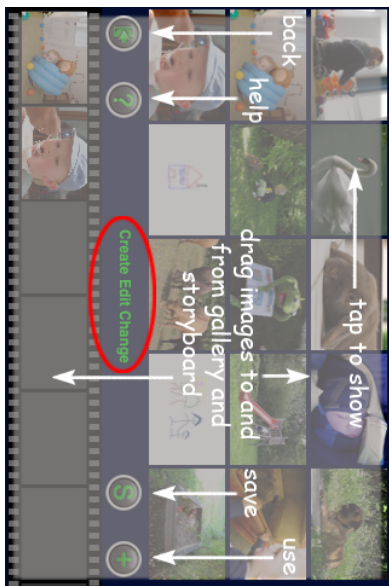


Figure 9



Figure 10

3. Usability features:

- i) Learnability: not easy to learn the functions.
- ii) Efficiency: Users might not be able to be efficient users easily, especially novice users.
- iii) Memorability: Not easy to remember the different functions; had to use the help button many times.

- iv) Couple of errors have been made but could there was the abilitPy to edit.
- v) Satisfaction: the design might not satisfy users and they might get frustrated by design choices.

iLancaster:

An app by the University of Lancaster aimed mainly at students but can be used by visitors.

1. Educational Features:

- i) Provides information about the university and news and events.
- ii) Provides personal timetables and staff directory.
- iii) Provides the ability to search the Library and view loans.
- iv) The ability to check Computer availability across campus see figure 12.
- v) Provide a map of the campus.

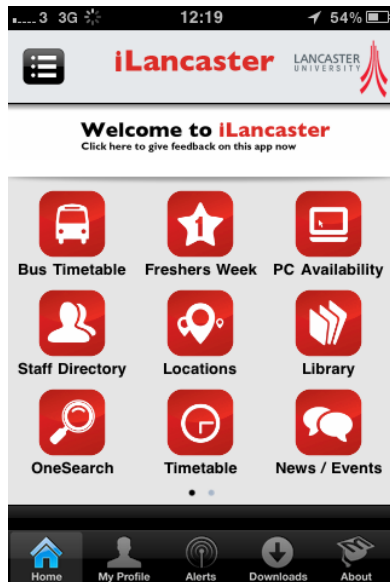


Figure 11

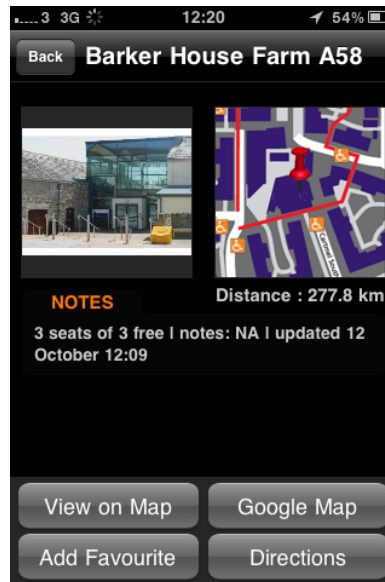


Figure 12

2. Technological features:

- i) You need to have log in to use the app. If you are a current student/staff this is not a problem because they already have user names. However, guests need to register to log in.
- ii) Cannot view bus timetable if you are far from the location unless you know the postcode.
- iii) Easy navigation system.
- iv) Gives options to download maps and guides
- v) Can edit your profile
- vi) Can add events and notes to get alerts.

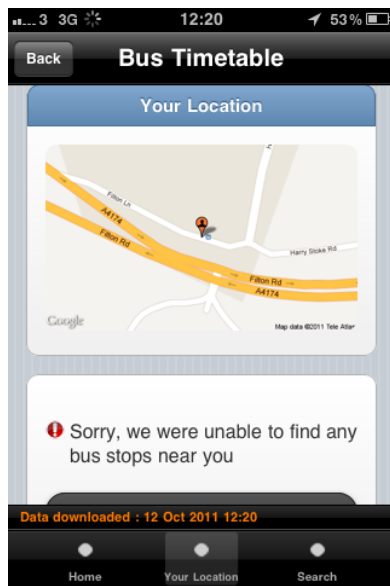


Figure 13

3. Usability Features:

- i) Learnability: it was easy to learn.
- ii) Efficiency: users can be efficient users easily.
- iii) Memorability: it was easy to remember different functions.
- iv) Number of errors: None.
- v) Satisfaction: the design satisfies the needs.

