



Using Developer-Centred Usability Inspection Methods on a Desktop Web Application to Produce Mobile Web Guidelines for the iPhone

Honours Project Final Report

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By The Road Runner
Matriculation Number: 28xxxxxxx

Supervisor - Dr Richard Foley
Second Marker – Iain Lambie

“Except where explicitly stated all work in this document is my own”

Signed: _____ Date: _____

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Abstract

Technology and connectivity advancements in mobile computing have seen the advent of the smartphone. Smartphones are highly capable devices with powerful on-board processing units, offering a more powerful means of communication than the contemporary feature phone. Utilisation of Internet services facilitates operations away from a fixed desktop environment whilst reproducing many of the functional characteristic associated with a desktop PC. Wireless and 3G technologies deliver a wide array of web services to users operating in ubiquitous domains. Migration of web applications, such as Caledonian University student homepage, intended for desktop usage, encounter usability problems when viewed on a smartphone device. Poor navigational controls and extensive scrolling are common features, highlighting a clear need to address the limitations of smartphones and specify appropriate requirements when designing web applications for a mobile domain. This project aims to evaluate to what extent a mobile web application, created using developer-centred inspection methods, would enhance user experiences whilst retaining core functionality.

The develop and test project elicited design requirements through the deployment of a heuristic evaluation inspection of the current Caledonian University student homepage interface, applying suitable W3C mobile web development guidelines, creating a prototype web application which was evaluated using both end user testing and interviews, obtaining qualitative and quantitative data for analysis.

Results obtained through analysis provided clear evidence that the mobile web application improved usability through the implementation of key functionality and improved navigation structures thus improving intuitiveness, whilst lowering the cognitive load on the user. The main goal of the project was to investigate the effective use of a developer-centred design approach and it was successfully concluded that this method was effective in producing high levels of usability for smartphone devices.

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1.0 Introduction

The final report introductory section defines three distinct areas of coverage stemming into sub-sectioning where required. The Project Background section provides an overall landscape highlighting evidence supporting the importance of the project within computing and key areas of focus leading to potential solutions and worthwhile investigations. A Project Overview describes the project method, aims and objectives concluding with specification of hypotheses. Finally, Report Structure provides an overall guide to the final report.

1.1 Project Background

Chronology of The Web and Mobile Devices

The creation of The Internet in the early 1970's and the effect it has had on global communications has been likened in magnitude to the invention of the telephone (Comer, 2000). Like the telephone, The Internet found a way to connect subscribers from around the world transforming the way individuals and organisations would exchange information and conduct business in the years to come. Electronic Mail and File Transfer are just two of the services associated with the Internet (Huitema, 2000). Perhaps the most recognisable and expansive service running on The Internet is the World Wide Web (web) (Moggridge, 2007).

When Tim Berners-Lee laid down the specifications for the web in 1990 (Berners-Lee & Fischetti, 2000) it was difficult to imagine back then how static text would evolve into dynamic, user controlled delivery of services over the web, such as commerce and education. Web Addressing (URI) (Berners-Lee, 1994), web Communication Protocol (HTTP) (Berners-Lee et al., 1996 [A]) and web Language (HTML) (Berners-Lee & Connolly, 1993) laid out in Berners-Lee original specifications still to this day, form the foundations on which web content is constructed. When Berners-Lee began his web development, he was programming to an interface and viewing this programmed work through a web browser at a 'workstation' (Berners-Lee, 1996 [B]). This presents the notion web content was originally intended for viewing via a desktop monitor when he refers to a 'workstation'. Berners-Lee and most of the computing world would be unaware at this early stage of the web's development that technological advancements would transform the hardware devices used to view the web.

Portable computer and mobile phone manufacturers in the mid 1990's were able to produce smaller units with increasingly more powerful processing power. Manufacturers benefited from the principles of a revised version of Moore's Law (Schaller, 1997), that microprocessors would double their capacity every year and a half. Harnessing smaller, more capable processors, mobile phones were able to emulate the operating characteristics of a desktop computer, albeit through a smaller interface.

