Investigating the Effectiveness of a Mobile Information System to Improve the Life of Students

Honours Final Report

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"Except where explicitly stated all work in this report, including the appendices, is my own"
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Abstract

Rapid advances in mobile technology have led to increasing incorporation and dependency of mobile devices in daily activities and the pervasive nature of this technology guided researchers to investigate how mobiles can aid users. Educational institutes have begun to understand the potential of this tool and the idea of supporting teaching fuels this research. Demands for electronic resources and data anytime, anywhere has resulted in the development of mobile information applications, highlighting the need to address issues regarding the limitation of mobile devices, the necessity for appropriate requirements, user collaboration, improved design and most importantly usability. This project aimed to evaluate to what extent a mobile application, developed using user-centred techniques, would improve information access and benefit students in their daily tasks.

Preliminary research, regarding functional requirements, uncovered the needs and expectations of Glasgow Caledonian University's School of Engineering and Computing students and thus began the collaborative process to develop a mobile guide. The university's website provides access to a multitude of information, including those identified by students as the required functions of use; lab timetables, staff contact details and university information and news.

This develop and test project employed user focus groups and expert heuristic evaluation methods to verify interface designs, develop and deploy an application which provided functionality on the move. After a 30 day field trial the application was evaluated using questionnaires, lab experiments and interviews. The combined evaluation methods allowed for testing of the application both in and out of context, gaining measureable values alongside user opinions.

Results and subsequent student feedback were very positive and proved that the developed mobile guide met student requirements and benefited the users providing accurate information on demand and improving the information seeking process by reducing task time, improving the user's overall learning experience. The projects main aim was to investigate the use of user centred design and it was concluded that the use of this method successfully created appropriate functionality, an efficient interface and overall a usable application. User centred design was critical to the project's success and without its utilisation the application would have most likely resulted in rejection.

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1.0 Introduction

This section will introduce the research area of mobile computing, the trends and apparent increased usage. Mobile learning is highlighted along with the increasing incorporation of mobile technology within education and more notably within universities. This emerging technology also has many issues regarding usability and cost which must be considered.

An overview of the project is then detailed including the project method, the research question and objectives, and concludes by specifying the hypotheses that will be examined. Finally, this section will detail the content of this document.

1.1 Background

Mobile Computing Today

As technology continues to advance, society increases its reliance upon it. Over the past decade the mobile phone has increased dramatically in ownership with almost 90% of the UK population possessing a mobile phone (Directgov 2009). Mobile phones have proved to be the fasted growing technology with ownership statistics recorded by ITU (2009) of 3,305 million mobile users which exceeds Internet (1,344mn) and phone line users (1,278mn). Mobile devices now come with more features as standard and the constant demand from users for ad-hoc information and increased functionality has lead to the development of smart phones. Users now use their mobile phones for more than just communicating and research has shown that people are ditching other forms of technology in favour for this "all-in-one" device with 12% of US 18-24 year olds abandoning their landline (Totten et al. 2005) and a prediction that mobile phones will out-sell digital cameras as these functions are becoming standard in mobile devices.

"Interaction convergence has already begun; most people will soon use a single device, with various modalities, for an increasing number of control tasks" (Korpipaa et al. 2006).

As mobile technology rapidly advances so must the developer's awareness of users needs and desires.

Whilst mobiles have been incorporated into many daily tasks, one such area which has recently been researched is the idea of using a mobile device to enhance learning. Mobile learning (m-learning) differs from e-learning as it removes the user from their normal static environment, in front of a PC or in a classroom. Research has demonstrated that whilst m-learning may be beneficial to students on the move (Thornton, Houser 2004) it still has many issues to overcome. Shudong, Higgins (2005) outlined the main problems facing m-learning, including the limitations of screen size, internet restrictions and the disruption of the users environment. These limitations have led researchers to the belief that, "faculty members find

it impossible to implement this new educational tool in their classes" (Ktoridou, Gregoriou & Eteokleous 2007). Therefore further research, training and skill must be acquired before this tool is fully incorporated into education and, until that time, it will be used to support learning and not replace it.

The idea of m-learning (or even e-learning) may not be incorporated in to the running of the academic operations, but the incorporation of mobile technology in student learning has been an evident area of investigation. Studies such as Liu, Liu & Yu (2008) try to vary the way in which information is displayed on Digital Learning Devices (DLD's), to retain student's attention and increase the likelihood of successful adoption, by integrating multimedia output. Kamata, Shibusawa & Yonekura (2006) demonstrated the adaption of existing web browsers for use on mobile phones so that students could "study learning content using their mobile phones anytime and anywhere". This idea of m-learning was well founded but highlighted common problems with e-learning such as device speed and display size. Another such study evaluated the transmission of information, using SMS messages within the context of education, concluding that although this system was beneficial for the students it raised concerns regarding ethics, consent and usability, ergonomics and design issues. While research has identified the advantages of m-learning and the likelihood of its existence in future education Rosman (2008), Lindquist et al. (2007) and Litchfield et al. (2009) all acknowledged the limitations that m-learning faces. Reasons such as these lead to the belief that mobiles should be used to supplement rather than deliver learning.

"mLearning is a means to enhance the broader learning experience, not (as we predicted for eLearning) a primary method for delivering courses/distance learning." (Mellow 2005)

Existing Problems

The majority of universities have embraced technology and are functioning with wireless access, networked campuses and use computers to aid in their administration. Computers play a vital part in providing both resources and information to the staff and students. Zhu, Wang & Ju (2004) revealed that "A well-implemented university portal can offer a number of benefits to a user of the system" and universities rely heavily on these web based portals to deliver information to their student population. This reliance can cause issues when students are off campus as it is known that whilst most students own a mobile phone the majority do not have internet access at home (Economides, Grousopoulou 2009). University websites also have difficulty in presenting information and studies by Ritter, Freed & Haskett (2005) have attempted to address the issue of how to present information to users. The research identified that varied university departments have diverse data, quantities of data and categories of users, therefore both the information and audience must be determined in order to improve presentation and access. Based on this knowledge universities are attempting to deliver electronic resources through alternative mediums whilst meeting the needs of students.

Mobile applications have arisen from this recent expansion in the mobile computing field and universities both in the UK and abroad have used these advances to their benefit and developed mobile applications specifically for their students and staff. These applications provide campus information for the students that they can utilise when they require, on the move (Coughlan 2009). One note of importance however regarding these existing projects is that they have been created for use on the iPhone, the uptake has been slow and they are mainly piloted applications in an attempt to gain student feedback. Research into mobile use has uncovered that the manufacturers Apple and Blackberry only hold 6% of the UK mobile phone handset market share (Which? 2009), therefore an iPhone application is not likely to reach the majority of the intended student audience. As a result, a mobile application built for a java platform would be more suitable and would address a universities information delivery issues. The only university that is known to have a Java application is Dundee University, (The University of Dundee 2009). These applications also require the user to access the internet, although most modern phones have the ability to connect to the internet students do not tend to utilise this facility due to monetary reasons, 77.6% of students do not use their phone for internet purposes (Totten et al. 2005). Although mobile charges are continuing to decrease, cost still remains an important issue for students (Litchfield et al. 2009). In light of these factors greater consideration must be made when designing applications for a specific audience.

Use of Mobile Information as a Solution

Studies such as Nachmias (2002) show that "universities are interested in providing effective and convenient access to information" and mobile information systems appear to be a logical solution to addressing the issues of how to combine high student mobile use with the need to support education. After preliminary research in to student opinions regarding the student website at Glasgow Caledonian University, it was uncovered that there was both a need and a desire to obtain information on the move. Focus groups were completed using a selection of students and required functionality for such a mobile application was uncovered. A rough prototype was generated which will be further developed using the requirements and screen designs based on the focus group results. This develop and test project aims to complete the design of this application and through development and deployment of the mobile guide, evaluate its usefulness within the university as an alternative option to the university website. Considerations must be made regarding the relevant issues of platform, connections and functions. User-centred design was an important choice that was made at the commencement of the project, founded on the basis that "Potential users are involved from the very beginning and are regularly consulted for evaluations of incremental prototypes" (Sharp, Rogers & Preece 2007). It is anticipated that by involving the user, designing applicable screens, including only required functions and reducing the cost that this will in turn increase the likelihood of acceptance by the students at the university. This will in turn allow for the evaluation of the anticipated benefits to the application user.

There are many areas of mobile information which have previously been explored and research has consequently highlighted usability issues. There is a need for a greater understanding of the benefits of mobile information. This project will attempt to explore these issues and advantages through a develop and test research method, thus creating a mobile guide for Glasgow Caledonian university students. The analysis of the results which emerged from evaluation of the application will be presented and will correlate to the anticipation that the mobile application will benefit the students through the reduction in time wasted completing common daily tasks. This project will evaluate the extent of the impact, positive or otherwise, on the students.

1.2 Project Overview

This section identifies the project method and the research question that the project attempts to answer. The objectives that must be completed are then detailed and the hypotheses stated.

1.2.1 Project Method

Initial research within the university has revealed the desire for improved information access. Past studies have exposed both the inherent student usage of mobiles (Corlett et al. 2005) and the benefits of information access anywhere, at any time (Perry et al. 2001). Mobile devices are predisposed to many human computer interaction (HCI) issues and therefore design practices must be carefully considered in order to increase the acceptance and usability of software. This demand for information, in conjunction with the relevance of mobile usability leads to the appropriateness of a develop and test research method which would create a tangible product, whilst evaluating the authors hypotheses. The project method of develop and test will involve the creation and evaluation of a mobile application which will provide specific functions for students within the school of engineering and computing (SEC). Through the completion of the development of a mobile application which utilises user-centred design it is anticipated that the project will benefit the university students and will be an improvement on the current information portal, the university website. In light of these beliefs the project research question will be:

To what extent would user-centred design methods allow a mobile application, created for use in a university as an alternative to their current information web portal, to overcome usability and acceptance issues and benefit the students in their daily tasks?

1.2.2 Objectives

The main aim of this project was to investigate the affect of user-centred design throughout the development of a mobile application, which would be used by the students to aid them in their daily tasks, to contribute to the learning experience rather than replace any aspects of it. The users were utilised in both the design and evaluation of the application and the results demonstrated the effectiveness of user-centred design and its contribution towards creating a usable application. In order to complete the overall project aim eight objectives were identified, relating to both primary and secondary research.

The objectives to be met through completion of a literature review were:

- Investigate the success and potential of mobiles information systems
  Similar projects which incorporate mobile information systems, education and mobile guides will be detailed. It is important to review literature relating to this research area in order for the author to portray an understanding of the research area and to introduce previous investigations, noting their successes and failures in order to build upon this work.

- Investigate mobile HCI issues
  This investigates the limitations within mobile devices and their interfaces and the restrictions of mobile devices, such as screen size. Ease of use versus usability is a common area of discussion and the literature review aimed to highlight the compromise developers attempt to make between design and functionality. Cognitive load and interruptions are also discussed. This investigation was undertaken to ensure the author possessed adequate knowledge to undertake appropriate application design and to provide an overview of the area of research.

- Investigate the user-centred design process in relation to mobile development
  In order to ensure that the designs of the mobile guide meet user expectations the users were involved in the design process. Design collaboration, iterative design, prototyping and the user-centred design process as a whole was therefore investigated during the literature review and presented in order to provide insight into the anticipated benefits of the procedure.

The objectives that were completed through the use of the primary method were:

- Complete the design process
  This involved the creation, evaluation (through both heuristic and user focus groups methods) and finalisation of designs.

- Develop and deploy application
  A mobile application was created based on the initial requirements and the designs which emerged from the user-centred design process. This was then tested and deployed within the university.

- Develop lab experiment and field study procedures and activities
  Lab experiments, questionnaires and field studies were carefully designed to ensure relevant data was obtained for analysis, evaluation and the data was then related to the projects hypotheses.

- Gather and analyse data
  Data was gathered by way of logged usage data from the mobile devices, data from lab experiment and the questionnaires. This data was classed as either quantitative or qualitative and was analysed using appropriate analysis techniques in order to evaluate the results in relation to the hypotheses and ultimately the research question.

- Write up final report
  Once the primary and secondary research was completed the project was fully documented within this report. Particulars of the project are detailed in their entirety and conclusions drawn in relation to the initial hypotheses.

1.2.3 Hypotheses

To ensure that the hypothesis is testable the mobile guide is compared to the alternative information resource currently used at the university, the student website. The literature review highlighted the necessity for accurate information on demand and the current issues with information seeking processes, and that information and technology contributes towards the overall student learning experience. Therefore proposed hypotheses are:

H1: A mobile guide would benefit students at the university by providing accurate information on demand and improving the information seeking process for students.

Improvement will be measured against such factors as improvement time, task completion rates, error rates etc

H2: The introduction of a mobile guide will improve the learning experience for its student users.

This can be evaluated easily as students can be asked to reflect on their past experience at university in comparison to having the mobile guide.

1.3 Report Structure

This section describes the remaining sections of this project report, identifying the content of the literature review, problem and systems analysis, design and implementation, testing and evaluation, and discussion and conclusions sections.

1.3.1 Literature Review

The literature review will be documented in section two of this report and will investigate the areas of mobile computing relevant to this project. The literature review section will

commence with an overview of the general research area before detailing the particular elements which relate to the given objectives. Research regarding mobile HCI issues and considerations, previous work combining mobile technology and education and their achievements and finally user-centred design related studies will be explored. Each area will be discussed and evaluated, the outcome of which will be the presentation of the resultant conclusions.

1.3.2 Problem & Systems Analysis

Section three of this document will detail the initial problem that has been identified in relation to this project. A general overview of the main stages and methods completed during the project will be explained and an explanation of the chosen lifecycle, iterative, will be given. The use of the develop and test method will be detailed along with the motivation of the project, the analysis of possible solutions and the identification of the problem which this project aims to overcome. The initial focus group research that was conducted prior to the official commencement of the project will be discussed and the outcomes detailed. This section will specify the requirements, relating to both functionality and design, which have emerged and system characteristics which must be incorporated into the designs and implementation of the mobile guide.

1.3.3 Design & Implementation

This area of the report, section four, will present the steps that were undertaken during the design of the mobile application interface and the evaluation process that were undertaken to validate the designs. Once the finalised designs are presented this section will then explain and justify the specific elements of programming the application, the key technology which allowed the author to perform evaluation and analysis.

1.3.4 Testing & Evaluation

Section five will detail the evaluation methods which were employed in order to test the author's hypotheses. A field study and lab experiment were both undertaken, the preparation, completion and outcomes of both will be explained and analysed. The findings of the evaluative methods will be presented and critically discussed in relations to the project's aims, objectives and overall premise.

1.3.5 Discussion of Results and Conclusions

Finally section six will provide a summary of the project and will discuss the results which emerged from the evaluation of the mobile application. The outcome of the project evaluations confirmed the positive affect of user-centred design, the improvements of the information seeking process and the overall improvement to the students learning experience. The results are again examined in relation to the research aims and stated hypotheses. The limitations which were placed on the project are identified before finally suggesting potential further areas of research which emerged from the analysis of the project results.

2.0 Literature Review

The literature review is vital to the project as is provides the basis of knowledge on which the author intends to build upon. The project area is researched through the gathering and understanding of past work in the field and this then enables methodologies to be understood. The author can then draw upon this knowledge to determine how the project will be carried out and how it will in turn be of value to the research area that they initially learned from.

The literature review will complete the following objectives, which were identified in the project overview section. The objectives of the literature review are:

- Investigate the success and potential of mobiles information systems
- Investigate mobile HCI issues
- Investigate user-centred design

2.1 Successes and Potentials of Mobiles Information Systems

As previously stated, the ever increasing dissemination of mobile devices has led to the emergent research within the mobile development field. One such area of great interest is that of mobile information systems, which researchers believe could enhance user's daily experiences (Griswold et al. 2004). Mobile application progression has led to studies which examine the use of mobile platforms within many domains including education, tourism and culture. The use of mobiles within education exploits the naturalistic tendencies of students towards mobile devices (Corlett et al. 2005, Holme, Sharples 2002), while public domains introduce mobile information and applications that would not normally be utilised in environments such as tourist attractions, hospitals and museums (Naismith, Sharples & Ting 2005, Abowd et al. 1997, Cheverst et al. 2000, Sharples 2000).

2.1.1 Motivation for Mobile Information

The motivation for mobile information accessibility derives directly from the users and as technology becomes increasingly ubiquitous and affordable, information must be made available (Oblinger 2006). As users become increasingly familiar with technology, their expectations of the ability and availability of the devices also grows. Members of the public are also proving to be more receptive to technology if it offers apparent benefits (Cheverst et al. 2000). Developers, institutions and companies are equally interested in providing information of value and convenience to targeted users (Nachmias 2002) and these aspirations have led to the combination of mobile devices and relevant information aids. The incorporation of mobile devices into everyday activities can lead to increased user engagement (Naismith, Sharples & Ting 2005), support education (Corlett et al. 2005), assist in activities such as navigation (Elmqvist et al. 2007) and the provision and organisation of information (den Hengst, van de Kar & Appelman 2004).

There are many advantages to providing information "anytime, anywhere", however research by Perry et al. (2001) has proven the imperativeness of understanding how a mobile device will benefit a user, as certain devices have proved to be more of a hindrance than a help. The user's tasks, environment and requirements must be fully understood before the benefits of a device can be ascertained. Not all fields are suited to mobile information and the predeterminations of the domain characteristics are vital to ensure the relevance of such a system (Crook, Barrowcliff 2001). This important fact has been supported by Liu et al. (2003) who, through field trials, concluded that not all activities "can or should" integrate mobile applications. While the motivation, or perhaps anticipation, regarding mobile applications and their potential benefits are extremely encouraging, those wishing to employ such technological tools must carefully consider their applicability, relevance and cost (Ganchev et al. 2006), areas which were examined prior to this project's development.

2.1.2 Outcomes of Comparable Research

Mobile information systems that not only provide information on the move but enhance user's activities have been investigated. Mobile computing has been identified through a literature review as the subsequent rational step in liberating users from their environment (Katz 2002) with several studies disclosing varying results and, most importantly, a knowledge base for future research and development to be built upon.

Despite the excitement and salutation surrounding mobile application, researchers such as Griswold et al. (2004) have acknowledged the rejection of device introduction to classroom environments, students were inconvenienced as they attempted to accommodate new technology and technical faults. Corlett et al. (2005) noted the decline in user participation during a 10 month field trial of mobile learning organiser; this was attributed to the lack of accurate requirements elicitation and poor interface designs, issues which will both be discussed in the following sections. A study by Elmqvist et al. (2007) focussed upon the functionality of a 3D mobile navigation application, to aid users in simple location tasks within a university student centre. It overlooked the usability of the device and the resultant feedback from users was therefore negative due to the relative size or "bulk" of the device. Research reporting how a sample of students made use of an infrastructure of computers understood the need for ubiquitous computing but the study illustrated that while distributed technology is advantageous, the need for stationary and private study is still required for undergraduate students (Crook, Barrowcliff 2001). Early research by Shepard (2001) documented the development of "TesterApp", a faculty and student service. The application, which intended to provide class timetables and student schedules in a PDA format, highlighted that applications must be easy to use and be specifically created for its intended use. This development resulted in the need for training and the adaption of existing information and websites which caused significant issues. Fortunately techniques and technology have advanced since this paper and developers are more aware of the importance for specifically created applications, for a precise purpose. Aforementioned papers such as these, which were discovered during the literature review, noted both the potential of such

apps and the positive response from staff and students, even in the early years of mobile technology.

Although research has exposed many different obstacles that mobile development must overcome it has also revealed valuable lessons and it is hoped that this will prevent future developers from making the same mistakes. The utilisation of mobile application development as a research method has led to the successful exploitation of many mobile systems. Ammenwerth et al. (2000) notes the overall advantage of mobile information access as being the "availability of relevant information at any location", while the introduction of a web based mobile campus assistant on Carnegie Mellon University's campus successfully provided users with multiple context-aware services (Sadeh, Chan & Van 2002). Mobile applications have progressed significantly from earlier periods when organisations simply utilised the available standard functions on mobile handsets such as SMS, Kingston University used SMS to support first year students, directing students towards appropriate resources and procedures (Stone 2004). Systems must be considered unobtrusive if they are to be considered pervasive in nature and users must trust the data provided and feel in control of the system they are using. ActiveCampus (Griswold et al. 2002), a university mobile guide which intended to offer services to students at the university of San Diego California, demonstrates that applications can be very successful by meeting user expectations and providing simple, relevant and unobtrusive services. This progression toward successful implementation has emerged from the continuing research, development and conclusions drawn from this evolving computing area.

The research uncovered in the literature review objective not only presented successes and failures of mobile related developments but also provided the author with a knowledge base regarding public perception, acceptability and expectations of such applications. It has been brought to light that students own multiple devices and take advantage of these devices to their benefit (Oblinger 2006). Research of mobile application trends within education identified the main target age group as being 18 to 24 (Anderson, Blackwood 2004), and also concluded that universities must adapt to meet the needs of students who regard mobile devices as essential tools for carrying out a range of tasks, including learning. De Freitas, Levene (2003) discussed the context of mobile technology within education, noting the need for access to learning resources as well as administrative information, such as timetables, to support the learning activities. The investigation of past research and the future prospects of mobile information applications has resulted in the awareness of the potential, appropriateness and limitations of such systems. A paper about m-learning (Trifonova, Ronchetti 2003), discusses a key point to consider which is that services should be considered to support students and lecturers. In light of the findings from past research the author is eager to emphasize that, in order to develop a successful mobile application, the domain area and users must benefit. The device and application must help, not hinder, activities (Perry et al. 2001), users must be able to easily use the application and the purpose, audience, design and domain must be carefully selected. On reflection of these factors the remaining sections of the literature review were examined and presented.

2.2 Mobile HCI Issues

Human computer interaction (HCI) has been noted as a vital design element and although its importance is not a new revelation it is deemed of greater importance in relation to mobile applications, as mobility take precedence over HCI tasks (Oulasvirta et al. 2005). Given that mobile computing occurs within an environment of multiple activities, cognitive resources must be considered and applications must apply minimal demand upon said resources. Techniques, which apply the feedback gained from experts during the evaluation of user interface designs, have been successfully utilised in projects such as Bertini, Gabrielli & Kimani (2006) who captured contextual requirements and assessed the relevance of mobile heuristics. Evaluation techniques such as heuristic assessment or field trials often uncover HCI defects (Cheverst et al. 2000) which effect user satisfaction and, in some cases, result in the rejection of the application. Studies have also suggested that the slow uptake of m-commerce is result of poor HCI design (Lee, Benbasat 2003); therefore the importance of this issue should not be underestimated. The limitations of both the user and the device itself must be examined in order to apply appropriate design aspects to this project.

2.2.1 Limitations and Restrictions of Mobile Devices

During the development of a system or application, the implementation platform must be carefully considered. Griswold et al. (2004) demonstrated the disadvantages that PDA's pose to mobile applications as usage numbers fell due to battery issues, lack of screen visibility on flat surfaces and even an apparently trivial matter of device storage, users could not fit it in their pocket. While mobile devices offer many benefits to users, they clearly have many alternative considerations and limitations in comparison to desktop computers. Screen size is one of the clear drawbacks, Ammenwerth et al. (2000) noted the importance of maximising the usage of the device screen, ensuring menus are optimal and data displayed is relevant. While menus must display appropriate options they must also take in to consideration the user's ability to select these options. Chittaro (2006) examined how information is selected and presented, noting the futile attempts of past research to present menus with multiple options. The menus were hard to see and select, as the attempts to fit all options on screen resulted in them being too small to be visible. Input must also be considered as mobile handsets do not have mouse control and most use buttons which can be hard to select, especially while on the move. Developers must utilise interfaces which allow for data presentation in a limited form, allow for menu and list design that reduces scrolling and overall an interface that reduces user task time and effort (Korpipää et al. 2004).

Non-interface limitations include power consumption and memory restrictions which are also a shortcoming of mobility, Ammenwerth et al. (2000) and Chittaro (2006) both attempted to accept and address these hardware issues by ensuring that processing requirements were minimised and process load was reduced where possible. Mobile devices must strike a balance between reaction to user demands and the storage requirements or size of application. Designers must surrender to the fact that users want information and functions to be equally

accessible (Kamba et al. 1996). Programming languages play an important part in this consideration and the literature review reaffirmed the author's decision regarding the use of J2ME, a choice which is discussed in greater depth within the implementation section. External considerations regarding mobile devices must also be contemplated, the same researchers illustrated the constant battle for user attention from HCI and cognitive tasks, audio output is not an ideal feedback mechanism and interruptions are inevitable (Nagata 2003).

The middle ground that must be found to address both physical and functional limitation (Kamba et al. 1996) is vital in the success of mobile development. It is clear from the literature review that developments which negate these considerations are futile. The understanding and acceptance of these constraints allow for the creation of applications which draw from these characteristics and build upon them rather than allowing them to delineate or negatively affect development achievements.

2.2.2 Ease of Use vs. Usability

This matter has been defined in early research by Johnson (1998) as "functionality does not exist for the user if that functionality is not usable"; therefore the literature review regarding HCI has clearly alerted the author to the increased importance and demand of design in mobile systems. The success of a development cannot purely be defined by the functionality, user satisfaction also relates highly to ease of use and interface design. Evaluation of a mobile educational resource (Naismith, Sharples & Ting 2005) recorded the "significant mental effort" that participants had to impart in order to successfully obtain navigation of both physical and information space. This led to "heads-down" participation and detracted the user from the rich visual environment and despite the positive responses from younger participants, older users reported difficulties in the learning and using of the application. This resulted in the research concluding that greater HCI considerations must be enforced and reinstated the importance of ease of use.

In order to meet user expectations, the limitations discussed previously must be overcome and functionality must be optimised. Amant, Horton & Ritter (2004) focussed on techniques for evaluating particular aspects of mobile usability, most notably, the hierarchical menus. From this study it was concluded that menu traversal must be further analysed in order for developers and users to benefit from optimised menus. Mobile tasks essentially rely upon the ability of users to perform precise and efficient tasks (Nagata 2003) and menu design has been suggested as a key factor in this facilitation. The greatest question raised through the analysis of this subject was how an application would respond to the question, "will it be free of effort and will it improve a task" (Davis 1989).

Despite the convictions of many researchers of the correlation between interface design and application success, the subjective early research by Davis (1989) found that usefulness was more strongly linked to usage than ease of use. Technology is accepted primarily for the

function it will assist users with and secondarily for the consideration of if it is simple or complex. “Ease of use may encourage but ease of use will not compensate for an app that is not of use” (Davis 1989).It is therefore concluded that while requirements must be accurately elicited in order to provide the desired functionality, equal importance must be placed on the interface design of a mobile application in order to ensure it is of use and is accepted by the intended audience.

This area of literature has increased the author’s awareness of the importance of careful consideration of functionality and design. Past research denotes principles which should be employed and portrays developments that intend to provide a foundation for future work to be built upon. Mobile HCI principles and considerations not only provide a knowledge base for developers but also lead to the significance of user-centred design and evaluation, which intends to further improve the probability of user acceptance.

2.3 User-Centred Design Processes in Relation to Mobile Development

In an attempt to investigate the value of user contribution a literature review relating to user-centred design was undertaken. As previously discussed, user involvement throughout the entire life cycle is considered to be an important factor in development success (Petrelli, Not 2006). Research conducted by Bodker, Buur (2002) and den Hengst, van de Kar & Appelman (2004) involve the creation of standards and principles which are considered to be of benefit to all mobile projects in response to the “failing capabilities of classical usability methods to cope with ubiquitous technologies” (Bodker, Buur 2002). The foundation for these principles is based upon the belief that developers must appreciate the importance of design collaboration and the techniques concerned, these papers also outline both the importance and the details of requirements elicitation. Design collaboration intends to lead to a system that users cannot only use but will want to use (Kukulska-Hulme 2007).

2.3.1 Iterative Design

In order to ensure the requirements and designs that have been created alongside the user are correctly implemented, iterative design is utilised. This lifecycle is chosen by most mobile developers (Holme, Sharples 2002, Naismith, Sharples & Ting 2005, Abowd et al. 1997, Cheverst et al. 2000, den Hengst, van de Kar & Appelman 2004, Oulasvirta et al. 2005, Sá, Carriço 2006, Iacucci, Kuutti & Ranta 2000) as there is a high risk of making poor design decisions; it is therefore advantageous to iterate and maintain tight design-evaluation feedback recursion (as can be seen in Figure 1 on the next page). Iqbal et al. (2005) examined the proposal that many developments fail because of ill defined requirements and that iterative design combined with user evaluation may lead to increased success as iteration tends to uncover errors and misinterpretations. Many other projects have supported the employment of users in the evaluation of designs such as Dadzie, Lanfranchi & Petrelli

(2009) who gauged the design and how varied levels of data, information and knowledge were mapped to support knowledge management. Another illustration can be observed in the work of Liarokapis, Conradi (2007) who made use of user evaluation to assess the interface of a PDA providing urban navigation.

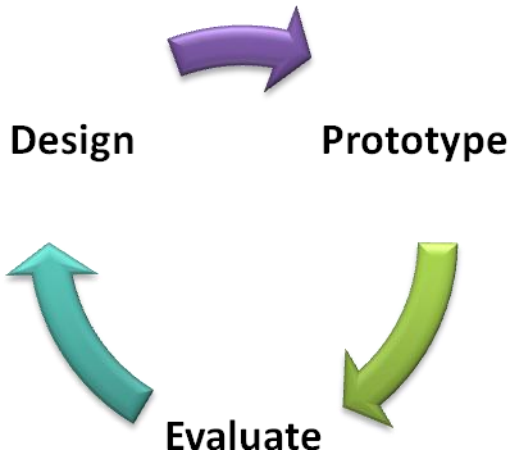

Figure 1 - Iterative Design Model

2.3.2 Prototyping and User Feedback

Paper prototyping for developing user interface designs has been successfully employed in the past in several projects such as de Sá, Carriço (2006) who focused on the importance of early evaluation and prototyping. Sharp, Rogers & Preece (2007) also demonstrated the use of prototypes to develop a design of a 'Manchester United Fan' mobile phone UI. It successfully outlined the benefits of paper prototyping such as collaborations, iterative design and reductions in both time and cost of the overall development. Prototyping, of both paper and software variety, ensures user feedback is understood and applied studies such as Sharples (2000) resulted in findings which acknowledged a need for improved user cooperation in design and an understanding of how interfaces can correspond to the user's skills. In contrast Sá, Carriço (2006) involved the development of educational software which was non-collaborative. This successfully supported the findings of this literature review as it highlighted the erroneous strategy of the developers and reinforced the research that shows greater success of collaborative developments.

Investigations of the types of user-centred design by Iqbal et al. (2005) in relation to the evaluation of ubiquitous services notes the difference between formative and summative evaluations. Formative evaluation intends to inform developers designing application, providing user feedback regarding initial versions, while summative evaluation aims to inform research regarding the assessment of an application or a comparison - to a time when the application did not exist or to a preceding or equivalent version. Since this project must complete both user-centred interface design and an overall application evaluation, both formative and summative evaluations must be completed. This literature review area has ensured the author is aware of the benefits of user collaboration in relation to both

requirements elicitation and design, has affirmed the author's choice to apply user-centred design to this project and will hopefully provide knowledge which can be applied to the project in an attempt to increase the applications acceptance and success. It is anticipated that the examination and utilisation of user-centred design will also overcome limitations, identified in previous sections, relating to device and application characteristics, as user feedback will lessen usability issues.

2.4 Literature Conclusion

Through the completion of a literature review the author has met the objectives of the secondary research. Investigations relating to the successes and potentials of mobiles information systems, mobile HCI issues and user-centred design uncovered vital areas of interest and importance which could be applied to this project.

Successes and Potentials of Mobiles Information Systems
The main issues identified were the requirement for mobile information, as users become more adapted to mobile devices and alternative methods of information retrieval, and the imperativeness of ensuring that the mobile information system is both appropriate and pervasive in the relation to the user and their tasks. Research highlighted whilst mobile applications appear to be beneficial all circumstances and conditions must be considered in order for it to be not only of use but also accepted by the users. These issues allowed for the key conclusions to be made that additional considered must be given to all influencing factors such as cost, audience and domain before an application can be deemed as potentially useful or necessary.

Past research enlightened the author in relation to the importance of task, user and domain selection. It reaffirmed the applications aspirations as relevant project justification was highlighted and similar projects successes and failings were learned from, the review of this specific literature validated the project as a possible aid for the intended audience. It was also vital to examine the use of mobile application development as a method of evaluation in order to justify the develop and test methodology.

Mobile HCI Issues
This area of analysis allowed the author to identify specific matters relating to HCI. It was discovered that mobile devices have many restrictions which must be considered and overcome in order to utilise the technology to the benefit of users. Application design and development must recognise the restrictions of device storage, screen size and input, deciding how best to present, store and edit data. Once limitations are overcome, designs must reduce user effort and ensure ease of use and reduce the chance of rejection by the intended audience. It could be concluded from these issues that HCI is of as much importance as the functionality of the application and developers must place great importance on these issues when designing for users.

Investigating HCI issues and device limitations ensured that design evaluations, platform considerations and the importance of acknowledging mobile restrictions were taken into consideration. The significance of designing for mobile devices was discussed as this project must impose a considerable amount of contemplation when creating the application for use on the move.

User-Centred Design

This area of review highlighted the issues that iterative design is not only the lifecycle of choice for most mobile developers but also for most designers, especially those employing user-centred design. The aspiration for developers to create an accurate, appropriate and accepted application is something that is reflected in the purpose of the iterative lifecycle. Literature showed that prototyping, feedback and continual iteration will reduce the likelihood of user dissatisfaction and provided the conclusion that user-centred design is more likely to result in an accepted artefact.

Prototyping, iterative design and user feedback were examined within this section and this was vital to the author's awareness of the need for iterative development in this ever increasing area of mobile and ubiquitous computing, ensuring user feedback and opinion aided in the construction and evolution of the application.

The completion of a literature review allowed for the acquisition of past research in order for this project to build upon the knowledge and conclusions of experienced research and past developers. It reinforced not only the background knowledge and justification which fed in to the project's aims and hypotheses but also aided the author in the choices made regarding appropriate methodology for the project's primary research.

3.0 Problems & Systems Analysis

The aim of this project was to investigate the effectiveness of user-centred design upon the development of a mobile application to improve the life of students. In order to fully evaluate this, the primary research method used in this project was develop and test. It has been noted by Oates (2006) that develop and test methods must contribute to knowledge in order to be of value and not simply be a demonstration of digital technology. In recognition of this, the project made use of user-centred design which, combined with the knowledge gained by the literature review regarding HCI issues and user-centred advantages, intended to overcome problems faced by similar projects (Sadeh, Chan & Van 2002, Lee, Benbasat 2003, Pascoe, Ryan & Morse 2000).

Develop and test methods have been utilised by many researchers (Griswold et al. 2004, Naismith, Sharples & Ting 2005, Elmqvist et al. 2007, Ganchev et al. 2006) who have assessed both hypotheses and innovative techniques based on the results of prototype development evaluation. This strategy focuses on the creation of new artefacts and this project has created a type of artefact known as an "instantiation" which is a classification of a working computer based system (Oates 2006). The working system, or application, has then been evaluated in relation to the current existing information provision.

The project has been completed within the engineering and computing department of the Glasgow Caledonian University and the students within the specific department were the prime intended audience. The developed application was designed and evaluated in collaboration with the students in relation to the university's website. The Glasgow Caledonian website currently provides all students with access to a multitude of information, including the functions identified by students as being the required functions of use; lab timetables, staff contact details and university information and news. The development design, implementation and evaluation, completed using both field studies and lab experiments (which themselves employed questionnaires and interviews) will be detailed in subsequent sections of this report. This section will detail the overall process and the methods involved during each step, the chosen lifecycle, the identified problem which this project attempted to address, the functionality identified and the chosen implementation domain.

3.1 Overall Project Methods

In order to provide a greater understanding of the project's stages and methods, this section will outline and describe the significant steps taken by the author throughout this project which contributed towards the investigation, development and evaluation of the mobile guide. Figure 2 on the following page displays the main stages that were completed during this project; requirements analysis, design, implementation and evaluation. Each stage involved varying methods which are listed, with any relevant outcomes noted.