Edinburgh- World Heritage City

1. Educational Features:

- i) Provides a guide to the cityscapes.
- ii) Provides number of tours that would guide the user to different sites to visit and explore.
- iii) Helps exploring the hidden stories behind a particular scape.
- iv) Each site on the tour provides the user with information. An image of the place and an audio to listen to.
- v) User's can add their comments and view previous comments by other users.
- vi) The user can play a game when touring, as he/she can collect points when spotting a site by pressing the 'spotted' button.
- vii) Provides a question about the site that the user can answer to collect extra points

2. Technological Features:

- i) Provides a list of tours that a user could choose from.
- ii) Once a tour has been chosen, the user can view the site either as a list or on the map.
- iii) Users can view photos taken by other users and can take a photo.
- iv) The map provided is clear and has many information that would help the tourist find the site they are looking for, however, adding the GPS function that would guide the user to

the site according to their location would make it easier for tourist who do not know the city well.

3. Usability Features:

- i) Learnability: it was easy to learn as a first time user.
- ii) Efficiency: users can be efficient users easily. The navigation system is clear and easy. The number of steps the user takes to complete a task is adequate.
- iii) Memorability: it was easy to remember different functions.
- iv) Number of errors: None.
- v) Satisfaction: the design satisfies the needs.

This application has many good features that would help designing our application. Having a list of sites corresponds to our list of hints. These hints can also be either shown as a list to students or on the map. The idea of clicking 'spotted' when spotting the site can also be implemented as students could press 'noted' or 'observed' when observing a particular hint provided. Students can also add comments that they find relevant.

Appendix J: Students' Extracts

Extracts from some of the groups' work showing:

1. Thorough observation.
2. Depth and detail in the insights
3. Depth and detail in translated data into PACT and functional and non-functional requirements

It should be pointed out that due to the fact that groups presented their work many of the evidence was verbal. Not all groups have documented their verbal presentation such as group B.

Group B:

Findings of ONE Zone Refectory

- Entrance Area
 - One door was only open
 - Staff are on help all the time.
 - temperature in room was warm, and had dim lights.
- Food Area
 - Food area is split into sections : traditional, theatre, express.
 - Choose their portion sizes
- Seating Area
 - Crowded in the seating area
 - Mostly in groups when getting food and eating.



Figure 1 Group B's Slide presentation

On following the generating of data of the particular persona we were looking for and developed in week 3, we as a group were asked to conduct an investigation into the OneZone refectory to help us broaden our knowledge of the system we are developing in which as mentioned earlier will be a healthy eating system. As you can see, we were asked to make notes on an Android App called sLearn in which we loaned out for use. We went to the refectory at the busiest time of the day at lunchtime in which we all as a group thought it was a perfect time to generate a lot of information for our PACT analysis which we did when we gathered the information. The PACT analysis is shown in the following slides.

Within the app, there were particular parts of the refectory we had to look at in particular in which you can see on this slide in particular was the entrance, food and seating area in which we put our findings into individual sections.

From our findings we found with the entrance that one of the doors wasn't open which would be a massive problem on a busy time such as lunchtime if there was a big queue waiting for their meals. We also found other people can easily get in and out at the time we were at the refectory but can be improved by opening both doors. There was also an important notice on the door showing that the onezone only accepts cash which made clear to the people using the refectory what payment method should be used. We also had to consider with our healthy eating system if we have a monitoring system then it has to be cash only.

Also the lines were unorganized, since the counters are split into sections. It also had a good variety of food. It was also clean and staff was on help all the time which made the customers more comfortable. In the environmental context for the customer, temperature of the room was warm and had dim lights which we will explain later on. Also people look around and hesitated which section to go to. They had a variety of menu stands to help make their decision. Once they made their choices, they ordered their meals.

Other aspects we found with the food and seating area is with the food area was split into sections: traditional, theatre, express. Also information about the food is available on the stands provided next to each section. They had many varieties: such as gluten free, hall, vegetarian, etc. The staff are prepared to give info to the students and the food is displayed to the users fully, and in great details: very appetising.

With the seating area we found users are offered the cutlery when they have to pay for their meals, no sign is shown to indicate the cutlery location, drinking waters are given in bottles, and they have to find the machine which houses them. Also it was crowded in the seating area. And most users were mostly in groups when getting food and eating they moved at their own pace. There was evidence of food wastage on the trays and they ate at their own pace, not rushed.