Existing Usability Problems

An insightful pilot study investigating mobile graphical components by Brewster & Cryer (1999) noted usability issues are prevalent in mobile interfaces comparable with desktop monitors when viewing web browsers as screen dimensions undergo reduction. Fifteen inches is a common display size for a desktop monitor measured diagonally across compared to a three-inch screen of a mobile interface. Potentially this represents a mobile interface one fifth of the viewing area users would be accustomed to when using a desktop monitor. Webpage navigation structure and content layout intended for desktop viewing (fixed Web) do not

always migrate as users might expect when viewed via a mobile interface, causing inconvenience to users who may experience extensive scrolling both vertically and horizontally whilst viewing webpage content (MacKay et al., 2004). Direct migration of desktop webpages viewed on mobile interfaces can result in information overload for the user. Too much redundant information on the interface results in clutter and can distract users from locating desired information (Nielsen, 1994).

A web adaption study systematically investigating mobile devices undertaken by Xiao et al (2008) evaluates connectivity of devices providing linkage with poor usability such as undesired scrolling thus, proposing users may witness higher than normal operational costs, as increased online usage is a direct result of ineffective desktop web applications running on mobile devices. Supplementary to the finding Xiao and colleagues recommend users require a customisable web application for specific mobile devices adopting a 'less is more' presentation of information. *Less* irrelevant information will result in *more* usability.

An empirical assessment of environmental factors conducted by Tsiaousis & Giaglis (2010) drawing on multidisciplinary theories recognises environmental context of mobile device usage directly influences usability values. Distractions of a visual and auditory nature degrade cognition, memory and user attention limiting overall performance thus reducing usability. Information presented on mobile devices must be succinct and intuitive if users are to benefit from web applications whilst on the move.

Evolutionary Development of Devices and Connectivity

As technology evolved, more powerful generations of mobile phones were referred to as 'mobile devices' that offered 'pervasive computing' (Dix et al., 2004), because devices now performed more than just facilitating a conversation. Economical and compact batteries mediated portability. Mobile devices were now capable of e-mail and web browsing services whilst users were on the move. This is upheld with IBM's definition of Pervasive Computing at the time, "*Convenient access, through a new class of appliances, to relevant information with the ability to easily take action on it when and where you need to*", (Hansmann et al., 2003). *Convenient access* is a referral to connectivity, *new class of appliance* acknowledges modern mobile devices whilst *easily take action* points to intuitive interactions via an interface.

A demonstration of internet growth and mobile device usage in the UK is evident in a recent 'Internet Access – Households and Individuals' survey undertaken by the Office for National Statistics (2010). 30.1 million Adults in the UK utilised Internet services nearly every day. From this figure of 31.1 million, 31% of the users connected via a mobile device, presenting a situation where almost 10 million users potentially view webpages on a mobile device. This statistic demonstrates that if web developers are to maximise mobile web audience potential, and deliver information in a 'user-friendly' fashion, developers need to produce mobile web versions of existent desktop websites and applications, applying suitable usability guidelines for each mobile device.

Evolutionary development of mobile devices at present seems unbounded. A new wave of devices known as 'smartphones' (Charlesworth, 2009) include additional functionality supplementary to that already mentioned, such as Global Positioning Systems (GPS), Personal Organisers, Desktop Synchronisation and direct manipulation with QWERTY keypads or multi-touch screens. According to the BBC Business News Mobile (2010), global smartphone sales have risen by 78% in 2010, from the previous year. Apple iPhone is a popular example of a smartphone with the same BBC news article revealing, 14.1 million units shipped globally in July to September quarterly sales figures for 2010. With both

mobile internet usage and iPhone global sales figures in mind, this represents a large proportion of consumers and developers universally benefiting from further investigations pertaining to mobile web usability for the iPhone. Ascension of the iPhone and enhancements in user experience is as much to do with advancements in network connectivity and software as it is to do with the already mentioned hardware capabilities.

Smartphones accessing web services via a browser need a constant wireless internet connection. Tarasewich (2003) raised the issue eight years ago detailing, although mobile devices were more compact than desktops, operation occurred in low-bandwidth parameters limiting capacity to download substantial quantities of data via the web. This limitation was partly responsible for the sluggish uptake by consumers of mobile devices at the time, as devices could not match the hardwired capabilities of a desktop computer.