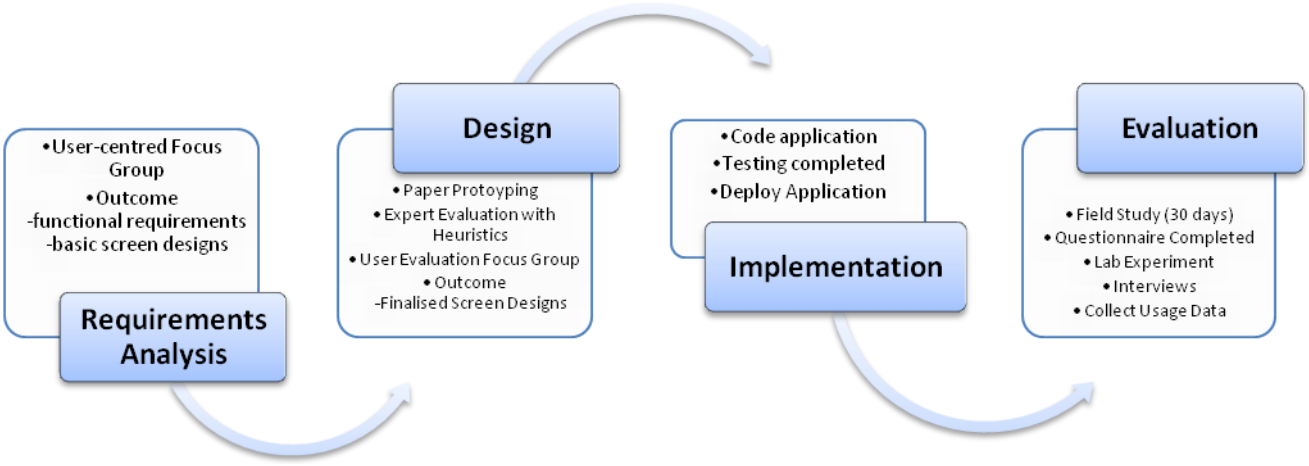

Figure 2 - Projects Main Stages

3.1.1 Requirements Analysis

The first stage, requirements analysis, was completed in order to ensure that adequate requirements were discovered. The literature review highlighted the benefits of user collaboration in relation to both requirements elicitation and design and that user-centred design will significantly increase the accuracy of requirements which in turn would create an application which is more likely to be accepted, successful and usable.

User-Centred Focus Group

Prior to this project, research was carried out to uncover the requirements, perceptions and, most importantly, the need for a mobile guide for students. A participant-based study verified that students would be very enthusiastic regarding the development of a mobile guide. Focus groups were carried out to elicit user requirements; brain storming and examinations of the university web site led the students to rate the importance of certain functions that arose and the participants also supplied invaluable insight to how they would like to see the information presented. The focus group also used methods such as low fidelity prototyping to allow the group members to create mock ups of how they envisaged the interaction taking place. This user-centred design approach not only highlighted problems relating to the universities existing web site but also validated most of the functions that were already implemented on the rough working prototype that was in existence. However, the students were not made aware of this prototype, so as not to influence their ideas or expectations. The result of this research was the validation of the belief that the mobile guide would benefit (and be welcomed by) the students but also provided a basis for the screen designs, required functionality and the need for further research and evaluation, by both experts and users. Many other projects have supported the employment of users in the evaluation of designs such as Dadzie, Lanfranchi & Petrelli (2009) who gauged the design and how varied levels of data, information and knowledge were mapped to support knowledge management. Another

illustration can be observed in the work of Liarokapis, Conradi (2007) who made use of user evaluation to assess the interface of a PDA providing urban navigation.

There were two main aims that were to be met for the purpose of this research. Firstly student opinions had to be obtained in order to identify desired/required functionality for the mobile assistant software. This was vital as the software is aimed at students, using it frequently, and therefore only necessary functionality must be provided to ensure the software's success. Superfluous functions may have resulted in the software being overlooked as alternative to the university website. The second aim of this research was to uncover a possible interface design with the aid of the students, which aimed to ensure a student-friendly 'look and feel'. It is believed that an interface which is designed in correlation with user opinion will be more successful than one created by the expert developers and designers alone.

The techniques chosen for this process were focus groups, prototypes (low fidelity), brainstorming and questionnaires. These techniques were researched and, through the findings of previous papers relating to interaction design, our choices were founded. A study reported in Nivala, Sarjakoski & Sarjakoski (2005) supported the decision to use low fidelity prototypes during the focus group brain storming as they presented to the users "quickly and cheaply". The focus groups were founded on the basis that "Potential users are involved from the very beginning and are regularly consulted for evaluations of incremental prototypes" (Sharp, Rogers & Preece 2007). Studies by sources such as Bontcheva (2001) and Vassileva (1996) have found that user-centred design affects both the product design and also on occasion the user interface layout. A paper by Petrelli & Not. (2005) proved the importance of involving the user at the design stage of a product, the design must be analysed critically by the user before it progresses to the development stage, this involvement is crucial if the product is to meet the users expectations and requirement. Many of the methods selected for this project have been based on the findings of past researchers and are proven successful (Svanaes 2004, de Sa 2006 and Kangas et al. 2005).

The focus groups conducted as part of the requirements analysis resulted in the desired functionality of the mobile guide and also provided insight in to the user's expectations of both the functionality and the design, this is detailed further in section 3.3.

3.1.2 Design

Following the research and the requirements gathered during the focus groups, relating to both the functions and the interface, the developer's next stage in this lifecycle was the design of the mobile application interface. As this project was incorporating users in the design process multiple screen options were created for evaluation. These designs were based upon the requirements and feedback of the initial research that has been conducted into the user requirements. The author created screen designs for each of the four identified functions and these were presented in the form of low fidelity paper prototypes. Paper prototyping proved to be a valuable method and was used in both the requirements and design processes, paper

designs were created and presented to both an expert and students for verification and feedback which allowed the developer to alter, improve and finalise the designs prior to implementation. This involved creating a paper based model of the intended product, again using the mobile sized cardboard handset prototype, which was used with participants of the initial focus groups. This allowed for a more realistic perspective of what the interface would look like on a mobile screen.

Paper prototyping

Paper prototyping has one significant advantage – it saves money. By creating prototypes on paper, they can easily be revisited and amended if and when required. Whereas creating a prototype system may require a lot of time and effort to amend if necessary. The paper prototyping will allow for fast and cheap prototype construction and will allow for modifications to be made with ease. Paper prototyping for developing user interface designs has been successfully employed in the past, in several projects such as de Sá, Carriço (2006) who focused on the importance of early evaluation and prototyping. Sharp, Rogers & Preece (2007) also demonstrated the use of prototypes to develop a design of a 'Manchester United Fan' mobile phone UI, and it successfully outlined the benefits of paper prototyping such as collaborations, iterative design and reductions in both time and cost. Another example can be seen in the work of Korpipaa et al. (2006) who used paper prototyping to evaluate the design of smart phones.

Heuristic Evaluation

It was vital that the design was evaluated by experts within the domain area of both mobile development and HCI. To ensure that the design was appropriately reviewed and assessed, the author presented the paper prototypes and designs of the intended system and gained feedback on the screen layouts and content. Feedback from experts for evaluating user interface designs has been successfully utilised by projects such as Bertini, Gabrielli & Kimani (2006) who captured contextual requirements and assessed the relevance of mobile heuristics. To assist in the evaluation of the screen designs for the mobile guide one of the university lecturers, who was a specialist in educational games and HCI, provided their time and expertise.

User Evaluation Focus Group

Studies have found that user-centred design affects both the product design and also on occasion the user interface layout. The importance of involving the user at the design stage of a product has also been noted, (Petrelli, Not 2006) the design must be analysed critically by the user before it progresses to the development stage, this involvement is crucial if the product is to meet the users expectations and requirement. Taking these findings into consideration, it was vital that the anticipated users of the mobile guide were used to evaluate the interface design.

Finalised Designs

Once the focus group and expert feedback was obtained the author could confidently amend and improve the screen designs which would provide the basis for the application interface. The design process is fully detailed in section 4.1.

3.1.3 Implementation

The implementation of the mobile guide was the next stage which can be seen in Figure 2. In order to create a mobile application many factors have to be taken into consideration including the size of the files and the intended platform. After research into platform share and alternative development options it was concluded that a Java based application would be implemented. One deciding factor was that, although increasing in popularity, applications designed for iPhones do not reach the same amount of users and, as discussed in section one, they have a very low market share percentage. Monitory restrictions are also a consideration and a possible reason as to why it is less likely that a student will own a phone such as this. Therefore an application that is created for a general platform will increase the size of attainable users.

Development Platform

Factors such as the size of the files and the intended platform have to be taken into consideration. The project's original software prototype was developed in J2ME, prior to the initial focus groups and requirements elicitation, and after further research into platform share it was reaffirmed that a Java based application was ideal and implementation would be continued within this platform. An application that is created for a general platform will increase the size of attainable users. J2ME will be used as it is specifically designed to be lightweight and caters for mobile application creation. J2ME will also allow evaluation of the software over multiple platforms as it is a programming language that does not require re-compilation when used on multiple devices. As previously mentioned the initial prototype was written in J2ME, therefore the progression and continued development was also simplified by completing coding using the same language. The familiarity of the developer with java as a programming language is also an advantage, the developers existing experience and knowledge will ensure the development time and required learning of technology skills is kept to a minimum. The Microsoft .Net Compact Framework (CF) was also examined as it has similar properties and allows for the use of .Net libraries (which are scaled down to take up less memory space) to create applications which run on Windows CE based mobile/embedded devices. The clear advantages of .Net CF, such as the common language runtime and the use of libraries made it a potential development choice. However the restrictions of using C# for windows based devices within a Visual Studio platform led to the author deciding against this option. Development platforms and alternatives were considered before concluding that NetBeans 6.8, a java IDE, would be used to develop the application.

NetBeans 6.8, a java Integrated Development Environment (IDE), will be used to develop the application, the author is not only familiar with this platform and the program setting but it is also readily available in the university. Additionally NetBeans IDE 6.8 has a module called the mobility pack, which allows programming**,** testing, debugging and deployment of applications that will run on mobile phones, PDAs, set-top boxes and embedded systems. Alternatives were also considered for the development: Symbian and Windows Mobile are both operating systems for smartphones, therefore development in these would alienate users

with regular mobile phones. IDE's Eclipse and Visual Studio were both contemplated which are similar to NetBeans 6.8 as they all support java development, however the added benefit of NetBeans 6.8 is the ability to use modules in component based development which in turn reduces complexity and development time.

The implementation therefore involved writing code in J2ME and testing the completed application before deploying it via a website. The deployment allowed students to download the application and use it with in a realistic evaluation in order for it to be evaluated and provide practical feedback. The details of all of the implementation tasks are detailed in section 4.2 and 4.3.

3.1.4 Evaluation

The final stage was the evaluation of the application, this involved a field study which lasted 30 days and was validated through the use of a questionnaire. This was followed by a lab experiment which involved task completion and interviews and finally usage data was retrieved from the student's mobile phones, the particulars of which are fully detailed in section five.

Field Study

As numerous papers have demonstrated it is important that applications are used in the fields for which they are intended (Göker, Myrhaug 2008), controlled environments will not result in accurate evaluation outcomes, however issues regarding the problems facing field research and its obtrusiveness (Isomursu, Kuutti & Väinämö 2004) were also carefully considered. In light of these findings it was vital that the deployment of the application and its use within the general day to day activities of the university students is undertaken. Only once it was used within context would the benefits or downfalls of the application truly emerge.

The field study was conducted over 30 days and occurred naturally as students downloaded and used the deployed application. Once the field trial was completed the students were contacted in order to obtain feedback via the medium of a questionnaire.

Questionnaires

Questionnaires have many advantages and disadvantages, including being low cost, easily distributed to many participants and also being difficult to design. Questionnaires are used by many researchers including Belwal, Belwal (2009) who demonstrated the number of questionnaires that must be distributed in order to obtain an adequate response. Oates (2006) further supports the use of questionnaires, highlighting the advantages of a well structured questionnaire to obtain multiple opinions in a cheap and effective way which can also be incorporated within other research strategies. This method of research must be carefully designed and implemented to gain the related benefits and this report proved the importance

of questionnaires as an evaluation method. Due to time constraints and the evaluation being conducted by one person, the questionnaire aimed to gather opinions from the users, these were then analysed and conclusions were drawn from these results. An additional characteristic of the questionnaire was that it was online; this allowed the author to gain multiple responses from the students who had used the application in a realistic environment.

Lab Experiment

After the field trial was completed and questionnaire responses were collected the students were contacted to request their assistance in conducting lab experiments. The purpose of the lab experiment was to perform tasks on both the mobile application and the university website in order to obtain quantitative data to investigate hypothesis one which relates to the accuracy and speed of information access. Whilst the measured results, which were obtained during the lab experiment, were of great importance it was also vital to directly ask the users selected questions to gain further knowledge regarding hypothesis two (improving the learning experience). Therefore in order to explore the related issues more deeply interviews were also conducted during this time.

Interviews

Interviews were conducted during the lab task research in order to directly obtain information and opinions from the students who had been using the mobile guide. The interview aimed to discover whether each individual has benefitted from the mobile guide, if they have any constructive feedback for future modifications and to understand the user's experience of using the guide during their day to day activities. This method was applied in order to evaluate hypothesis two which stated that the introduction of the guide would improve the learning experience of the user. As previously mentioned, the author would evaluate this through student reflection, comparing their experiences at university with and without the mobile guide and also through the enquiry of the mobile guides design, functionality and usability.

Data Usage

During the development of the mobile application a method was created which logged the usage of the application and its associated functions. The purpose of this additional evaluation method was to provide data which would clearly demonstrate the preferred functionality and would therefore support or disprove the success of user-centred design and its importance in requirement elicitation.

Each stage of the overall project methods and its associated techniques resulted in the acquisition of relevant data which the author analysed in relation to the hypotheses and project aim. The details of each stage and the vital contributions of each process are all presented in the subsequent report sections.

3.2 Lifecycle

Iterative development is a software development lifecycle that suits the development of mobile applications well (Jones, Marsden 2006). The iterative nature of the lifecycle ensures that there is constant input and feedback between the user and developer throughout every stage of the development. As discussed previously the iterative lifecycle allows for the incorporation of user-centred design, a key aspect of this project. Users will offer continual critique and verification of aspects from requirements to interface designs, increasing the likelihood of application success. The literature review has identified that projects such as Raento et al. (2005) have successfully used this lifecycle and the conclusions drawn from section two confirmed the author's belief that iterative design successfully integrates user-centred methodology, whilst allowing for repeated development phases to certify accurate design and development, leading to the increased probability of user acceptance.

The initial stage of the development was the requirements analysis which was completed via the initial research and focus groups. Based upon this feedback the designs were created to represent the intended user interface. Heuristic evaluation and user focus groups were then conducted in order to have the designs verified by both expert and user. Modifications were subsequently applied to the designs in accordance to the relevant feedback and these designs were finally incorporated in the coding of the application. Once the programming of the application was completed the system was deployed in order to gain feedback for the evaluation phase of the project.

The next section will discuss the first stage in this iterative lifecycle, the requirements analysis, and section four and five will further detail the design and implementation and evaluation stages of this development.

3.3 Requirements Analysis

As mobile phones have developed and improved, they have continued to become an ever increasing part of day to day life. Mobile devices now come with features such as WAP, Bluetooth and mobile applications as standard. This has led to an increased reliance on a personal mobile device to provide the user with the information they desire on demand. This requirement along with the preference of electronic vs. hardcopies of information has led to the proposed development of a mobile application to aid students during their time at university. This application intended to provide the most frequently used applications or required information normally accessed through computers by the students whilst on campus. It was also intended to include new functionality that is perceived to assist students and alleviate the need to access information in a static location, therefore providing adhoc information. The project emerged from the comments and feedback of past and present students regarding their everyday tasks at university, and as mobile technology has evolved this venture became increasingly feasible.

3.3.1 Initial Focus Groups

Focus groups provided an informal setting whilst collecting multiple opinions simultaneously from a varied group of students and additionally all opinions would be gathered at once. Other options were disregarded such as surveys, which can take a long time to gather information, interviews, which are difficult to establish the correct set of questions and may result in unpredictable data, and observation, which is more formal and can be difficult and time consuming to analyse.

The key aims of the focus groups were to:

- Uncover more details about our participants, namely in their background and attitude towards use of their mobile devices
- Uncover the functional and non-functional requirements that students would have of the mobile application under design
- Uncover preliminary design principles and guidelines that would help expert designers develop the final look of the mobile application

Methods

The focus groups consisted of note card, oral brainstorming, paper prototyping and general discussions to assist in the designing and evaluation of the software.

Oral Brainstorming

This technique was chosen in order to allow the participants to feed off each other's comments and ideas during the interface design idea process. Oral brainstorming is often a technique used in a group where individuals may not have specific suggestions but through collective discussion and creation they may generate an idea that would have not otherwise been discovered. Brainstorming however must be controlled, if there is a dominant person in the group they may direct the other participants towards an idea which is of only one origin and not a collective and evolved decision. Oral brainstorming only took place once the participants had considered the application separately and created individual ideas in order to ensure that a single idea is not developed and becomes a single point of focus; multiple ideas must be discussed and considered.

Note Card Brainstorming

Note card brainstorming followed on naturally from the oral brainstorming session. It was chosen to ensure that all participants agreed on the desired functionality requirements for the proposed software. This was done by placing all highlighted functionality, from the oral brainstorming session, onto note cards and rearranged into order ranging from most desired to least desired functionality. Similar to the oral brainstorming, a note card brainstorming session must be approached with care as one person may try to dominate the session.

Paper Prototypes

The main factor for choosing this technique was due to the time and money constraints on the research as well as the success of previous studies involved paper prototypes. The paper prototyping used for this research involved the use of a mobile device created from cardboard and paper screens. Each participant was asked to depict their vision of the software interface and to then feed their paper screens through the mobile prototype to simulate a walkthrough of the scenario.

Compared with video and functional prototyping methods, this method is relatively cost free. With other methods, time and money has to be used in order to create a working software prototype for participants to use and evaluate. Feedback to these prototypes often involves several efforts of amending and re-evaluating the prototype until all participants are fully satisfied. Paper prototyping however, enables participants to depict their own visions of the interface and give feedback to each other there and then. Any amendments that they feel need to be made can be done instantly. However, there is the possibility that some participants version of the software interface and/or functionality may be unrealistic compared to the end product.

Participants

As the mobile application was to be developed for student use, the participants of each focus group were vital in obtaining an accurate indication of what intended users would want to see, both in terms of functionality and interface requirements. To do so, a range of students, from undergraduates to recent graduates and post graduate students took part to give a true reflection on what students would want within the mobile application. Students were recruited amongst the student body in the School of Engineering and Computing for the purposes of the focus groups. Eight participants were recruited, two female and six male, out of which two were mature students (over 30). The students came from various levels of the programmes offered by the School and included two third year, three fourth years, one MSc and two PhD students. The students were recruited via posters and email. The focus groups took place in a controlled environment, the participants were being actively videoed during the activities that took place and two researchers took notes and guided the discussions and tasks (as seen in Figure 3 below).

Figure 3 - The Focus Group Participants during Brainstorming

Tasks and Outcomes

Once the "Essential" functions had been identified, each of the participants were then asked to spend 10 minutes browsing the university's home page to identify how easy it was to find the information for the functions they had uncovered. Each function was given a rating of 1-5 on ease of locating information with 1 being easy and 5 being unable to find the information. This task was vital in the identification of realistic requirements for the mobile application as it made the participants more aware of how difficult it was to find information for some of the functions highlighted. This made them more determined as to their essentiality within the mobile application. Accessing staff details was a function indentified within both focus groups that was amongst the hardest to locate within the university home page.

Finally, as the desired functions had been stated, the participants were presented with mobile prototypes along with a series of screen cut outs and cardboard mobile phones (Figure 4).

Figure 4 - Cardboard Prop

Each was then asked to depict their visual representation of a menu for the mobile application as well as the steps involved in at least one of the essential functions identified. This not only allowed the researchers to view the visualised end product, but each participant could also give feedback on what they felt should and should not be implemented into the interface of the application.

Whilst the participant designs were not able to provide the basis for screen designs they did present insight into the required and expected style of interface. The following images (Figure 5, Figure 6) are paper prototypes that were designed by students during the focus groups.

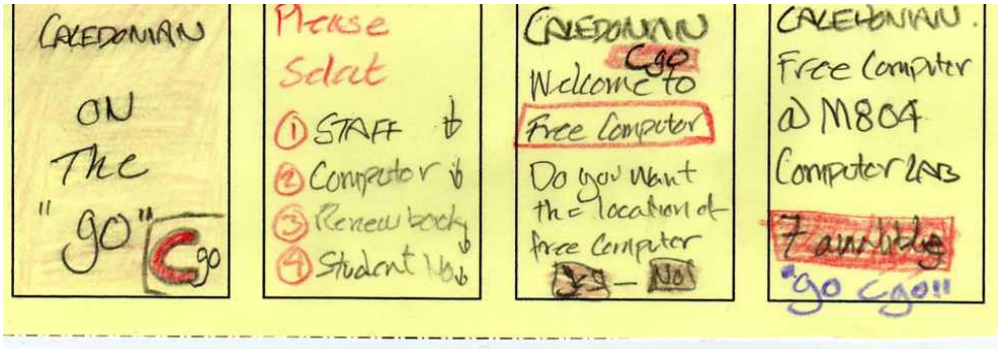

Figure 5 - Splash Screen, Main menu, Find a Computer

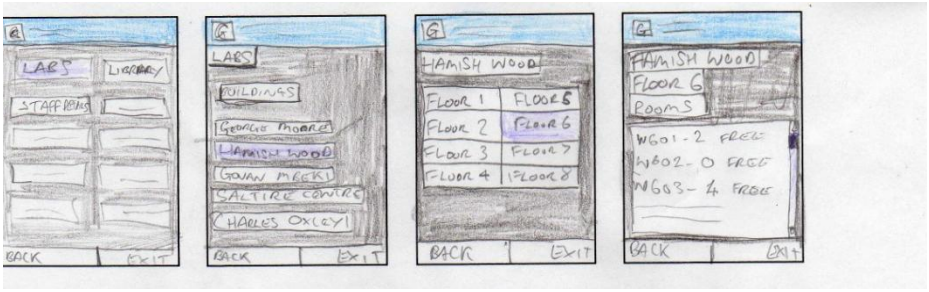

Figure 6 - Finding a Free Computer

The final products can be viewed in Appendix A. Debriefing was then used to give participants a chance to view and evaluate the current functional prototype that existed, feedback was gathered and used to assess the software's suitability.

Two separate focus groups were conducted and despite both focus groups containing a variety of participants, the functions featured in the 'Required' category were similar, if not identical in some instances. From both focus groups, there were 2 identified functions that were distinguished: the ability to view free labs and view staff details.

For both groups, the ability to view labs and computers which are free was the most important function that the mobile application should contain. All participants agreed that finding out where and when there are free computers within the School is often difficult and can lead to them wasting a lot of time trying to locate one. Hence, by having a function that would allow them to see where there is a free computer or an in depth lab timetable, it would save students a considerable amount of valuable time. There were two main suggestions as to how this function should be implemented:

- In a style similar to the screen shown on the Ground floor of the Saltire Centre. This would involve the student choosing which floor or building they wish to check for a free computer. The room and/or building, would then display the amount of free computers using a bar containing green for the amount of free computers and red for the taken computers along with a percentage of computers in use.

- The other option would be to view either a lab timetable or click on a view free labs option. The lab timetable option would display a timetable detailing which labs are occupied and when. The view free labs option would display a list of labs which are currently unoccupied, displaying the computers within the lab as either green or red to state if they are available or not.

The second required function from all participants was the ability to view staff details. When each participant performed the task of finding the identified functions on the university's website, this was one piece of information the majority of participants had problems locating. Therefore, this function is deemed essential to allow students ease of use of contacting or knowing where to find staff if necessary. The details that should be contained include name, room number, email address, position held within the university.

As well as the aforementioned functionality, other required functions included:

- The ability to perform (or reminders of) book renewal
- Both exam and class timetables, with possible personalisation ability
- A map/rough guide to the university
- A "What's On" calendar informing of events taking place within the university
- Obtaining student contact information for people on your course i.e. email address, phone number

In addition to the desired functionality, the participants were also quite specific about the proposed interface for the software. This was highlighted by the use of the paper prototypes and the feedback the participants provide on each interface design Overall, by ensuring that the desired functionality and interface requirements are built into the software, this will improve the likelihood of successfully improving student tasks.

3.3.2 Identified Functional Requirements

Based on the outcomes of initial focus groups it was possible to proceed with the development to accommodate what emerged as the four principal requirements from the students. These were:

1. Finding a free computer
2. Finding a member of staff contact details
3. Viewing university news/events
4. Viewing general university-related info

The findings from preliminary focus groups revealed that the requirements could be easily addressed. The students were not asking for new material or reformatted material – rather, information which should be readily available from existing sources within a university's IT infrastructure, such as class timetables, computer usage data, news feeds, event details etc.

As previously noted during the literature review the main issues which appear to contribute to the success, or otherwise, of a mobile information system is the appropriateness of requirements. This issue was overcome during the initial focus groups which ensured that the students' opinions and desires were considered and applied. The preliminary findings from this early research also certified the appropriateness of the number of functions that would be developed as cut down functionality is vital in the creation of relevant and usable applications.

Another issue, also discussed earlier in the literature review, was the use of mobile technology within an educational context which notes the need for access to learning resources as well as administrative information in order to support learning activities (De Freitas, Levene 2003). By providing functions which provide access to resources such as

timetables and contact information, which were highlighted as the most important requirements of the application by the students, this mobile information system will aim to overcome acceptance issues faced by previous developments. The application will not only be relevant, context driven and useful but will also be more likely to be accepted by the students as the requirements emerged from their ideas, discussions and decisions.

The literature review also concluded that additional considerations must be given to all influencing factors such as cost, audience and domain before an application can be deemed as potentially useful or necessary. During the focus groups, discussion occurred relating to the students use of 3rd party applications, Bluetooth and WAP services. Whilst the literature review has proven that the development of a mobile system will provide greater freedom and flexibility for the user, freeing them from the desktop, and the intended audience was carefully considered prior to focus group recruitment, cost must also be considered. It emerged from the focus group participants that the cost of operating the application must be minimal, charges would not be acceptable in relation to obtaining information and therefore a key requirement of this application would be to negate cost. Platform and technology choices were previously discussed in this section noting the significance of cost considerations which were made prior to development. Requirements were also uncovered relating to the interface design of the mobile application during the focus groups, an area of importance which was also discussed within the literature review.

The utilisation of users during the entire development process was reviewed during the user-centred design section of the literature review and the conclusions drawn from this examination were vital to the author's awareness of the need for iterative development in this ever increasing area of mobile and ubiquitous computing, ensuring user feedback and opinion aided in the construction and evolution of the application. This also justified the need for an iterative lifecycle and as previously mentioned literature showed that prototyping, feedback and continual iteration will reduce the likelihood of user dissatisfaction and provided the conclusion that user-centred design is more likely to result in an accepted artefact. This employment of users in the recognition of design and presentation considerations led to the identification of implementation and interface requirements.

3.3.3 Implementation & Interface Requirements

In addition to the desired functionality, the participants were also quite specific about non functional requirements such as the proposed interface for the software. This was highlighted by the use of the paper prototypes and participants providing feedback on each interface design. It was apparent from the range of interface designs that the software front end should be simple and easy to use; mimicking existing mobile software interfaces. This requirement involved the inclusion of screen size consideration, ensuring the options made available to the user were easy to read and select. Wherever possible, the number of steps required to access a particular function should be minimal therefore making it easier to use. In addition, all participants were drawn towards having a menu in the form of icons giving the main menu a minimalist look and feel to it. These requirements reflect the HCI issues previously

mentioned, that developers must utilise interfaces which allow for data presentation in a limited form, allow for menu and list design that reduces scrolling and overall an interface that reduces user task time and effort (Korpipää et al. 2004). The limitations of mobile devices were clearly discussed during the literature review and allowed the author to identify specific matters relating to HCI. Mobile devices have many restrictions which must be considered and overcome in order to utilise the technology to the benefit of users and deciding how best to present, store and edit data will ensure the acceptance and usability of a newly created system. As previously noted, application design and development must recognise the restrictions of device storage, screen size and input and by overcoming these issues, design may reduce user effort and ensure ease of use and reduce the chance of rejection by the intended audience. Investigating HCI issues and device limitations ensured that design evaluations, platform considerations and the importance of acknowledging mobile restrictions were taken in to consideration. The significance of designing for mobile devices was discussed as this project must impose a considerable amount of contemplation when creating the application for use on the move.

Outcomes from both the focus groups and the literature review led to the design requirements for the mobile application:

- The interface must be simple and easy to use
- Menu should be icon based (mimicking existing mobile interfaces)
- Number of steps to access functions and information should be minimal

The importance of interface requirements cannot be over emphasised and it has been suggested by such experts as Chittaro (2006) that HCI is of as much importance as the functionality of the application.

3.4 Conclusion

The literature review and focus group successfully contributed towards both the justification of the mobile applications creation and the selected choices of the applications intended characteristics. The motivation for the application clearly emerged from the desires of the students and the inclusions of their involvement and opinions led to the identification of four required functions, alongside interface requirements. The functions will provide information to students regarding lab availability, staff contact details, university news and university information. An existing application prototype was created prior to the requirements research and the focus groups were conducted in an attempt to validate the original developers selected functionality and designs. The focus group provided validation for the prototype but also provided significant insight into further development and refinement of the initial software which was basic and limited in functionality. The literature review and focus groups resulted in the identification of the characteristics regarding both functionality and design for the proposed applications. This allowed the author to proceed with the design and implementation of the mobile information system to accommodate the needs and desires of the students.

4.0 Design & Implementation

This section will detail the choices made by the author in relation to the developmental aspects of the project, following on from the identification of requirements. The relevant stages of design, implementation, testing and finally deployment will be detailed.

The following sections will further detail the design and implementation stages of the lifecycle which were previously noted in section three, specifying how each phase contributed towards the final development, which in turn allowed the author to evaluate the application and draw associated conclusions.

4.1 Design

This section details the full design stage of the iterative lifecycle. Initial designs were create based upon user requirements. These were evaluated by an expert, revised, evaluated by users and then finalised prior to implementation.

4.1.1 Initial Screen Designs

The four separate functions which were stated as requirements were placed into an icon based menu and each function had three alternative designs, displaying the options of both design and functionality. These alternatives attempted to present issues which had been discussed in the requirements elicitation, such as the preference of selecting data over multiple steps or with less steps but involving the need to scroll. Data presentation options can be seen in Figure 7 below, these paper prototypes represent the 'uni info' function and the two options were to display all the information on two tabs or to allow the user to 'drill down' and view less information on the screen but with the compromise of increased steps.

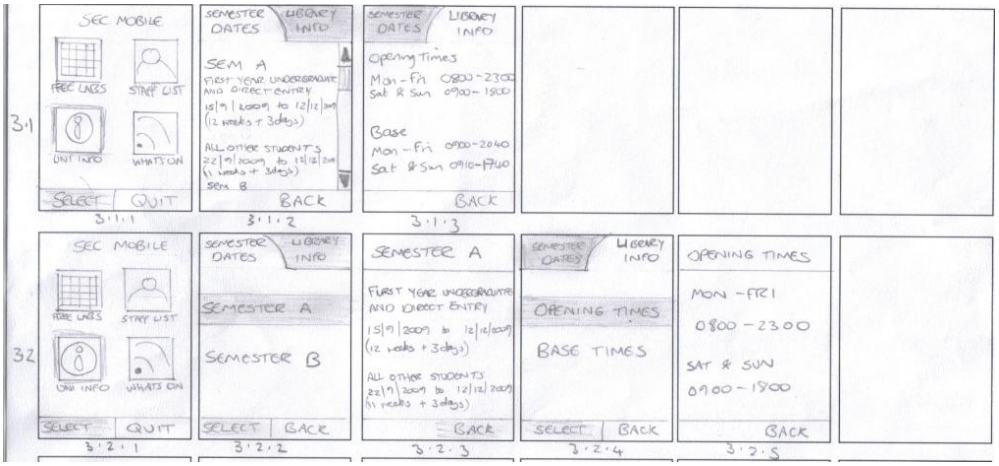

Figure 7 - Screen Designs Alternatives for 'Uni Info' Function

The possibility of personalisation was also examined, with the designs in Figure 8 presenting the option to bookmark favourite labs. Personalisation was highlighted by Bertini, Gabrielli & Kimani (2006) and Korpipaa et al. (2006) as an increasing area of importance. The variety of users and their preferences make it near impossible for designers to create applications suitable for all and personalisation allows users to add preferences and provides flexibility for both developers and end users.

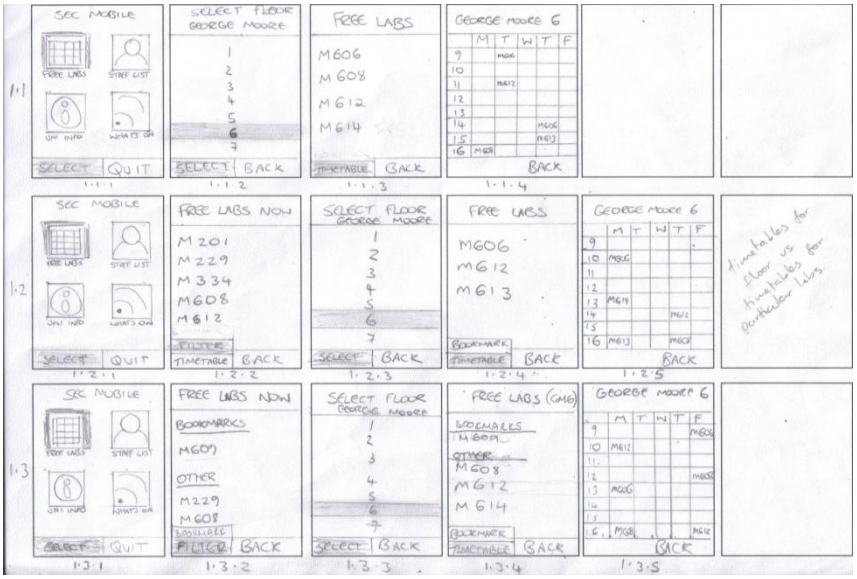

Figure 8 - Screen Designs Alternatives for Free Labs Function

Once designs for all functions were satisfactorily created, and the author believed that the designs modelled the varied options, and possible designs adequately, they were presented to both users and experts for evaluation and feedback to allow for selection and refinement prior to finalising the designs. (All screen designs can been seen in Appendix B)

4.1.2 Heuristic Evaluation

Mobile heuristics were selected and were based upon the research by Bertini, Gabrielli & Kimani (2006) who captured contextual requirements and assessed the relevance of mobile heuristics. As discussed within the literature review, techniques which apply the feedback gained from experts during the evaluation of user interface designs, have been successfully utilised projects and evaluation techniques such as heuristic assessment or field trials often uncover HCI defects (Cheverst et al. 2000). The heuristics supplied to the expert allowed for valuable and measurable feedback. The expert that benevolently supplied their time and expertise was a lecturer from the School of Engineering and Computing department, who has particular interest in the development of games within education and also human computer interaction. The expert met with the author to discuss the project and anticipated outcomes of the expert evaluation.

To ensure the heuristic evaluation was systematic and resulted in useful feedback the author created a 'heuristic pack' which consisted of a mobile heuristics form (Figure 9) – to evaluate the screens against, a heuristics marking table – to fill in and make comments on the screen designs, a navigation map (Figure 10 on the following page) - to help gain an understanding of the mobile applications model, screen designs labelled 1,2,3,4 and cardboard mobile phone (there were also scenarios 1.4,2.4 & 4.4 detailing "incorrect outcomes" i.e. null results in search) and finally detailed information of tasks – table outlining details of screens, user options and actions, which was simply provided to further clarify screen designs, but was not essential. (The full contents of the heuristic pack can be found in Appendix C). This pack was discussed with and verified by the author's initial supervisor who was involved in refining the screen designs prior to the heuristic evaluation. As the supervisor was also an expert within mobile HCI this discursive validation was viewed as a secondary expert evaluation. Due to the structured nature of the heuristic pack it was possible for evaluation and feedback to occur without supervision or the authors' intervention.

Mobile Heuristics

1—Visibility of system status and losability/findability of the mobile device: Keep the user informed about what is going on.
2—Match between system and the real world: present the information to the user in a natural and logical order
3—Consistency and mapping: the users conceptual model should be consistent with the context.
4—Good ergonomics and minimalist design: Screens do not contain irrelevant or rarely needed information
5—Ease of input, screen readability, and glaceability: Screen content should be easy to read and navigate through. The user should be able to quickly get the crucial information from the system by glancing at it.
6—Flexibility, efficiency of use, and personalization: Allow mobile users to tailor/personalize frequent actions, as well as to dynamically configure the system according to contextual needs
7—Aesthetic, privacy, and social conventions: Mobile interaction with the system should be comfortable and respectful of social conventions
8—Realistic error management: Shield mobile users from errors. When an error occurs messages should be plain and precise, allow user to cope gracefully.