Figure 2 Group B's thorough observation

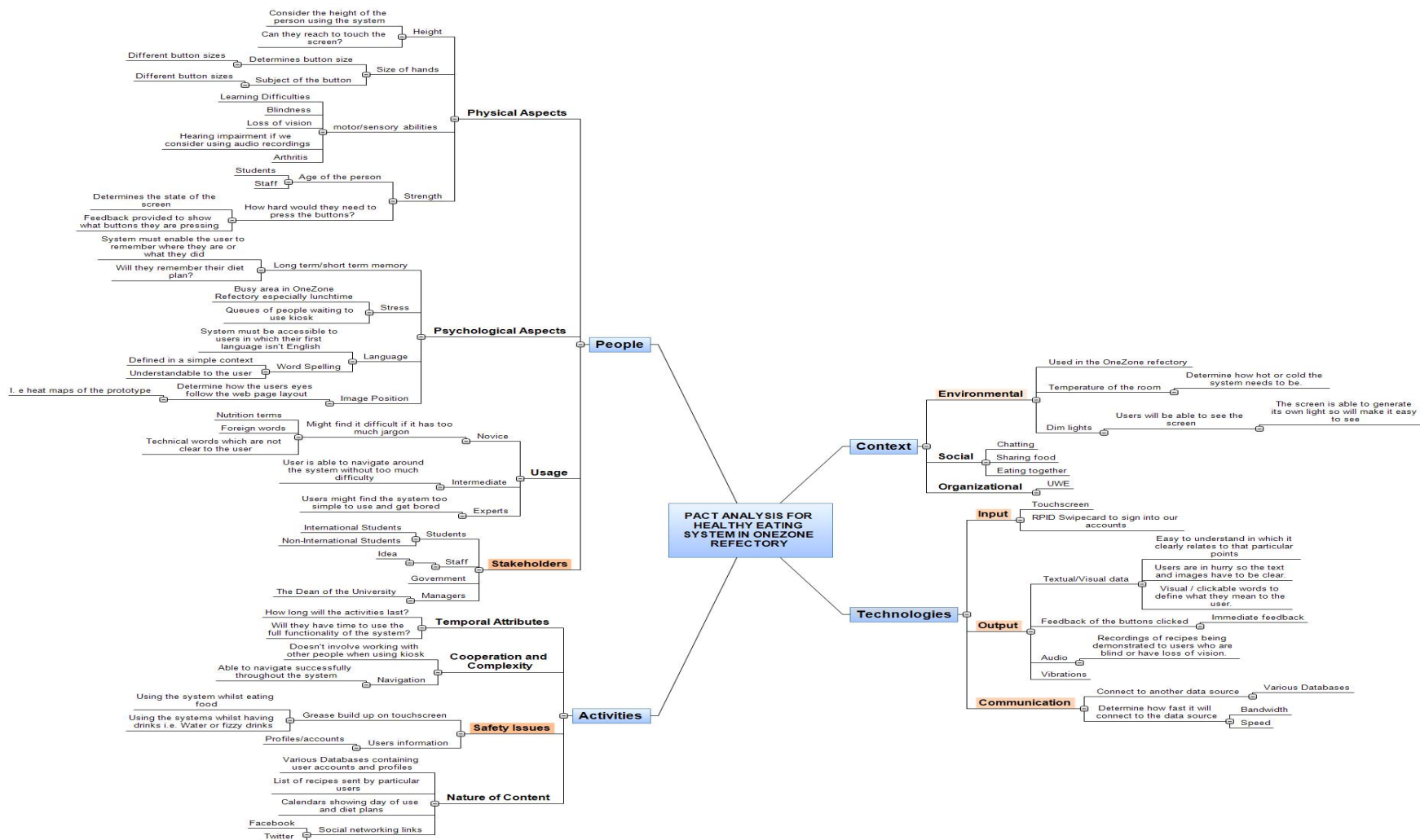


Figure 3 Group B's PACT

After generating the information from the OneZone refectory, we made a PACT analysis in which we looked at the People, Activities and Context and Technology that we found from this investigation and will consider into our Healthy Eating System.

As you can see, we carried out a lot of analysis so will cut down to the main issues we found which are coloured in pink as shown. The stakeholders we found when looking at this investigation and would be involved with the system in general we believed to be the managers, staff such as the lecturers, departments such as the financial, human resource, sales, IT firms, technicians etc., us the students who we are mostly particularly looking to use it in general and mainly the government.