Nowadays low-bandwidth is not the limiting factor in connectivity that it once was. Smartphones utilise ubiquitous deployment of Wireless Local Area Networks (WLAN's) facilitating Wi-Fi usage by means of network access points termed 'hotspots' (Agarwal et al., 2007). A working example of a WLAN operates within Glasgow Caledonian University (2010), where a campus wide WLAN is available to students with Wi-Fi enabled devices. Communication advancements in the area of 3G wireless networks have additionally improved downstream times seen through increased data rates transmitted to smartphones (Ekstrom et al., 2006). Now that mobile connectivity ably matches smartphone processing power. This goes some way in explaining consumer uptake of iPhones globally.

Potential Solutions

The World Wide Web Consortium (W3C) is an Organisation who develops protocols and standards associated with the web such as HTML standard and HTTP protocol mentioned earlier in the introduction (Berners-Lee et al, 2010). Long-term growth of the web is a main objective of the W3C. Organisational standards have evolved accommodating advancements in both web and smartphone usage. Mobile web development is an area the W3C has acknowledged where mobile web authors need to apply alternative design considerations to those selected in designing a website intended for a desktop computer. New web language (HTML5), web content positioning (CSS3) and web interactivity (JavaScript) are technologies recommended by the W3C (W3C, 2010). Although application of new W3C mobile web technologies and best development practices are important, it is equally important to incorporate benchmarked development principles throughout any lifecycle (Leichtenstern & Andre, 2008). Analysis of human participants undertaking evaluation of a system supports design processes possibly influencing future iterations.

Interaction Design (ID) is a broad term that describes the design of interactive products, supporting ways in which people communicate and interact in everyday life encompassing theory, research and design practice. Human Computer Interface (HCI) has a narrower focus than ID defined by Dennis Wixon of the Special Interest Group on Computer-Human Interaction describing HCI as, "*concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them*" (SIGCHI, 1992). Optimisation of human well-being and overall system performance are borne from close overlapping of ergonomics and human factors thus enhancing the user experience.

Smith & Mosier (1986) emphasise system interface significance and user interactions therein citing system failure consequentially leading to under usage of poorly designed interfaces. Both researchers compiled a comprehensive list of design principles collected from fellow academics in the system design field consisting of papers, articles and technical reports,

combining all findings into one report listing over nine hundred guidelines. Applying every guideline in the Smith & Mosier report to every design, evaluation and implementation may intimidate developers in both quantity and complexity and therefore is not cost effective for small-scale projects.

A low cost, more acceptable design approach from Nielsen (1993) promotes an idea of 'discount usability engineering' directly addressing quality and complexity through a distillation of Smith & Mosier's paper delivering his version of design principles. *User Task Observation, Scenarios, Simplified Thinking Aloud* and *Heuristic Evaluation* techniques form four foundations for Nielsen's overall method. Nielsen acknowledges counter-examples of design methods are available but utilising his discount usability methods (in part or in whole) in design, inspection and testing of a system uncovers a high rate of erroneous usability problems. A recent study testing Nielsen's theories undertaken by Hwaing & Salvendy (2010) concluded through examination of both Thinking Aloud (TA) and Heuristic Evaluation (HE) inspection methods that 80% of usability errors were located concurring with Nielsen's view. Nielsen further explains usability is not a single, one-dimensional property of a user interface, citing five usability attributes;

- *Learnability* – A system that is easy to learn will encourage users to undertake work immediately.
- *Efficiency* – Systems should be efficient to use, so once a user has learned a system, high levels of productivity will be possible.
- *Memorability* – Systems should be easy to remember, so the casual user is able to return to a system after an absence without the need to restart the learning process of operation.
- *Errors* – Systems should have a low error rate providing users with easy recovery if errors do occur.
- *Satisfaction* – Systems should be pleasant to use providing satisfaction to users.

The design, evaluation and implementation of a mobile web application intended for smartphone usage would directly benefit with the convergence of protocols and standards recommended by the W3C and Nielsen's discount engineering principles. Flexibility is a key characteristic in Nielsen's discount usability engineering methods. An evaluative usability inspection can be performed on an existing web application where a sole developer can apply a heuristic evaluative approach, capable of identifying a high percentage of usability problems resulting in recommendations guiding subsequent designs for a variety of devices and operational environments.