Rating	Description
0	I don't agree that this is a usability problem at all
1	Cosmetic problem only. Need not be fixed unless extra time is available on project
2	Minor usability problem. Fixing this should be given low priority
3	Major usability problem. Important to fix, so should be given high Priority
4	Usability catastrophes. Imperative to fix this before product can be released

Figure 9 - Mobile Heuristics

Navigation Chart

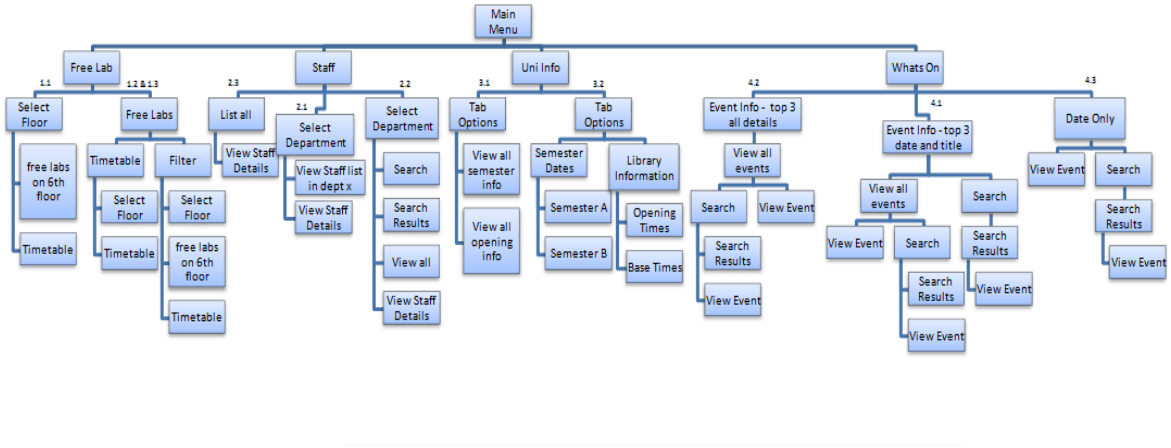

Figure 10 - Mobile Guide Navigation Chart

The expert was asked to complete four tasks:

Step 1: Read mobile heuristics form

Step 2: View navigation map

Step 3: Using the card board prototype view and understand the paper screen designs, (using the detailed information of tasks if required).

Step 4: Evaluate the screens against the heuristics provided on the "Mobile Heuristics" form.

The feedback from the heuristic evaluation generally related to the clarity of screen and button titles, one such comment was in relation to the timetable view of screen 1.1 (in Figure 11 below), "The timetable has a number of confusing elements, I was expecting to see a timetable for a chosen lab, not the floor"

Figure 11 - Screen Design 1.1

Another important observation made by the expert was if students would understand the categories displayed in screens 2.1.2, this was a consideration made by the developer prior to the evaluation and it was hoped that this issue would be commented on by either the expert or the users (Figure 12).

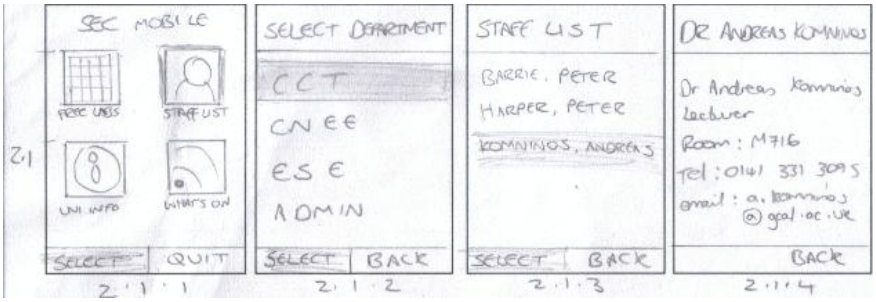

Figure 12 - Screen Design 2.1

The comments relating to the 'uni info' function (designs previously displayed, Figure 7) were also of great importance, "Too many screens to navigate. 3.1 is a cleaner approach", as was later validated during user evaluation. The entire expert feedback (which can be found in Appendix D) was analysed and assimilated by the author, subsequently amendments were made to the designs and specific issues were noted for additional discussion during the next stage, user evaluation.

This expert assessment further supported the user-centred design and evaluation and therefore led the author to create an application which had less design problems and more likelihood of user acceptance. Alterations and improvements which were required to meet the expert's expectations of accepted standards were rectified and once the designs have been amended, in accordance with the expert feedback, the designs were presented to a selection of students.

4.1.3 Focus Group User Evaluations

The user feedback was gathered through a small focus group, using a sample of students who ranged in age and were both male and female, as to reflect the intended users of the final application and the group did not consist of any previously involved student participants. Four students were recruited via email, again utilising this fast, cheap and effective method of communication and conscription. The focus groups were conducted in a quiet environment over the period of an hour and the students were encouraged to speak openly about their views of each set of screen designs, which were shown to them in turn, while the author noted likes, dislikes and concerns. The focus group gained feedback on all screen designs and also discussed the issues raised by the expert in relation to the number of steps, information display and ambiguity (the focus group plan can be seen in Appendix E).

Free Lab Function

All participants like the screen design labelled 1.3 which included the option to bookmark their favourite labs. They felt that if they could bookmark the 6th floor labs, which they stated they always use, then they would not require the need to filter by selecting the floor number. However all participants stated that they would like to see the list of free labs first before having the option to view a list of labs. The issue raised by expert evaluation regarding the "view timetable" option was reflected by the students, who stated that they would want to see a timetable for the lab they had selected on the list and not a timetable for the whole floor. The students did not like design 1.2 (Figure 13) and stated that although 1.1 (Figure 14) was simple it did not provide enough functionality.

Figure 13 - Screen Design 1.2

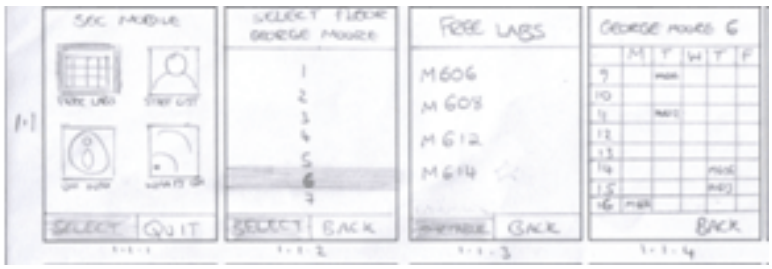

Figure 14 - Screen Design 1.1

Staff Contact Function

The students were not aware of the individual departments within the School of Engineering and Computing and when asked what department any of their current lecturers were in only one student knew. The students therefore stated that they would prefer that the staff contacts were initially displayed and if you wished to reduce/filter the staff list then you could do so by the departments but the names of each would have to be written fully and not abbreviated, as they were in the initial design. The use of the search option in the design was preferred as it overcame the confusion of the relevant department but students also claimed that when on the move they would rather scroll to information than attempt a further step of data entry, something which was also mentioned by the expert. When questioned how the students would like the contacts to be made available they all agreed that they would be using the

function to find someone in particular and therefore would like all contacts to be available and they could filter the contacts by typing the lecturer's name. If this was unsuccessful, or too time consuming, then they would like the option to search by department.

University Information Function

None of the participants like the title 'uni info', again reflecting feedback from the expert evaluations; they thought that the term "general information" would be more appropriate. The majority of the participants agreed that screen design 3.2 was preferred, however one person preferred 3.1 which displayed all information on the single screen with the option to change tabs to display either semester dates, or opening times for the library and base. The individual student who preferred this claimed that they would rather scroll information than select more options when using this function on the move. This caused further discussion within the group and caused revision of opinions. 3.2 contained an extra step to obtain information, separating the dates in to semester A and B, and the times in to library and base times. It was also stated that 3.2 looked the most similar to the website which made the students feel more comfortable as it was what they are used to. The students who preferred this claimed that 3.1 was "too busy" and with only one more step the information would be easier to read. They stated that they thought that the tabs still made the information easy to display and although they would rather have fewer steps to obtain information, only one additional step would be acceptable. Further discussions with both groups led to the turnaround in opinions, the students decided that design 3.1 would be preferred as the information could be scrolled quickly and therefore an extra step would not be required.

What's On Function

All of the participants like the design labelled 4.1 (Figure 15) the most. The claimed that 4.2 (Figure 16) displayed too much information and 4.3 (Figure 17) was too basic.

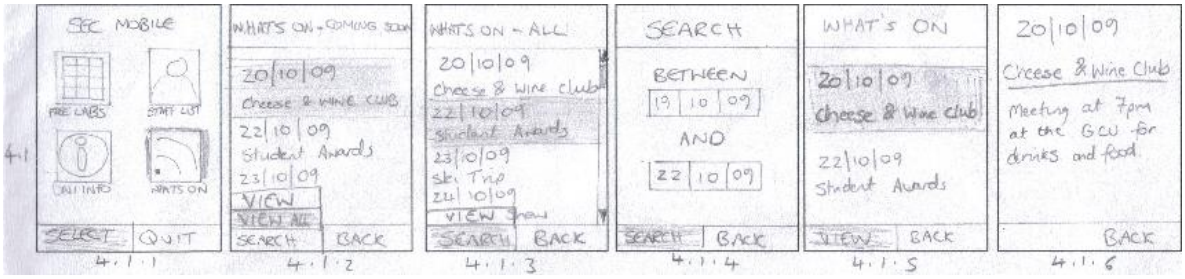

Figure 15 - Screen Design 4.1

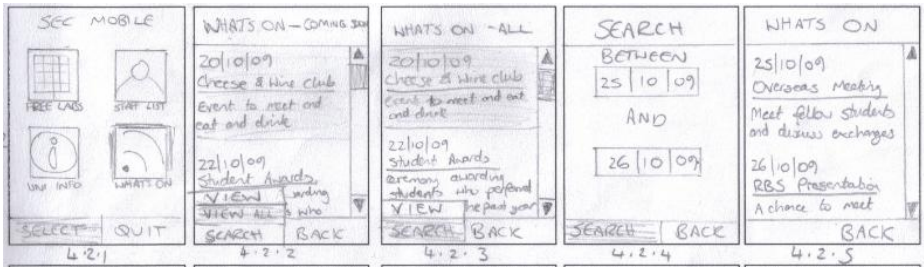

Figure 16 - Screen Design 4.2

Students stated that 4.3 which just displayed the date of an event and no information would be "too much work" to constantly select and go back to view the different events.

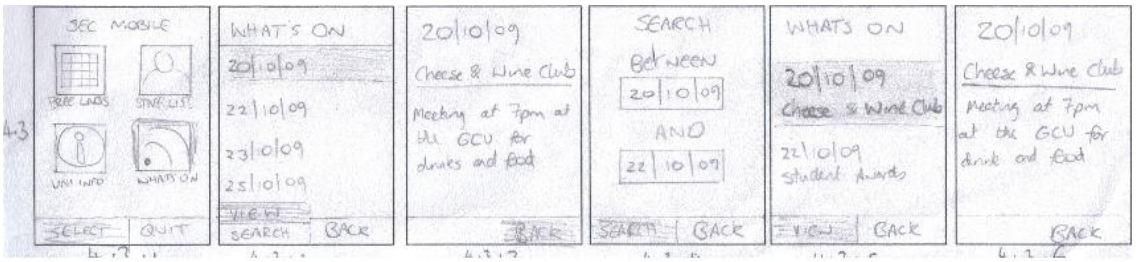

Figure 17 - Screen Design 4.3

When asked if they would use this function only one student claimed that they would, a complete contrast to the findings from the initial focus groups which gathered the required functionality. Further discussion uncovered that the students would prefer this function to link to the university website via live feed as they claimed that this would keep the function both simple and reliable.

In addition to the discussion of screen preference the students provided insight into the following pre-prepared questions:

Student questions

- *Were you aware of the online tool to view lab availability?*
    - All students were aware of this tool however they had a few issues with it. One student said that they knew of it but had never used it. Another claimed that they had only attempted to look at it once but couldn't as there was a problem using, it crashed and they thought it was unreliable. The other two students had only used it once out of curiosity.
    - All students felt that it was a 'pointless' tool as you had to be on a computer to view the usage details which most students would want to know in order to find a free computer.

- *Would you prefer more steps to view information or fewer steps but more information displayed on each screen?*
    - The students agreed that they would only forgo an increased number of steps for a simpler display of information if it was purely an increase of one step. They said that as they have to view the information on the move they would not want to have to focus purely on identifying the required information from a busy screen.
    - The improvement of information layout would have to be justified for this extra step to be worthwhile, otherwise the students would prefer to scroll.

- *Would you use the live lab usage on the application or did you prefer to see if a class was on?*
    - This question raised the most issues and resulted in the longest discussion. The outcome was that the students preferred to see if a class was on or not and

would not solely want to use the live usage as they may walk in to a 'quiet' class. They did however say that they liked having the option to use both and would not solely want to rely on the use of the static timetable. It was decided that the students would probably use a combination of both. If no labs were displayed as free at the time they required then they would use the live lab function to find a class with the least computer usage, and if the lecturer allowed it, or if it was unstaffed, then they could attempt to use a computer in that lab.

- *What function(s) do you think you would use the most?*
    - All students stated that they would use the "free labs" function the most as this is a current annoyance to the students.

The focus group was concluded with the students agreeing on chosen preferred screen options for each function; 1.3, 2.2, 3.1, 4.1. The findings of the focus group were extremely beneficial and were successful in the attainment of user opinion to allow the author to confidently amend and improve the applications interface design. The difference in initial designs and finalised designs supported the author's research and findings which suggested that software may be significantly improved, in relation to both functionality requirements and design, when there is greater involvement of users and experts in the early stages of software developments. Once the focus group was conducted and a design evaluation completed, the designs were amended, finalised and allowed for development to commence.

4.1.4 Finalised Screen Designs

After contemplation of the feedback and comments of both the expert and the users the author applied the findings and amended the screen designs. The following diagrams represent the finalised designs which the author based the applications interface upon.

Figure 18 below displays the 'Free Labs' function, allowing users to immediately view currently free labs, as requested by the students. On selection of 'view all' the user can then view all labs and either mark a lab as a favourite (a phrase noted as a preference to the previously used 'bookmark') or view live lab usage which additionally used colour coding to convey information.

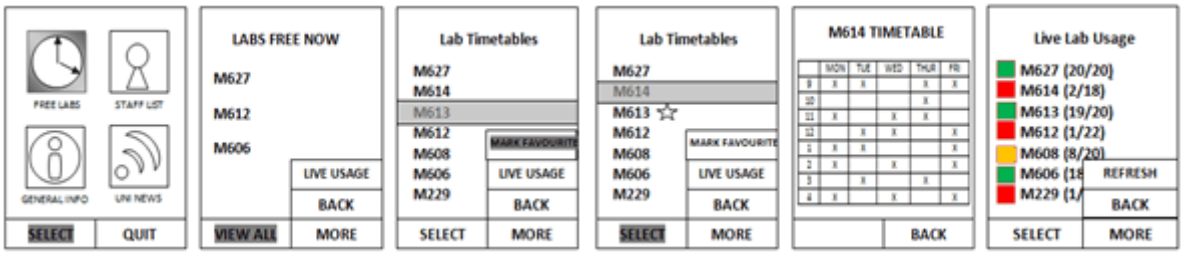

Figure 18- Finalised Design Free Labs

Figure 19 shows the 'Staff List' function, displaying all staff details on the first screen and allowing the user to either scroll, filter or view by department. This allows the user the flexibility of finding information in a manner best suited to them and ensured that the user's opinions and preferences were applied from the focus groups.

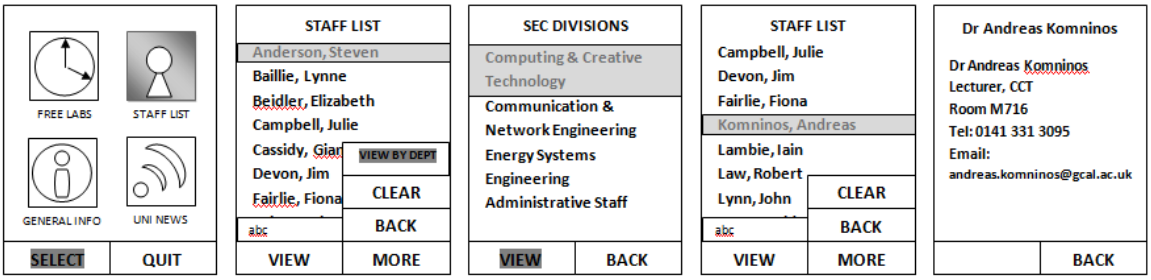

Figure 19- Finalised Design Staff List

'General Info' function is displayed in Figure 20 and did not differ greatly from the initial screen designs which were preferred by both users and expert. The phrase general info has been adopted to replace the afore used 'uni info' heading but the information remains in tabbed form over two screens, allowing the user to scroll to view all data. The phrase 'What's On' was also replaced by 'Uni News' after feedback from the evaluation stage.

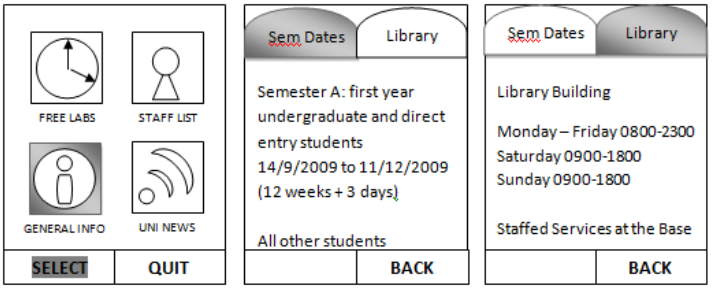

Figure 20 - Finalised Design General Info

The use of such an iterative and detailed design process allowed for the refinement and overall continued improvement of both the interface and functionality of the application. This ensured that the application would not only be as close to the users envisaged system as possible but also ensured that the knowledge gained through the literature review, which stated the benefits of iterative and user-centred design was acknowledged and applied. The finalisation of screen designs allowed the developer to progress to the implementation stage of the lifecycle and to apply the interface designs to the high fidelity application prototype, which would then be used in the evaluation and analysis of the projects aims and hypothesis. All finalised designs can be viewed in Appendix F.

4.2 Implementation

The following section details the execution of the development of the application, the choices made in relation to the programming language and development platforms that would be used to create the mobile system were previously discussed in section three. Details regarding the actual code structure and programmatic methods utilised are outlined and finally the testing of the application is discussed.

4.2.1 Application Development

The development of the application continued on from the basic software prototype that was created prior to initial focus groups. This provided a basic structure and systems architecture for the developer to improve, adjust and build upon to create the system desired by students. The application consists of a midlet called MenuMidlet.java which contains the main functionality and employs lists, record stores and screens to store, retrieve and present data to the user. Additional java files provide functions such as XML parsing (LabReader.java) and internal table population (Lab.java). J2ME Polish class libraries provide extra capabilities including filtered lists, tabbed forms and Rss browsers, and resource files in the form of text and image files provide the icons, images and XML data used to generate the application content. The following sections detail specific features of the implemented code.

XML Parsing

Data relating to staff contact details and lab timetables are stored in text files within XML tags, allowing for the parsing of structured data. This is done within the code using a KXmlParser, a lightweight xml parser which is specifically intended for limited systems such as applets. It is a small pull parser and features cursor API instead of event objects, leading to smaller object creation overheads. In order to utilise this parser an additional resource file was imported and then an object was created within the main menu midlet. This object then used the associated methods to process any text file which is taken as a parameter. By using external text resource files the loaded data can be altered without encroaching upon the actual application code.

Examples of lab and staff details structures are displayed below.

```
<lab>
        <name>M627</name>
        <class>
                <day>Mo</day>
                <time>9</time>
                <duration>1</duration>
                <classname>x</classname>
        </class>
        <class>
                <day>Mo</day>
                <time>10</time>
                <duration>2</duration>
                <classname>x</classname>
        </class>
<lab>
```

```
<staffmember>
                    <title>Mr.</title>
                    <name>John</name>
                    <surname>Smith</surname>
                    <post>Lecturer</post>
                    <division>CCT</division>
                    <telephone>0141 3316677</telephone>
                    <email>john.smith@gcal.ac.uk</email>
                    <room>M607a</room>
                    <image>null</image>
</staffmember>
```

Rss Feeds

Rss feeds are utilised within the application in order to allow students to connect to the universities Wi-Fi and obtain live information and news in the 'Uni News' function. The RssBrowser class is supplied via J2ME Polish class imports and supports the use of rss feeds within a mobile application. The following code is used in the midlet, alongside the imported library function, which allows mobile devices to connect to the internet and retrieve selected feeds via http addresses, which were supplied by the university's IT department:

```
switch (rssList.getSelectedIndex())
{
     case 0: rssBrowser.go("http://www.caledonian.ac.uk/newsevents
              /feeds/feeds.php?s =fnynunrnbninansntnpn");
             break;
     case 1:rssBrowser.go("http://www.caledonian.ac.uk/newsevents
            /feeds/feeds.php?s=feyeuerebeieaesete");
            break;
    default: break;
 }
```

Rss feeds were also used for the retrieval of live lab usage, these were again supplied by the university's IT department but caused some controversial issues to be raised. The live usage was considered unsafe and may put students at risk if the live usage was used out with normal timetabled teaching hours, especially if it displayed a sole user alone in a lab. The compromise that was found involved the addition of code in the application which allowed or prevented the use of this function depending on the time of day. During university class times the live usage could be viewed; out with this time the message "Live usage not available at the weekend" or "Live usage not available after 5pm" would be displayed to the user (as can been seen in Figure 21 below which depicts the users view, depending on the time of day).

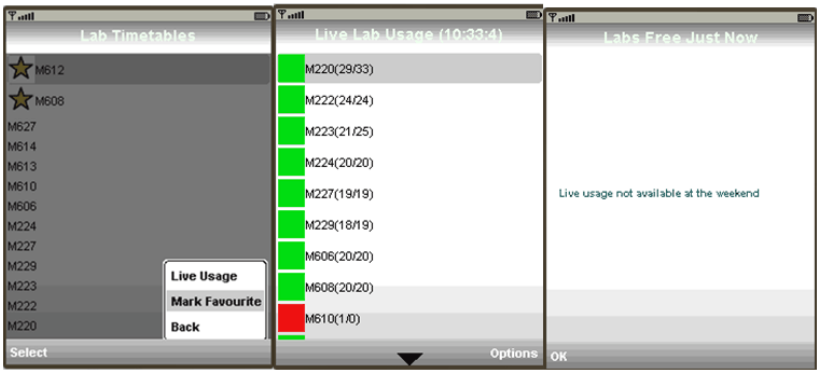

Figure 21 - Screen Shots of Live Usage Function

Logging Usage Data

As well as conducting user tasks the application also stores logging data during the user's activities. The purpose of storing user activities was to provide additional data, after the field study had been completed, which would present the functions most used and would therefore impartially demonstrate the accuracy of user-centred requirements elicitation.

The following function is used to add the details of what function was used and when.

```
public void addtolog(String entry)
    {
       String logEntry=null;
       try{
          Date date = new Date();
          logEntry = entry + date.getTime()+">";
          rs = RecordStore.openRecordStore("log",true,1, true);
          byte bytes[] = logEntry.getBytes();
          rs.addRecord(bytes,0,bytes.length);
          readRecords();
          rs.closeRecordStore();
         } catch(Exception e){}
    }
```

This data is stored in a shared record store for later access, XML tags were added to the string entry to echo an XML structure and this would allow for simplified data processing and retrieval. A basic application called 'getLogData' which consists of a separate menumidlet.java file was created by the author. Its sole task was data retrieval. Students participating in the lab experiments would load this second application on to their mobile phone and once started it would display the usage data in the XML format and on selection of a 'showdetails' command would display a screen similar to Figure 22. This was done by accessing the shared record store and establishing a connection. A method called count() processes the data to count the number of occurrences of certain function names which were then displayed so the author could record the data.

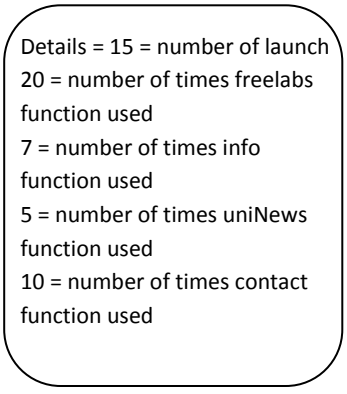

Figure 22 - Example of Screen Displaying Usage Data in Log Application

Mark Favourite Labs

There were multiple methods used in the application to ensure tasks were performed effectively and appeared seamless to the user. The use of the method markFavourite() allowed for user personalisation (the applied code can be seen below in Figure 23), continuing the implementation of user opinions and feedback from the user-centred design as well as heuristic number six (flexibility, efficiency of use, and personalization) which was used by the expert during the design evaluation. When marking a lab as a favourite the method appends a star image to the lab name and reorders the list with the favourite labs placed at the top for improved ease of use, students can clearly identify and select their 'favourite' labs.

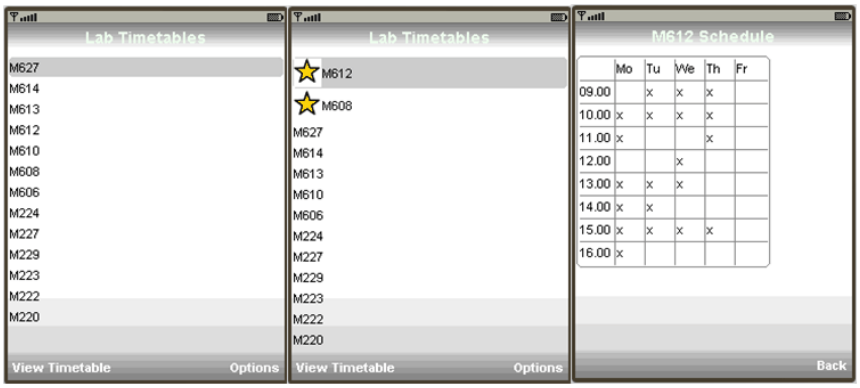

Figure 23 - Free Labs Function, Mark Favourite Personalisation

The author was satisfied with the choice of J2ME for the implementation of the mobile guide and while the development of mobile applications was a relatively new experience, the steep learning curve added to the knowledge and skills that were continually gained and built upon during the project.

All implemented code for both the SEC Mobile guide and the getLogData (data retrieval) application can be found in Appendix G and in the attached code files.

4.2.2 Testing

Once the application code was completed it was vital that testing was undertaken to ensure that the mobile guide was free from bugs and operated as intended once deployed. Try catch blocks prevented the application from crashing and extra code was added to ensure the application paused or exited as required, when receiving phone calls or when requested by the user. The test plans for the application will be generated through the examination of the mobile guide requirements that were outlined by the students. Black box and white box testing ensured that the system was tested as a whole, and also tested the code, its execution and ensured that it implemented functions, loops and all possible clauses. The testing was designed in such a way that each possible selection made by the user was tested, to make sure errors and exceptions do not cause any problems. If the user accidentally pressed buttons

such as exit then extra alerts were displayed, requiring user acknowledgement, in order to prevent mistakes. The application was also tested over multiple devices; this was not only tested by the user but was also supported by the downloading of the application by students who had various different mobile handsets. Failure to test an application adequately would not only lead to the inability to obtain data for evaluation but would also result in the failure of the author to produce a successful application which met user requirements and expectations. The test cases and outcomes of these tests can been viewed in Appendix H. Once the author was satisfied with the testing of the application, which in reality could never be bug free, progression could be made to the deployment of the SEC Mobile Guide.

4.3 Deployment

Following development and testing, the application was deployed throughout the university in order to allow it to be evaluated in a realistic environment. The following sections detail the ways in which the mobile application was advertised and distributed.

4.3.1 Advertising the Application

Using the medium of email and posters the mobile information systems was advertised to students within the School of Engineering and Computing. The application was advertised as a trial release and students were invited to use it prior to its official release. An email detailing the purpose of the application was sent to all relevant students with a link to a website in which they could obtain the mobile guide. Posters were also distributed (see Appendix I) as an additional method of advertising and were located in student laboratories and corridors.

Many advertising methods were considered and, through research, certain methods were selected and dismissed. Possible methods that were evaluated and discarded were lab interception and by letter. Lab interception was a consideration as the targeted students would be done on the university campus, in the labs. Unfortunately due to this work being conducted by a single person this would prove to be inefficient and would not result in the required number of participants within the restricted time, this method was therefore redundant. Participant request by letter was a possibility, but was dismissed due to the time scale of the required arrangements. Letter deployment and the time for response would have taken too long and was less reliable than email. Both time restrictions and personnel limitations resulted in the following alternative methods being employed.

Email was a method chosen as it provided mass contact to university students and immediate response. Email addresses will be obtained from the university department, from personal student contacts and from the computing society. Mass emails were sent on two occasions offering the “SEC Mobile Guide”. Emails are fast and efficient, one single email can be delivered to many recipients immediately and, in turn, responses can be immediate, however emails are not guaranteed to be read or acknowledged and a high number of students must be emailed in order to receive a desired number of responses. Over 200 students were contacted

in the attempt to recruit 30 students in order to obtain a fair representation of the potential users of the application.

Posters aimed to advertise the mobile guide as an extra form of advertising in the hope that students would visit the website and wish to be included in the subsequent research. The posters were designed to be clearly understood and, as mentioned, were posted in several locations throughout the university and computing department. Around 15 posters were displayed providing a basic outline of the mobile application, the purpose of the guide and the web address which allowed students to download the application for free. Posters are a cheap and effective way to reach students, who may not be contactable through communication means, in multiple locations.

4.3.2 Deployment Techniques

The website which the students were encouraged to visit via the aforementioned advertising was created to allow the students to gain information relating to the application. It also allowed them to download the associated jar file (Java Archive File), which contains classes and associated metadata allowing for application distribution via a single file.

The website was created using HTML tags within a simple notepad file which could then be opened with, and tested via, an internet browser. The website consisted of six HTML pages; index (home page which can be seen in Figure 24), FAQ, contact us, download, form done (page displayed once download details we submitted) and about. Additional PHP files were created to create the registration form to document the details of those who downloaded the application.

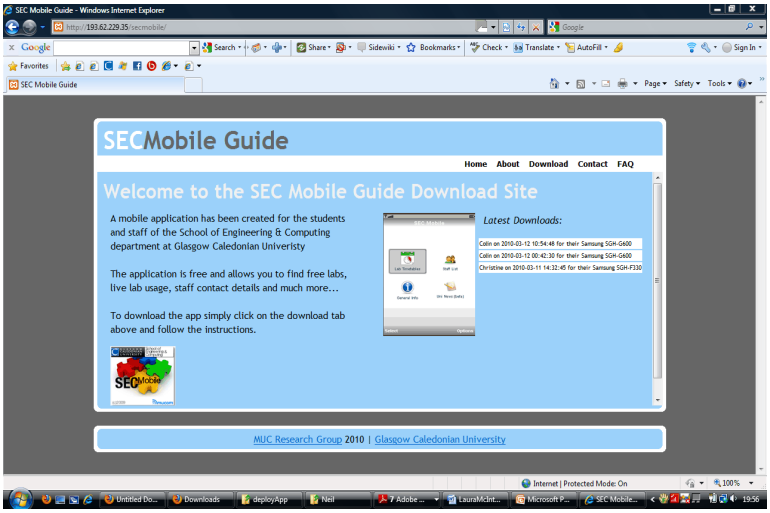

Figure 24 - Index Page of Download Website

The web pages supplied information regarding the application, its intended purpose and allowed the users to enter their personal details in order to download the executable jar file.

JavaScript was used with the pages to validate the data entered by the user on the client side and once the personal data was successfully submitted further code handled the data and inserted it into a table which could only be accessed by the developer. The form that was to be completed by the students required the entry of details regarding age, which had be over 18 in order to conform with ethical considerations, name, course details, email address and mobile handset. This table was then used to analyse the variety of students who had downloaded the application and the types of handsets it was being used on.

The table provided vital contact details for the students using the application which could then be used to later invite them to participate in the evaluation of the application. All screen shots of the website can be viewed in Appendix J and the html files are found within Appendix K and the attached code files.

5.0 Testing & Evaluation

This section will detail the evaluation methods which were employed in order to test the author's hypotheses. A field study and lab experiment were both undertaken, the preparation, completion and outcomes of both will be explained and analysed. The findings of the evaluative methods will be presented and critically discussed in relation to the project's aims, objectives and overall premise.

5.1 Evaluation Methods

In order to allow for comprehensive evaluation and analysis of the mobile guide, both analytical and empirical methods were considered. Analytical methods such as cognitive walk through or expert appraisals are valuable forms of evaluation and usually provide a greater number of errors or issues than other comparable research. An expert evaluation was conducted during the design stage of the project as a form of formative evaluation and identified potential usability issues using the set of provided mobile heuristics. Analytical methods do not directly involve users and would be beneficial in terms of reducing execution time, however empirical methods supply the most realistic approximation of usability and a more comprehensible record of significant issues. User involvement is vital for empirical evaluation methods which include such techniques as experiments, observations and query based (using interviews or questionnaires). Empirical evaluation involves users and in order to undertake these techniques the human subjects must be familiar with the interface they are evaluating; methodical planning and preparation is required in order to gain the essential appraisal outcomes. Whilst the benefits of empirical evaluation are apparent more important is the consideration of the initial hypotheses:

1. A mobile guide would benefit students at the university by providing accurate information on demand and improving the information seeking process for students.
2. The introduction of a mobile guide will improve the learning experience for its student users.

Both hypotheses would be evaluated using the measure of improvement regarding students' tasks and via the reflected opinions of students, therefore expert evaluation would provide insufficient outcomes to allow for hypotheses evaluations.

The two empirical evaluation approaches selected by the author were a field study and a lab experiment. The field study would allow for a realistic trial of the application and the lab experiment would provide systematic results within a controlled environment. The combination of field studies and lab experiments are supported by work such as Iqbal et al. (2005), who demonstrated the importance of combining controlled empirical methods with "real" evaluation. The utilisation of both types of assessment instruments provides a risk reduction, as this project was undertaken within limited time constraints it was vital that the response data gathered during the evaluation was valid and significant. By undertaking two

forms of evaluation, deficient results of one method could be compensated by the other. This combined approach also provided results of both quantitative and qualitative data; Golafshani (2003) noted the varied uses of quantitative and qualitative research and the importance of reliable results. Controlling conditions and retesting are also factors which enhance dependability and research reinforced the importance of valid techniques to permit result acquisition which allowed the author to meet the previously outlined objectives. The two selected evaluation methods were completed after the SEC Mobile Guide had been deployed for one month, commencing with the field trial and subsequently undertaking the lab experiment, the details of both will now be examined.

5.2 Field Study

A field trial occurred naturally as the students downloaded the available mobile guide from the deployment website - http://secmobile.kicks-ass.net . It was intended that this spontaneous field trial would allow the guide to be more accurately tested as the user was not being told what functions to use or tasks to undertake, which would better reflect the guide's role in, and contribution towards, students activities. The field trial was performed independently, without author intervention, for one month allowing the students to not only incorporate the use of the application in to their daily activities but also to allow them to become acquainted with the interface and provided functions. As previously mentioned, the use of the website to deploy the application also provided the author with contact details for the participating students, which totalled 28. After the month time period had passed the author appealed to the users to complete a pre-designed online questionnaire. The students were contacted by email, thanking them for downloading the application, requesting feedback and providing them with a link to an online survey.

5.2.1 Questionnaire

The questionnaire was constructed using an online survey provider which allowed the questionnaire to be completed from multiple locations via the internet, alleviating user and author exertion as the survey could be completed at the students' convenience. The initial questions were used to collect the students details, such as name, age (to ensure they were above the required participation age of 18 for ethical compliance), course title and year of study. The subsequent questions were closed question which involved the user providing answers through scales and ranking so that the data can be analysed from a statistical viewpoint. The use of the Likert scale was also incorporated to allow the students to specify their level of agreement to statements regarding the usability and this scale has been used in similar mobile evaluation projects (Corlett et al. 2005, Thornton, Houser 2004).

The questions which were included in the questionnaire emerged from the literature review research in which it was concluded that the success of a mobile application was reliant upon appropriate functionality, an adequate interface and feedback provided through the employment of user-centred design. Based upon these findings the questions within the

questionnaire related to these areas posing questions which related to the usability and design of the guide as well as the overall frequency of function and application use, the affects and benefits of the application in comparison to the university website (the full questionnaire can be seen in Appendix L).

5.2.2 Questionnaire Results

Responses were collected over a period of three weeks and resulted in 16 completed questionnaires, 57% of students who initially downloaded the application (all questionnaire results can be viewed in Appendix M). As involvement was voluntary and no incentive was involved in obtaining student participation this number of responses was satisfactory and provided the author with significant data to analyse and conclude feedback.

All of the questions within the questionnaire related to hypothesis two which related to the overall improvement of the students learning experience. The initial questions (1-5) collected data relating to the participant's background information. Question six presented the user with a number of statements relating to the mobile applications design and usability to which they selected a level of agreement. Question seven related to the users frequency of use of the mobile application and question eight enquired about the use of the specific functions. Question nine related to the effect which the mobile application had upon the students use of the university website and question ten attempted to find out the students opinion regarding the overall benefit of the application.

Student Information

From these responses it was clear that this student sample successfully reflected the intended audience. Seven 2nd years, three 3rd years and six 4th years participated of which 13 were male and 3 were female (as can be seen in Figure 25), statistics that closely reflect the believed percentage of woman that are completing engineering or computing degrees (14%), according to the Engineering Council (Glasgow Caledonian University, 2010).