Within Activities when developing the system we had to consider the safety issues such as grease will build up on the touchscreen when using it in the refectory whilst eating food and fizzy drinks. We also have to consider users information such as their profiles and accounts and prevent authorization from other users looking into a particular user's account etc.

Within Context, we have to consider where the system will be located which will be in the OneZone refectory and as mentioned in the previous slide the temperature of the room and the lightness within the room it is being used in. As you can see the temperature of the room would affect the system greatly depending on how hot or cold the room is, as it has the smell of baked food, we assumed the system will be warm. Also having dim lights will affect the environment as users will be able to see the screen and the screen will be able to generate its own light so will make it easy to see for the user.

With technologies in particular we had to consider the input, output and communication of the system all together. With input, we had to consider the touchscreen and the swipe card which will be used to log onto the system. Also output as such you would have textual or visual data in which it will be easy to understand and will clearly relate to the particular points. Also users are in an hurry so the text and images have to be clear and visual clickable words to define what they mean to the user. We also considered feedback in which how fast does it take to go to another section of the webpage when clicked on. Also with audio we were considering if they were blind or had loss of vision that they should have recordings of recipes demonstrated and we also mentioned vibrations. With communication we could connect to various data sources such as various databases which will store the recipes and the number of users using the system and also determine how fast it will connect to the data source such as the speed and bandwidth.

I will now pass you onto ~~●~~ who will discuss the functional and non-functional requirements of the healthy eating system.

Figure 4 Group B's insights and functional and non-functional requirements

Group C:

Observations & PACT

We conducted an observation of the OneZone refectory at two separate times (morning/lunchtime) and noted a couple of key things;

- Students often knew exactly what they wanted before they even entered the refectory, meaning they just walked in, picked up their items and proceeded through in a quick fashion. This is likely due to being regulars.
- Staff seem willing to help however when it gets busier there is a lot less room for that.
- Most people who are eating in groups use the seating area, whereas most who are on their own buy something they can leave with.

From this we can draw up a PACT analysis of the new system, our user group will be students who use it regularly.

Person	Activity	Context	Technology
Often know what they want before entering.	Ordering food is undertaken every day by a lot of people (temporal).	Gets very busy/hectic around lunchtime.	Touch screen input
Varying shapes and sizes.		Most people move in groups.	Wheelchair accessible
Some with disabilities	Ordering food is often rushed.	Noisy in the busier hours.	LCD screen output shouldn't be a problem in the refectory.
Some very stressed	Likely to get interrupted by friends talking or other distractions.	Might be carrying books/ other items	Sound should not be key.
For the most part intelligent			

Using this PACT analysis we can derive a set of requirements that will fit the our target audience. The system needs to accommodate for a wide range of both physical and mental models, be simple enough to use when in a rush and must have various accessibility tools for those with disabilities.

- The system must be flexible for different user requirements & tastes (such as allergies, dietary requirements & user budgets).
- Designing for multiple user groups (staff / students) is complicated due to a wide range of technical expertise among them.
- Thus the system should be intuitive and be simple to use for all skill levels with consistent mapping and visibility to ensure ease of use.
- Due to the high pressure environment of the One Zone many considerations should be made such as efficiency of use and privacy (such as no audible announcements of food choice)

Figure 6 Group C's insights

Functional/Non-functional Requirements

Functional:

- **MUST:** Display nutritional information various level of complexity. (hide/show)
- Cost calculator, calculates cost of food when ordering, also list price details of each product.
- Place order using online credits.
- Recommend food based on previous meals/current calorie intake tracking
- **SHOULD:** Filterable by allergies/vegetarian options.
- Set weight/calorie goals using the system.
- Stock available, only displays food that's in stock.
- **COULD:** Update credits on the machine rather than just online

Non-Functional:

- **MUST:** Understandable step by step guide/help.
- Wheelchair accessible.
- The system needs to be maintainable by the technicians running it.
- **SHOULD:** Efficient, easy to use.
- Color scheme simple and fitting to the system/target audience.
- **COULD:** As it's a touch screen the buttons need good affordance to simulate real button presses.
- Pleasing aesthetics
- **WANT** Adjustable height on kiosk
- **WANT** Pivot-able screen

Figure 7 Group C's functional and non-functional requirements

Group L:

Thorough observation.

Entrance

How quickly do people move and orientate themselves in the area?

A higher amount of customers seem to be returning customers and know more or less what they want: Be that a fry-up or salad. Some are milling about and looking at the options. The different areas are decently well designated, and actual navigation seems to not be a big problem.