Increased Delivery of Web Services

Mobile Web browsers permit mobile device platforms access to applications and Web services delivered over the Internet. Web services negate installation locally on a user's device, but instead see deployment on a Web server (Sommerville, 2010). A benefit of deploying on a web server is modifications or updates are performed on the Web server as opposed to every individual device therefore greatly reducing costs and processing power. Wright (2009) looks to a new era of rich Internet applications driven by the latest version of the de-facto web language HTML5, complimented with evermore-powerful Web scripting languages leading to possibilities of a Web server hosting the Operating System for mobile devices.

Raman (2009) talks of sustainable, dynamic delivery of information over the Web with ever more intelligent mobile Web browsers processing HTML5, JavaScript, DOM, AJAX, jQuery and CSS3 Web technologies making smartphones capable of offering an end user experience comparable to that of a desktop when considering response and capability factors. Safari exemplifies an intelligent mobile Web browser (Want, R., 2010), installed as standard on the iPhone. Safari is capable of processing new Web technologies giving the appearance Web applications are locally hosted.

Examples give a clear indication of current market trends shifting towards a platform independent Web. Previously Web services may have needed a Java platform to run on each device. This is no longer the case with Web services delivered and viewed through highly functional and adaptive web browsers such as Safari. Frederick & Lal (2009) evaluate several smartphone Web browsers ascertaining modern day mobile Web browsers are highly functional but cannot provide enhancement for poorly designed desktop Web applications running on a smartphone browser, advising the requirement of a device-centric Web application to maximise user experiences. An example of an organisation deploying a mobile web application is Amazon. An informal developer-centred inspection of the Amazon desktop website conducted by the author concluded the desktop web application has a 'busy' interface whose migration to a smartphone browser provides poor usability. However, fundamental interface elements (search facility, categories and shopping cart) persist in the Amazon mobile version providing an intuitive interface whilst retaining core functionality.

There is a need for a greater understanding of how mobile web applications should be suitably designed to address smartphone operational characteristics in dynamic environments, thus improving overall usability. A develop and test project has been chosen to measure the suitability of developer-centred inspection methods with analysis collected from end user evaluations to ascertain if said inspection methods enhanced usability whilst still retaining core functionality

1.2 Project Overview

This section illustrates the project method and the research question that the overall project attempts to answer. Outlined literature objectives and primary research objectives feature with the hypotheses stated with justification.

1.2.1 Project Method

Ong et al. (2008) investigate user-centred development of systems concluding overall acceptance of a system undergoes enhancement with the involvement of potential users during development but noting large user groups present logistical and financial complexities. Nielsen & Molich (1990) concur with the work of Ong et al. through heuristic evaluation of four systems however, acknowledging logistical and financial complexities with large user groups are a hindrance. Economical evaluation is achievable with a recommendation that an expert user can perform an initial usability inspection on an existing system, locating a high correlation of faults, negating requirements of user group involvement throughout. A low cost developer-centred usability inspection in the form of a Heuristic Evaluation on the current desktop Glasgow Caledonian University Student web application provides guidance in planning, designing and building a mobile web version operating on an iPhone. A prototype usability inspection by end users will affirm the robustness and usefulness of the mobile

system. A greater understanding of how mobile presentation of information to end users is required. Undertaking a develop and test research method will improve understanding of presentation relating to mobile web applications. Analysis of investigative qualitative and quantitative research techniques and results produced will provide an efficiency measure to which the mobile web application can be compared to the desktop web application viewed on a smartphone device.

Mobile usability restrictions are identifiable from previous studies investigating porting desktop web applications directly onto mobile devices. Trevor et al, (2001) emphasis a need for simplicity delivered via a customised user interface (UI). On-board hardware, small screen displays, input peripherals and operational environments are limitation variables needing careful consideration when conducting the design process of mobile web applications. Cross-platform design is not a viable option for a web application intended to run on both desktop and mobile environments. A factor-five difference in screen size between a three inch iPhone display and a fifteen inch PC monitor, is simply too much of a variant for the same application interface to scale adequately. Mobile differs greatly from the PC environment and necessitates a separate web application with a much simplified user experience required (Nielsen & Loranger 2006).

Producing a mobile web version of Glasgow Caledonian University Student Home Page running on an iPhone will evaluate the proposed hypotheses whilst establishing the effectiveness of developer-centred inspection methods in the design process. It is anticipated completion of a targeted mobile web application will deliver an intuitive interface overcoming desktop usability issues, providing an enhanced end-user experience comparable to the desktop. Establishment of a research question based on factors stated provides embodiment and direction for the project undertaking.