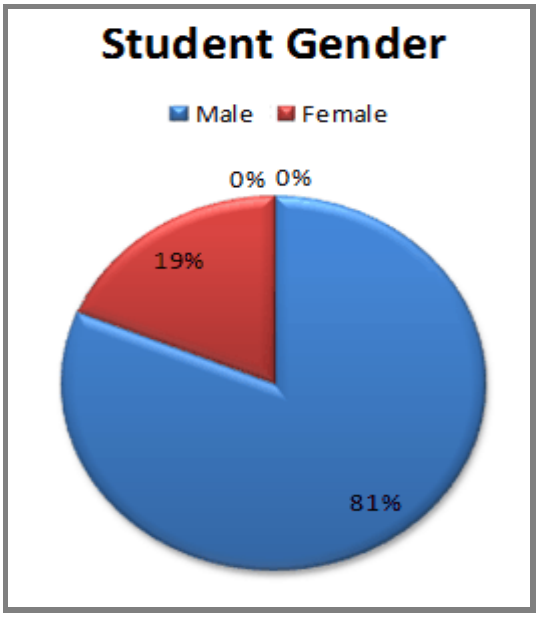

Figure 25 - Pie Chart of Student Gender

The students came from an equal distribution of courses including networking, computing, web systems development, games software development and information systems development, providing the author with a selection of student opinions. The age of participants ranged between 18 and 25 with one extreme value of 48, again successfully reflecting the student body age range. The confirmation of the students personal and course details demonstrated a reflection of the intended student audience and therefore proved the validity of the response and results. The subsequent questions related to the application itself.

Rated Opinion Statements

Question six involved the use of the aforementioned Likert scale in which students rated statements which related to application design, usage and usability. As displayed in the figure below (Figure 26) the student response was positive and confirmed the author's second hypothesis that the mobile application would improve the students' daily tasks. The statement "The application improved my daily tasks at university" received four strongly agree ratings and seven agree ratings, no student disagreed with this statement. The first hypothesis also noted the importance of ensuring the benefits resulted from accurate data provision and the statement "I felt the information was reliable" received five strongly agree ratings and nine agree ratings, again no student disagreed with this statement.

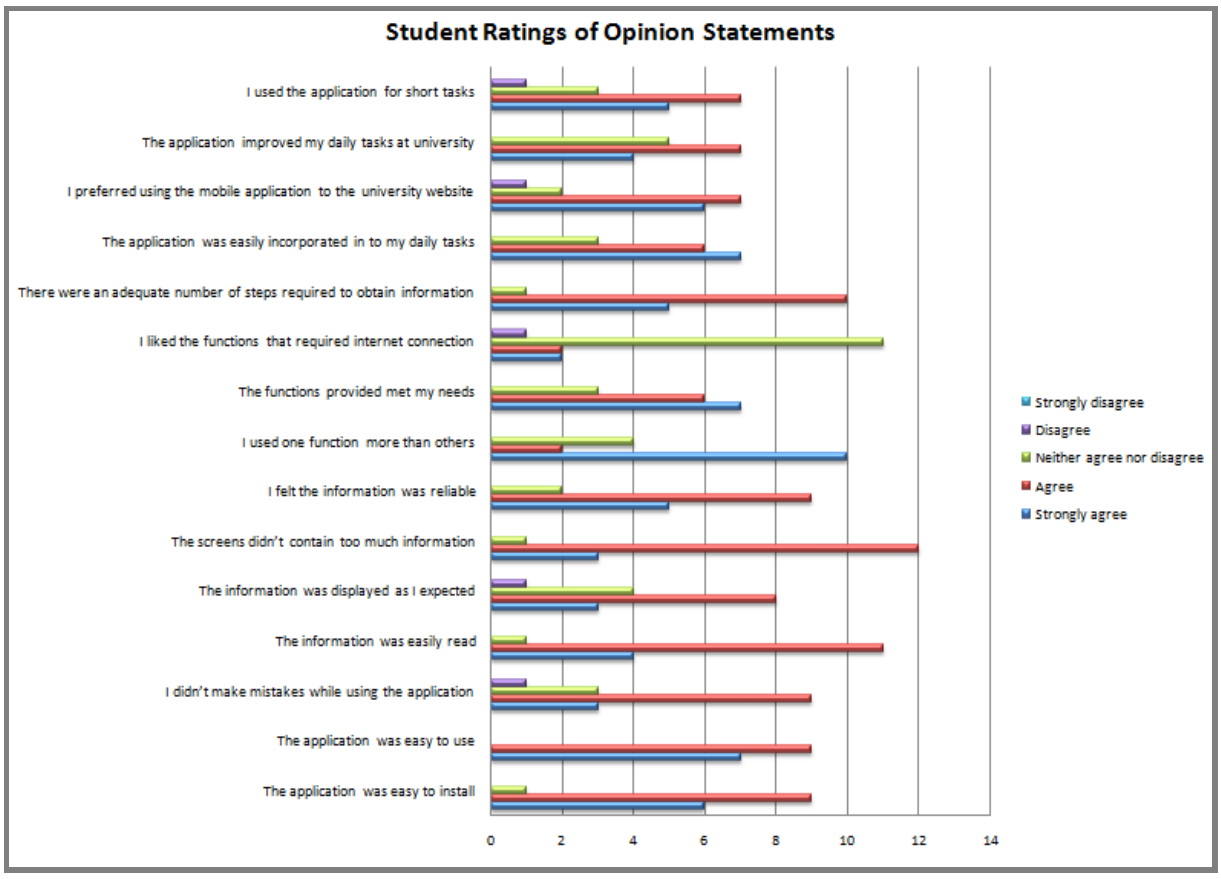

Figure 26 - Bar Chart Student Opinion Statements

Frequency of Use

Question seven posed the question "How often did you use the SEC Mobile Guide app?" with the answer options being: everyday, a few times a week, once a week, once a fortnight, once a month, rarely or other. As displayed in Figure 27 the majority of students, nine, used the mobile guide a few times a week and three of the participants used it every day. These encouraging usage statistics supported the literature review findings that a mobile application is more likely to be accepted and incorporated when user-centred design is utilised and results in improved functionality and design.

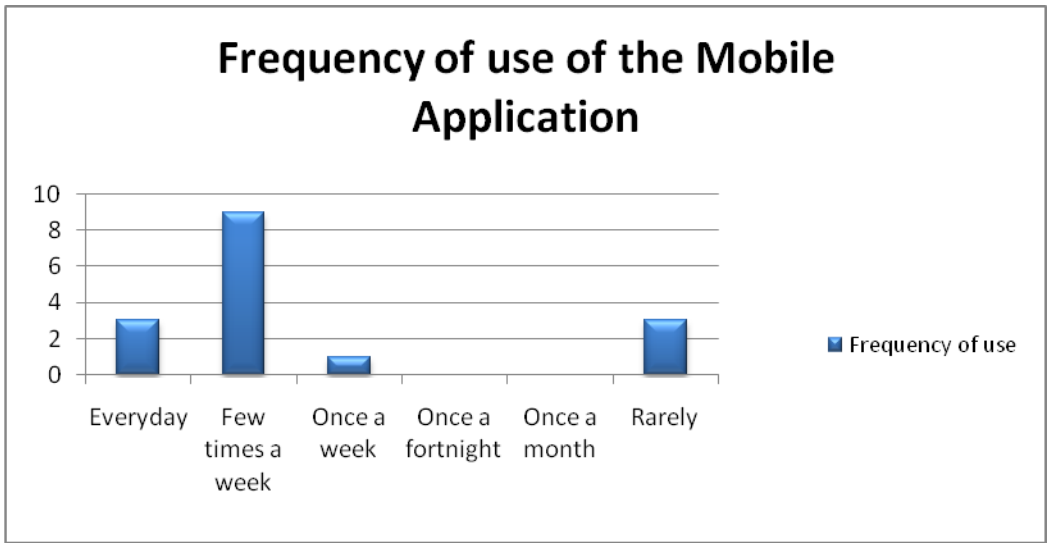

Figure 27 - Bar Chart Frequency of Use

Frequency of Function Use

Question eight intended to validate the functionality choice made during the initial focus groups. The questionnaire captured the student's usage of each of the four functions. During the initial focus groups the most desired function was the free lab function, the results of this questionnaire reflected this as it was the most frequently used function during the field trial (10 students rating their use as often). The least important of the desired functions was the university news function and again this question mirrored student opinions as 11 students rated this function as rarely used (see Figure 28).

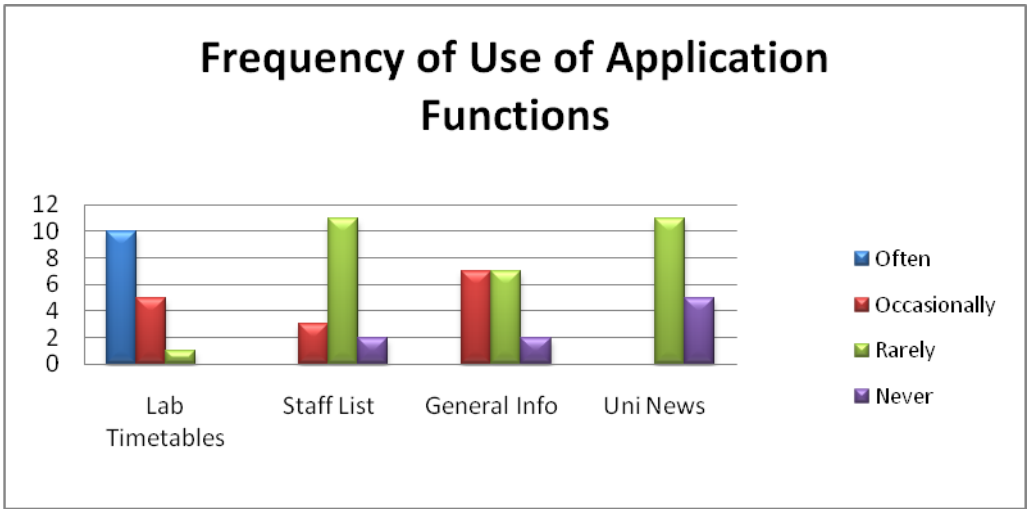

Figure 28 - Bar Chart Frequency of Use of Functions

Mobile Application's Effect

Question nine enquired as to the effect of the mobile application on the student's current use of the university website. As the mobile guide was created as an alternative to the website it was important to find out if the application resulted in an alteration of normal use. As expected, usage of the website did not increase and 44% of respondents confirmed a reduction of website usage due to the mobile application (shown in Figure 29)

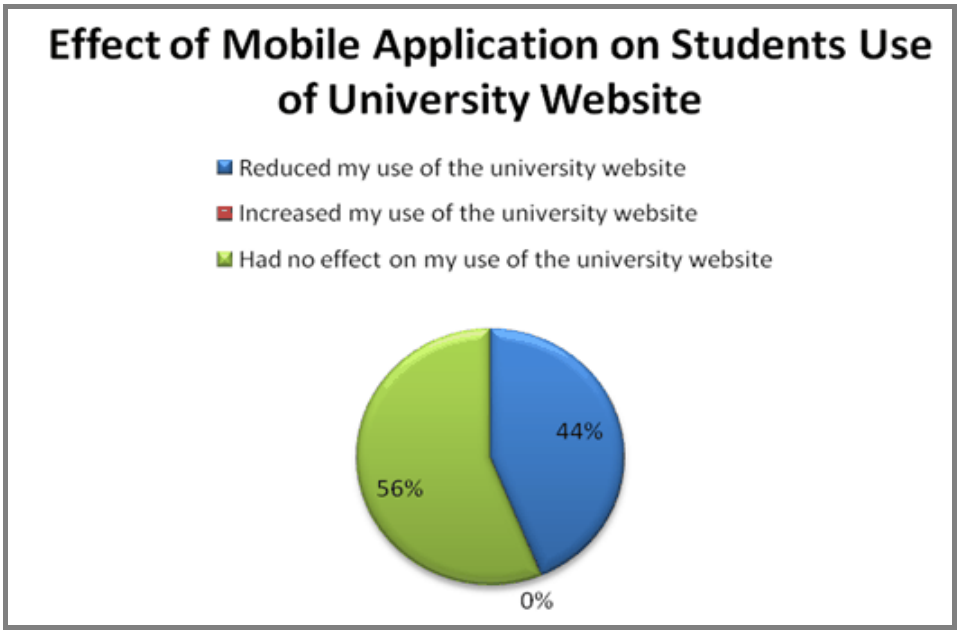

Figure 29 - Pie Chart Effect on Website

Mobile Application's Benefits

Finally, question ten attempted to provide further verification that the mobile application would benefit the students. As can be seen in Figure 30, no responses were provided by the students other than yes, with 44% agreeing it was very beneficial.

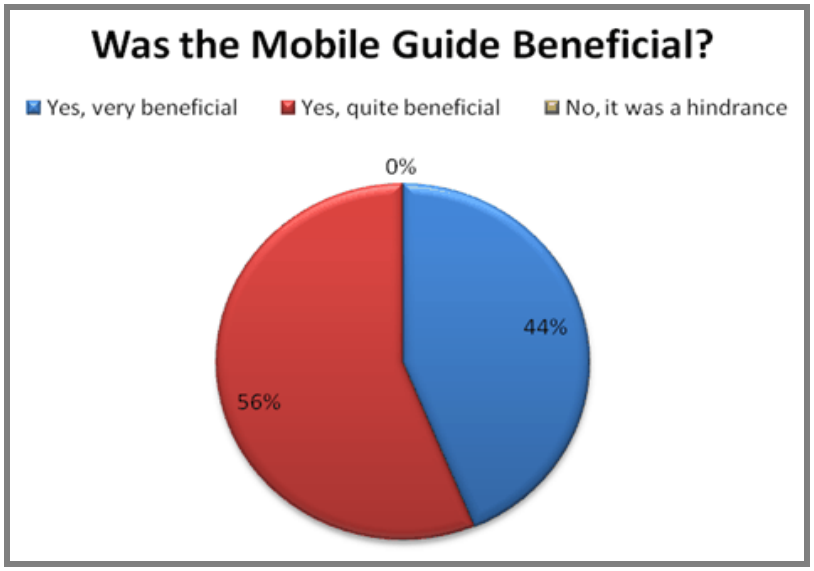

Figure 30 - Pie Chart Was the Application Beneficial

5.2.3 Usage Data

As discussed in section 4.3.2, an additional application was created in order to retrieve the usage statistics of each student. The 'addtolog' method was used each time the application or one of the main functions were initiated or terminated, adding the function name and usage time to a separate record store. Prior to the lab experiment task completion each participant was supplied a copy of the basic "Log" application in order to view their usage of the application during the course of the field study. The lab students were used to gather this data as they were the students whom the author made physical contact with, however this data was not related to the lab experiment itself. The author transmitted the required jar file to each student via Bluetooth transference. On starting the application and selecting the "showdetails" command the usage statistics (previously detailed) were displayed allowing the author to note down each student's data. (The acquired data can be seen alongside the lab experiment results in Appendix O).

Table 1 - Usage Statistics Retrieved Using Log Application

Participant	*No of times Launch used*	*No of times Lab Timetable used*	*No of times contact used*	*No of times info used*	*No of times uni news used*
1	39	33	2	4	1
2	14	11	1	2	1
3	28	52	7	12	12
4	34	40	4	6	2
5	32	32	1	4	1
6	22	22	2	1	1
7	40	59	5	8	2
8	35	32	1	5	1

The table of usage not only demonstrated that the mobile guide was being used by the students, providing realistic feedback for analysis but also highlighted the usage of particular functions. As it can be seen in Table 1 the student participants clearly used the free lab function to a greater extent than the other three functions. The total lab timetable function usage (281 times) outweighs the combined usage of all other three functions which totalled 86. This unbalanced distribution of function usage was not surprising as during the initial focus groups the requirement to search for free labs was ranked as the function of greatest importance to the students.

These results were very informative and provided comparative data for the second evaluation method, the lab experiment.

5.3 Lab Experiment

Once the field trial was completed the students were contacted, as previously mentioned, by email in order to obtain feedback. At this time the students were also invited to partake in lab experiments which aimed to obtain quantitative data as statistics were recorded during task completion on both the mobile application and the university's website. Additional information was also due to be collected during the experiment; the logging data which was discussed in the implementation section and qualitative data in the form of semi structured interviews. As the experiment tasks and interviews were completed at the same time the results of both will now be presented and discussed. Both qualitative and quantitative data was collected to compensate for the inadequacies of sole data type collection, as noted by Golafshani (2003), therefore different analysis methods will be appropriately applied to each result type. All aspects of the lab experiment will be fully detailed in the following sections.

5.3.1 Participants

The lab participants were a subset of the students that were involved in the field study, four of which were also involved in the design focus groups which were conducted to finalise the mobile guides screen designs. It was intended that by using students from the field study the lab experiment participants would have greater comprehension and familiarity of the mobile guide, they would have already learned, used and become accustomed to the application when completing tasks which would provide more accurate and comparable results. The participants were contacted by means of both email and personal invitation, requesting their assistance with a lab experiment which would involve user tasks and an interview. Over the period of a week the author received eight student acknowledgements and divided the participants into two experimental groups, inviting each individual to one of the two lab experiments at a time that was most suitable, based upon a list of times they had previously stated they were available. The separation into two groups of four students provided smaller numbers of participants which allowed for greater control and easier result recording, important issues when methods are being implemented by a solitary researcher. Increased experimental control relates to earlier considerations regarding accuracy of results, the applicability of probability negatively effecting data and the importance of the author enforcing as much control on experiments as possible will help to increase the chance of valid data.

5.3.2 Tasks

The lab experiment consisted of both user tasks and interviews; this section will detail the selected tasks that the participants undertook. To examine hypothesis one the author had to unearth data relating to the anticipated improvements of the students information seeking process, in order to deem the mobile guide as beneficial. Improvements were to be measured against such factors as task duration, number of errors, completion rates and number of steps taken. To judge improvements, measurements of both information seeking methods had to be

observed therefore tasks using both the mobile application and the existing university website were constructed and data relating to measurements of error and success rates, number of steps and duration time of tasks recorded for data analysis. Student performance will then be compared to the same information seeking tasks completed on the university website, the alternative choice for student information retrieval. This methodology is supported by research by Hui, Fong & Lau (2002) who utilised users to test the suitability of a web based campus information system. The specific tasks involved were:

1. Get staff contact details – Iain Lambie
2. Find a free lab in an hour's time
3. Find the start date of semester B
4. Find the most current GCU news event

Each task related to one of the four main functions on the mobile guide; 1 Staff List, 2 Free Labs, 3 General Info, 4 Uni News. Task one involved the search for the contact details of a university lecturer, the name was selected at random and simply provided designated reference data. Task 2 was to find a free lab in an hour's time, the significant condition of the lab time was because during the initial focus groups it emerged that most students were unaware of the static timetables available online. The university's IT department had recently added live lab usage statistics to the university's home page. The provision of the free computer information for the current time was beneficial for students, but did not allow for forward planning or provide information regarding class allocation. To fully test the mobile applications function of static class data, which allowed the student to use the function during or ahead of the required time, the task must involve the detection of free labs ahead of schedule and not by using the live lab function on the mobile guide and in the university. It was found during the initial requirements focus groups that the students did not normally use the live lab information in the Saltire Centre (the university's library); this therefore introduced a limitation to the mobile guide and to its evaluation. Boundaries such as user's typical behaviour provide constraints to user-centred evaluation and whilst the mobile application was still developed with this available functionality, further studies into its usage amongst non-SEC students would have to be undertaken in order to fully represent the functions value. Task three was the simply search for the start date of semester B, this provided the employment of the 'general info' function and ensured the user knew how to find this basic data on both resource mediums. Similarly task four was used to illustrate the use of the final application function and the choice of requesting the most recent university news item was to provide the participants with a goal reference.

The participants were introduced to the lab experiment, providing brief explanation of the experiments purpose and how their tasks were going to be completed and recorded (the full lab experiment plan can be viewed in Appendix N). Each student was asked to bring their mobile device, ensuring that they were using a handset that they were most familiar with and removing any factors which may affect the experimental results such as additional learning or handset variation. The mobile tasks were completed on the individual handsets and the website tasks were completed on the university's lab computers and the author ensured that the computer resources were present and available prior to the session commencement. The

participants were taken in turn, each being asked to complete the four tasks on their mobile phone and then on the university's website. Pre-prepared forms were used to complete details relating to the duration, number of errors, number of steps and if the task was successfully complete. A stop watch was required to accurately record duration times and simple paper and pencil resources were required to note the experimental results. Each measurement and record was made solely by the author, allowing the participant to focus fully on the requested task. It was explained to the user that they could take as long as they wanted on each task and could abandon a task at any point if they would normally (out with an experimental environment) stop due to frustration or boredom.

As the students were familiar with both the mobile application and the website these tasks were all completed relatively quickly allowing the author to progress to the interview. The complete table of results can be viewed in Appendix O.

5.3.3 Task Results

The experiment tasks undertaken by each of the eight student participants resulted in purely quantitative data, delivering the results of task duration, error rate, success and number of steps. The following tables and charts display these results following the performance of mean, median and mode calculations, in an attempt to demonstrate a greater correlation between the values and take a broad view of the values rather than inspecting them individually. It will also be noted that there were a number of observations made by the author during the task completion which proved to be insightful supplementary results; these will be discussed during the presentation of the interview (qualitative) results.

The first graph (Figure 31) relates to the duration of each task, the second and fourth graphs (Figure 32 & Figure 34) displays the number of errors that occurred during each task and if each student successfully completed the requested tasks. The third graph (Figure 33) relates to the number of steps taken during each task and whilst this value does not imply a vital factor of application success it is a requirement previously defined by the students that there should be a minimal number of steps. During the heuristic evaluation great importance was placed upon the appropriate labelling of functions and user options to ensure that tasks are successfully completed and done so within an appropriate time, errors would obviously result in delay and increased completion time. The literature review also highlighted issues relating to the interruptions and errors that can occur with mobile use and also the restrictions of the devices, such as screen size and menu selection.

Duration of Tasks

The first set of results relate to the amount of time each participant took to complete a given task. To compare the duration values obtained from the tasks undertaken on the mobile guide with those from the website, all eight participant's times were added. Mean, median and

mode calculations were then performed to give single values for the individual information access tools (the full results table can be viewed in Appendix O). It can be clearly seen from Figure 31 below that the overall duration time for the website tasks far exceeds that of the mobile guide tasks.

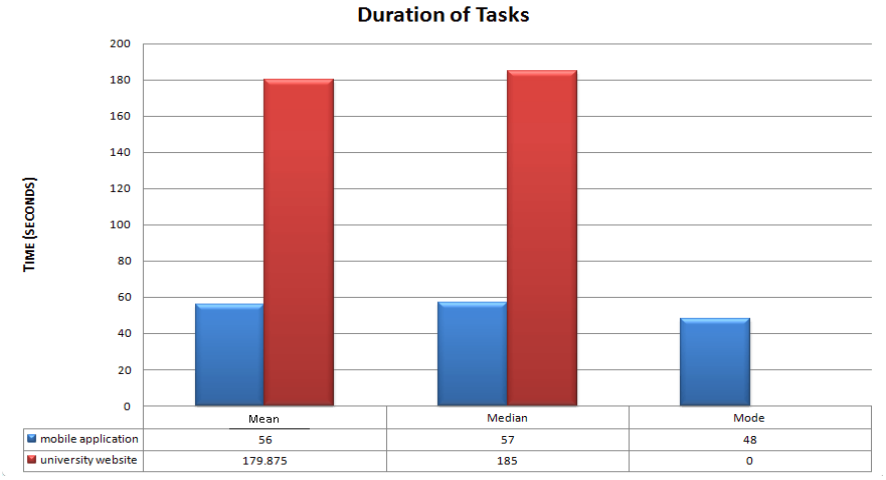

Figure 31 - Lab Experiment Duration of Tasks

In all instances of task activity every student took longer to complete the website based tasks and took at least twice as long to do so, a value which can be seen in the graph (Figure 31) where the mean duration time for the mobile application is 56 seconds and the mean value for the university website is more than three times that value, 179. Whilst this result was expected it was not anticipated to be such a noticeable difference. The university website has a multitude of information readily available to students whilst the mobile guide was developed with the knowledge from the literature review which noted the importance of implementing appropriate functionality, creating efficient interface and menu designs and overall employing user-centred design to verify the appropriateness and usability of the application. In doing so the author has successfully created an application which allows students to complete tasks and retrieve relevant data in a shorter period of time.

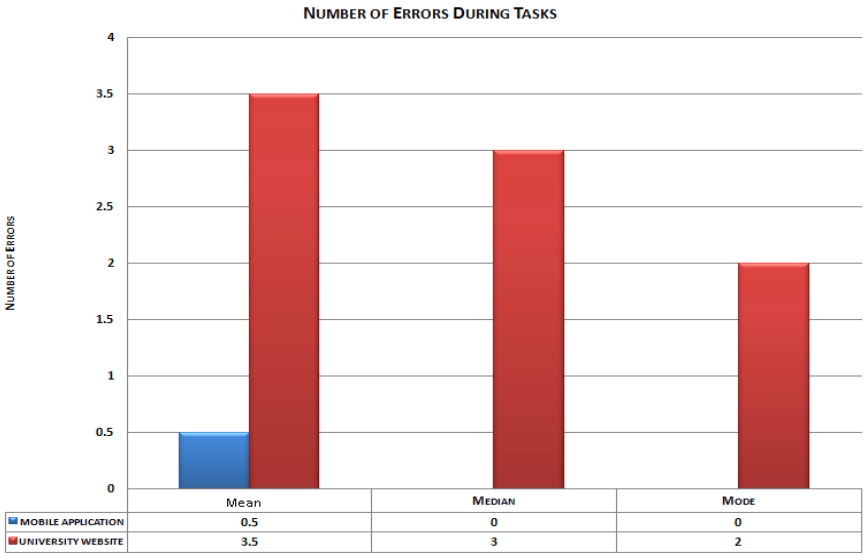

Figure 32 - Lab Experiment Errors of Tasks

Number of Errors

Figure 32 on the previous page displays the recorded values of errors made by each student during the four mobile and four website tasks. These values have again been combined to provide a generalised examination of the data and it is very clear from the diagram that the numbers of error occurrences are significantly greater during the website tasks. The mode values of 0 and 2 were found in relation to the mobile guide and website respectively. The mean values of 0.5 for the application and 3.5 for the website demonstrate the author's findings whilst undertaking this experiment. The participants made significantly more errors whilst using the website and this was due to the 'guess' approach that most students used in an attempt to complete a task, selecting options on the website and then returning to the previous page when it was realised to be a mistake. The simple design of the mobile guide's menu is supported by consistently fewer errors during each task.

Number of Steps

The number of steps were also less for the mobile guide but the difference was not as significant. Figure 33 displays the totality of participant results for both the mobile guide and the website in which the mean values of each were 17 (mobile guide) and 19.5 (website). As previously mentioned, the number of steps were not vital to the success of the application, it was a requirement previously defined by the students that there should be a minimal number of steps and these results illustrate that this was implemented effectively.

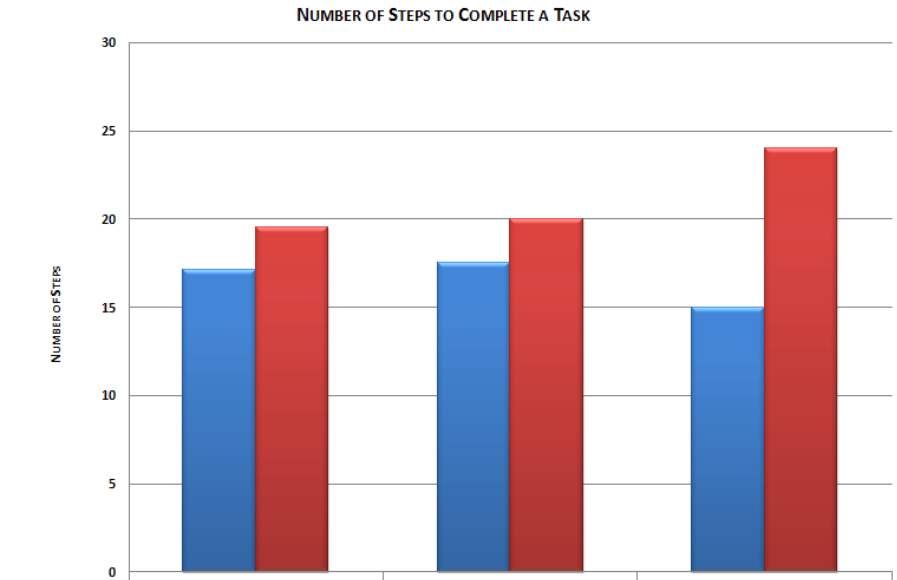

Figure 33 - Lab Experiment Number of Tasks Steps

Task Success

The factor of successful task completion was the final recorded aspect of the lab experiment. Research which emerged from the literature review discussed the overall advantage of mobile information access as being the "availability of relevant information at any location"

(Ammenwerth et al. 2000) and the main requirement of this mobile application was to provide students access to information on the move. It was also concluded that while requirements must be accurately elicited in order to provide the desired functionality, equal importance must be placed on the interface design of a mobile application in order to ensure it is of use and is accepted by the intended audience. Based upon these considerations it was vital to record if the information tools, on which tasks would be undertaken, generated successful outcomes. Each student was asked to obtain a specific piece of information during the task experiments and gaining this information contributed towards the overall success rate (out of four possible successes) for each tool.

Figure 34 clearly displays the 100% success rate (four out of four) for all participants undertaking the tasks using the mobile guide. In comparison the mean value of the website task success rate falls below 50% with a median and mode value of two.

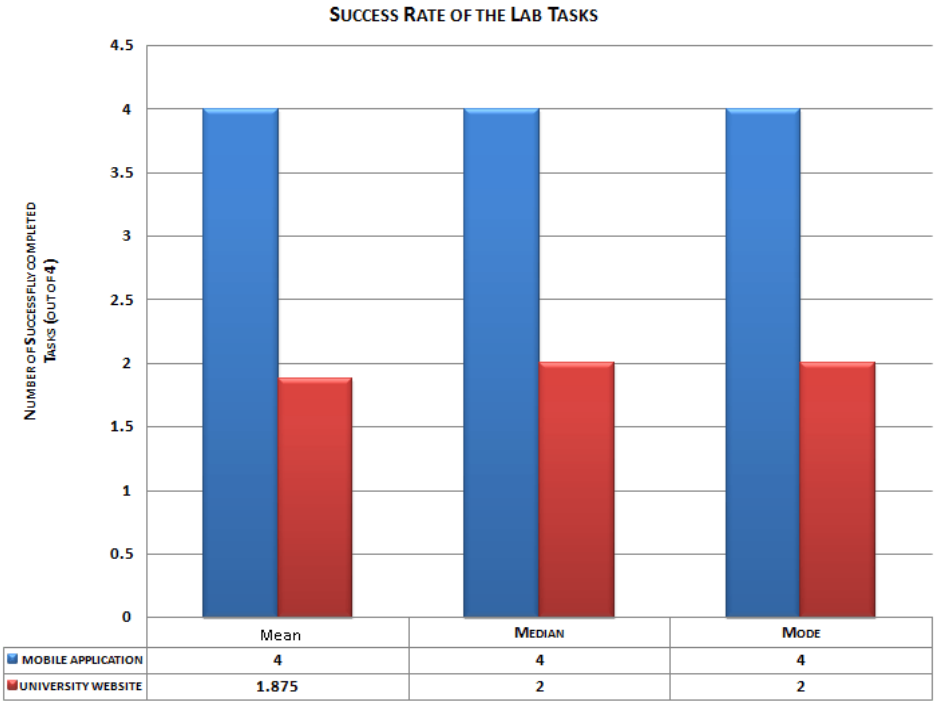

Figure 34 - Lab Experiment Task Successes

By measuring the number of errors, and if the tasks was successful or not, the author could determine if the utilisation of user and expert evaluation improved the applications design and improved the usability of the guide to an extent which resulted in improved tasks completion. The use of both requirements and design focus groups provided and refined the mobile guide's attributes and, although further research would be required to support these results, it can be seen that the mobile guide is an obvious improvement upon the website in terms of tasks completion These results also support the belief that the mobile guide has ultimately met the requirement outlined by the students for a simple and easy to use interface.

In order to ensure statistical data is not purely coincidental, T testing will be employed; this involves using the mean and standard deviation of data to evaluate if the difference is significant between two sets of data or if the difference in results is related to the improved functionality of the mobile application over the website. Quantitative analysis is vital in ensuring that there is a link between data or if observed patterns are merely attributable to chance (Oates 2006). The T tests were performed on the duration values of the experimental task for both the mobile device and the website. This involved using matched pairs T-testing which looks at the mean and difference in values for each task duration result (using the mobile guide or the website). If $p<0.05$ then down to chance, if $p> 0.05$ then there is a significance in the results.

Table 2 - Table of T-Test Results

Mobile Guide	**Website**
33	140
70	208
72	169
63	158
57	95
56	257
48	201
48	211
Mean = 55.875	Mean = 179.875
Standard Deviation = 12.86676	Standard Deviation = 50.06407
Standard Error = 4.54909	Standard Error = 17.70032
p = 8.80710297253E-06	

Table 2 simply illustrates that the performance of T-testing on the total duration of tasks on both the mobile guide and the website resulted in a p value of 8.8. As this value is greater than 0.05 it can be concluded that the experimental data, which resulted from the task completion, is not simply an element of chance and provides additional support to the lab experiments quantitative data.

Further observations were made during the lab tasks, only one of the participants knew that there were lab timetables available on the university website and the related task proved difficult for most of the participants, with only three of the five successfully completing the task of finding a free lab on the website. Task 4 – finding most current GCU news event was the second task of difficulty. While the students struggled with such tasks as finding staff details on the website they did have some sort of idea of how to achieve it even if they were not successful, however in doing task 4 they took fewer steps or attempts and two even selected the New2GCU option. This task proved to be the most confusing to the participants and was also understood to be the task of least importance to the students.

The controlled lab experiments were undertaken to acquire relevant and accurate quantitative data and the values of all the evidential statistical outcomes were notably greater for the university website. It supports the author's first hypothesis that the guide would offer benefits to users by providing accurate information on demand and improving the information seeking

process for students. The mobile guide, in terms of numerical and measurable research, has clearly improved this process and this is also supported by qualitative data in the form of the interview results.

5.3.4 Interview

The interview consisted of a set of pre-prepared questions and each student was asked for their opinions in turn, allowing each student to answer separately and to also hear each other's response. Questions were asked relating to functionality, design and the overall perceived benefits the students found in using the application. Table 3 below demonstrates how the interview questions were categorised.

Table 3 - Interview Questions and Associated Areas

Question	Associated Area
1. Did you use the lab usage on the application or did you prefer to see if a class was on?	Literature Review Section 2.1 and 2.3 – the potential benefits of mobile applications and user-centred design effect
2. What function(s) did you use the most?	Literature Review Section 2.1 and 2.3 – the potential benefits of mobile applications and user-centred design effect
3. Are there any functions you feel are not required /could be removed?	Literature Review Section 2.1 and 2.3 – the potential benefits of mobile applications and user-centred design effect
4. Did you feel the application helped or hindered your usual day to day tasks?	Literature Review Section 2.1, 2.2 and 2.3 – the potential benefits of mobile applications, usability and user-centred design effect
5. Would you like to add anything to the mobile guide? Any improvements?	Literature Review Section 2.1 and 2.3 – the potential benefits of mobile applications and user-centred design effect
6. Were you happy with the screen display/layout?	Literature Review Section 2.2 – HCI design and usability
7. Did you feel the introduction of a mobile guide improved the learning experience? If so how?	Literature Review Section 2.1 – the potential benefits of mobile applications
8. Did the mobile application improve your opinion of the SEC? If so to what extent?	Literature Review Section 2.1 – the potential benefits of mobile applications

The questions emerged from the need to further validate the questionnaire results and also the quantitative results recorded during their task experiment as it was vital to project that the evaluation tasks are conscientiously designed to increase both the validity and usefulness of the data obtained. The complete interview questions and responses can be seen in Appendix P.

5.3.5 Interview Results

As explained in the previous section the interviews that were conducted during the lab experiment sessions aimed to discover whether each individual has benefitted from the mobile guide, if they have any constructive feedback for future modifications and to understand the user's experience of using the guide during their day to day activities. This method was applied in order to evaluate hypothesis two which stated that the introduction of the guide would improve the learning experience of the user. Each question related to areas of the literature review and this, alongside additional observations made during task completion, further contributed to the author's qualitative data (the full interview feedback and outcomes can be seen in Appendix P).

Table 4 - Outcome of Interview Questions

Question	Associated Area	Outcome of Interviews
1	Literature Review (LR) Section 2.1 and 2.3	Only two participants used the live lab usage function, one participant didn't fully understand what it was and wasn't aware of the similar function on the university website and in the Saltire centre. The remaining students did not ever feel the need to use it.
2	LR 2.1 and 2.3	All students stated without hesitation that they used the free lab function the most
3	LR 2.1 and 2.3	All participants, apart from one, claimed that they were unsure that they would ever require the 'uni news' function. They said it was a good function to have but if they wanted the information they were more likely to access it via the university website. One student questioned the need of having so many staff contact details on the application
4	LR 2.1, 2.2 and 2.3	All participants agreed that the application helped them in their daily tasks. The use of the free lab function reduced the student's time "wandering" corridors trying to find a computer before they could complete work and they said it reduced the apprehension of going into a lab as they knew that there was/wasn't a class on and they could directly go to a computer and complete work. The students used the application to find staff details which they claimed had previously taken up a lot of their time, searching the university website, sometimes to no avail. Overall the application was found to reduce the students "wasted" time and aid them in their daily tasks and reduce frustration.
5	LR 2.1, 2.2 and 2.3	Two students suggested the addition of a personal class timetable so they would not have to carry a paper copy with them. One student said that an improvement would be to add a command which would immediately return you to the main menu.
6	LR 2.2	All 8 participants liked the design and layout of the mobile guide. They all thought that it presented data clearly and compared it to the university website which had "too much" information. All students said the app was easy to use and used it for short tasks.