Do people seem to know what sort of food they want, or do they seem to hesitate before approaching a particular area?

Especially what appear to be new customers read the signs, though it seems people are a little bit uncomfortable standing and reading, and some just go for the obvious option without understanding all the options. Returning customers have either already read the signs, or they don't care so much what is on them.]

How crowded is the entrance area? Track one or two people to see what is happening.

Right when I got there, it was not overly crowded, but there was still a small crowd waiting for food. There was a queue, and some people were looking at the salad bar and sandwiches. It was still easy to navigate, but people needed to check where they were going, or there might have been minor collisions.

Tracking: male, early 40s, possibly a lecturer enters, goes over to the salad bar and looks at a few items and at the box sizes. Goes over to the sandwiches and also looks at the drinks but then goes over to the hot food queue and look at the signs. Ends up ordering fish and chips and picks up condiments and cutlery before going to the cash registry.

Seating Area

Observe one or two people as they enter the seating area. Do they have any difficulties finding cutlery, sauces or drinking water?

Tracking person 1, female: >20yrs, purchased salad. No problems finding cutlery, probably been here before. Has a bottle of water, so not looking to buy drinking water. Unknown is she is aware of the possibility of getting regular drinking water.

Tracking person 2, male: ~20yrs, English breakfast, with two friends. Walked halfway to a table before realising he did not have cutlery. Looked around and set down plate, then went back to the cutlery table and picked up fork and knife as well as ketchup, salt and mayo. Had purchased a coke.

How do they move? Are they mostly in groups or their own? How crowded is the seating area?

The seating area is perhaps a little over half full in terms of free seats, but most tables have people seated. It's possible to move about quite unhindered, but not between some tables. Most people are seated with someone else, but quite a few are also eating on their own. However, about 1/3 or 1/4 of occupied tables has just one person.

Do people seem to eat in a hurried way, or do they take time over their food? Is there evidence of food wastage on the tray trollies?

Groups of people seem a lot more relaxed eating and socialising, taking whatever time they need to eat. Single customers seem a little bit more focused on finishing their food and get on with other activities. The room is quite loud with the sound of the customers, so it does not feel very relaxed.

There is a lot of food wasted. In some cases people left most of their food. I don't have that much experience with cafeterias, but it seems to be more than would be expected.

Figure 8 Group L's observation

Food Area

How are the different food areas designated? Is information about food and its nutritional value readily available?

The areas are divided up into the "cooked food" area to the left from the entrance, and to the right one can find a salad bar and sandwiches and assorted foods.

There is a distinct lack of nutritional value, though there is a colour guide (traffic lights) to indicate just how bad the cooked food is, and how often a particular food should be eaten. It's sort of encouraging having more healthy things with your fry-up, like tomato, instead of something less healthy (bacon). Though the item price is about the same, so even if a person is interested in more nutritional food, it seems like you are being screwed by choosing the tomato.

A lot of thought clearly went into the design of this traffic light design though, and the idea is good, but our interview subjects have all complained about a lack of information, so perhaps it's not exactly what customers want.

Observe how staff communicates with each other and with customers. Do staff seem ready to give information about the food to customers?

The staff seems very task-orientated, and though there is some inter-staff communication, it's very topic-specific. They do not seem ready to give information about specifically the nutritional values of the food, but they do have basic information such as where (some of) the products are from. However, this seems situational: might not be a service they have been trained to provide.

How is the food displayed? Are specific combinations of food encouraged or discouraged? Can people choose their portion sizes?

The food is presented on signs and is easy to grasp what is available and what is "encouraged". The selection of healthier options, however, is a bit quite small and obviously aimed to students who want a fry-up or equally "bad" food. Some combinations can be made with especially the fry-ups, and it IS possible to choose slightly more healthy combinations and the colour-coding on the traffic light signs indicate what is better or worse. However, it's not presented in an otherwise attractive light and most people prefer the greasier options.

The salad bar does not look very appetising, but you can choose your portion size. The healthy options are not very emphasised; in fact the opposite can be said.