Can a desktop website viewed on an iPhone, be reconstructed with the aid of developer-centred usability inspection methods, to produce HCI guidelines to develop an accessible mobile web application with an intuitive interface, enhancing usability whilst retaining core functionality?

1.2.2 Project Aims and Objectives

The overall project aim is to measure how successfully developer-centred HCI usability inspection methods can be applied to an existing desktop web application resulting in guidelines to build a mobile application operating on a smartphone device that ultimately is characterised through enhanced usability. Verification of the project success will be provided through a simplistic lab based end user evaluation of a prototype. Identification of project objectives is integral to the successful construction of the project. Defining objectives identifies significant measurable achievements that build towards the ultimate aim of the project. Objectives are categorised into both Literature Objectives and Primary Research Objectives. Literature objectives justify the area of investigation and how it fits into a broader context recognising that mobile web development is by no means at the limits of understanding and there are possibly an infinite number of discoveries yet to be made. Consequentially, the literature survey enables interested parties to view the grounds from which the project was developed. Results from the project will provide web programmers with a clear understanding of how to apply HCI principles within a mobile application development process. Primary research objectives follow on from the literature objectives

utilising the applied research to design a practical application that is a fundamental component to measure the suggested hypotheses.

Objectives met through the literature review are listed below:

- Identify the HCI characteristics of a typical smartphone platform
Smartphone platforms and parameters are very different from fixed desktop environments with notable distinctions even from legacy mobile phones. Limitations such as screen size and differing input peripherals (touch–screen or keyboard) between devices merits exploration. Information obtained from a thorough literature review identifying smartphone platform characteristics will influence the overall development process. Capabilities of smartphones will determine web technologies implemented.
- Investigate and determine web-based guidelines for good usability on a smartphone platform
Mobile web application development guidelines can streamline development processes with benchmarked design principles that factor in unique prerequisites pertaining to a mobile operating environment. A careful examination intent on verifying accuracies of fellow practitioner’s investigative works will lead to discussions on the appropriateness of findings, with a view that knowledge gained will directly assist primary research activities.
- Understand mobile specific language features of web scripting
A literature review in this area will provide foundational understanding of semantics associated with web scripts within the mobile domain. Appropriate web-programming language choices will undergo appraisal with an in-depth review of how selections can be leveraged in a mobile computing domain, ultimately engineering potent usability characteristics.
- Understand the key characteristics of usability inspection methods as a applied to mobile web application design and identify the user inspection methods to use
HCI usability inspection methods must be understood in relation to the relevance each method will have within the project. Sample inspection methods are discussed in the background section, but not all of the methods are relevant to the project. web inspection methods will be identified and their inclusion justified.

Objectives that will be met through the primary research method are listed below:

- Apply the usability inspection methods along with the identified mobile HCI guidelines to the desktop version of the web application
The desktop web application underwent a usability inspection utilising developer-centred heuristics in tandem with the W3C mobile development guidelines. Results obtained provided requirement to structure the building of the mobile web application.

- Build the mobile web application using the relative HCI design
A mobile web application was built from the results of the developer-centred usability inspection on the desktop version. A post implementation review of the mobile web application prototype took place at the end of the build process.
- Evaluate the development via a simplistic lab-based empirical evaluation
A low cost end user evaluation took place in a University lab with evaluators. A comparison of the desktop web application and the mobile web application was undertaken. Formative evaluation took place through individual performance measurement on each web application (desktop and mobile) providing quantitative data. Qualitative data collection took place through short evaluator interviews after evaluators have interacted with the systems.

1.2.3 Hypotheses

A comparative analysis between the desktop web application and the mobile web application will take place with both applications viewed on the iPhone. Data derived from end user empirical evaluation will test the hypotheses. Literary justification substantiates both hypotheses with reference to key sources.

H1 - A mobile web application of the Student Homepage will offer greater usability to the end user compared to the desktop version when viewed using an iPhone.

Justification

Holzinger (2005) discusses both usability inspection methods and evaluative methods and advises that a system that is easy to use will affect the user's performance and satisfaction. Supplementary to this discussion, acceptability by the user affects whether the system is used. Kim (2010) reports that time based usability studies on a smartphone platform such as the iPhone will benefit the evaluation of mobile web applications.