7	LR 2.1	All 8 students answered yes and all claimed that this was due to the reduction in time wasted searching for a lab to be able to get on with university work.
8	LR 2.1	All 8 students answered yes and this was due to the fact that they all felt that the SEC was reacting to the students demands and also proving that the department was "able to teach and develop" relevant software.

The above table (Table 4) presents the discussions which occurred subsequent to the lab experiments and provides substantial support for both hypotheses and reaffirmed the findings of the literature review. The mobile application appeared to exceed the expectation of the participating students who claimed that they used it more than they anticipated and found it of more use than expected. The main benefit to the users was the dramatic reduction in time wasted trying to find a free lab and all users agreed that this alone would have been reason enough for the full introduction of the mobile application.

The results of the lab experiment and interviews, which were undertaken in collaboration with the eight student participants, were controlled and comprehensive and aimed to validate the mobile guide and its associated hypotheses.

5.4 Conclusion of Evaluation Method Results

The evaluation methods of a lab experiment (including tasks and interviews) and a field study (involving an online questionnaire) were all successfully completed and the associated results were recorded, analysed and compared. The questionnaire provided feedback from numerous students who had used the application in the intended environment which allowed for more realistic responses. The outcome of the questionnaire and field study was the collection of student opinions and comparative data which contributed towards the choice of questions which were posed during the interviews. The lab experiment supplied substantial insight in to student usage, opinion and expectations of the mobile application. These additional findings would not have been ascertained if it wasn't for this controlled method.

Overall the quantitative and qualitative outcomes obtained through the lab experiment and interview resulted in data which reaffirmed the findings of the literature review, provided validity for each opposing research method and most significantly supported the author's hypotheses. It was clear from the evaluation results that the utilisation of user-centred design successfully resulted in an application which was not only accepted by the students and frequently used but was also deemed as usable and relevant, proving that the selected functionality and interface design were effective and appropriate.

6.0 Discussions & Conclusions

This section will contain the final overall conclusions of the project. A brief summary of the project will be presented prior to the final discussion of the project outcomes and results. This definitive discussion will detail the author's discoveries in relation to the initial investigation and specified hypotheses. The project will be considered in relation to its limitations and the potential implications for the research area and future work.

6.1 Project Résumé

The ever increasing dissemination of mobile devices has led to the emergent research within the mobile development field. Researchers believe that mobile information systems could enhance user's daily experiences (Griswold et al. 2004) and mobile application progression has led to studies which examine the use of mobile platforms within the educational domain. The use of mobiles within education exploits the naturalistic tendencies of students towards mobile devices (Corlett et al. 2005, Holme, Sharples 2002) and a literature review was undertaken to investigate the uses of mobile applications within education, the limitations of devices, considerations which should be made in relation to design and the overall benefits of user-centred design.

The aim of this project was to examine and answer the research question:

To what extent would user-centred design methods allow a mobile application, created for use in a university as an alternative to their current information web portal, to overcome usability and acceptance issues and benefit the students in their daily tasks?

Based upon this, the project's purpose was to evaluate the extent of the impact of user-centred design on the development of a mobile application and the application's subsequent affect, positive or otherwise, on the students. This was completed by means of a develop and test project, creating a mobile guide and performing evaluations in the form of a field trial and a lab experiment. The mobile guide was developed using requirements elicited from the School of Engineering and Computing (SEC) students during focus groups and user-centred design techniques were then utilised. Once the requirements were finalised, simple paper screen designs were created and refined using feedback from a heuristic evaluation and user focus groups. These finalised screen designs were then implemented as the mobile guide was developed and deployed to the intended users. The intended audience were the students of the SEC, comprising of both male and female students who were typically aged between 18 and 25. The deployment of the guide to the student body allowed for a realistic evaluation within the intended environment. After a 30 day field trial, feedback was gathered by means of a questionnaire and eight of the field trial participants partook in further evaluative lab experiments tasks and interviews. The resultant qualitative and quantitative data, which was gathered during this necessary evaluation, significantly contributed towards the authors conclusions in relation to the initial hypotheses:

H1: A mobile guide would benefit students at the university by providing accurate information on demand and improving the information seeking process for students.

H2: The introduction of a mobile guide will improve the learning experience for its student users.

6.2 Final Discussion of Results

The main aim of this project was to ascertain the extent to which user-centred design would affect the development of a mobile application which would assist students and improve their daily activities. The examination made into the improvements that user-centred design made to the development of a mobile guide, its acceptance and perceived usefulness enveloped both the requirements analysis and design stages. A variety of results were presented in section five which detailed the outcomes of the field trial (questionnaire results) and the lab experiment (user tasks and interviews). Whilst the benefits of information access anywhere, at any time have been suggested by experts (Perry et al. 2001) student opinions and feedback certainly verified and corroborated these claims with 100% of student participants agreeing that the SEC mobile guide benefitted their daily activities. The questionnaire results clearly provided positive feedback with such finding as 44% of the participants stating that the mobile guide reduced their use, and therefore their reliance on, the university's website. This statistic was of interest as it was noted in the literature review that university websites frequently have difficulty in presenting information and studies by Ritter, Freed & Haskett (2005) have attempted to address the issue of how to present information to users. Whilst university websites provide a vital portal of information they are not readily accessible on the move and they also cause reliance issues and different access to this information is required to cater for the differing environment, user and information situations. Therefore the reduction in student use of the university website suggests that this application has successfully provided an alternate information access solution, adhering to the advice of experts.

Questionnaire Conclusions

The most significant results which emerged from the questionnaire were the use of the Likert scale to evaluate design features of the application. No negative responses (disagree or strongly disagree) were supplied by the participants in relation to questions relating to adequate data presentation and ease of use, with 44% strongly agreeing and 56% agreeing that the application was easy to use. These questions were based upon the necessity to validate if the user-centred design process overcame specific issues and it was ultimately concluded that iterative design and expert and user design evaluation were key development strategies in overcoming issues which were identified during the literature review in relation to ill defined requirements, poor interface design and ultimately user rejection. One of the questions posed to the users was intended to validate the functionality choice made during the initial focus groups, ensuring that the requirements of this project were not ill defined. The questionnaire captured the student's usage of each of the four functions. During the initial focus groups the most desired function was the free lab function, the results of the

questionnaire reflected this as it was the most frequently used function during the field trial (10 out of the 16 students rating their use as often). The least important of the desired functions was the university news function and again the related questionnaire question mirrored student opinions as 11 students rated this function as rarely used. These results therefore confirmed that accurate requirements were defined prior to the implementation. The final question within the questionnaire was used to directly attempt to verify the first hypothesis that the mobile application would benefit the students, as previously mentioned no response were provided by the students other than yes, with 44% agreeing it was very beneficial.

Lab Experiment Conclusions

The hypotheses of this project related not only to the expected benefits of a mobile application to daily tasks through the provision of information but also the overall improvements of the overall learning experience. The lab experiments aimed to provide both qualitative and quantitative data which would support each hypothesis. Section five presented the results which demonstrated the apparent success of the mobile guide in exceeding the expectations of its users and received full agreement from the student participants that the application improved their daily tasks. Whilst student opinion was vital in the evaluation it could not be presented alone and had to be verified with measurable data in the form of the lab task measurements. Completion of tasks, which related to each of the key functions of the mobile guide, provided the author with tasks which were monitored for errors, success rates, duration and number of steps. Based upon these results the author could determine that the vast improvements in task related measurements between the website and mobile guide suggested an overall improvement in the user information seeking process. Average duration time was reduced from 179 seconds to just 56 and the number of average errors fell from 3.5 to 0.5. This was a result of the utilisation of users during the identification of requirements, by employing user-centred design requirement accuracy was enhanced, interface designs were refined and improved, all of which led to the improvement of information retrieval and task completion.

The interviews, which were conducted subsequent to the task completion, resulted in extremely insightful information which would not have been obtained through the sole completion of controlled and structured lab experiments and questionnaires. The mobile application appeared to exceed the expectation of the participating students who claimed that they used it more than they anticipated and found it of more use than expected. The main benefit to the users was the dramatic reduction in time wasted trying to find a free lab and all users agreed that this alone would have been reason enough for the full introduction of the mobile application.

User-Centred Design

Overall the field study, questionnaire, lab tasks and interviews successfully provided comprehensive results which supported both hypotheses; a mobile guide would benefit students at the university by providing accurate information on demand and improving the information seeking process for students; the introduction of a mobile guide will improve the

learning experience for student users. The student opinions verified the benefits and the improvement of the learning experience, the recorded tasks improvements show the improvement in information access and the questionnaires further corroborate the user satisfaction of use, requirements and design, all of which were improved using a user-centred design approach. User-centred design has proven to be highly beneficial in the elicitation, and implementation, of accurate functionality, the refinement of the application design and the eventual evaluation of the mobile guide. This successful implementation of user-centred design also proves beneficial to the research area as a whole, past research has highlighted the need for increase application of this design strategy (Iqbal et al. 2005) in an attempt to verify its benefits and potential in future developments.

6.3 Project Limitations & Future Work

Whilst the results of this project proved to be supportive of the authors hypotheses there are factors which may have imposed limitations on the research and its associated results. The time restrictions placed upon this research resulted in the field study being limited to 30 days, clearly this project was on a small scale and limitations are expected, however they may affect the feedback and a longer term study may have uncovered further insights. The mobile application was aimed at the students within the SEC department and therefore the students used to evaluate the mobile guide were all computing and engineering students with perhaps heightened knowledge and experience of mobile applications and/or technology. The results therefore cannot be generalised for all GCU students as it is not known if non-technical students would respond as positively.

Whilst the limitations stated demonstrate the restrictions experienced during this research they also suggest further work that could be undertaken. The presentation of these results to the Glasgow Caledonian University stakeholders may encourage the utilisation of a mobile application within other departments. Based upon the findings of this project further work could be carried out creating a similar mobile guide for the university as a whole or for an alternative department. This work would then involve evaluation with a different user group, the results of which could be compared against the SEC mobile guide outcomes to determine if similar positive benefits were ascertained. A longer field trial could be undertaken in order to discover if the outcomes differed, insight increased or if, as noted by Corlett et al. (2005) user participation would decline during extended and sometimes unnecessarily long studies. For this project the evaluation methods were viewed as summative, if the project was carried on then research could be viewed as formative and further iterations, design refinement and altered/improved functions could be completed. The evaluation stage of this project highlighted the usage of the specific functions, displaying that the ‘free lab’ function was used the most whilst functions such as the ‘uni news’ were barely used. Therefore further analysis and user collaboration could help to refine and alter the functions, increasing overall usage and providing functions which may be of more use.

The area of context-aware mobile applications emerged during the literature review with papers such as Sadeh, Chan & Van (2002) demonstrating the achievements of a web based mobile campus assistant on Carnegie Mellon University's campus which successfully provided users with multiple context-aware services. Context-awareness can be categorised into location, time, activity and identity, all areas which can alter a computer system in accordance with changes in the user's environment. This area of research is not only growing in importance but also appeared to correlate with many of the research papers which the author encountered, demonstrating the corresponding areas of importance. Based upon the clear association of the two areas, an area of further work would be the introduction of context-aware functionality to the mobile guide. The mobile guide could potentially present free labs based upon the detection of the user's location using GPS or allow for student communication or interaction based upon their location and identity. The addition of context-awareness would allow the mobile guide to provide increasingly relevant data with the intention of further improving the student learning experience.

Whilst this project investigated the development of a mobile application within a Java platform, utilising user-centred design, further work could be done in alternative domains or using different development techniques. Despite iPhone platform share being identified as minimal, the development of iPhone apps is increasing and a future project may be the creation of a mobile guide for this mobile device, if adoption increases as predicted (Which? 2009). Platform share may increase and the device itself may offer additional functionality and abilities, therefore the outcome of the same project within a different technology may result in entirely different outcomes. User-centred design was the main method utilised during the development of the SEC mobile guide and future work could involved other development strategies such as model driven or rapid application development.

This project is by no means complete and the provision of additional resources would permit further research in to how this application could be best utilised, improved and, most significantly, how it can contribute towards the associated research areas.

6.4 Conclusion

This project was undertaken to discover the extent to which user-centred design would affect the development of a mobile application which could benefit Glasgow Caledonian University computing and engineering students by providing an improved information seeking tool. The application was created for use on mobile phones as an alternative to their current information web portal and was created using user-centred design methods in an attempt to overcome usability and acceptance issues and benefit the students in their daily tasks. The results which emerged from the evaluation techniques of field trials and lab experiments supported the hypotheses which stated that the mobile guide would not only be beneficial by providing accurate information on demand and improving the information seeking process but would also improve the users overall learning experience.

Despite being a small scale project with limited time and resources a multitude of activities, research and exploration was undertaken which all contributed towards the successful development and evaluation of a java based mobile guide which overcame limitations identified in the literature review. Considerations regarding device screen size, usability, relevant requirements and cost were all acknowledged, considered and verified with both expert and user evaluation and feedback. Even though solutions were found to overcome or reduce these limitations results still suggested that mobile applications still have many issues. Research has demonstrated that whilst m-learning may be beneficial to students on the move (Thornton, Houser 2004) there remain many concerns. It was found during the initial literature review that although mobile charges are continuing to decrease, cost still remains an important issue for students (Litchfield et al. 2009). This issue was considered when deciding on the implementation of selected internet based functions on the mobile guide. The internet connection costs were to be overcome by using the university's internet but the field trial and interviews showed that selected students had various issues. This required additional time and effort to connect to a different network to use live usage or RSS functions and they decided they would rather rely on the static data or not use a function at all than complete this additional exertion. In light of these factors greater consideration must be made when designing applications for a specific audience, such as students, and as relevant contemplations were made during this development regarding cost, additional studies may be required to further examine this issue.

Overall the project proved successful and the benefits were clearly demonstrated by both direct and indirect evaluation results. The achievements of this project were not only due to meticulous research and task completion but also due to the knowledge gained from previous work within the field. Research by Göker, Myrhaug (2008) depicted the necessity of ensuring there is a context match between an evaluation and the application and the author therefore ensured that all evaluation strategies, their associated elements and outcomes, were carefully selected and controlled.

User-centred design resulted in the elicitation and implementation of appropriate functionality, it assisted in the refinement and creation of efficient interface and menu designs and overall the employment of user-centred design verified the appropriateness and usability of the application. Whilst the research undertaken prior to the development noted its benefits, this project has successfully demonstrated this technique throughout each stage of the development with the evaluation methods ultimately revealing results which were evidential of the advantages of user-centred design.

This project has most significantly provided supportive research as it reflects other similar developments such as ActiveCampus (Griswold et al. 2002), a university mobile guide which intended to offer services to students at the university of San Diego California. ActiveCampus demonstrated that applications can be very successful by meeting user expectations and providing simple, relevant and unobtrusive services, achievements which the SEC mobile guide has also attained.

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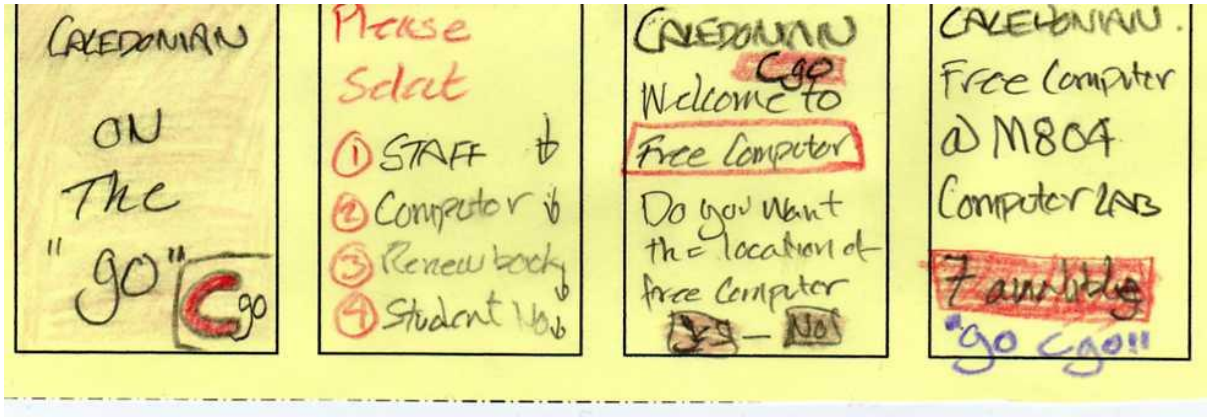
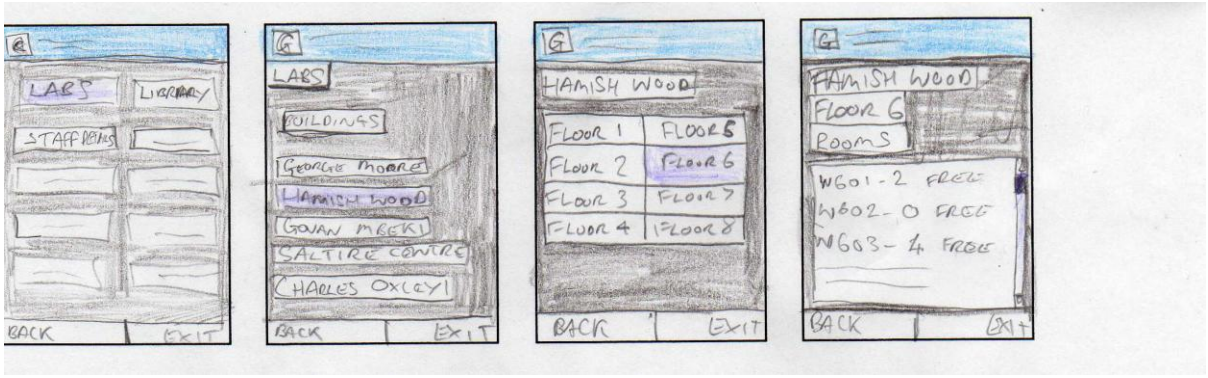
8.0 Appendices

Appendix A Paper Prototypes

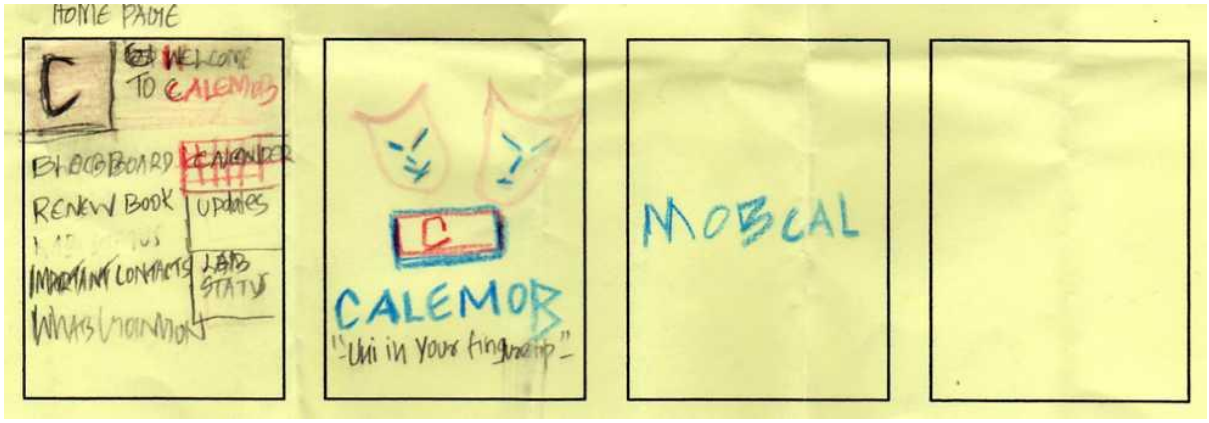
The following images are scanned paper prototypes (low-fidelity) that were designed by students during the focus groups.



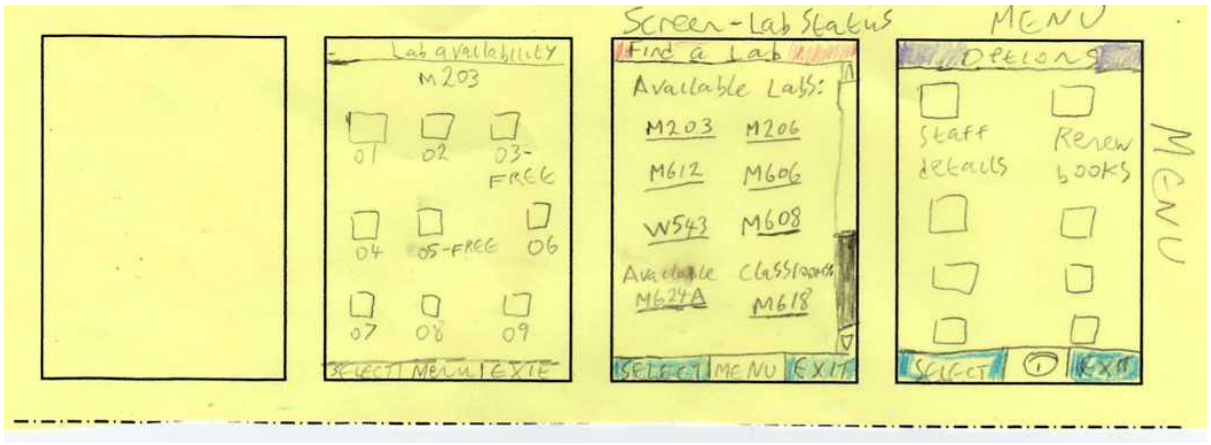
Splash screen, Main menu, Find a Computer (a)(b)



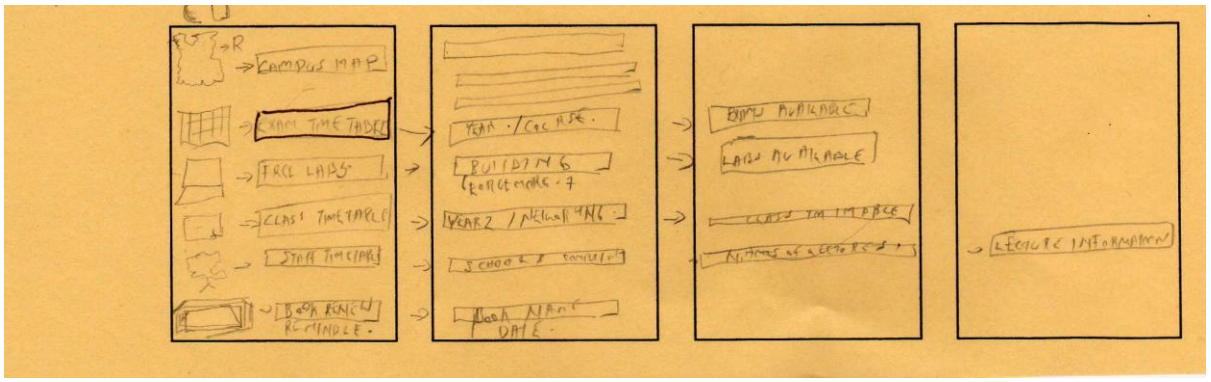
Finding a free computer



Main menu and Splash screen

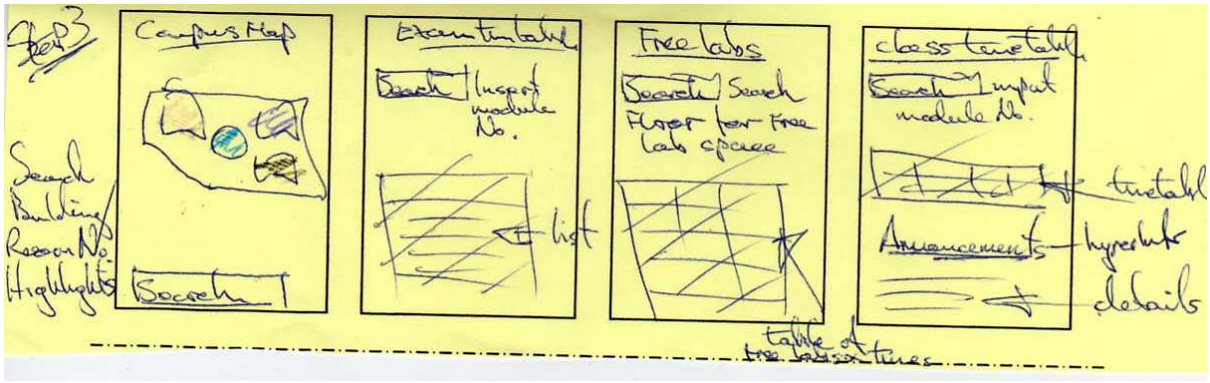


Finding a free computer

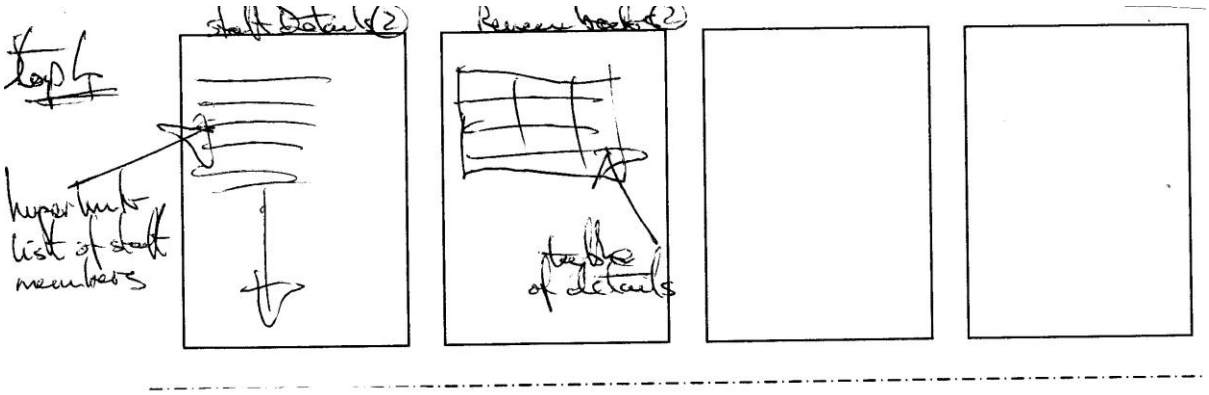


Main Menu and Exam Timetable

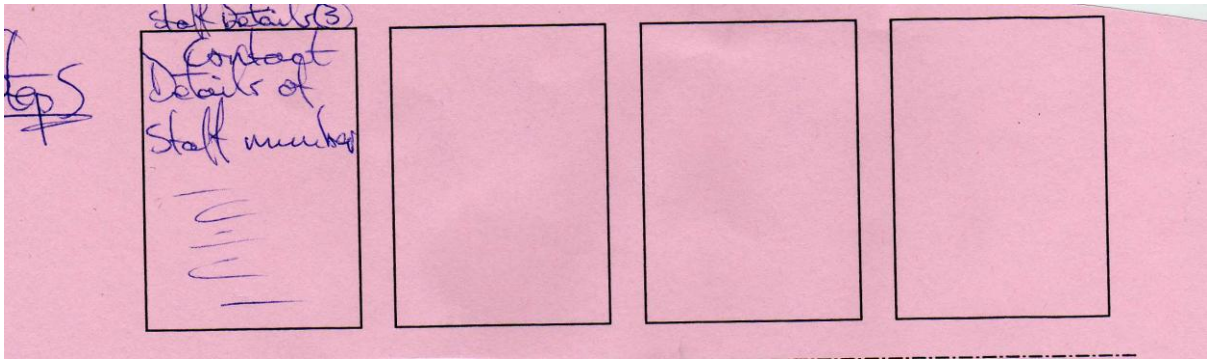
Main Screen with options and Splash Screen



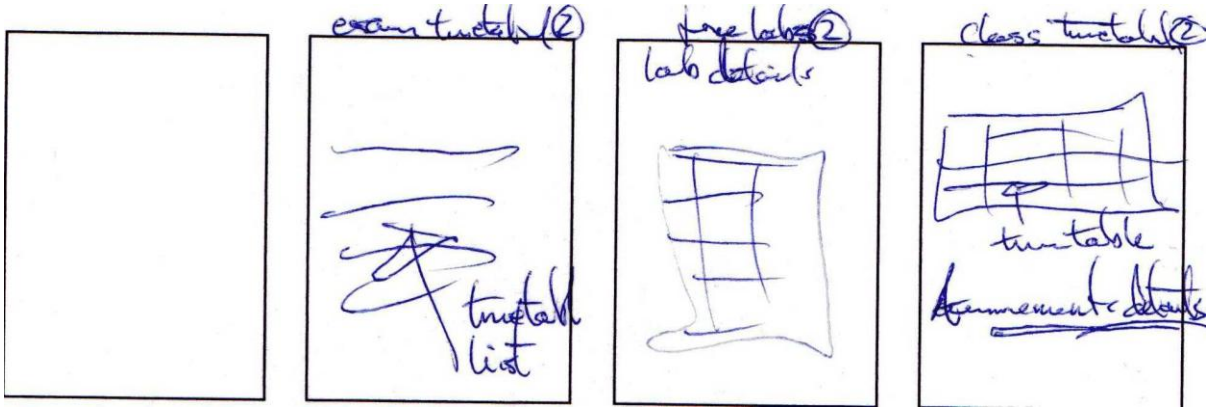
Campus map, Exam timetables, Free labs, Class timetables



Staff Details, Renew Books



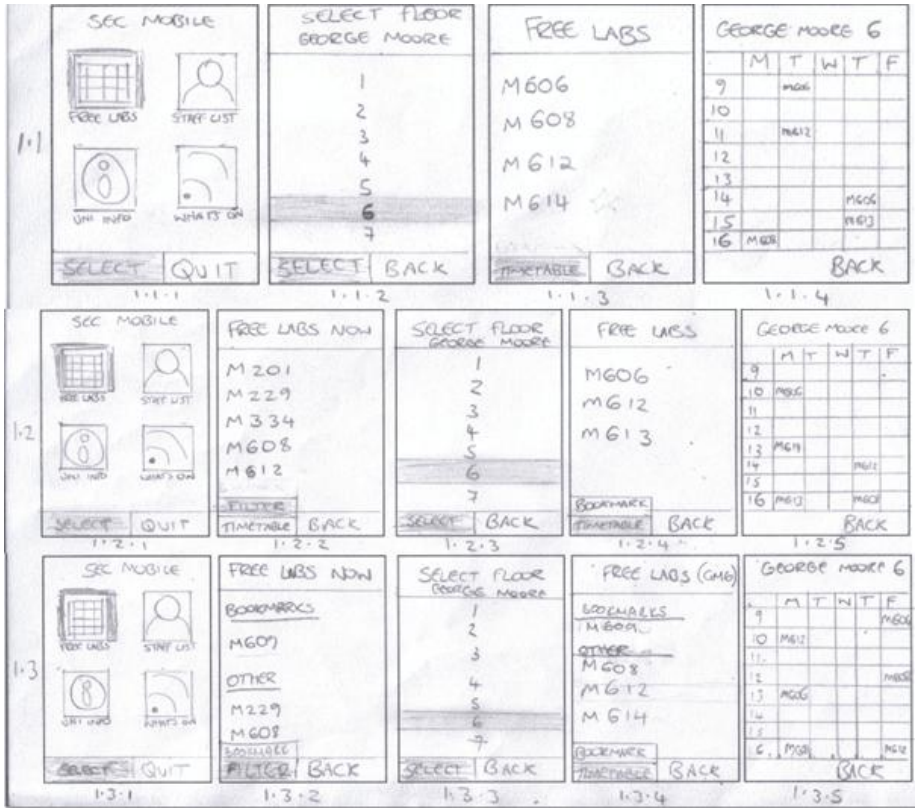
Staff Details



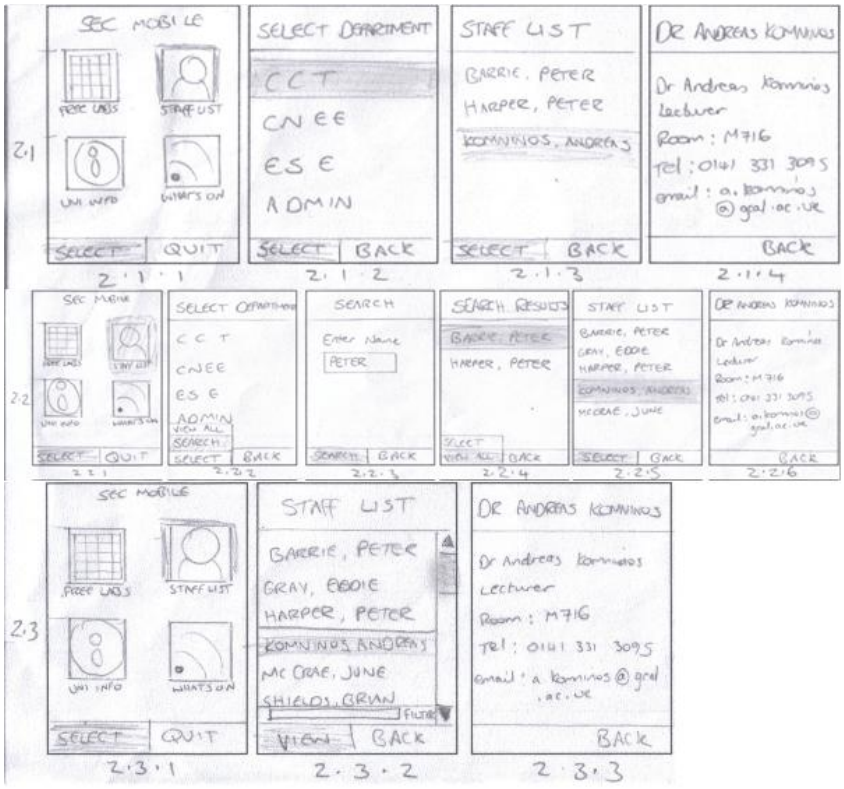
Exam Timetables, Free labs, Class Timetables

Appendix B Initial Screen Designs

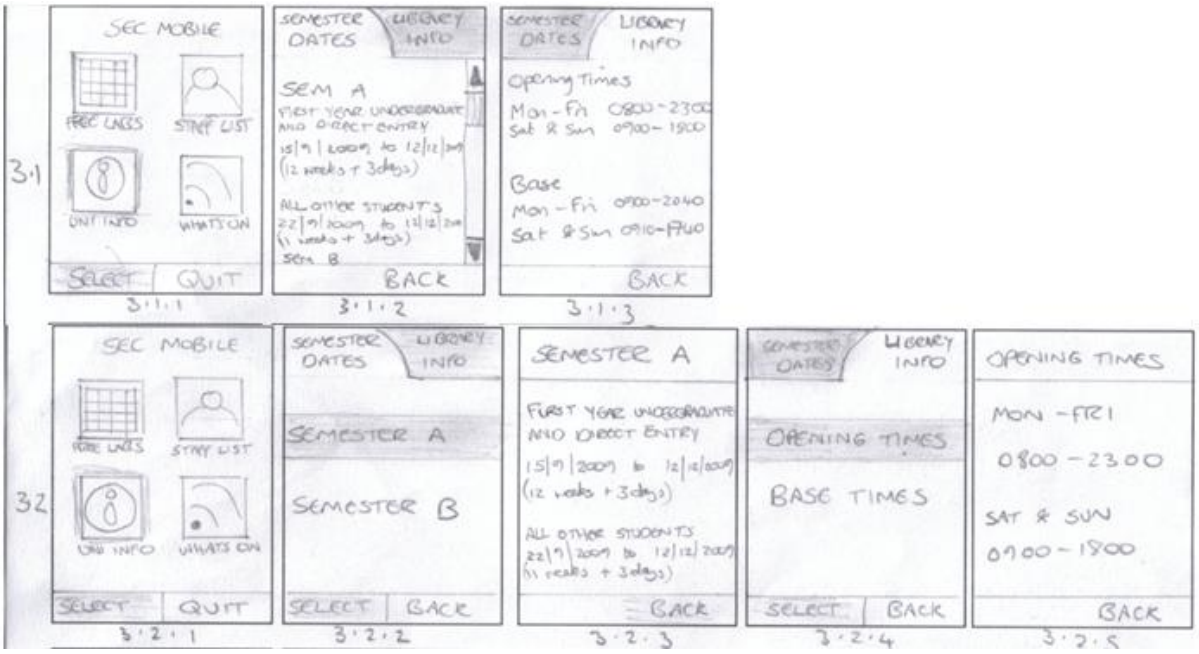
Free Lab Function



Staff List Function

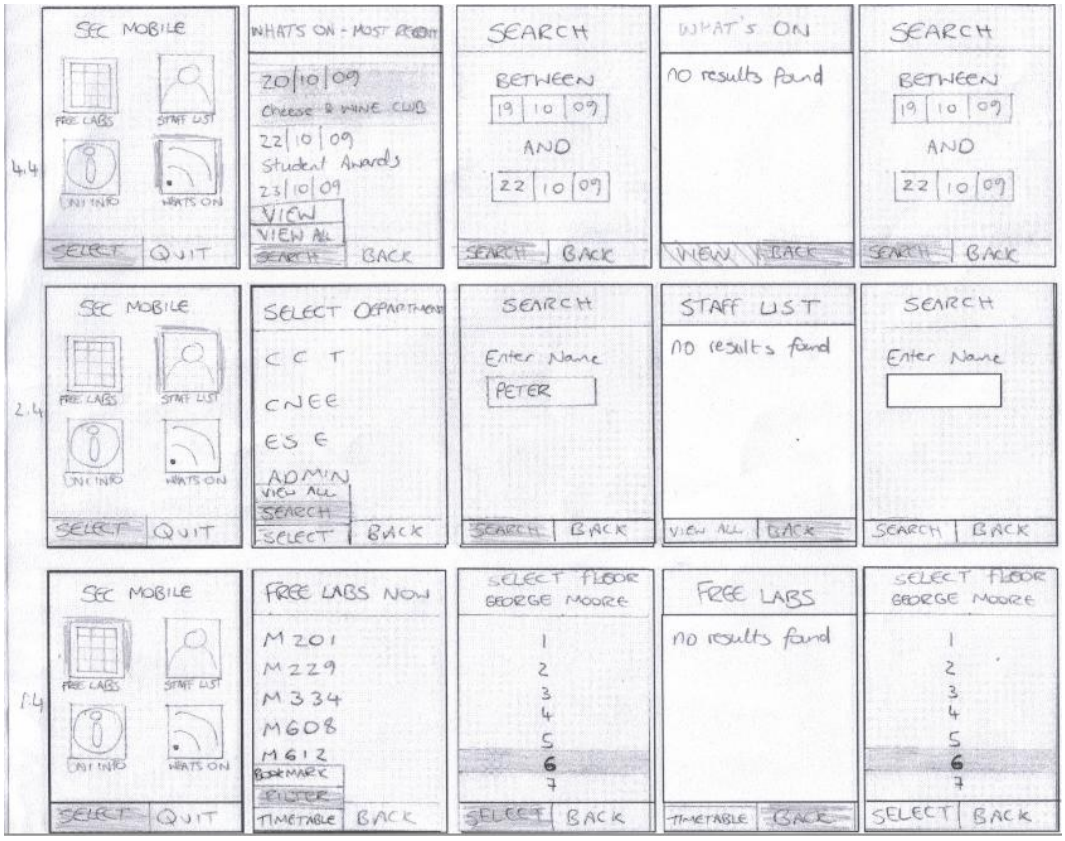


Uni Info Function



What's On Function

Alternative/Error Outcomes for Each Function



Appendix C **Heuristic Pack**

Mobile Guide – Expert Evaluation

This document includes:

1. Mobile Heuristics form – to evaluate the screens against
2. Heuristics marking table – to fill in and make comments on the screen designs
3. A navigation map (on page 5) - to help gain an understanding of the mobile applications model.
4. Screen designs labelled 1,2,3,4 and cardboard mobile phone (NOTE: there are also scenarios 1.4,2.4 & 4.4 detailing "incorrect outcomes" i.e. null results in search)
5. Detailed Information of Tasks – table outlining details of screens, user options and actions. May be used to further clarify screen designs but not essential.