Figure 9 Group L's Observation part 2

Depth and detail in translated data into PACT, In order to view their detailed explanation see <http://www.mindomo.com/mindmap/60c46a6a4bfc4a91bfeb3ad43822f454>

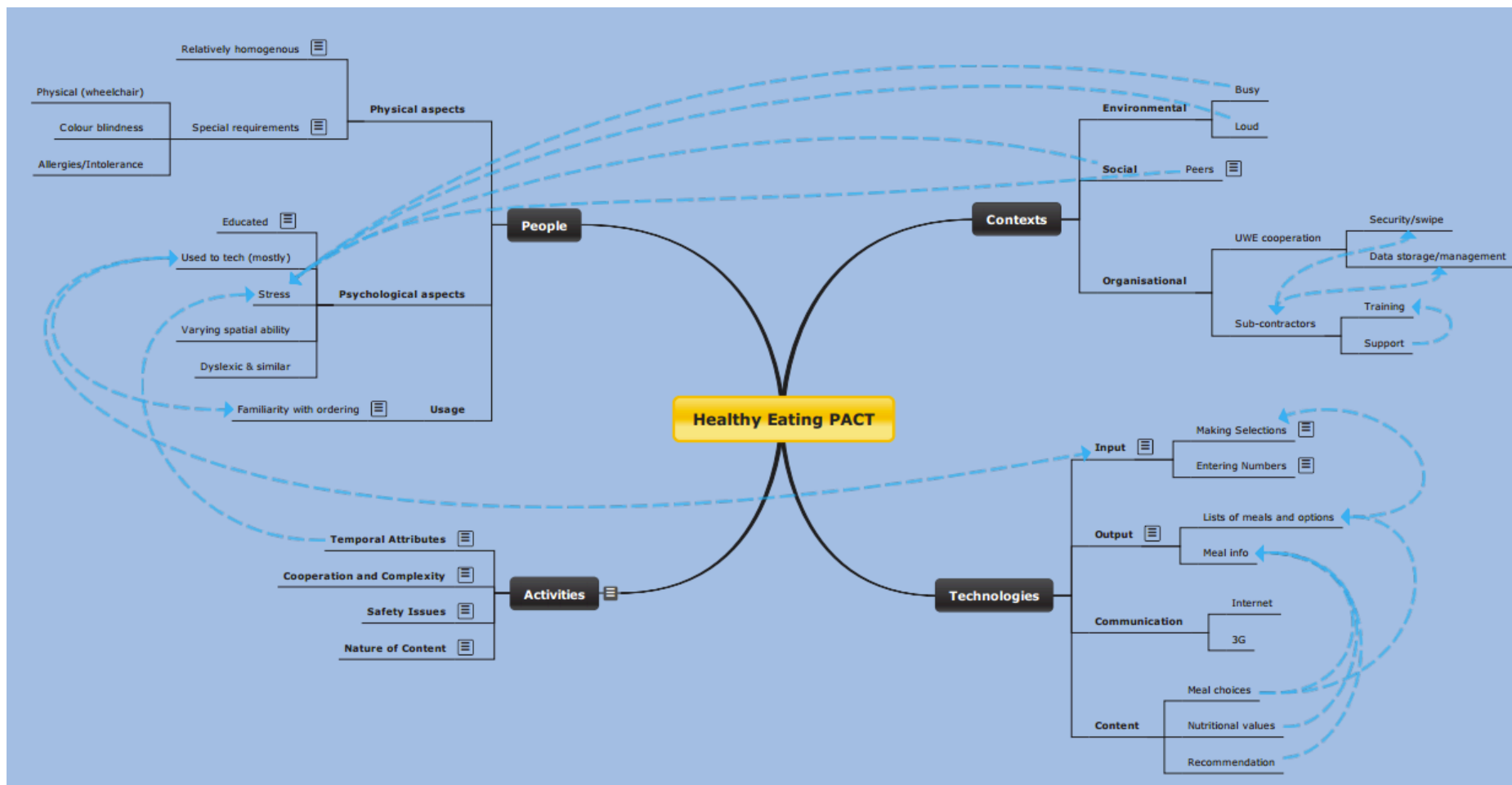


Figure 10 Group L's PACT

Functional Requirements:

Account services:

- Ability to create account with student ID in order to save information.
- Form for user to enter their needs & goals
- A recommendations page catered to the user's needs/goals.
- Language and visual preferences
- Ability to save and retrieve menus.