H2 - In performing like for like tasks, the mobile web application will have a higher rate of successful end user interactions compared to the desktop version of the Student Homepage.

Justification

User evaluations performed on the mobile and desktop applications will provide participants with a real usage context of both web applications. Kangus & Kinnunen (2005) identify evaluative testing as a useful instrument in measuring end users ability to perform detailed interaction and performance of tasks where success versus error rates on both applications can be compared.

1.3 Report Structure

This section outlines the remaining sections of the report, identifying the content of the literature review, problem and system analysis, design and implementation, testing and evaluation and discussion and conclusions.

1.3.1 Literature Review

The literature review is contained in section two of the report, providing a foundation of knowledge for the project. Critical evaluation of literature provides a firm understanding of the subject area. The literature review section provides a general backdrop to usability issues associated with smartphones, leading to a coherent argument which will critically evaluate past and current research in the field, identify the project in a wider context and show some justification as to why the project is of importance, finally leading to conclusions drawn from each literature review objective.

1.3.2 Problem & System Analysis

Section three of the report investigates the problems associated with migrating desktop web applications onto an iPhone. Overall project development methods are detailed outlining the development lifecycle to be used in the project, then exploring HCI guidelines and W3C mobile web development guidelines. Developer-centred inspection methods are applied to the Caledonian University student homepage delivering a specific list of functional and non-functional requirements for use in the design process, finishing with a section conclusion.

1.3.3 Design & Implementation

The fourth section of the report begins to construct the mobile web application from the requirements gathered in section three. The steps undertaken to achieve the objectives for this section are - interface design, system architecture, building individual components, implementation and application testing all occur in this chapter, with a post-implementation inspection occurring on a functional prototype before end user evaluation. Application of technologies used and some illustration is given regarding screen designs with some code samples detailing how usability problems were overcome through robust design techniques.

1.3.4 End User Evaluation

Section five of the report is concerned with the end user evaluations, which conduct usability inspections on the mobile web application prototype. Empirical evaluative methodologies are used gathering both quantitative and qualitative data types, derived through performance measurement and interviews. Details on the usefulness of the test and how test evaluators were recruited is also detailed. Finally in the section data is presented via charts and commentary with conclusion of the process of evaluation delivered at the end.

1.3.5 Discussion & Conclusions

Section six provides a summary of the overall project, discussing results which were obtained in the evaluation of the mobile web application. Project outcome in relation to developer-centred design and its successes are outlined with justification of the original hypotheses and relevance to the overall research question. Limitations imposed on the project are outlined with future development recommendations and finally an overall project conclusion.

2.0 Literature Review

The literature review is an essential part of the project. A knowledge base is continuously built upon providing support for project direction. Academic journals, books, conference proceedings, theses, company reports and manuals relating to mobile computing and HCI will contribute to the authors overall understanding of the areas to be investigated. A summary of each literature objective will be contained at the end of each section.

Literature review objectives include:

- Identify the HCI characteristics of a typical smartphone platform
- Investigate and determine web-based guidelines for good usability on a smartphone platform
- Understand mobile specific language features of web scripting
- Understand the key characteristics of usability inspection methods as applied to mobile web application design and identify the user inspection methods to use

2.1 Identify The HCI Characteristics of a Typical Smartphone Platform

The initial literature review in the project background section details an evolutionary progression of smartphones, which offer advanced computing ability and increased connectivity over a contemporary feature phone. Smartphones run complete operating systems enabling a rich user experience in pervasive computing (Chun & Maniatis, 2009). The uptake in smartphone usage has increased demand for mobile programmers who can write for mobile platforms such as the Apple iPhone, Google Android and Research in Motion's Blackberry (Bloomberg Businessweek, 2010). With the rise in smartphone usage, mobile web programmers, to improve interaction capabilities whilst users are on the move, have placed a strong emphasis on HCI (Muhanna et al., 2009). Good interface design should aim to reduce the cognitive load on the user. In order to create a useful mobile web application a programmer needs to understand the HCI characteristics of the target device. Chittaro (2006) identifies some key characteristics of smartphones. Displays, input peripherals and techniques and context of usage provide areas of focus for the following sub-sections. Power consumption, although not a direct HCI issue with smartphones, will influence a web programmer's choice of software when building a mobile web application and is included in this section.