Below details the numbering system used for the paper designs. Each screen strip shows an alternative design option.

Screens:

1. Tasks relating to "Free Labs"

Scenario – User wants to find a free lab on the 6th floor of the George Moore building. They also want to view the floors timetable to see availability later in the week.

2. Tasks relating to "Staff List"

Scenario – User wishes to find the contact details of a SEC staff member.

3. Tasks relating to "Uni Info"

Scenario – Student wants to view the semester and library time details.

4. Tasks relating to "What's On"

Scenario – Student wants to view events which are happening within the university.

Tasks

Step 1: Read mobile heuristics form

Step 2: View navigation map

Step 3: Using the card board prototype view and understand the paper screen designs, (using the detailed information of tasks if required).

Step 4: Evaluate the screens against the heuristics provided on the "Mobile Heuristics" form (page 2)

Mobile Heuristics

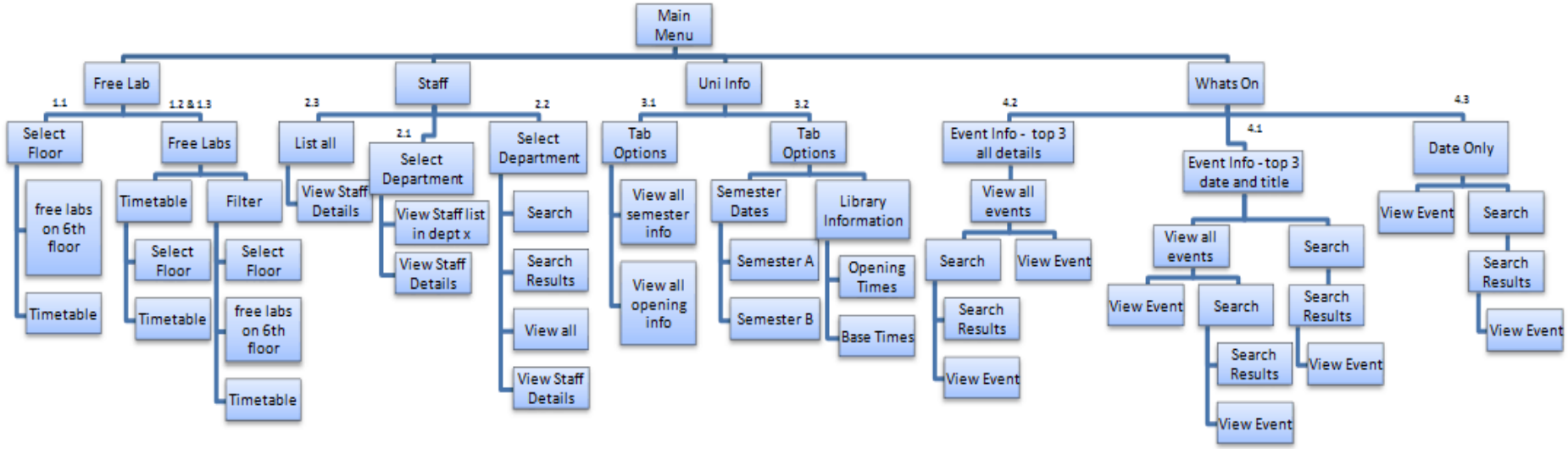
1—Visibility of system status and losability/findability of the mobile device: Keep the user informed about what is going on.
2—Match between system and the real world: present the information to the user in a natural and logical order
3—Consistency and mapping: the users conceptual model should be consistent with the context.
4—Good ergonomics and minimalist design: Screens do not contain irrelevant or rarely needed information
5—Ease of input, screen readability, and glaceability: Screen content should be easy to read and navigate through. The user should be able to quickly get the crucial information from the system by glancing at it.
6—Flexibility, efficiency of use, and personalization: Allow mobile users to tailor/personalize frequent actions, as well as to dynamically configure the system according to contextual needs
7—Aesthetic, privacy, and social conventions: Mobile interaction with the system should be comfortable and respectful of social conventions
8—Realistic error management: Shield mobile users from errors. When an error occurs messages should be plain and precise, allow user to cope gracefully.

Rating	Description
0	I don't agree that this is a usability problem at all
1	Cosmetic problem only. Need not be fixed unless extra time is available on project
2	Minor usability problem. Fixing this should be given low priority
3	Major usability problem. Important to fix, so should be given high Priority
4	Usability catastrophes. Imperative to fix this before product can be released

	Visibility of system	Match between system & the real world	Consistency and mapping	Good ergonomics and minimalist design	Ease of input, screen readability & placeability	Flexibility, efficiency of use & personalization	Aesthetic, privacy, and social	Realistic error management
Screen	**1.1**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**1.2**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**1.3**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**2.1**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**2.2**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**2.3**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Rating(0-4)								
Comment								
Screen	**3.1**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**3.2**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**4.1**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**4.2**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								
Screen	**4.3**							
Heuristic	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rating(0-4)								
Comment								

Navigation Chart



Detailed Information of Tasks

Task Number	Screen Number	Displayed	Options	User Action
1.1	1.1.1	Main menu with four options	• Select • Quit	select 'free labs'
	1.1.2	List of selectable floor numbers	• Select • Back	Scroll to floor and press select
	1.1.3	List of labs free on selected floor	• Timetable • Back	• Select timetable
	1.1.4	Timetable of all labs on selected floor	• Back	
1.2	1.2.1	Main menu with four options	• Select • Quit	select 'free labs'
	1.2.2	List of free labs on all floors	• Filter • Timetable • Back	Select filter
	1.2.3	List of selectable floor numbers	• Select • Back	Scroll to floor and press select
	1.2.4	List of labs free on selected floor	• Bookmark • Timetable • Back	Select timetable
	1.2.5	Timetable of all labs on selected floor	• Back	
1.3	1.3.1	Main menu with four options	• Select • Quit	Select 'free labs'
	1.3.2	Free labs available now with bookmark(favourite) labs listed first	• Bookmark • Filter • Back	Select filter
	1.3.3	List of selectable floor numbers	• Select • Back	Scroll to floor and press select
	1.3.4	List of labs free on selected floor	• Bookmark • Timetable • Back	Select timetable
	1.3.5	Timetable of all labs on selected floor	• Back	

Task Number	Screen Number	Displayed	Options	User Actions
2.1	2.1.1	Main menu with four options	• Select • Quit	Select 'staff list'
	2.1.2	Department options to select	• Select • Back	Scroll to department and select
	2.1.3	Staff members within selected department	• Select • Back	
	2.1.4	Staff details	• Back	
2.2	2.2.1	Main menu with four options	• Select • Quit	Select 'staff list'
	2.2.2	Department options to select	• View all • Search • Select • Back	Select search option
	2.2.3	Search Page with field for user to enter staff name	• Search • Back	Enter name and select search
	2.2.4	Search results – list of staff	• Select • View All	Select view All
	2.2.5	Staff List (all a-z)	• Select • Back	Scroll and select staff member
	2.2.6	Staff details	• Back	
2.3	2.3.1	Main menu with four options	• Select • Quit	Select 'staff list'
	2.3.2	List of all staff a-z with filter option at bottom and 3 most used at the top	• View • Back	Enter letters to filter names/ scroll and select view
	2.3.3	Staff details	• Back	

Task Number	Screen Number	User Action	Options	User Action
3.1	3.1.1	Main menu with four options	• Select • Quit	Select ‘uni info’
	3.1.2	Tabbed information – semester dates, scrollable	• Back	Press right key on handset
	3.1.3	Tabbed information – library information, scrollable	• Back	
3.2	3.2.1	Main menu with four options	• Select • Quit	Select ‘uni info’
	3.2.2	Tabbed information – list of semester dates options	• Select • Back	Scroll and press select
	3.2.3	Information of semester A dates	• Back	Select back and press right key on handset
	3.2.4	Tabbed information – library information list of two options	• Select • Back	Scroll and press select
	3.2.5	Opening time information	• Back	

Task Number	Screen Number	Displayed	Options	User Action
4.1	4.1.1	Main menu with four options	• Select • Quit	Select ‘whats on’
	4.1.2	3 most recent events – date and title	• View • View all • Search • Back	Select view all
	4.1.3	All events, scrollable	• View • Search • Back	Select search
	4.1.4	2 date fields to search between	• Search • Back	Enter dates and select search
	4.1.5	Search results	• View • Back	Scroll and select event
	4.1.6	Individual Event information	• Back	
4.2	4.2.1	Main menu with four options	• Select • Quit	Select ‘whats on’
	4.2.2	3 most recent events – date, title and information	• View • View all • Search • Back	Select view all
	4.2.3	All events - – date, title and information, scrollable	• View • Search • Back	Select search
	4.2.4	2 date fields to search between	• Search • Back	Enter dates and select search
	4.2.5	Results of events – date, title and information, scrollable	• Back	
4.3	4.3.1	Main menu with four options	• Select • Quit	Select ‘whats on’
	4.3.2	All events – date only	• View • Search • Back	Select view
	4.3.3	Individual Event information	• Back	Select back and then search
	4.3.4	2 date fields to search between	• Search • Back	Enter dates and select search
	4.3.5	Search results	• View • Back	Scroll and select event
	4.3.6	Individual Event information	• Back	

Appendix D Heuristic Expert Feedback

1.1

1	2	3	4	5	6	7	8
3	0	2	0	1	0	0	0

COMMENTS

1. One wonders what I would uncover selecting 'Uni Info'. Is SEC not a sub-category of Uni Info? All options will reveal uni info, so this seems a miscellaneous heading.
2. 'what's on' not mapping easily with icon. Why not go with 'social radar'?
3. The timetable has a number of confusing elements:
   i. I was expecting to see a timetable for the lab, not the floor
   ii. Not clear if labs are busy or free if shown in the timetable

1.2

1	2	3	4	5	6	7	8
3	2	2	2	1	0	0	0

COMMENTS

1. One wonders what I would uncover selecting 'Uni Info'. Is SEC not a sub-category of Uni Info? All options will reveal uni info, so this seems a miscellaneous heading.
2. By having more than 2 navigation menu items (Filter / Select / Back) it is not easy to see how one might choose between them. I presume up/down scrolls through the labs, so what do I need to press to get the 'extra' navigation option?
3. The sudden identification of George Moore on screen 1.2.3 suggests that you have data for different buildings.
4. The timetable has a number of confusing elements:
   i. I was expecting to see a timetable for the lab, not the floor
   ii. Not clear if labs are busy or free if shown up in the timetable
   iii. What would you see if you select Timetable at 1.2.2? A timetable for the whole building, or would it start from Level 1?
5. The bookmark option on 1.2.4 is unclear. Am I bookmarking a screen, a floor, or a lab?

1.3

1	2	3	4	5	6	7	8
3	2	2	2	1	0	0	0

COMMENTS

1. The word 'Filter' is a little too technical. Would *'Floor?'* not be better?
2. By having more than 2 navigation menu items (Filter / Select / Back) it is not easy to see how one might choose between them. I presume up/down scrolls through the labs, so what do I need to press to get the 'extra' navigation option?
3. Do all bookmarks show on screen 1.2.2, or just bookmarked labs that are currently available? You can work it out if you think about it, but as a user I don't want to think about it. Maybe just have bookmarked labs appear at the top of a single list, rather than having two lists. Do they need to be marked as being bookmarked?
4. The timetable has a number of confusing elements:
   i. I was expecting to see a timetable for a chosen lab, not the floor
   ii. Not clear if labs are busy or free if shown up in the timetable

1.4

1	2	3	4	5	6	7	8
3	2	2	2	1	0	0	0

COMMENTS

1. Too many navigation options.
2. Not clear what Timetable would give me on 1.4.2. By floor, room, or building?
3. What would Bookmark give me on 1.4.2? Free labs filtered by bookmark, or an option to bookmark a lab?
4. Not clear what Timetable would give me on 1.4.4, as there are no labs available. Why have it available as an option.

2.1

1	2	3	4	5	6	7	8
0	0	0	0	2	0	0	0

COMMENTS

1. Do students understand the terms and categories offered on 2.1.2?

2.2

1	2	3	4	5	6	7	8
3	3	3	3	2	0	0	0

COMMENTS

1. Given the data presented on screen, *search* option on 2.2.2 would suggest that the user was searching for a department, not a member of staff. Same for *ViewAll*.
2. By having more than 2 navigation menu items (View All/ Search / Select) it is not easy to see how one might choose between them. I presume up/down scrolls through the departments, so what do I need to press to get the 'search' option?
3. the hassle of data input on the phone, I guess users will most likely prefer scroll over search

2.3

1	2	3	4	5	6	7	8
0	0	0	2	0	0	0	0

COMMENTS

1. I have difficulty understanding the filter comment on 2.3.2. Is this something the user can control?
2. why waste screen real estate on a scroll bar? Is the Rollerdex metaphor a little cleaner?

2.4

1	2	3	4	5	6	7	8
3	3	3	3	2	0	0	0

COMMENTS

1. Given the data presented on screen, *search* option on 2.2.2 would suggest that the user was searching for a department, not a member of staff. Same for *ViewAll*.
2. *Search* on 2.4.2 provides a different result to choosing *Search* on 2.4.3

3.1

1	2	3	4	5	6	7	8
0	1	0	0	0	0	0	0

COMMENTS

1. Not clear what one would expect to see under Uni Info. It seems to be about opening times - either as a semester, or as a library. Is there a clearer phrasing?

3.2

1	2	3	4	5	6	7	8
0	1	0	0	0	0	0	0

COMMENTS

1. Too many screens to navigate. 3.1 is a cleaner approach.

Appendix E Design Focus Group Plan

Mobile Guide Design Evaluation Focus Groups

Opening talk

Thank you for attending this focus group.
As stated in the email, the purpose of this workshop is to get student views on the designs for a new mobile application that is being developed. The software in question is a mobile assistant, which is aimed to assist students whilst at university to make life daily tasks easier.

The focus group will last approximately an hour and will run as follows:

- Brief introduction to application concept – 5mins
- Discuss groups mobile use and daily tasks in university – 10mins
- Invite participants to analyse university website, use for the related tasks – 10mins
- Present students with screen designs options, explain/walkthrough – 10mins
- Discussion of good and bad points – 10mins
- Decide on chosen design – 10mins
- Debriefing – 5mins

Ethics

Everything said and done is confidential and will not be used outside of the room except for the purposes of the research.
Every statement is right, there are no wrong answers.
Please do not hesitate to disagree with any statements made.
Please do not speak at once.
You can leave at any point during the focus group.

5 W's

Who

- Designed for
- Would use it

What

- Is it
- Does it do
- Should it do

When

- Could it be used

Why

- Use it at all
- Is it better than the site / hard copy – is it worth having it?

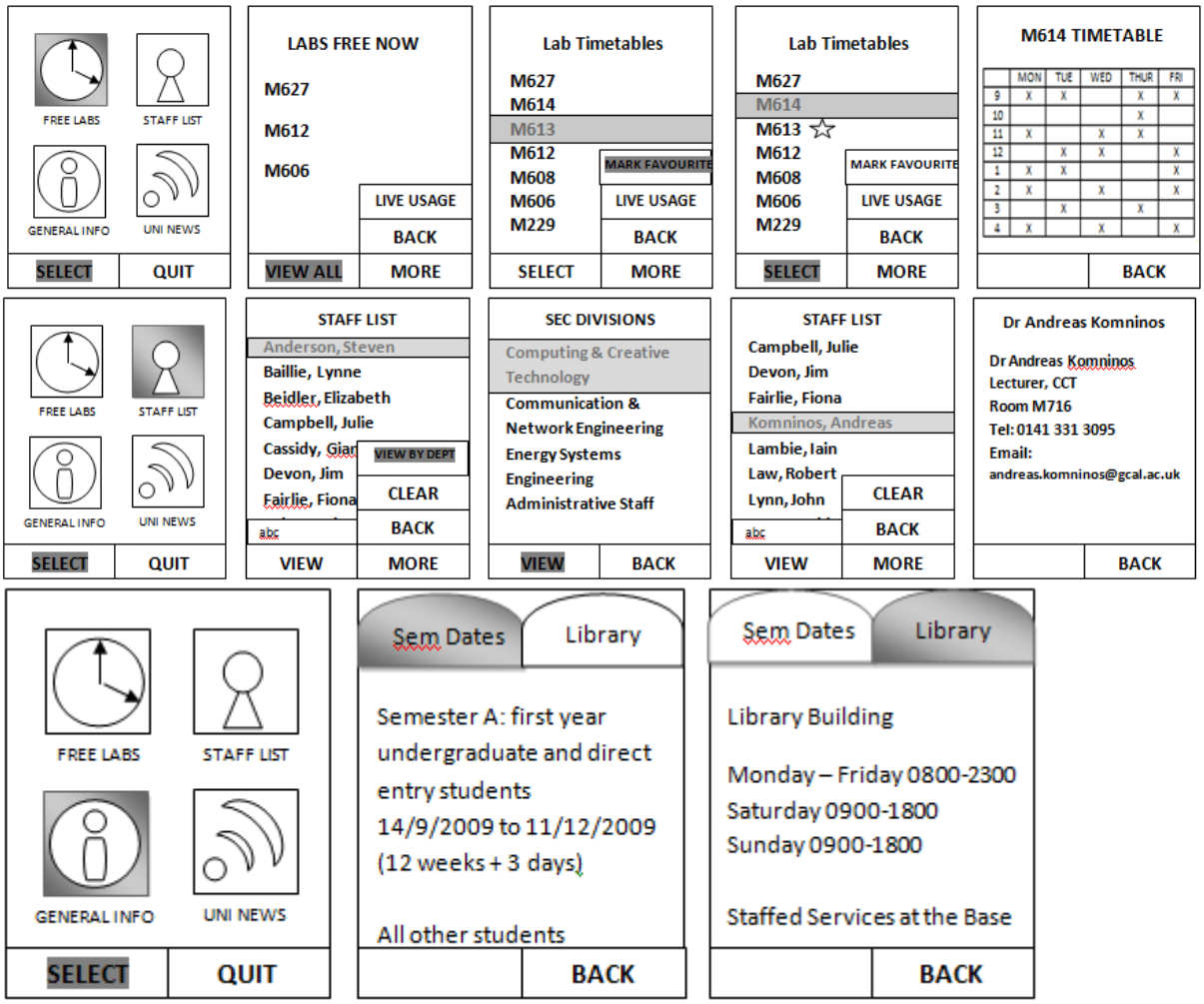
How

- To use it

Student questions

- What course are you on?
- Out with timetabled hours, how often are you in university?
- What do you use the university website for?
- Are you aware that you can obtain staff details and free lab information on the university website? Do you use these resources?
- How many steps would you be happy with taking to gain information?
- Are you aware of the SEC departments?
  - Computing & Creative Technologies
  - Communication, Network & Electronic Engineering
  - Energy Systems Engineering