Generic services

- List of all food served in the Onezone, split up into meals (Breakfast, Lunch, etc.)
- A basic page for each food type containing important nutrition information (Carbs, calories, suggested serving, etc.)
- Allergy/intolerance information, with warning symbols for common allergies. (Such as nuts).
- Search function
- Opening hours of Onezone

Non-functional requirements:

- Administration (Keeping the software up to date)
- Security and privacy.
- Location of the HEIS

Figure 11 Group L's functional and non-functional requirements

Group M:

Depth and detail functional and non-functional requirements



Figure 12 Group M's Requirements

User/Usability Requirements

User requirements

Must Have

- Interest in healthy eating
- Knowledge of application

Should Have

- Familiarity with recent technology
- Knowledge of own current diet/
eating habits

Could Have

- Special dietary requirements

Usability requirements

Must Have

- Understandable menu/buttons
- Understandable purpose
- Good documentation

Should Have

- Good feedback
- Intuitive system workings
- Error messages
- Good, attractive design

Could Have

- Ability to undo actions

Figure 13 Group M's requirements part 2

Functional Requirements

Must Have

- Login - The system needs a login page so that users can login to their own page and get information about the food they have eaten and get personalised recommended meals.
- Order meals (menu) - The system needs to be able to let the user order meals and get a token to hand over at the onezone.
- Information on meals
 - Calories - Each meal should have calorie information which can be added to your total daily calories when you order the meal.
 - number of your 5-a-day - It should say how many of your 5 a day is in the meal.
 - Nutritional information - It should give nutritional information about the meal which will include energy, fat, salt and protein.
 - allergy information - It should give allergy information saying if it contains - or contains traces of - nuts, gluten and dairy.
 - vegetarian/vegan information - It should also give information if its suitable for vegetarians or vegans.

Should Have

- Calorie Calculator - The system could include a calorie calculator which would calculate how many calories you are getting each day.
 - Food - It would calculate food by the user entering in what food they have eaten.
 - Exercise - Users could enter how much calories they have lost from exercise to get a more accurate calculation of the calories.

Could Have

- Online website or phone app to update calories and information - The system could have an mobile app version or a browser version which means users don't have to go to the system to update their meals and other information, they can do it on the go or at home.

Figure 14 Group M's requirement Part 3

Data Requirements

Must Have

- User information - must have database of users and their personal information along with their personal calorie information and any dietary requirements.
- Nutritional information - must have nutritional information about each meal that can be ordered.
- Menu data - must have a menu database which contains all the meals and prices.
- Payment data - This is the tokens that the user gets when ordering a meal. This needs to be connected to

Should Have

- Calorie information - should have a database of foods with calories & nutrition information which the user can use to create meals that they have eaten for the calorie calculator.
- Graphs of data - should be able to display the data as a graph to show the users calories / 5-a-day over time.

Could Have

- Store card information - this means the user only has to enter their card information once when buying tokens using the system. The downside to this is the database could get hacked and lots of students card info could get stolen. It doesn't take that long to enter in your card number each time. They might use a chip and pin device which would make paying safe and fast.

Figure 15 Group M's requirement part 4

Group H:



Figure 16 Group H's Observation and PACT

Healthy Eating Application

Research Derived Requirements

Data

- * Highlight allergic ingredients
- * Calories
- * Portions of fruit/veg 5-a-day
- * Nutritional info (how the meal contributes to daily targets)
- * Cost of meals / Healthily Meal of the day

Environment

- * Hand sanitizers / screen wipes before/after!
- * Needs to be accessible
- * Multiple installations
- * Screen glare

Social

- * Ability to feedback on how App functions
- * Social Media integration: share achievements, awards, leaderboards, 'like' buttons for menu choices



User

- * Logon to the system
- * Interaction experience stimulating and enjoyable
- * Updatable menu
- * Goals that individuals can set & track user data
- * System should also enable students to place their order, and receive a collection token
- * Use online credits to pay for their meal

Usability

- * Quick and easy to use
- * Minimal input from user
- * Large pressable buttons - affordance/feedback
- * Colour blind/sight impaired
- * Adjustable screen to take into account screen glare
- * logical path through the app
- * give users only one path to a screen

Figure 17 Group H's requirements

Group E's work:

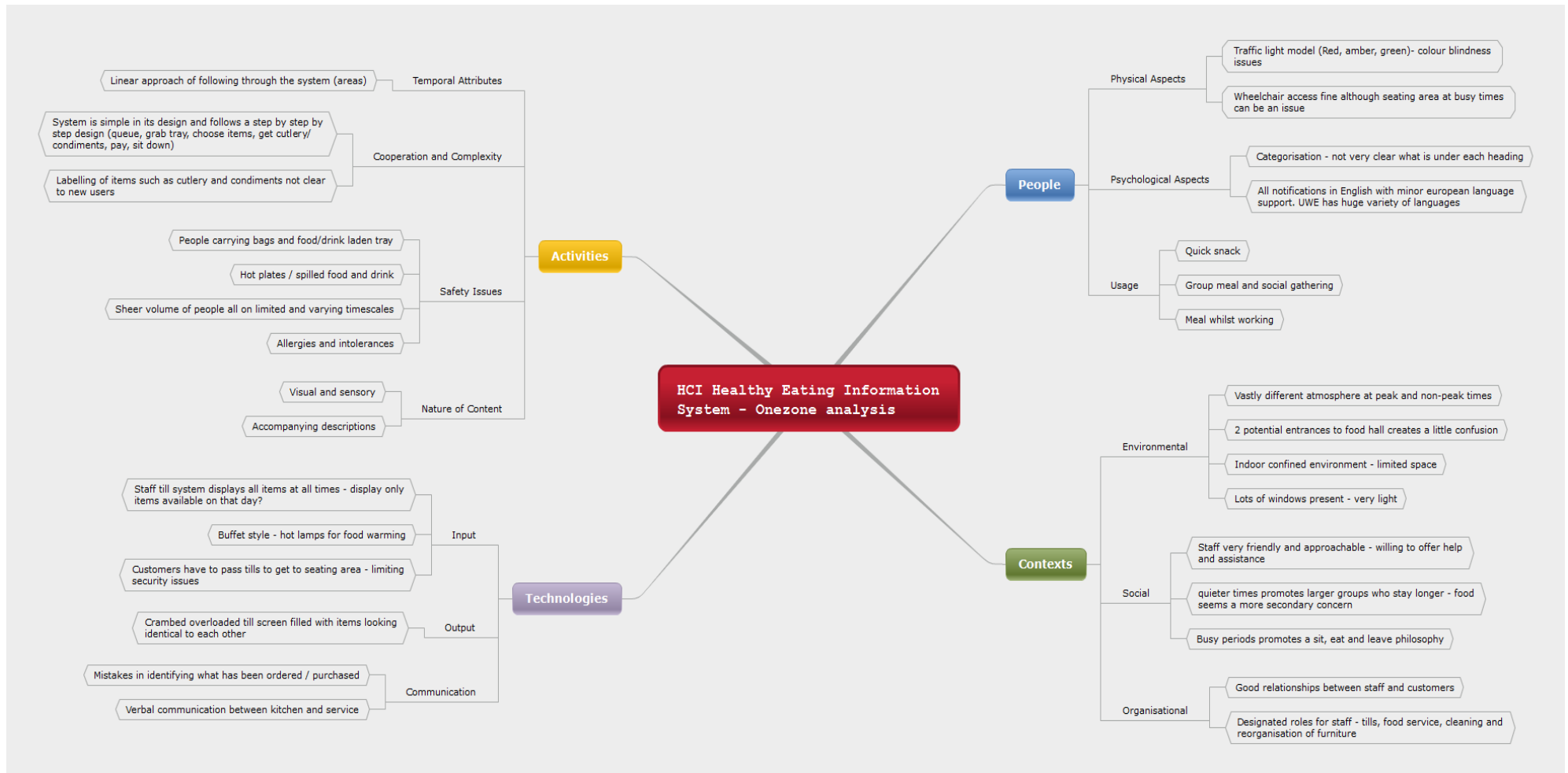


Figure 18 Group E's PACT

Insight Gained	Emerging Requirement
Time constraints causing bad eating habits	Allow to search by time required for meal
Recording progress motivates users and allows for pattern spotting in eating habits	Allow users to record a meal diary and analyse the data over periods of time
Personalisation and options keep the user “hooked” to the Application	Allow for Personalisation with Calorie Calculator, allergy filters, favourite meals and a food diary
Intuitiveness and simplicity are key to a good touch-screen design	Interface should combine speed with quality. Feedback and tactility are always needed.
Advances in technology such as multi-touch must be kept in mind at all times	The interaction should be designed for gestures and web capability
Standard data inputs, such as keyboard typing, is cumbersome on phones	Almost all data inputs should avoid direct text entering. Sliders, options and buttons are fine.
Minimal information should be displayed on the screen, because of restrictions in screen size	There will be many options to see ‘more information’
However, lots of information should be kept about each meal and user to make a reliable match.	A complex database would need to be stored, and all information would need to be in-depth.
Instructions should be as frequent and as obvious as possible.	Explain any complex action at least once

Figure 19 Group E's requirements