2.1.1 Displays

Reduced screen size is the most notable difference between a smartphone and a desktop. A typical desktop monitor measures fifteen inches (diagonally) and an Apple iPhone screen measures three and a half inches (diagonally) (Apple 2011). An even smaller screen appears on the Blackberry curve measuring two inches (diagonally) (Blackberry, 2011). An interface, which is a fifth or a sixth of the size of a desktop display, necessitates a web application specifically targeted at the smartphone screen size.

A study of users viewing desktop web applications on mobile devices (Jones et al., 1999) found that small screen users performed a substantial number of scrolling activities in attempting to complete some predefined tasks. Nielsen (2010) conducted a recent eye tracking survey stating that horizontal scrolling on any device should be avoided at all cost

and long pages (vertical scrolling) continue to be problematic due to users limited attention span. Users prefer to avoid the extra effort and favour interfaces, which deliver information quickly with minimal effort. Furthermore, the survey stated that web application users spent 80% of viewing time focused on information above the page fold. Conversely, the same users spent only 20% of their time looking for information below the fold. Any web application designed for a smartphone must prioritise the information architecture so that users can access essential information on the first page with minimal scrolling. In light of this information, *Tables* should be avoided, as they would require users to scroll both vertically and horizontally to view on a smartphone.

Eisenstein et al., (2001) conducted a study into the application of model-based techniques relating to development of UI's for mobile computers. In the study, a discussion of platform constraints is undertaken. Low-resolution displays, at the time, were considered an obstacle in accepting mobile devices. Screen depth and resolution technology has progressed since the study was conducted with Liquid Crystal Technology (LCD) developments supporting users in trouble free usage of mobile devices through colourful flat screen interface (Ziefle, 2009). Smartphones now have upgraded pixel displays with the Apple iPhone3 displaying a screen resolution of 480x320 compared to a desktop monitor display of 1024x768. Developers need to understand target device resolution settings providing a higher resolution image, which exceeds capabilities of a device, will result in bandwidth wastage.

Table 1 features a tabularised presentation of technical specifications retrieved from Apple (2010) and Dell (2011) illustrating differences between an iPhone versus a typical desktop PC. Most notable differences between devices are display size and resolution which is acknowledged as a key design consideration for any web application viewed on a mobile device.

Table 1 - Smartphone versus Desktop

	Apple iPhone 3	Dell Inspiron 2205 Desktop
Display size	90mm	500mm
Resolution	480x320 px	1024x768
Storage	16 GB (fixed)	320GB
Processor	Apple 3 (1Ghz)	AMD 1.6Ghz
Memory	512 Mb DRAM	3GB

2.1.2 Input peripherals and Techniques

Smartphones have an array of methods in which the user can manipulate the interface. Blackberry devices exhibit optimisation characteristics suitable to a business market (Hamer, 2010) with some models featuring a permanently available QWERTY style keyboard. Most users are instantly familiar with this input feature as it is a small-scale version of a PC keyboard. However, a keyboard that is fixed limits the amount of screen space available to the user. Small keypads and micro joysticks can be inadequate for performing complex tasks such as form fills or clicking on tight navigation links.

The iPhone adopts multi touch technology (Ebner et al., 2010) which allows for advanced intuitive interactions based on gestures with the user's finger. Direct manipulation of the UI touchscreen controls all functionality of the device. Removal of a traditional fixed keyboard by Apple designers has provided a larger display area, which can be, viewed in both landscape and portrait orientations. JavaScript *onresize* and *onorientationchange* 'event

captures' register the shift from landscape to portrait and automatically expand or decrease the content to fit the display screen.

2.1.3 Context of Usage

Expanding on concepts relating to environmental context of device usage introduced in the background section, it is important to understand variable distractions of both a visual and an auditory nature prevail in ubiquitous computing domains differing greatly from relatively consistent desktop operational surroundings. Karlson et al, (2009) undertook an intensive logging field-study of smartphone versus desktop PC usage patterns. Conclusions of pattern usage revealed smartphones provided participants with extensible means in which to carry out work related tasks out with conventional working hours. However, cognitive loads increased due to modulation of lighting conditions whilst viewing screen displays conjoined with introduction of background noises resulting in dissipated productivity when performing like for like tasks against a desktop PC. Conceptual design must presuppose restrictive smartphone operation environments prioritising succinctness and intuitiveness in mobile application design.