Appendix F Finalised Designs



Appendix G Code Listings

MENUMIDLET.JAVA

```
/*
 * This file is part of J2ME Polish.
 *
 * J2ME Polish is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License as published by
 * the Free Software Foundation; either version 2 of the License, or
 * (at your option) any later version.
 *
 * J2ME Polish is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even the implied warranty of
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
 * GNU General Public License for more details.
 *
 * You should have received a copy of the GNU General Public License
 * along with J2ME Polish; if not, write to the Free Software
 * Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA  02111-1307  USA
 *
 * Commercial licenses are also available, please
 * refer to the accompanying LICENSE.txt or visit
 * http://www.j2mepolish.org for details.
 */
package de.enough.polish.sample.accessible;

import javax.microedition.lcdui.*;
import javax.microedition.midlet.MIDlet;
import javax.microedition.midlet.MIDletStateChangeException;
import java.util.Vector;
import java.util.Enumeration;
import java.util.Date;
import java.util.Calendar;
import de.enough.polish.util.Locale;
import de.enough.polish.ui.FilteredList;
import de.enough.polish.ui.TabbedForm;
import de.enough.polish.ui.TableItem;
import de.enough.polish.browser.rss.RssBrowser;

import org.kxml2.io.KXmlParser;
import org.xmlpull.v1.XmlPullParser;
import java.io.InputStream;
import java.io.InputStreamReader;

import javax.microedition.rms.RecordEnumeration;
import javax.microedition.rms.RecordStore;

//Author: Andreas Komninos, Jessica Rabbit
//#ifdef polish.debugEnabled
//# import de.enough.polish.util.Debug;
//#endif


public class MenuMidlet extends MIDlet implements CommandListener {

    //creation of required variables
    SplashScreen splash = new SplashScreen();
    List menuScreen;
    FilteredList staffList, allStaffList;
```

```
List labList, divisionList, rssList, liveLabList, freeLabs;
Alert staffDetails;
Alert liveLabs;
Form labDetails;
Vector thestaff = new Vector();
Vector thelabs = new Vector();
 Vector labs = new Vector();
TabbedForm info;
Form rssForm;
RssBrowser rssBrowser;
private int from=0; //determines to which screen the back command goes to
RecordStore rs;
RecordStore favRs;
RecordStore newLabsRs;
Date date = new Date();
int x=1;
RecordEnumeration recordEnumeration;
private Filter filter;
boolean labsAreLoaded = false;
static final String REC_STORE = "NewLabs";

        //creation of required commands
        Command quitCmd = new Command( Locale.get("cmd.Quit"), Command.EXIT, 10 );
        Command chooseCmd = new Command ("Select", Command.OK, 1);
Command backCmd = new Command("Back", Command.BACK, 10);
Command rssListBack = new Command ("RSS list", Command.BACK, 10);
Command viewStaffCmd = new Command("View", Command.OK, 1);
Command viewLabCmd = new Command("View Timetable", Command.OK, 1);
Command viewAllLabCmd = new Command("View All Labs", Command.OK, 1);
Command viewFreeLabCmd = new Command("View Free Labs", Command.OK, 1);
Command liveOk = new Command("", Command.OK, 1);
Command creditsCmd = new Command("About", Command.OK, 9);
Command liveLabCmd = new Command ("Live Usage", Command.OK, 9);
Command reloadLiveLabCmd = new Command ("Refresh", Command.OK, 9);
Command searchCmd = new Command ("Search", Command.OK, 9);
Command viewDept = new Command ("View By Dept", Command.OK, 9);
Command favouriteCmd = new Command ("Mark Favourite", Command.OK, 9);
Command yesCommand = new Command ("yes", Command.OK, 9);
Command noCommand = new Command ("no", Command.OK, 9);

        Display display;

//Author: Andreas Komninos, Jessica Rabbit
        public MenuMidlet() {
                super();

      //creation of required lists and forms, associating each with a style
      //#style staffList
                allStaffList = new FilteredList("All Staff List", Choice.IMPLICIT);
      allStaffList.addCommand(backCmd);
      allStaffList.addCommand(viewStaffCmd);
      allStaffList.addCommand(viewDept);
      this.allStaffList.setCommandListener(this);

      //#style staffList
                staffList = new FilteredList("Staff List", Choice.IMPLICIT);
      staffList.addCommand(backCmd);
      staffList.addCommand(viewStaffCmd);
      this.staffList.setCommandListener(this);

      //#style labTableScreen
```

```
        labDetails = new Form("");
        labDetails.setCommandListener(this);
        labDetails.addCommand(backCmd);

        //#style staffList
        labList = new List("Lab Timetables", Choice.IMPLICIT);
        labList.setSelectCommand(viewLabCmd);
        labList.addCommand(favouriteCmd);
        labList.addCommand(backCmd);
//          labList.addCommand(viewFreeLabCmd);
        labList.addCommand(liveLabCmd);
        this.labList.setCommandListener(this);

         //#style staffList
        freeLabs = new List("Labs Free Now ", Choice.IMPLICIT);
        freeLabs.setSelectCommand(viewAllLabCmd);
        freeLabs.addCommand(viewAllLabCmd);
        freeLabs.addCommand(backCmd);
        freeLabs.addCommand(liveLabCmd);
        this.freeLabs.setCommandListener(this);

         //#style staffList
        divisionList = new List("SEC Divisions", Choice.IMPLICIT);
        divisionList.append("Computing & Creative Technology", null);
        divisionList.append("Commmunication & Network Engineering", null);
        divisionList.append("Energy Systems Engineering", null);
        divisionList.append("Administrative Staff", null);
        divisionList.addCommand(backCmd);
        this.divisionList.setCommandListener(this);

        //#style staffList
        this.liveLabList= new List("Live Lab Usage", Choice.IMPLICIT);
        this.liveLabList.addCommand(liveOk);
        this.liveLabList.addCommand(reloadLiveLabCmd);
        this.liveLabList.addCommand(backCmd);
        this.liveLabList.setCommandListener(this);

        //creation of main menu and the associated menu options (4 main functions)
        //#style mainScreen
                    this.menuScreen = new List("SEC Mobile", List.IMPLICIT);
                    //#style mainItem
                    this.menuScreen.append("Lab Timetables", null);
                    //#style mainItem
                    this.menuScreen.append("Staff List", null);
                    //#style mainItem
                    this.menuScreen.append("General Info", null);
        ////#style mainItem
                    ///this.menuScreen.append("Our Courses", null);
        //#style mainItem
                    this.menuScreen.append("Uni News", null);
                    ////#style mainItem
                    //this.menuScreen.append("Quit", null);
        this.menuScreen.setSelectCommand(chooseCmd);
                    this.menuScreen.addCommand( this.quitCmd );
        this.menuScreen.addCommand(creditsCmd);
                    this.menuScreen.setCommandListener(this);

        String[] tabnames = {"Sem.Dates", "Library", "Contact"};
        //creation of tabbed screen and options for general info function
        //#style infoScreen
        info=new TabbedForm("University Information", tabnames, null);
```

```
        info.append(0, new StringItem(null, readSimpleText("/semdates.txt")));
        info.append(1, new StringItem(null, readSimpleText("/library.txt")));
        info.append(2, new StringItem(null, readSimpleText("/contact.txt")));
        info.addCommand(backCmd);
        info.setCommandListener(this);


        //creation of Rss list, form and browser required for uni news function
        //#style staffList
        rssList = new List("Choose RSS feed", List.IMPLICIT);
        rssList.addCommand(backCmd);
        rssList.setCommandListener(this);
        rssList.append("GCU News", null);
        rssList.append("Events", null);

        rssForm= new Form("GCU News");
        //#style rssBrowser
        rssBrowser = new RssBrowser();
        rssForm.append(rssBrowser);
        rssForm.addCommand(rssListBack);
        rssForm.setCommandListener(this);

                        //#debug
                        System.out.println("initialisation done.");
          }

    //Author: Andreas Komninos, Jessica Rabbit
            protected void startApp() throws MIDletStateChangeException {
                        //#debug
                        System.out.println("setting display.");

        this.display = Display.getDisplay(this);
                        splash.setFullScreenMode(true);
        this.display.setCurrent(splash);
        try{
          //shows splash screen for 2 seconds before displaying menu
          Thread.sleep(2000);

          this.display.setCurrent( this.menuScreen );

       rs = RecordStore.openRecordStore("log",true,1, true);

        }
        catch (Exception e)
        {

        }

         addtolog("<launch time=");
          }

          protected void pauseApp() {
                        // ignore
          }

          protected void destroyApp(boolean unconditional) throws MIDletStateChangeException {
                        // just quit
                    addtolog("</launch time=");
          }
    //function which controls the actions to be taken when commands are selected,
    //dependent on the currently displayed screen
```

```
//Author: Jessica Rabbit
        public void commandAction(Command cmd, Displayable screen) {
                if (screen == this.menuScreen)
    {
                        if (cmd == chooseCmd) {
                                int selectedItem = this.menuScreen.getSelectedIndex();
                                switch (selectedItem) {
                                        case 0:
                    addtolog("<section name=free labs time=");
                    showFreeLabs();
                    break;
                                        case 1:
                    loadStaffList(allStaffList, thestaff, "/allStaff.txt");
                    this.display.setCurrent(allStaffList);
                    addtolog("<section name=contact list time=");
                    break;
                                        case 2:
                    this.display.setCurrent(info);
                    addtolog("<section name=uni info time=");
                    break;
                case 3:
                    this.display.setCurrent(rssList);//news
                    addtolog("<section name=news time=");
                    break;
                                        default:
                    addtolog("</launch time=");
                    notifyDestroyed();
                                }
                        } else if (cmd == this.quitCmd) {
          quit();
                        }
        else if(cmd==this.creditsCmd)
        {
          try{
            Image i =Image.createImage("/mucomsm.png");
            Alert a = new Alert("About...", "SEC Mobile v1.0.1\n(c)2009 \nMobile & Ubiquitous Computing Group" +
                "\nhttp://www.mucom.mobi", i, AlertType.INFO);
            a.setTimeout(Alert.FOREVER);
            this.display.setCurrent(a);
          }
          catch(Exception e)
          {
          }

        }
                }
    if(screen==this.allStaffList)
    {
      if(cmd==viewStaffCmd)
      {
        showStaff(allStaffList.getSelectedIndex());
      }
      if(cmd==viewDept)
      {
        this.display.setCurrent(divisionList);
      }
      if (cmd.getCommandType()==Command.BACK)
      {
        this.display.setCurrent(menuScreen);
        addtolog("</section time=");
      }
```

```
}
if (screen==this.staffList)
{
   if (cmd.getCommandType()==Command.BACK)
   {
      this.display.setCurrent(divisionList);
   }
   if (cmd==viewStaffCmd)
   {
      showStaff(staffList.getSelectedIndex());
   }
}
if(screen==this.freeLabs)
{
   if (cmd==viewAllLabCmd)
   {
       //loadLabs();
      this.display.setCurrent(labList);
   }
   if (cmd.getCommandType()==Command.BACK)
   {
      this.display.setCurrent(menuScreen);
      addtolog("</section time=");
      try{rs.closeRecordStore();}catch(Exception e){}
   }
   if(cmd==liveLabCmd)
   {
      checkLiveLabs();
   }
}
if(screen==this.labList)
{
   if (cmd==favouriteCmd)
   {
      markFavourite(labList.getString(labList.getSelectedIndex()),labList.getSelectedIndex());
      loadLabs();
   }
   if (cmd.getCommandType()==Command.BACK)
   {
     showFreeLabs();
   }
   if (cmd==viewLabCmd)
   {
     getIndex(labList.getString(labList.getSelectedIndex()));

      from = 0; //i.e. when back pressed, go back to the static timetable list
   }

   if(cmd==liveLabCmd)
   {
      checkLiveLabs();
   }
}
if(screen==this.liveLabList)
{
   if(cmd.getCommandType()==Command.BACK)
   {
      this.display.setCurrent(labList);
   }
  if(cmd.getCommandType()==Command.OK){getIndex(liveLabList.getString(liveLabList.getSelectedIndex()));}
   if (cmd==reloadLiveLabCmd)
```

```
    {
      liveLabList.deleteAll();
      checkLiveLabs();
    }
  }
  if(screen==this.labDetails)
  {
    if (cmd.getCommandType()==Command.BACK)
    {
      if (from ==0)
      {
        this.display.setCurrent(labList);
      }
      else
      {
        this.display.setCurrent(liveLabList);
      }
    }
  }
  if (screen==this.info)
  {
    if (cmd.getCommandType()==Command.BACK)
    {
      this.display.setCurrent(menuScreen);
      addtolog("</section time=");
    }
  }
  if(screen==divisionList)
  {
    if (cmd==divisionList.SELECT_COMMAND)
    {
      switch (divisionList.getSelectedIndex())
      {
        case 0:
          loadStaffList(staffList, thestaff, "/cct.txt");
          this.display.setCurrent(staffList);
          break;
        case 1:
          loadStaffList(staffList, thestaff, "/cnee.txt");
          this.display.setCurrent(staffList);
          break;
        case 2:
          loadStaffList(staffList, thestaff, "/ese.txt");
          this.display.setCurrent(staffList);
          break;
        case 3:
          loadStaffList(staffList, thestaff, "/admin.txt");
          this.display.setCurrent(staffList);
          break;
        default:
          break;
      }
    }
    if (cmd.getCommandType()==Command.BACK)
    {
      this.display.setCurrent(allStaffList);
    }

  }
  if(screen==rssList)
  {
```

```
            if (cmd==List.SELECT_COMMAND)
            {
              Alert alert = new Alert("Warning", "Connection to web is required!\n Do you want to allow connection?",null,null);
               alert.setTimeout(Alert.FOREVER);
               alert.setType(AlertType.CONFIRMATION);
               alert.addCommand(yesCommand);
               alert.addCommand(noCommand);
               alert.setCommandListener(this);
               display.setCurrent(alert);
            }
            if (cmd.getCommandType()==Command.BACK)
            {
               this.display.setCurrent(menuScreen);
               addtolog("</section time=");
            }
         }
         if(cmd==yesCommand)
            {
               switch (rssList.getSelectedIndex())
               {
                  case 0:
                     rssBrowser.go("http://www.caledonian.ac.uk/newsevents/feeds/feeds.php?s=fnynunrnbninansntnpn");
                     break;
                  case 1:
                     rssBrowser.go("http://www.caledonian.ac.uk/newsevents/feeds/feeds.php?s=feyeuerebeieaesete");
                     break;
                  default:
                     break;
               }
               this.display.setCurrent(rssForm);
            }
            if(cmd==noCommand)
            {
               this.display.setCurrent(menuScreen);
            }

         if(screen==rssForm)
         {
            if (cmd==rssListBack)
            {
               this.display.setCurrent(rssList);
            }
         }
            }

      //function which loads list of staff
      //takes parameters of list to be populated with the first and surname of staff,
      //vector the data is to be added to which can be displayed when list item is selected
      //and the resource file which contains string in xml format
      //Author: Andreas Komninos
            private void loadStaffList(FilteredList fl, Vector v, String resource)
      {
         fl.deleteAll();
         v.removeAllElements();
         KXmlParser p = new KXmlParser();
         InputStream is;

         try{
            is=getClass().getResourceAsStream(resource);
            p.setInput(new InputStreamReader(is));
            p.nextTag();
```

```
            p.require(XmlPullParser.START_TAG, null, "staff");
            while(p.nextTag()!= XmlPullParser.END_TAG)
            {
               p.require(XmlPullParser.START_TAG, null, "staffmember");
               Staff s1 = new Staff();
               while(p.nextTag()!=XmlPullParser.END_TAG)
               {
                  p.require(XmlPullParser.START_TAG, null, null);

                  String tagname = p.getName();
                  String text = p.nextText();
                  System.out.println(tagname+":"+text);

                  if (tagname.equals("title"))
                     s1.title = text;
                  else if (tagname.equals("name"))
                     s1.name=text;
                  else if (tagname.equals("surname"))
                     s1.surname = text;
                  else if (tagname.equals("post"))
                     s1.post= text;
                  else if (tagname.equals("division"))
                     s1.division =text;
                  else if (tagname.equals("telephone"))
                     s1.telephone=text;
                  else if (tagname.equals("email"))
                     s1.email=text;
                  else if (tagname.equals("room"))
                     s1.room=text;
                  else if (tagname.equals("image"))
                     s1.image=text;

                  p.require(XmlPullParser.END_TAG, null, tagname);
               }
               p.require(XmlPullParser.END_TAG, null, "staffmember");
               v.addElement(s1);
               //fl.append(s1.returnFullName(), null);
            }
            p.require(XmlPullParser.END_TAG, null, "staff");

            //sort vector
            sortList(v);
            //populate screen
            for (int h=0;h<v.size(); h++)
            {
               Staff b = (Staff)v.elementAt(h);
               fl.append(b.surname+", "+b.name, null);
            }
         }
         catch (Exception e)
         {
            e.printStackTrace();
         }
           }
   //displays staff details as an alert, uses list item index to reference staff details
   //uses Staff class and returnDetails() method within Staff.java
   //Author: Andreas Komninos
   private void showStaff(int index)
   {
      Staff s = (Staff)thestaff.elementAt(index);
```

```
    staffDetails = new Alert(s.title+" "+s.name+" "+s.surname);
    staffDetails.setType(AlertType.INFO);
    staffDetails.setTimeout(Alert.FOREVER);
    staffDetails.setString(s.returnDetails());
    this.display.setCurrent(staffDetails);
}


//uses LabReader class to obtain, process and display live lab usage
//Author: Andreas Komninos
private void liveLabs()
{
   {
      try{
      LabReader lr = new LabReader(this);
      Thread lrt = new Thread(lr);
      lrt.start();
      }
      catch (Exception e)
      {

      }
   }
      this.display.setCurrent(liveLabList);
}

//method to load static lab details
//checks for favourite labs and displays list items with/without favourite image accordingly
//Author: Jessica Rabbit
private void loadLabs()
{
      KXmlParser p = new KXmlParser();
      InputStream is;
      Image star=null;
      List favList,nonFavList;
      favList = new List("favList", Choice.IMPLICIT);
      nonFavList = new List("nonFavList", Choice.IMPLICIT);
      thelabs.removeAllElements();

      try
      {
         star = Image.createImage("/star.png");
      }
      catch(Exception e){System.out.println("image didnt work");}
      try
      {
         //delete list items from previous use
      labList.deleteAll();
      favList.deleteAll();
      nonFavList.deleteAll();
      }
      catch(Exception e){System.out.println("delete didnt work");}
      try{
         //processes xml data
            is=getClass().getResourceAsStream("/labs.txt");
            p.setInput(new InputStreamReader(is));
            p.nextTag();

            p.require(XmlPullParser.START_TAG, null, "labs");
            while(p.nextTag()!= XmlPullParser.END_TAG)
            {
```

```
p.require(XmlPullParser.START_TAG, null, "lab");
Lab l1 = new Lab();

while(p.nextTag()!=XmlPullParser.END_TAG)
{
   p.require(XmlPullParser.START_TAG, null, null);
   String tagname = p.getName();

   if (tagname.equals("name"))
   {
      l1.name = p.nextText();
      //check if lab is  a favourite and if it is then adds to favList
      //else adds it to the nonFavList
     if(checkFavourite(l1.name)==true)
     {
         favList.append(l1.name, star);
         System.out.println("check favourite =true so add to fav list"+l1.name);
     }
     else
     {
        nonFavList.append(l1.name, null);
         System.out.println("check favourite =false so add to nonfav list"+l1.name);
     }
   }

   else
     //processes lab class data
   if(tagname.equals("class"))
   {
     p.require(XmlPullParser.START_TAG, null, null);
     int duration=0;
     int time=0;
     int day=0;

     while(p.nextTag()!=XmlPullParser.END_TAG)
     {
        p.require(XmlPullParser.START_TAG, null, null);
        String tagname2=p.getName();
        String text = p.nextText();

        if (tagname2.equals("day"))
        {
           if(text.equals("Mo"))
              day=0;
           else if(text.equals("Tu"))
              day=1;
           else if(text.equals("We"))
              day=2;
           else if(text.equals("Th"))
              day=3;
           else if(text.equals("Fr"))
              day=4;
        }
        else if(tagname2.equals("time"))
        {
           time=Integer.parseInt(text) - 9;
        }
        else if (tagname2.equals("duration"))
        {
           duration=Integer.parseInt(text);
        }
```

```
                    else if (tagname2.equals("classname"))
                    {
                      if(time!=-1 && duration!=0)
                       l1.setSlot(day, time, duration, text);
                    }
                    p.require(XmlPullParser.END_TAG, null, tagname2);
                  }
                  p.require(XmlPullParser.END_TAG, null, tagname);
                }
                p.require(XmlPullParser.END_TAG, null, tagname);
              }
              p.require(XmlPullParser.END_TAG, null, "lab");
              thelabs.addElement(l1);
            }
            p.require(XmlPullParser.END_TAG, null, "labs");

            // add the contents of the fav list to the new lab record store and to the lab list
           for(int i=0;i<favList.size();i++)
           {
             labList.append(favList.getString(i), star);
            }

            //then add the contents of the non fav list to the new lab record store and to the lab list
            for(int i=0;i<nonFavList.size()+1;i++)
           {
            labList.append(nonFavList.getString(i), null);
        }
       }
       catch(Exception e){}
       this.display.setCurrent(labList);
}

//method used to display timetable of a specific lab
//uses Lab class to create timetable layout and display
//Author: Andreas Komninos
private void showLab(int index)
{
   Lab l = (Lab)thelabs.elementAt(index);

   labDetails.setTitle(l.name+" Schedule");
   labDetails.deleteAll();

   //#style labTable
   TableItem t = new TableItem(6, 9);

   t.set(0,0,"");
   t.set(1,0,"Mo");
   t.set(2,0,"Tu");
   t.set(3,0,"We");
   t.set(4,0,"Th");
   t.set(5,0,"Fr");
   t.set(0,1,"09.00");
   t.set(0,2,"10.00");
   t.set(0,3,"11.00");
   t.set(0,4,"12.00");
   t.set(0,5,"13.00");
   t.set(0,6,"14.00");
   t.set(0,7,"15.00");
   t.set(0,8,"16.00");

   for(int x=1; x<6; x++)
```

```
    {
      for (int y=1; y<9; y++)
      {
        t.set(x, y, l.slots[x-1][y-1]);
      }
    }

    t.setLayout(TableItem.LAYOUT_CENTER);
    labDetails.append(t);
    this.display.setCurrent(labDetails);
}

//method used to allow user to mark labs in lablist as favourite
//Author: Jessica Rabbit
private void markFavourite(String listIndexName, int listIndex)
{
    String aString = listIndexName;
    aString  = ">"+aString;
    Lab l = (Lab)thelabs.elementAt(listIndex);

     //if already a favourite
    if(checkFavourite(aString)==true)
    {
      try
      {
        //byte array required to add/remove data from record stores
       byte[] recData = new byte[500];
       int len;

       for (int i = 1; i <= favRs.getNumRecords(); i++)
       {
          String rsData=null;
          if (favRs.getRecordSize(i) > recData.length)
          {
           recData = new byte[favRs.getRecordSize(i)];}
           len = favRs.getRecord(i, recData, 0);
           rsData =new String(recData,0,len);
           if(rsData.indexOf(aString)!=-1)
           {
              favRs.deleteRecord(i);
           }
       }
      }
      catch (Exception e){}
    }
    else
    {//if not favourite
      String favLab = "<labName>"+aString+"<indexNumber>"+listIndex;

      try{
         favRs = RecordStore.openRecordStore("favourite",true);
         byte bytes[] = favLab.getBytes();
         favRs.addRecord(bytes,0,bytes.length);
        }catch(Exception e){}

      //#debug
       //code just to read the records store, test that it is working
      try
      {
       // Intentionally make this too small to test code below
         byte[] recData = new byte[5];
```

```
          int len;
          int records = favRs.getNumRecords();
          System.out.println("---------there are records in the favourite RS "+records+"----------");

         for (int i = 1; i <= favRs.getNumRecords(); i++)
         {
          if (favRs.getRecordSize(i) > recData.length)
          recData = new byte[favRs.getRecordSize(i)];
          len = favRs.getRecord(i, recData, 0);
          System.out.println("Record #" + i + ": " + new String(recData, 0, len));
         }
        }
        catch (Exception e){}
        this.display.setCurrent(labList);
    }
}

//method to display free labs only
//Author: Andreas Komninos, Jessica Rabbit
private void showFreeLabs()
{
try{favRs = RecordStore.openRecordStore("favourite",true);}catch(Exception e){}

    freeLabs.deleteAll();
    //boolean to ensure freelabs not added to if user returns to screen during same usage session
   if(labsAreLoaded==false)
   {
      loadLabs();
       labsAreLoaded=true;
   }
   Date d = new Date();
   Calendar c = Calendar.getInstance();

   c.setTime(d);
   int hour = c.get(Calendar.HOUR_OF_DAY);
   int day = c.get(Calendar.DAY_OF_WEEK);
   System.out.println("Original Hour: "+hour+ " Day "+day);

   String s="";

   hour = hour -8-1;
   day = day -2;

   System.out.println("Converted Hour: "+hour+ " Day "+day);
   //checks time and day, if not 9-5 or mon-fri then alternative message displayed
  if(day>=0 && day<=4)
   {
      System.out.println("Mon to Fri");
     if (hour>=0 && hour <=7)
  //  if(day>=0 && day<=4)
      {
         System.out.println("9-5");
         for(Enumeration e=thelabs.elements(); e.hasMoreElements();)
         {
            Lab l = (Lab)e.nextElement();

            if (l.slots[day][hour].equals("      "))
            {
               s+=l.name+"\n";
               System.out.println(l.name);
            }
```

```
            }
            freeLabs.append(s, null);
        }
        else
        {
            s="Most of the labs are free after 5PM" +
                "\nOpening times are 09.00-20.30";
                freeLabs.append(s, null);
        }
    }
    else
    {
        s="None of the labs are booked for classes over the weekend." +
            "\nOpening times are 10.00-15.30";
            freeLabs.append(s, null);
    }

    this.display.setCurrent(freeLabs);
}

//method to check time of day and day of week
//before allowing live lab usage to be displayed
private void checkLiveLabs()
{
    Date d = new Date();
    Calendar c = Calendar.getInstance();

    c.setTime(d);
    int hour = c.get(Calendar.HOUR_OF_DAY);
    int day = c.get(Calendar.DAY_OF_WEEK);
    System.out.println("Original Hour: "+hour+ " Day "+day);

    String s="";

    hour = hour -8-1;
    day = day -2;

    System.out.println("Converted Hour: "+hour+ " Day "+day);
    if(day>=0 && day<=4)
    {
        System.out.println("Mon to Fri");
        if (hour>=0 && hour <=7)
        {
          liveLabs();
        }
        else
        {
            s="Live usage not available after 5pm";

            liveLabs=new Alert("Labs Free Just Now");
            liveLabs.setType(AlertType.INFO);
            liveLabs.setTimeout(Alert.FOREVER);
            liveLabs.setString(s);

            this.display.setCurrent(liveLabs);
        }
    }
    else
    {
        s="Live usage not available at the weekend";
```

```
        liveLabs=new Alert("Labs Free Just Now");
        liveLabs.setType(AlertType.INFO);
        liveLabs.setTimeout(Alert.FOREVER);
        liveLabs.setString(s);
        this.display.setCurrent(liveLabs);
    }
}

        private void quit() {
    addtolog("</launch time=");
    notifyDestroyed();
        }
//method to read data from files
//Author: Andreas Komninos
private String readSimpleText(String url)
{
    char z='a';
    int x=0;
    String s="";

    try{
        InputStream is = getClass().getResourceAsStream(url);
        InputStreamReader ir = new InputStreamReader(is);
        do
        {
            x=ir.read();
            z=(char)x;
            s+=z;
        }
        while(x!=-1);
    }
    catch (Exception e){}
    return s;
}

//sort list, data within resouces in random order
//Author: Andreas Komninos
public void sortList(Vector list)
{
    quicksort(list, 0, list.size()-1);
}

// quicksort a[left] to a[right]
//Author: Andreas Komninos
public static void quicksort(Vector a, int left, int right)
{
    if (right <= left) return;
    int i = partition(a, left, right);
    quicksort(a, left, i-1);
    quicksort(a, i+1, right);
}

// partition a[left] to a[right], assumes left < right
//Author: Andreas Komninos
private static int partition(Vector a, int left, int right)
{
    int i = left - 1;
    int j = right;
    while (true) {
        while (less((Staff)a.elementAt(++i), (Staff)a.elementAt(right)))     // find item on left to swap
            ;                           // a[right] acts as sentinel
```

```
      while (less((Staff)a.elementAt(right), (Staff)a.elementAt(--j)))     // find item on right to swap
         if (j == left) break;          // don't go out-of-bounds
      if (i >= j) break;                // check if pointers cross
      exch(a, i, j);                   // swap two elements into place
    }
    exch(a, i, right);                  // swap with partition element
    return i;
  }

  //used within partition method
  //Author: Andreas Komninos
  private static boolean less(Staff x, Staff y) {
    //comparisons++;
    int a = x.surname.compareTo(y.surname);
    if (a<0)
      return true;
    else
      return false;
  }

  // exchange a[i] and a[j]
  //Author: Andreas Komninos
  private static void exch(Vector a, int i, int j) {
    //exchanges++;
    Staff swap = (Staff)a.elementAt(i);
    //a.elementAt(i) = a.elementAt(j);
    a.setElementAt(a.elementAt(j), i);
    //a.elementAt(j) = swap;
    a.setElementAt(swap, j);
  }

  //method used to add strings to recordstore for future referencing of user activity
  //adds time and string in xml format
  //Author: Jessica Rabbit
  public void addtolog(String entry)
  {
    String logEntry=null;
    try{
      Date date = new Date();
      logEntry = entry + date.getTime()+">";
      rs = RecordStore.openRecordStore("log",true,1, true);
      byte bytes[] = logEntry.getBytes();
      rs.addRecord(bytes,0,bytes.length);
      readRecords();
      rs.closeRecordStore();
    } catch(Exception e){}

  }

  //method used for testing addtolog method
  //Author: Jessica Rabbit
  public void readRecords()
  {
    try
    {
     // Intentionally make this too small to test code below
     byte[] recData = new byte[5];
     int len;

     for (int i = 1; i <= rs.getNumRecords(); i++)
     {
```

```
        if (rs.getRecordSize(i) > recData.length)
        recData = new byte[rs.getRecordSize(i)];

        len = rs.getRecord(i, recData, 0);
        System.out.println("Record #" + i + ": " + new String(recData, 0, len));
        System.out.println("------------------------------");
       }
      }
      catch (Exception e)
      {
      }
    }

    //checks if lab already exists on favRs
    //Author: Jessica Rabbit
    public boolean checkFavourite(String listNumber)
    {
      boolean isFavourite = false;
      String lNum = listNumber;
      recordEnumeration = null;
      filter = null;
      filter = new Filter(lNum);
       try{
            recordEnumeration = null;
            recordEnumeration = favRs.enumerateRecords(filter, null, false);

            if (recordEnumeration.numRecords() > 0)
            {
              isFavourite = true;
            }
          }catch(Exception e){System.out.println(e.toString()+" error message");}


         if (RecordStore.listRecordStores() != null)
         {
          try
          {
           recordEnumeration.destroy();
           filter.filterClose();
          }
          catch (Exception error){}
         }
      return isFavourite;
    }

    //method that takes in a string(lab name)and sets position based on string
    //Author: Jessica Rabbit
    private void getIndex(String labName)
    {
      int position=0;
      String lName = labName;
      if(lName.equalsIgnoreCase("M627"))
      {position=0;}
      if(lName.equalsIgnoreCase("M614"))
      {position=1;}
      if(lName.equalsIgnoreCase("M613"))
      {position=2;}
      if(lName.equalsIgnoreCase("M612"))
      {position=3;}
      if(lName.equalsIgnoreCase("M610"))
      {position=4;}
```

```
        if(lName.equalsIgnoreCase("M608"))
        {position=5;}
        if(lName.equalsIgnoreCase("M606"))
        {position=6;}
        if(lName.equalsIgnoreCase("M224"))
        {position=7;}
        if(lName.equalsIgnoreCase("M227"))
        {position=8;}
        if(lName.equalsIgnoreCase("M229"))
        {position=9;}
        if(lName.equalsIgnoreCase("M223"))
        {position=10;}
        if(lName.equalsIgnoreCase("M222"))
        {position=11;}
        if(lName.equalsIgnoreCase("M220"))
        {position=12;}

       //shows lab at int position
       showLab(position);
      }
}
```

SPLASHSCREEN.JAVA

```
/*
 * To change this template, choose Tools | Templates
 * and open the template in the editor.
 */

package de.enough.polish.sample.accessible;
import javax.microedition.lcdui.Canvas;
import javax.microedition.lcdui.Graphics;
import javax.microedition.lcdui.Image;
/**
 *
 * @author Andreas Komninos
 */
//class to create a splash screen canvas which is displayed on start of applcation
public class SplashScreen extends Canvas{

   SplashScreen()
   {
      //repaint();
      //this.setFullScreenMode(true);
   }
   public void paint(Graphics g)
   {
      try{
         g.setColor(255,255,255);
         g.fillRect(0,0,getWidth()-1, getHeight()-1);
         Image i = Image.createImage("/seclogo.png");
         g.drawImage(i, getWidth()/2,getHeight()/2,Graphics.HCENTER|Graphics.VCENTER);
         //g.drawImage(i, getWidth()/2,getHeight()/2, Graphics.BASELINE|Graphics.HCENTER);
      }
      catch (Exception e)
      {
         e.printStackTrace();
         g.setColor(0,0,150);
         g.fillRect(0,0,getWidth()-1, getHeight()-1);
      }

   }
```

}

LABREADER.JAVA

```
/*
 * To change this template, choose Tools | Templates
 * and open the template in the editor.
 */

package de.enough.polish.sample.accessible;

/**
 *
 * @author Andreas Komninos, Jessica Rabbit
 */

import javax.microedition.io.Connector;
import javax.microedition.io.HttpConnection;
import java.io.InputStream;
import java.io.InputStreamReader;
import org.kxml2.io.KXmlParser;
import org.xmlpull.v1.XmlPullParser;
import java.util.Calendar;
import javax.microedition.lcdui.Image;

//class which processes and displays live lab usage data
public class LabReader implements Runnable {

   private MenuMidlet m;

   public LabReader(MenuMidlet m1)
   {
      m=m1;
   }

   public void run()
   {
      KXmlParser p = new KXmlParser();
      InputStream is;
      HttpConnection c;


      String entry="";
      String lab;
      int total, used, free;
      float rate;
      Image colour=null;
      Image red=null;
      Image amber=null;
      Image green=null;
      try{
         red =Image.createImage("/red.png");
         amber =Image.createImage("/amber.png");
         green =Image.createImage("/green.png");
      }catch(Exception e){}
      try
      {
         m.liveLabList.deleteAll();

         Calendar cal = Calendar.getInstance();
         m.liveLabList.setTitle("Live Lab Usage ("+cal.get(Calendar.HOUR_OF_DAY)+":"+
                  cal.get(Calendar.MINUTE)+":"+cal.get(Calendar.SECOND)+")");
```

```
c= (HttpConnection)Connector.open("http://status.gcal.ac.uk/secxml.php");
is = c.openInputStream();
p.setInput(new InputStreamReader(is));
System.out.println("Connection OK");
//processes xml data
p.nextTag();
p.require(XmlPullParser.START_TAG, null, "XML");
while (p.nextTag()!=XmlPullParser.END_TAG)
{
   p.require(XmlPullParser.START_TAG, null, "Computer_Usage");
   while (p.nextTag()!=XmlPullParser.END_TAG)
   {
      lab=p.getAttributeValue(0);
      total=Integer.parseInt(p.getAttributeValue(1));
      used = Integer.parseInt(p.nextText());
      free = total-used;
      if (total!=0)
      {
         rate = ((float)free)/total;
      }
      else
      {    rate = 0;

      }
      //depending on rate traffic light colours are applied
         if(rate >= 0.6)
         {
         entry = lab + "("+free+"/"+total+")";
         colour=green;
         }
         else
         {
            if (rate>=0.25)
            {
               entry = lab + "("+free+"/"+total+")";
               colour=amber;
            }
            else
            {
               if (rate>=0.1)
               {
                  entry = lab + "("+free+"/"+total+")";
                  colour=red;
               }
               else
               {
                  if (rate<=0)
                  {
                     entry = lab + "("+free+"/"+total+")";
                     colour=red;

                  }
               }
            }
         }
      //#debug
      System.out.println("Appending "+entry+ " rate = "+rate);
      m.liveLabList.append(entry, colour);
   }
   break;
```

```
        }



      }
      catch (Exception e)
      {
         e.printStackTrace();
         m.liveLabList.append(e.getMessage(), null);
      }

      m.display.setCurrent(m.liveLabList);
   }
}
```

LAB.JAVA

```
/*
 * To change this template, choose Tools | Templates
 * and open the template in the editor.
 */

package de.enough.polish.sample.accessible;

/**
 *
 * @author Andreas Komninos
 */

//class which creates the lab timetable structure
public class Lab {
   public String name;
   public String[][] slots;

   public Lab()
   {
      slots = new String[5][8];
      for(int z=0; z<5; z++)
      {
         for (int x=0;x<8; x++)
            slots[z][x]="      ";
      }
   }

   public void setSlot(int day, int slot, int duration, String classname)
   {
      for (int x=0; x<duration; x++)
         slots[day][slot+x]=classname;
   }

   public String returnSchedule()
   {
      String s="0";
      for(int x=0;x<8;x++)
      {
         s+= x+9+".00: "+slots[x]+"\n";
      }

      return s;
   }
```

STAFF.JAVA

```
//Author: Andreas Komninos
package de.enough.polish.sample.accessible;

//class which builds string of staff details and returns the string
// class takes parameters of strings provided my MenuMidlet
public class Staff {
   public String title;
   public String name;
   public String surname;
   public String post;
   public String division;
   public String telephone;
   public String email;
   public String room;
   public String image;

    public Staff(){}
   public Staff(String t, String n, String s, String p, String d, String te, String e, String r, String i)
   {
      title = t;
      name = n;
      surname = s;
      post = p;
      division = d;
      telephone = te;
      email = e;
      room = r;
      image = i;
   }
   public String returnFullName()
   {
      return surname+", "+name+" ("+title+")";
   }
   public String returnDetails()
   {
      return title+" "+name+" "+surname+"\n"+post+", "+division+"\n"+
            "Room: "+room+"\n"+
            "Tel: "+telephone+"\n"+
            "Email: "+email+"\n";
   }
}
```

FILTER.JAVA

```
package de.enough.polish.sample.accessible;
import java.io.ByteArrayInputStream;
import java.io.DataInputStream;
import javax.microedition.rms.RecordFilter;

/**
 * @author Andreas Komninos
 */
//class to filter the staff list
class Filter implements RecordFilter
{
  private String search = null;
  private ByteArrayInputStream inputstream = null;
  private DataInputStream datainputstream = null;
  public Filter(String search)
  {
    this.search = search.toLowerCase();
```

```
 }
 public boolean matches(byte[] suspect)
 {
  String string = new String(suspect).toLowerCase();
  if (string!= null && string.indexOf(search) != -1)
   return true;
  else
   return false;
 }
 public void filterClose()
 {
  try
  {
   if (inputstream != null)
   {
    inputstream.close();
   }
   if (datainputstream != null)
   {
    datainputstream.close();
   }
  }
  catch ( Exception error)
  {
  }
 }
}
```

GETLOGDATA PROJECT CODE

```
/*
 * This file is part of J2ME Polish.
 *
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 * it under the terms of the GNU General Public License as published by
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 *
 * Commercial licenses are also available, please
 * refer to the accompanying LICENSE.txt or visit
 * http://www.j2mepolish.org for details.
 */
package de.enough.polish.sample.accessible;

import javax.microedition.lcdui.*;
import javax.microedition.midlet.MIDlet;
import javax.microedition.midlet.MIDletStateChangeException;
import java.util.Vector;
import java.util.Enumeration;
import java.util.Date;
import java.util.Calendar;
import org.kxml2.io.KXmlParser;
import org.xmlpull.v1.XmlPullParser;
import java.io.InputStream;
import java.io.InputStreamReader;
```

```
import javax.microedition.rms.RecordStore;

//#ifdef polish.debugEnabled
//# import de.enough.polish.util.Debug;
//#endif

/**
 * @author Jessica Rabbit
 */
public class MenuMidlet extends MIDlet implements CommandListener {

		SplashScreen splash = new SplashScreen();

	List loglist,numberist,detailist;
	String logString;
	RecordStore rs1;
	String input;

		Command details = new Command ("Show Details", Command.OK, 1);
		Command used = new Command ("times used", Command.OK, 1);

		Display display;

		public MenuMidlet() {
			super();

			//#debug
			System.out.println("initialisation done.");
		}

		protected void startApp() throws MIDletStateChangeException {
			//#debug
			System.out.println("setting display.");

		this.display = Display.getDisplay(this);
			splash.setFullScreenMode(true);
		this.display.setCurrent(splash);
		try{

		   Thread.sleep(2000);

		}
		catch (Exception e){}
		//create a list called log to add the data from the record store to
		loglist = new List("Log", Choice.IMPLICIT);
		try{
		   //open the shared record store
		   rs1= RecordStore.openRecordStore("log","MUCom Group (A.Komninos)","SEC Mobile" );

		}catch(Exception e){System.out.println(e.toString()+"didnt work !!!");

		Alert alert = new Alert("Error", "Cannot access shared rs1", null, null);
		alert.setTimeout(Alert.FOREVER);
		alert.setType(AlertType.ERROR);
		display.setCurrent(alert);
		}
		String rsData=null;
		//get all data from the record store and add it to the log list
		try
		{
		  byte[] recData = new byte[5];
		  int len;
		  for (int i = 1; i <= rs1.getNumRecords(); i++)
		  {
		     rsData=null;
```

```
            if (rs1.getRecordSize(i) > recData.length)
            {
              recData = new byte[rs1.getRecordSize(i)];
            }
              len = rs1.getRecord(i, recData, 0);
              rsData =new String(recData,0,len);
              loglist.append(rsData, null);
          }
          }catch(Exception e){Alert alert = new Alert("Error", "Cannot access shared rs at position"+rsData+e.toString(), null, null);

         alert.setTimeout(Alert.FOREVER);
         alert.setType(AlertType.ERROR);
         display.setCurrent(alert);}
         loglist.addCommand(details);
         loglist.addCommand(used);
         this.loglist.setCommandListener(this);

           this.display.setCurrent(loglist );
           int i=0;
           //add every list item to a string called input
           while( i<loglist.size())
           {
              input=input + loglist.getString(i);
              i++;
           }
}

         protected void pauseApp() {
         }

         protected void destroyApp(boolean unconditional) throws MIDletStateChangeException {
                  // just quit
         }

         public void commandAction(Command cmd, Displayable screen) {
              //command to view the details of the application usage
              if(cmd == details)
              {
                 //uses the count method to search the string for the number of occurences of a word
                 //then adds the number to string s with additional explanation
                 int number = count("<launch");
                 String s = Integer.toString(number)+"= number of launch, "+"\n";
                 int freeLabs = count("free");
                 s = s+Integer.toString(freeLabs)+"= number of times freelabs function used, "+"\n";
                 int uniInfo = count("uni");
                 s = s+Integer.toString(uniInfo)+"= number of times info function used, "+"\n";
                 int uniNews = count("news");
                 s = s+Integer.toString(uniNews)+"= number of times uniNews function used, "+"\n";
                 int contact = count("contact");
                 s = s+Integer.toString(contact)+"= number of times contact function used, "+"\n";

                 Alert alert = new Alert( "Error", "Details= "+s, null, null);

                 alert.setTimeout(Alert.FOREVER);
                 alert.setType(AlertType.ERROR);
                 display.setCurrent(alert);
              }
              //command to simply view the number of times the application was launched
              if(cmd == used)
              {
                 int num = count("<launch");
                 Alert alert = new Alert("Error", "count= "+num, null, null);

                 alert.setTimeout(Alert.FOREVER);
                 alert.setType(AlertType.ERROR);
```

```
                    display.setCurrent(alert);
                }
        }

        private String readSimpleText(String url)
        {
            char z='a';
            int x=0;
            String s="";

            try{
                InputStream is = getClass().getResourceAsStream(url);
                InputStreamReader ir = new InputStreamReader(is);
                do
                {
                    x=ir.read();
                    z=(char)x;
                    s+=z;
                }while(x!=-1);
            }
            catch (Exception e){}
            return s;
        }

    //method to count the number of times a string occurs in the usage data
    public int count(String subSt) {
         String substring = subSt;

     int count = 0;
     int idx = 0;

     while ((idx = input.indexOf(substring, idx)) != -1)
     {
       idx++;
       count++;
     }

     return count;
    }


}
```

Appendix H Test Cases

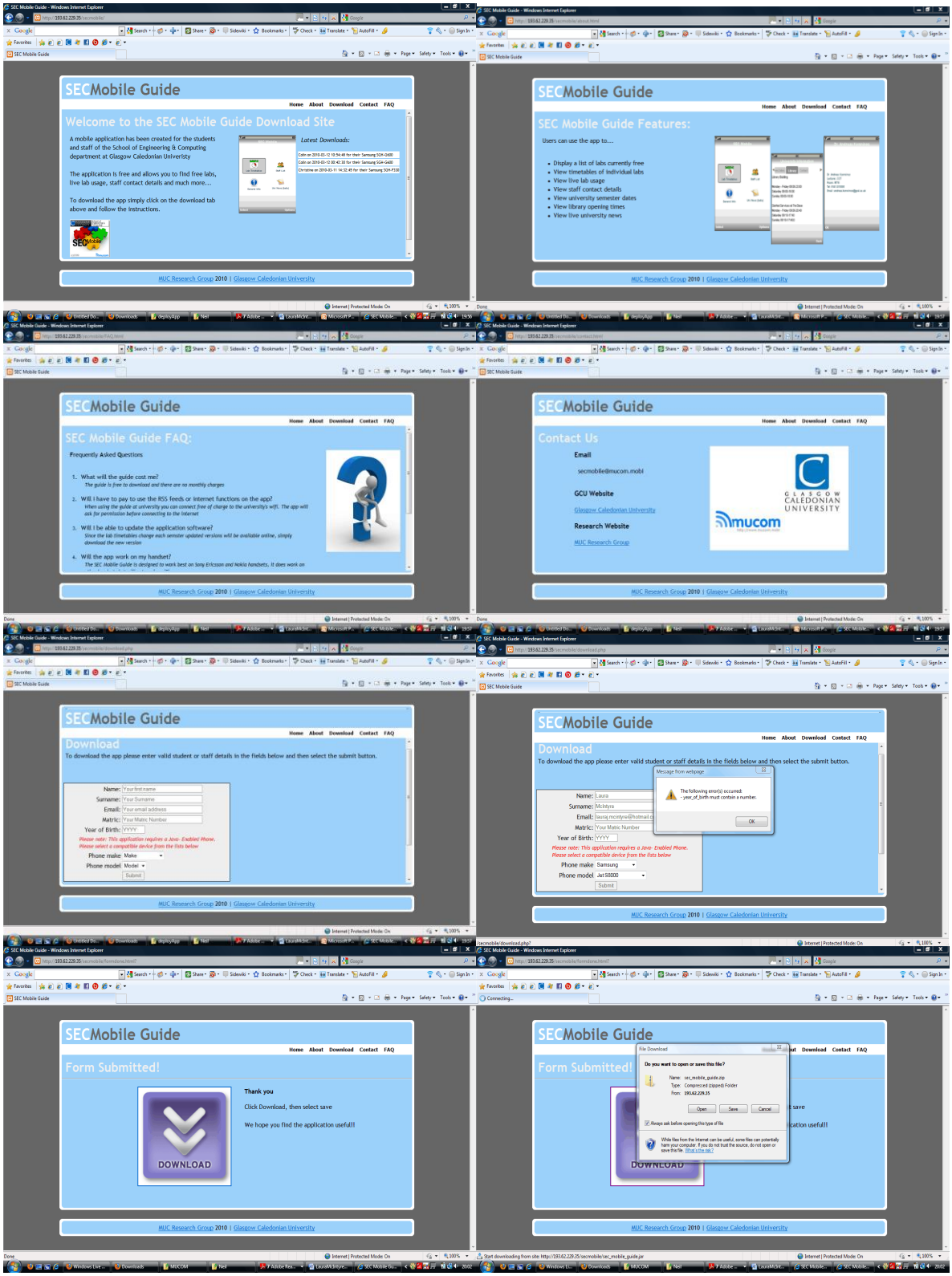
Test Case ID	Test Scenario	Type of Test Case	Prerequisites, if any	Test Steps	Test Data, if any	Expected Result	Actual Result	Pass/ Fail
F1	The application starts and displays splash screen before menu	Functional	Start up SEC application	1. Run application	SEC application	Splash screen is displayed for 1 second and then menu appears	Splash screen is displayed for 1 second and then menu appears	Pass
F2	The application will allow users select one of four menu options	Functional	Start up SEC application	1. Run the application 2. Attempt to select menu option	SEC application	Each menu option can be highlighted and selected	Each menu option can be highlighted and selected	Pass
F3	Selecting the lab menu option displays the free labs available at that time (if before 5pm or not weekend)	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables"	SEC application	A list of free labs are displayed	A list of free labs are displayed	Pass
F4	Selecting the lab menu option displays the free labs available at that time (if after 5pm or not weekend)	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables"	SEC application	The screen displays a message stating that most labs are free after 5pm	The screen displays a message stating that most labs are free after 5pm	Pass
F5	Selecting the lab menu option displays the free labs available at that time (if before 5pm or is the weekend)	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables"	SEC application	The screen displays a message stating that labs are not booked over the weekend	The screen displays a message stating that labs are not booked over the weekend	Pass
F6	Users can select view all labs from the "free labs" page and navigate to a list of labs in the George Moore building.	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables" 3. Select "view all labs"	SEC application	A list of all labs are displayed	A list of all labs are displayed	Pass
F7	Users can select view all labs from the "free labs" page and navigate to a list of labs in the George Moore building.	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables" 3. Select "view all labs"	SEC application	A list of all labs are displayed	A list of all labs are displayed	Pass
F8	Users can select to mark favourite labs	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables" 3. Select "view all labs" 4.Scroll to desired lab 5. Select "mark favourite" from options	SEC application	Highlighted lab is marked with a star symbol and list is reordered with favourites at the top	Highlighted lab is marked with a star symbol and list is reordered with favourites at the top	Pass
F9	Favourite labs are still marked if the user exits and restarts the application	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables" 3. Select "view all labs" 4.Scroll to desired lab 5. Select "mark favourite" from options 6. Exit the application 7. Repeat steps 1-3	SEC application	Favourite labs are still marked with a star symbol and list is reordered with favourites at the top	Favourite labs are still marked with a star symbol and list is reordered with favourites at the top	Pass
F10	Users can view a timetable for any listed lab	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables" 3. Select "view all labs" 4.Scroll to desired lab 5. Select "select"	SEC application	A timetable is displayed for the corresponding highlighted lab	A timetable is displayed for the corresponding highlighted lab	Pass
F11	Users can view a timetable for any listed lab after favourites have been selected and list reordered	Functional	Start up SEC application	1. Run the application 2. Select "lab timetables" 3. Select "view all labs" 4.Scroll to desired lab 5. Select "mark favourite" from options 6. Select "select"	SEC application	Highlighted lab is marked with a star symbol and list is reordered with favourites at the top and timetable is displayed for the corresponding highlighted lab	Highlighted lab is marked with a star symbol and list is reordered with favourites at the top and timetable is displayed for the corresponding highlighted lab	Pass
F12	All back commands take the user to the previous screen viewed.	Functional	SEC application	1 Run the application 2. Select "lab timetables" 3. Select "view all labs" 4. Select "back" 5. Select "back"	SEC application	Each time the back command is selected the screen displayed is the previously displayed screen	Each time the back command is selected the screen displayed is the previously displayed screen	Pass

F13	The application pauses whenever the phone they are using receives a phone call	Functional	SEC application	1. Run the application 2. Phone the phone that the application is running on	SEC application	The application pauses whenever the phone they are using receives a phone call	The application pauses whenever the phone they are using receives a phone call	Pass
F14	Use can view live lab usage during university opening times	Functional	SEC application	1 Run the application 2. Select "lab timetables" 3. Select "live lab usage"	SEC application, internet/wifi connection	Live lab usage is displayed	Live lab usage is displayed	Pass
F15	Use cannot view live lab usage out with university opening times	Functional	SEC application	1 Run the application 2. Select "lab timetables" 3. Select "live lab usage"	SEC application	Connection to the internet is not attempted and message is displayed to the user that live lab usage is not available at the weekend	Connection to the internet is not attempted and message is displayed to the user that live lab usage is not available at the weekend	Pass
F16	Selecting the staff list menu option displays a list of all SEC staff members	Functional	Start up SEC application	1. Run the application 2. Select "staff list"	SEC application	A list of all staff member names are displayed	A list of all staff member names are displayed	Pass
F17	User can view contact details of staff members	Functional	SEC application	1. Run the application 2. Select "staff list" 3. Scroll to and select staff member	SEC application, staff member name: Peter Barrie	Screen display staff members contact details of Peter Barrie	Screen display staff members contact details of Peter Barrie	Pass
F18	User can find a staff member in a certain department	Functional	SEC application	1. Run the application 2. Select "staff list" 3. select "view by dept" 4. Select admin 5. Scroll to and select staff member	SEC application, staff member name: Tia Bryan	The list contents display only administrative staff members and then the contact details of Tia Bryan	The list contents display only administrative staff members and then the contact details of Tia Bryan	Pass
F19	User can filter list to view contact details of staff members	Functional	SEC application	1. Run the application 2. Select "staff list" 3. Type in first 3 letters of name to reduce list items 4.Scroll to and select staff member	SEC application, staff member name: Peter Barrie	List is reduced by text input. Screen display staff members contact details of Peter Barrie	List is reduced by text input. Screen display staff members contact details of Peter Barrie	Pass
F20	Selecting the general info menu option displays tabular university information	Functional	Start up SEC application	1. Run the application 2. Select "general info"	SEC application	Semester date information is displayed on the first tab	Semester date information is displayed on the first tab	Pass
F21	Users can scroll left and right to view different information tabs in the general information section	Functional	Start up SEC application	1. Run the application 2. Select "general info" 3. Scroll left	SEC application	Library and contact information is displayed on tabbed screens	Library and contact information is displayed on tabbed screens	Pass
F22	Selecting the uni news menu option displays a list of feeds to select	Functional	Start up SEC application	1. Run the application 2. Select "uni news"	SEC application	A list is displayed allowing the user to choose an RSS feed	A list is displayed allowing the user to choose an RSS feed	Pass
F23	The user can view RSS feeds regarding the university news and events	Functional	Start up SEC application	1. Run the application 2. Select "uni news" 3. Select "GCU news"	SEC application, internet/wifi connection	User is asked to connect to the internet and then web pages are displayed containing uni news information	User is asked to connect to the internet and then web pages are displayed containing uni news information	Pass
F24	The user can exit the application using "exit" commands	Functional	Start up SEC application	1. Run the application 2. Select "exit"	SEC application	Application exits	Application exits	Pass
F25	The user can exit the application using the handsets controls	Functional	Start up SEC application	1. Run the application 2. Press handsets standby/exit/cancel call button	SEC application	Application exits	Application exits	Pass

I1	The application interface shall provide graphics next to each menu item	Interface	SEC application	1. Run the application	Application graphics	The application interface includes the relevant graphics when necessary	The application interface includes the relevant graphics when necessary	Pass
I4	The application interface shall provide menu features for number of options available to users	Interface	SEC application	1. Run the application 2. Use each function and observe the menu options available to users	Application menus	The application interface provide relevant menu with options for the users	The application interface provide relevant menu with options for the users	Pass
I5	The applications interface shall be consistent throughout the application	Interface	SEC application	1. Run the application 2. Use alternative functions	Application Interfaces	The application interfaces are consistent throughout the application	The application interfaces are consistent throughout the application	Pass
I6	Any text displayed on the application interfaces shall be easy to read for the users	Interface	SEC application	1. Run the application 2. Use alternative functions	Application Interfaces	The text displayed on the application is easy to read	The text displayed on the application is easy to read	Pass
P1	The applications interfaces will move smoothly from one to the next without any waiting time	Performance	SEC application	1. Navigate through the application. 2. Record the waiting time from one screen to the next	SEC application.	The application interfaces move smoothly from one to the other without any waiting time	The application interfaces move smoothly from one to the other without any waiting time	Pass
P3	The application shall be robust	Performance	SEC application	1. Allow user to run the application 2. Question their views on any problems they encountered with the system and how smoothly it ran for them	SEC application	The application is robust	The application is robust	Pass
Q1	The application will require no training to use	Qualification	SEC application	1. Allow test participant to use the application 2. Observe the participants ability to use the application	SEC application	The application can be easily used by the participant without being given any pre-instructions for the application	The application can be easily used by the participant without being given any pre-instructions for the application	Pass
Q2	The application must be able to run on a number of different mobile phones	Qualification	SEC application	1. Install the application on the different models of phones 2. Observe if the applications run effectively on the different phones	SEC application	The application can run on a number of different mobile phones	The application can run on a number of different mobile phones	Pass

Appendix I **Deployment Poster**

Appendix J Deployment Website Screen Shots



Appendix K Deployment Website Html Code

Index.html

```
<html><head>
<title>SEC Mobile Guide</title>
<link REL="STYLESHEET" TYPE="text/css" HREF="style.css" Title="SEC Mobile Guide">
</head><body>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<h1>SEC<span class="gray">Mobile Guide</span></h1>
                <div  id="menu">
                        <ul>
                                <li><a href="index.html">Home</a></li>
                                <li><a href="about.html">About</a></li>
                                <li><a href="download.html">Download</a></li>
                                <li><a href="contact.html">Contact</a></li>
                                <li><a href="FAQ.html">FAQ</a></li>
                        </ul>
                </div>
<div id="main_text">
<h2>Welcome to the SEC Mobile Guide Download Site</h2>
<br><br>
<table border="0" width="100%" cellpadding="10">
<tr>
<td width="50%" valign="top">
<p>A mobile application has been created for the students and staff of the School of Engineering & Computing department at Glasgow Caledonian Univeristy
<br><br>The application is free and allows you to find free labs, live lab usage, staff contact details and much more...
<br><br>To download the app simply click on the download tab above and follow the instructions.
</p></td>
<td width="50%" valign="top">
<img src="seclogo.gif" align="top" width="240" height="240">
<img src="menu.gif" align="top" width="150" height="240">
</td></tr></table></div>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div><br>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<center>
<a href="http://www.mucom.mobi/">MUC Research Group</a> 2010 | <a
href="http://www.gcal.ac.uk/">Glasgow Caledonian University</a>
```

```
</center>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div></body></html>
```

About.html

```
<html><head>
<title>SEC Mobile Guide</title>
<link REL="STYLESHEET" TYPE="text/css" HREF="style.css" Title="SEC Mobile Guide">
</head><body>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<h1>SEC<span class="gray">Mobile Guide</span></h1>
                    <div  id="menu">
                            <ul>
                                    <li><a href="index.html">Home</a></li>
                                    <li><a href="about.html">About</a></li>
                                    <li><a href="download.html">Download</a></li>
                                    <li><a href="contact.html">Contact</a></li>

                                    <li><a href="FAQ.html">FAQ</a></li>
                            </ul>
                    </div>
<div id="main_text">
<h2>SEC Mobile Guide Features:</h2>
<table border="0" width="100%" cellpadding="10">
<tr>
<td width="50%" valign="top">
<p>Users can use the app to...</P>
<ul>
<li>Display a list of labs currently free</li>
<li>View timetables of individual labs</li>
<li>View live lab usage</li>
<li>View staff contact details</li>
<li>View university semester dates</li>
<li>View library opening times</li>
<li>View live university news</li>
</ul></td>
<td width="50%" valign="top">
<img src="menu.gif" align="left" width="150" height="240">
<img src="contact.gif" align="right" width="150" height="240">
<br><br>
<img src="library.gif" align="bottom" width="140" height="230">
</td></tr></table></div>
```

```
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div><br>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<center>
<a href="http://www.mucom.mobi/">MUC Research Group</a> 2010 | <a
href="http://www.gcal.ac.uk/">Glasgow Caledonian University</a>
</center>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div></body></html>
```

FAQ.html

```
<html><head>
<title>SEC Mobile Guide</title>
<link REL="STYLESHEET" TYPE="text/css" HREF="style.css" Title="SEC Mobile Guide">
</head><body>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<h1>SEC<span class="gray">Mobile Guide</span></h1>
                    <div  id="menu">
                              <ul>
                                        <li><a href="index.html">Home</a></li>
                                        <li><a href="about.html">About</a></li>
                                        <li><a href="download.html">Download</a></li>
                                        <li><a href="contact.html">Contact</a></li>

                                        <li><a href="FAQ.html">FAQ</a></li>
                              </ul>
                    </div>
<div id="main_text">
<h2>SEC Mobile Guide FAQ:</h2>
<table border="0" width="100%" cellpadding="10">
<tr>
<td width="80%" valign="top">
<p><b>F</b>requently <b>A</b>sked <b>Q</b>uestions</P>
<ol>
<li>What will the guide cost me?</li>
<p><small/><i>The guide is free to download and there are no monthly charges</i></p>
<li><big/>Will I have to pay to use the RSS feeds or internet functions on the app?</li>
```

<small/>When using the guide at university you can connect free of charge to the university's wifi. The app will ask for permission before connecting to the internet
<big/>Will I be able to update the application software?
<small/>Since the lab timetables change each semster updated versions will be available online, simply download the new version
<big/>Will the app work on my handset?
<small/>The SEC Mobile Guide is designed to work best on Sony Ericsson and Nokia handsets, it does work on other handsets but will not work on iPhones
<big/>Can I use the live lab usage to check computer availability?
<small/>The "live lab usage" function can be used alongside the lab timetabels to find a free computer during university hours. Most computers are free after 5pm and there are no timetabled classes after 5pm or at the weekend
<big/>How do I get the app on my phone once I download the file?
<small/>Once you have downloaded the jar file transfer it on to your mobile phone using bluetooth or a USB cable. Then go to the file location on your mobile, open it and it will prompt you to install the software. </td>
<td width="20%" valign="top">
<img src="Questionmark.jpg" align="left" width="200" height="260">
</td></tr></table>

MUC Research Group 2010 | <a
href="http://www.gcal.ac.uk/">Glasgow Caledonian University

</body></html>

Contact.html

<html><head>
<title>SEC Mobile Guide</title>
<link REL="STYLESHEET" TYPE="text/css" HREF="style.css" Title="SEC Mobile Guide">
</head><body>

<h1>SECMobile Guide</h1>

```
                <div  id="menu">
                        <ul>
                                <li><a href="index.html">Home</a></li>
                                <li><a href="about.html">About</a></li>
                                <li><a href="download.html">Download</a></li>
                                <li><a href="contact.html">Contact</a></li>

                                <li><a href="FAQ.html">FAQ</a></li>
                        </ul>
                </div>
<div id="main_text">
<h2>Contact Us</h2>
<table border="0" width="100%" cellpadding="10">
<tr>
<td width="10%" valign="top">
</td>
<td width="40%" valign="top">
<h3>Email</h3>
<p>lmcint36@caledonian.ac.uk</P>
<h3>GCU Website</h3>
<a href="http://www.gcal.ac.uk/">Glasgow Caledonian University</a>
<h3>Research Website</h3>
<a href="http://www.mucom.mobi/">MUC Research Group</a>
</td>
<td width="40%" valign="top">
<img src="gcu.jpg" align="right" width="150" height="150">
<br><br><br><br><br><br><br>
<img src="MUCOM.jpg" align="left" width="180" height="80">
</td>
<td width="10%" valign="top">
</td></tr></table></div>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div><br>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<center>
<a href="http://www.mucom.mobi/">MUC Research Group</a> 2010 | <a
href="http://www.gcal.ac.uk/">Glasgow Caledonian University</a>
</center>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div></body></html>
```

Download.html

```
<html><head>
<script type="text/javascript">
function validate_required(field,alerttxt){
with (field){
 if (value==null||value==""||value=="Your Name"||value=="Your Email"||value=="Your Matric
Number"||value=="YYYY") {
   alert(alerttxt);return false;}
 else   {   return true;   }
 }
}
function validate_form(thisform){
with (thisform)  {
 if (validate_required(dname,"All fields must be filled out!")==false)
 {dname.focus();return false;}
  if (validate_required(demail,"All fields must be filled out!")==false)
 {demail.focus();return false;}
  if (validate_required(dmat,"All fields must be filled out!")==false)
 {dmat.focus();return false;}
  if (validate_required(dyear,"All fields must be filled out!")==false)
 {dyear.focus();return false;}
 }
}
</script>
<title>SEC Mobile Guide</title>
<link REL="STYLESHEET" TYPE="text/css" HREF="style.css" Title="SEC Mobile Guide">
</head><body>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<h1>SEC<span class="gray">Mobile Guide</span></h1>
                    <div  id="menu">
                              <ul>
                                        <li><a href="index.html">Home</a></li>
                                        <li><a href="about.html">About</a></li>
                                        <li><a href="download.html">Download</a></li>
                                        <li><a href="contact.html">Contact</a></li>
                                        <li><a href="FAQ.html">FAQ</a></li>
                              </ul>
                    </div>
<div id="main_text">
<h2>Download</h2>
<p>To download the app please enter valid student or staff details in the fields below and then select the
submit button.</p>
<center>
<FORM ACTION="formdone.html" onsubmit="return validate_form(this)" METHOD="POST">
<p align="center">Name:
<input name="dname" value="Your Name" type="text" size="30" />
<p align="center">Email:
```

```
<input name="demail" value="Your Email" type="text" size="30" />
<p align="center">Matric Number:
<input name="dmat" value="Your Matric Number" type="text" size="30" />
<p align="center">Year of Birth:
<input name="dyear" value="YYYY" type="text" size="4" />
<p align="center"><input type="submit" value="Submit" />
</form></center></div>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div><br>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<center>
<a href="http://www.mucom.mobi/">MUC Research Group</a> 2010 | <a
href="http://www.gcal.ac.uk/">Glasgow Caledonian University</a>
</center>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div></body></html>
```

Formdone.html

```
<html><head>
<title>SEC Mobile Guide</title>
<link REL="STYLESHEET" TYPE="text/css" HREF="style.css" Title="SEC Mobile Guide">
</head><body>
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<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<h1>SEC<span class="gray">Mobile Guide</span></h1>
                <div  id="menu">
                        <ul>
                                <li><a href="index.html">Home</a></li>
                                <li><a href="about.html">About</a></li>
                                <li><a href="download.html">Download</a></li>
                                <li><a href="contact.html">Contact</a></li>
                                <li><a href="FAQ.html">FAQ</a></li>
                        </ul>
                </div>
<div id="main_text">
<h2>Form Submitted!</h2>
<hr/>
<table border="0" width="100%" cellpadding="10">
<tr>
```

```
<td width="50%" valign="top">
<a href="sec_mobile_guide.jar"><img src="dl.gif" align="right" width="250" height="240"></a>
</td>
<td width="50%" valign="top">
<p><b>Thank you</b></p>
<p >Click Download, then select save<br><br>We hope you find the application useful!!</p>
</td></tr></table></div>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div><br>
<div class="nifty">
<b class="rtop"><b class="r1"></b><b class="r2"></b><b class="r3"></b><b class="r4"></b></b>
<div class="nifty2">
<b class="rtop2"><b class="r12"></b><b class="r22"></b><b class="r32"></b><b class="r42"></b></b>
<center>
<a href="http://www.mucom.mobi/">MUC Research Group</a> 2010 | <a
href="http://www.gcal.ac.uk/">Glasgow Caledonian University</a>
</center>
<b class="rbottom2"><b class="r42"></b><b class="r32"></b><b class="r22"></b><b class="r12"></b></b>
</div>
<b class="rbottom"><b class="r4"></b><b class="r3"></b><b class="r2"></b><b class="r1"></b></b>
</div></body></html>
```

Appendix L Blank Online Questionnaire

1. Please enter your name

2. What year of study are you currently in?

1st Year ◉ 2nd Year ○ 3rd Year ○ 4th Year ○ 5th Year ○ Other_____

3. Please enter the title of your course

4. What sex are you?

○ Male ○ Female ○ Rather not say

5. What age are you?

6. Please rate the following statements

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The application was easy to install	○	○	○	○	○
The application was easy to use	○	○	○	○	○
I didn't make mistakes while using the application	○	○	○	○	○
The information was easily read	○	○	○	○	○
The information was displayed as I expected	○	○	○	○	○
The screens didn't contain too much information	○	○	○	○	○
I felt the information was reliable	○	○	○	○	○
I used one function more than others	○	○	○	○	○
The functions provided met my needs	○	○	○	○	○
I liked the functions that required internet connection	○	○	○	○	○
There were an adequate number of steps required to obtain information	○	○	○	○	○
The application was easily incorporated in to my daily tasks	○	○	○	○	○
I preferred using the mobile application to the university website	○	○	○	○	○
The application improved my daily tasks at university	○	○	○	○	○
I used the application for short tasks	○	○	○	○	○

7. How often did you use the SEC Mobile Guide app?

○ Everyday
○ A few times a week
○ Once a week
○ Once a fortnight
○ Once a month
○ Rarely
○ Other (please specify)

8. Please rate the frequency of use of each function

	Often	Occasionally	Rarely	Never
General Info	○	○	○	○
Lab Timetables	○	○	○	○
Staff List	○	○	○	○
Uni News	○	○	○	○

9. Please select the most accurate answer.
The mobile application's available functions...

◉ reduced my use of the university website
○ increased my use of the university website
○ had no effect on my use of the university website

10. Overall did you find the SEC Mobile Guide beneficial in your daily (student related) tasks?

○ Yes, Very beneficial
○ Yes, quite beneficial
○ No, it was a hindrance

Appendix M Online Questionnaire Results

1. Please enter your name — Download

	Response Count
Hide replies	11

1.	Paula	Thu, Mar 25, 2010 12:20 PM	Find...
2.	Gary	Wed, Mar 24, 2010 1:41 PM	Find...
3.	Colin McCormick	Sun, Mar 21, 2010 1:08 PM	Find...
4.	Lawrence McGavin	Sun, Mar 21, 2010 9:18 AM	Find...
5.	Chris McNamee	Thu, Mar 18, 2010 12:06 PM	Find...
6.	Mark Griffiths	Mon, Mar 15, 2010 5:21 PM	Find...
7.	Paul Reynolds	Thu, Mar 11, 2010 9:31 PM	Find...
8.	Kenny	Thu, Mar 11, 2010 4:21 PM	Find...
9.	Cameron Findlay	Thu, Mar 11, 2010 3:57 PM	Find...
10.	Stephen McIntyre	Thu, Mar 11, 2010 3:06 PM	Find...
11.	Andrew Young	Thu, Mar 11, 2010 2:13 PM	Find...

25 responses per page

answered question	11
skipped question	5

2. What year of study are you currently in? — Create Chart — Download

	Response Percent	Response Count
1st Year	0.0%	0
2nd Year	**43.8%**	**7**
3rd Year	18.8%	3
4th Year	37.5%	6
5th Year	0.0%	0
Other	0.0%	0
Other		0
answered question		16
skipped question		0

3. Please enter the title of your course — Download

	Response Count
Hide replies	16

1.	Internet Software Development	Thu, Mar 25, 2010 12:20 PM	Find...
2.	Bsc (Hons) Computing	Wed, Mar 24, 2010 1:41 PM	Find...
3.	Information Systems Development	Sun, Mar 21, 2010 8:23 PM	Find...
4.	Computer Games	Sun, Mar 21, 2010 1:10 PM	Find...
5.	Bsc(Hons) Computing (Web Systems Development)	Sun, Mar 21, 2010 1:08 PM	Find...
6.	Networking and System Support	Sun, Mar 21, 2010 9:18 AM	Find...
7.	BSc Internet Software Development	Sun, Mar 21, 2010 2:00 AM	Find...
8.	web systems development	Sat, Mar 20, 2010 9:46 PM	Find...
9.	BSc Computing	Thu, Mar 18, 2010 12:06 PM	Find...
10.	Games Software Development	Tue, Mar 16, 2010 3:40 PM	Find...
11.	BSc. Networking and systems support	Mon, Mar 15, 2010 5:21 PM	Find...
12.	BSc (Hons) Computing	Thu, Mar 11, 2010 9:31 PM	Find...
13.	Web Systems Development	Thu, Mar 11, 2010 4:21 PM	Find...
14.	Bsc Internet Software Development	Thu, Mar 11, 2010 3:57 PM	Find...
15.	Computer Games Software Development	Thu, Mar 11, 2010 3:06 PM	Find...
16.	Computing with Web Systems Development	Thu, Mar 11, 2010 2:13 PM	Find...

25 responses per page

answered question	16
skipped question	0

4. What sex are you? Create Chart | Download

	Response Percent	Response Count
Male	81.3%	13
Female	18.8%	3
Rather not say	0.0%	0
answered question		16
skipped question		0

5. What age are you? Download

Hide replies

		Response Count
1.	21	Thu, Mar 25, 2010 12:20 PM Find...
2.	22	Wed, Mar 24, 2010 1:41 PM Find...
3.	20	Sun, Mar 21, 2010 8:23 PM Find...
4.	20	Sun, Mar 21, 2010 1:10 PM Find...
5.	20	Sun, Mar 21, 2010 1:08 PM Find...
6.	48	Sun, Mar 21, 2010 9:18 AM Find...
7.	22	Sun, Mar 21, 2010 2:00 AM Find...
8.	25	Sat, Mar 20, 2010 9:46 PM Find...
9.	22	Thu, Mar 18, 2010 12:06 PM Find...
10.	19	Tue, Mar 16, 2010 3:40 PM Find...
11.	21	Mon, Mar 15, 2010 5:21 PM Find...
12.	21	Thu, Mar 11, 2010 9:31 PM Find...
13.	25	Thu, Mar 11, 2010 4:21 PM Find...
14.	25	Thu, Mar 11, 2010 3:57 PM Find...
15.	19	Thu, Mar 11, 2010 3:06 PM Find...
16.	19	Thu, Mar 11, 2010 2:13 PM Find...

25 responses per page

answered question		16
skipped question		0

6. Please rate the following statements Create Chart | Download

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Response Count
The application was easy to install	37.5% (6)	**56.3% (9)**	6.3% (1)	0.0% (0)	0.0% (0)	16
The application was easy to use	43.8% (7)	**56.3% (9)**	0.0% (0)	0.0% (0)	0.0% (0)	16
I didn't make mistakes while using the application	18.8% (3)	**56.3% (9)**	18.8% (3)	6.3% (1)	0.0% (0)	16
The information was easily read	25.0% (4)	**68.8% (11)**	6.3% (1)	0.0% (0)	0.0% (0)	16
The information was displayed as I expected	18.8% (3)	**50.0% (8)**	25.0% (4)	6.3% (1)	0.0% (0)	16
The screens didn't contain too much information	18.8% (3)	**75.0% (12)**	6.3% (1)	0.0% (0)	0.0% (0)	16
I felt the information was reliable	31.3% (5)	**56.3% (9)**	12.5% (2)	0.0% (0)	0.0% (0)	16
I used one function more than others	**62.5% (10)**	12.5% (2)	25.0% (4)	0.0% (0)	0.0% (0)	16
The functions provided met my needs	**43.8% (7)**	37.5% (6)	18.8% (3)	0.0% (0)	0.0% (0)	16
I liked the functions that required internet connection	12.5% (2)	12.5% (2)	**68.8% (11)**	6.3% (1)	0.0% (0)	16
There were an adequate number of steps required to obtain information	31.3% (5)	**62.5% (10)**	6.3% (1)	0.0% (0)	0.0% (0)	16
The application was easily incorporated in to my daily tasks	**43.8% (7)**	37.5% (6)	18.8% (3)	0.0% (0)	0.0% (0)	16
I preferred using the mobile application to the university website	37.5% (6)	**43.8% (7)**	12.5% (2)	6.3% (1)	0.0% (0)	16
The application improved my daily tasks at university	25.0% (4)	**43.8% (7)**	31.3% (5)	0.0% (0)	0.0% (0)	16
I used the application for short tasks	31.3% (5)	**43.8% (7)**	18.8% (3)	6.3% (1)	0.0% (0)	16
					answered question	16
					skipped question	0

7. How often did you use the SEC Mobile Guide app? Create Chart Download

	Response Percent	Response Count
Everyday	18.8%	3
A few times a week	**56.3%**	**9**
Once a week	6.3%	1
Once a fortnight	0.0%	0
Once a month	0.0%	0
Rarely	18.8%	3
Other (please specify)	0.0%	0
	answered question	**16**
	skipped question	**0**

8. Please rate the frequency of use of each function Create Chart Download

	Often	Occasionally	Rarely	Never	Rating Average	Response Count
Lab Timetables	**62.5% (10)**	31.3% (5)	6.3% (1)	0.0% (0)	1.44	16
Staff List	0.0% (0)	18.8% (3)	**68.8% (11)**	12.5% (2)	2.94	16
General Info	0.0% (0)	**43.8% (7)**	**43.8% (7)**	12.5% (2)	2.69	16
Uni News	0.0% (0)	0.0% (0)	**68.8% (11)**	31.3% (5)	3.31	16
				answered question		**16**
				skipped question		**0**

9. Please select the most accurate answer. The mobile application's available functions... Create Chart Download

	Response Percent	Response Count
reduced my use of the university website	43.8%	7
increased my use of the university website	0.0%	0
had no effect on my use of the university website	**56.3%**	**9**
	answered question	**16**
	skipped question	**0**

10. Overall did you find the SEC Mobile Guide beneficial in your daily (student related) tasks? Create Chart Download

	Response Percent	Response Count
Yes, Very beneficial	43.8%	7
Yes, quite beneficial	**56.3%**	**9**
No, it was a hindrance	0.0%	0
Show replies Please add any extra comments		4
	answered question	**16**
	skipped question	**0**

Appendix N Lab Experiment Plan

Mobile Guide Application – Lab Experiment

Opening talk

Thank you for attending this focus group.
As stated in the email, the purpose of this workshop is to get student views on the designs for a new mobile application that is being developed. The software in question is a mobile assistant, which is aimed to assist students whilst at university to make life daily tasks easier.

The lab experiment will last approximately an hour and will run as follows:

- Brief introduction to experiment purpose – to record results of their use of the application – 5mins
- Carry out tasks on mobile application – 15mins
- Carry out tasks on web site– 15mins
- Complete interview/questionnaire with all participants – 15mins
- Debriefing – 5mins

Tasks

- 1 – Get staff contact details – Iain Lambie (random choice)
- 2 – Find a free lab in an hour's time
- 3 – Find the start date of semester B
- 4 – Find the most current GCU news event

Participants complete tasks 1-4 on mobile
Results recorded on paper

Participants complete tasks 1-4 on pc
Results recorded on paper

Interview Questions

1. Did you use the lab usage on the application or did you prefer to see if a class was on?
2. What function(s) did you use the most?
3. Are there any functions you feel are not required/could be removed?
4. Did you feel the application helped or hindered your usual day to day tasks?
5. Would you like to add anything to the mobile guide? Any improvements?
6. Were you happy with the screen display/layout?

Hypothesis Based Questions

1. Did you feel the introduction of a mobile guide improved the learning experience? If so how?
2. Did the mobile application improve your opinion of the SEC? If so to what extent?

Appendix O Lab Experiment Results & Usage Data

	Mobile Application				Total	University Website				Total	Usage Data				
	Task 1	**Task 2**	**Task 3**	**Task 4**		**Task 1**	**Task 2**	**Task 3**	**Task 4**		*No of times Launch used*	*No of times Lab Timetable used*	*No of times contact used*	*No of times info used*	*No of times uni news used*
Participant 1											39	33	2	4	1
Duration (seconds)	13	5	5	10	33	39	41	3	57	140					
No. of errors	0	0	0	0	0	0	0	0	2	2					
No. Of Steps	5	3	3	4	15	13	5	1	5	24					
Successful Y/N	Y	Y	Y	Y	4	N	N	Y	Y	2					
Participant 2											14	11	1	2	1
Duration (seconds)	24	25	4	17	70	63	72	25	48	208					
No. of errors	1	0	0	0	1	1	1	0	1	3					
No. Of Steps	4	6	3	4	17	3	4	1	2	10					
Successful Y/N	Y	Y	Y	Y	4	N	N	Y	N	1					
Participant 3											28	52	7	12	12
Duration (seconds)	20	25	7	20	72	81	71	5	12	169					
No. of errors	0	0	0	0	0	4	2	0	0	6					
No. Of Steps	2	12	3	4	21	10	16	2	1	29					
Successful Y/N	Y	Y	Y	Y	4	N	Y	Y	Y	3					
Participant 4											34	40	4	6	2
Duration (seconds)	20	30	3	10	63	80	62	7	9	158					
No. of errors	0	1	0	0	1	0	1	0	0	1					
No. Of Steps	4	8	3	4	19	6	5	1	1	13					
Successful Y/N	Y	Y	Y	Y	4	N	N	Y	Y	2					
Participant 5											32	32	1	4	1
Duration (seconds)	21	20	4	13	58	28	54	8	5	95					
No. of errors	0	2	0	0	2	1	2	0	0	3					
No. Of Steps	5	6	3	4	18	8	12	1	1	22					
Successful Y/N	Y	Y	Y	Y	4	N	Y	Y	Y	3					
Participant 6											22	22	2	1	1
Duration (seconds)	22	12	6	16	56	79	88	25	65	257					
No. of errors	0	0	0	0	0	1	0	0	1	2					
No. Of Steps	3	4	3	4	14	6	6	1	3	16					
Successful Y/N	Y	Y	Y	Y	4	N	Y	Y	N	2					
Participant 7											40	59	5	8	2
Duration (seconds)	16	14	6	12	48	72	68	10	51	201					
No. of errors	0	0	0	0	0	2	1	0	2	5					
No. Of Steps	4	7	3	4	18	6	5	1	6	18					
Successful Y/N	Y	Y	Y	Y	4	N	N	Y	N	1					
Participant 8											35	32	1	5	1
Duration (seconds)	18	11	5	14	48	66	75	12	58	211					
No. of errors	0	0	0	0	0	3	1	0	2	6					
No. Of Steps	4	4	3	4	15	10	9	1	4	24					
Successful Y/N	Y	Y	Y	Y	4	N	N	Y	N	1					

Appendix P **Interview Results**

Lab Experiment Interview Feedback

Conclusions from General Discussion – Q&A Findings:

- Did you use the live lab usage on the application or did you prefer to see if a class was on?
    - Only two participants used the live lab usage function
    - One participant didn't understand what it was – wasn't aware of similar function on uni website and in library
    - The remaining students did not ever feel the need to use it.
- What function(s) did you use the most?
    - All participants stated without hesitation that they used the free lab function the most .
- Were there any functions you feel are not required/could be removed?
    - All participants, apart from one, claimed that they were unsure that they would ever require the uni news function. They said it was a good function to have but if they wanted the information they were more likely to access it via the university website.
- Did you feel the application helped or hindered you usual day to day tasks?
    - All participants agreed that the application helped them in their daily tasks. The use of the free lab function reduced the student's time "wandering" corridors trying to find a computer before they could complete work and they said it reduced the apprehension of going in to a lab as they knew that there was/wasn't a class on and they could directly go to a computer and complete work.
    - The students used the application to find staff details which they claimed had previously taken up a lot of their time, searching the university website, sometimes to no avail.
    - Overall the application was found to reduce the students "wasted" time and aid them in their daily tasks and reduce frustration.

General findings

Most students unaware of filter for staff contact list in mobile app, time wasted scrolling.

Majority of students failed 2 out of 4 tasks in uni web site, did not know how to find news events and did not know that lab timetables were available.

Individual Findings

Participant 1 – 4th Year Computing Student Male (22)

- Would have liked a function to be able to search for lab timetables by time rather than having to look through all timetables
- Very happy with data presentation, felt it was easy to read and use on the move
- Used the app more than they anticipated, they said that this was due to the good design
- Was the only student to use the filter function in task 1 to find staff contact details – resulted in fastest timed result

Participant 2 - 2nd Year Games Software Development Student Male (19)

- Liked the way the data was presented and found it easy to use, obvious button options and functions.
- They found lab timetable function very useful but wasn't so sure about the other functions. Only used general info once or twice and didn't use the uni news, said it wasn't something they really looked at on uni website normally. This was shown in task 4 of the lab experiment, when asked to find most recent GCU news event on the website this student selected the NEW2GCU option, which was incorrect and eventually gave up trying to find the news section, they were unsuccessful in the task.

Participant 3 - 4th Year Computing Student Male (21)

- Used the timetable function the most and found it more useful than expected
- Did not use the uni news function, this wasn't due to it requiring internet access but he simply wasn't interested.
- Found the staff contacts useful but claimed it was hard to scroll through all the staff and found that there was too many staff contacts that were never used. Was not knowledgeable enough about the schools departments and who belonged to each to use this to filter the number of contacts and was not aware of the filter function on the full list.
- Reduced roaming time as he wouldn't have thought to check ahead of time online.
- Student suggested improvement by adding class timetables so he wouldn't have to carry his paper timetable about, claimed it would increase his use further.

Participant 4 - 4th Year Computing Student Male (22)

- Student was surprised at the amount he used the application and claimed it was because it was much easier than the university website, the data was presented in a much simpler form.
- Was happy with the layout and would not add anything to the application, felt it was simple and effective.
- This student like many found task 2 difficult on the uni website. Went to live lab usage on the site so could only view labs currently available, did not know that lab timetables were available.

Participant 5 - 4th Year Internet Software Development Student Female (21)

- Liked the way the data was presented on the application
- Felt that there should be a direct button option to take you back to main menu, said she felt that there were too many steps to go back to main menu, constantly selecting back option.
- Used the lab timetable function the most as it was the "most relevant"
- Rarely used staff list as she felt that by 4th year she knew where to find the relevant staff and how to contact them, may be more useful for 1st years.
- Did not really like the functions that required internet access as she did not have free internet on her phone and the time taken to connect to university wifi wasn't "worth the hassle".
- In relation to the general info function she said that it was easy to state when she used it, if she was on a computer then she knew where to find the information and would use the website but if she was on the move she would use the phone, purely dependant on location scenario.
- Used the app more than expected, was very handy to look up lab timetables and reduced her time "wandering" to find a free lab, therefore reduced wasted time and improved daily activities.

Participant 6 – 3rd Year Networking and systems support Student Male (21)

- Student used it more than he expected but simply for lab timetables, used the other three functions out of interest but did not find he used them in daily tasks.
- Liked layout of data and said it was good that it presented the most used tasks clearly in comparison to uni site which had "too much" information and too many options on the home page.
- Asked if it would be possible to add class timetables as this was the other thing he needed daily.

Participant 7 – 2nd Year Web Systems Development Student Male (25)

- Liked the layout and ease of use of application, felt the functions were appropriate but still used the lab timetable function more than the others.
- Used more than thought but for shorter periods of time than expected.

Participant 8 - 2nd Year Information Systems Development Student Female (20)

- Liked the layout, number of key presses and found it easy to use on the move.
- Used about as much as she thought she would but found it more useful than expected
- Preferred using it to the university website and used it for short tasks
- Found it very beneficial and stated that it was used mainly for lab timetable function.

Responses to Hypothesis questions

Did you feel the introduction of a mobile guide improved the learning experience? If so how?

1. Yes it did, searching for free labs to continue coursework had often been a time consuming process, now with this mobile application I can check for free space while travelling to university.
2. I feel as if the introduction of the mobile guide has improved my learning experience in terms of being able to work quicker by being able to find free labs easily. This has benefitted me when I have needed to maximise the time I have available to complete work by finding a free computer.
3. Yes, especially with the class timetables that I use often. It allowed me to find out when the appropriate labs were free so that I could complete my work outside of scheduled classes.
4. I feel the mobile application did improve the learning experience in the sense that you could manage your time more effectively as you could use the application to search for free labs to work in instead of having to physically check for a free lab.
5. Yes, I felt less tied to the university website, which I don't like as it is too cluttered with information and it allowed me to carry out tasks more efficiently like finding a free lab.
6. Yes, it improved it by making it easier to find a lab and letting me get on with my work faster.
7. Yes, my main issue at university is the time I waste trying to find a lab to do work in on my breaks, this guide reduced this time dramatically
8. Yes, it increased the amount of time I can spend doing university work. The guide made it quicker to find information like contacts and semester dates and also allowed me to stop getting annoyed each time I had to go on a lab hunt as I knew exactly which ones were free or busy.

Did the mobile application improve your opinion of the School of Engineering and Computing (SEC)? If so, to what extent?

1. Yes it did, it raised my level of confidence in the department's ability to teach and develop relevant and reliable software applications.
2. I believe the application has improved my opinion of SEC as the introduction of the mobile guide has shown that the problems of finding relative information has been addressed and that the problems that student have are being dealt with.
3. Yes I'd say so. The app gave me more information than I would have found, or even thought to look for, in the main university website and helped me to access important information on my course.
4. This did improve my opinion of the school as it showed they were providing a practical and convenient way of finding various forms of information regarding the school, making the information more readily available.
5. Yes it improved my opinion as the SEC department appears to be teaching relevant up to date skills and are keeping up with advancing technology rather than being left behind in both technology and teaching.
6. Yes it made me feel that the department was "practising what it preached"
7. Yes, it increased my opinion of the department by providing a modern technical solution to an everyday problem for students
8. Yes, by seeing what a student within the department has created, it made me more confident about my potential over the remainder of my course.