2.1.3 Power Consumption

The central processing unit (CPU) is the hardware element of any computer system that processes the instructions of the computer programmes. Technology advancements such as Moore's Law discussed in the background section have seen smartphones take advantage of more powerful processors. Smartphones are powered with batteries, which are limited in size and therefore capacity. Carroll & Heiser (2010) conducted an energy management study of a smartphone (HTC Dream). Results found that the CPU was the biggest drain on battery life and recommend ways in which the processor could be power managed. Investigations revealed a way to reduce processor workload when operating in a mobile web environment is to reduce the number of linked sources out with the web application domain. A reduction in HTTP requests from the server to the client will endure battery life. AJAX is an interrelated group of web development methods used to create interactive web applications (Zepeda & Chapa, 2007) and serves as a solution directly addressing excessive power demands of web services. AJAX requests will reduce processing power as technologies asynchronously retrieve data from the server without refreshing the complete page on view.

2.1.4 Objective Summary

Literature evaluation of HCI characteristics of smartphone platforms has heightened understanding of variable factors directly influencing functionality and design. Past research illustrates consistent patterns in information retrieval by users supporting a view that, if a mobile web application is to undergo successful design, it must present essential information to the user first and foremost. User acceptance is directly linked to ease of use (navigation and information architecture) and the ability to lower the cognitive load on users whilst traversing pervasive environments. Conclusions drawn from literary investigations into HCI characteristics will feature in the literature conclusions section after outlining all objectives.

2.2 Investigate and Determine Web-Based Guidelines For Good Usability on a Smartphone Platform

The literature review corroborates investigations into web guidelines for the smartphone platform. Guidelines are paramount in developing mobile web applications. Determining and applying guidelines will improve accessibility and interoperability and result in a usable web application. Pressman (2010) provides a lengthy review regarding interface design principles and guidelines inserting this statement at the beginning of his review, “*The user interface of a web application is its first impression*”. Failure to ‘grab’ a potential user immediately, regardless of content or processing capabilities will result in the user engaging in another web application.

The World Wide Web Consortium (W3C) is the main international standards organisation for the World Wide Web. The W3C oversee and develop web standards and issue regular guidelines on many areas of the web. Within the W3C web portal, a guidance section titled ‘Web of Devices’ features extensive development initiatives for a *Mobile Web* (W3C 2010). A growing demand for a quality mobile experience is recognised by the W3C, stipulating site authors who specifically design applications with mobility in mind will undoubtedly provide an enhanced user experience benefiting mobile users. Challenges posed by CPU limitations, network costs and delays, pointing devices and keyboard differences merit bespoke design considerations to properly harness personal, always-available nature and context aware capabilities of smartphone devices.

In light of this information, W3C has produced a Mobile Web Best Practices 1.0 Web Standard comprising of ten themes, offering signage for content producers to broaden audiences, creating effective web applications, offering browsing convenience on smartphone devices.

- **Design for one Web** – Content designed with diverse devices in mind reduces cost, increases flexibility and reaches the needs of more people. Thematic consistency should prevail and harness capabilities of target devices to enhance the end user experience. Ensuring application stability in testing phases requires cross-browser feature tests on actual target devices eradicating test suite uncertainties of device emulators.
- **Rely on Web standards** – Standards are the best guarantee of interoperability in the highly fragmented market of smartphones and browsers. Valid markup, content format support and character encoding commonality unify a robust design approach. Implementation of style sheets separates content from layout, whilst properly nested structure elements allows easier adaption of content in situations where content needs to be divided into several pages.
- **Stay away from known hazards** – Thoughtful design can reduce usability problems due to already mentioned small screens and keyboards. Pop-ups, layout tables, nested tables and frames should be excluded in mobile design processes as possible inclusion will certainly impinge on usability of the UI.
- **Be cautious of device limitations** – A mobile device capability assessment will occur before a particular web technology undergoes consideration for use, ensuring coherent rendering of code via device web browsers. Applications relying on cookie sessions, objects, scripts, style sheet support and extensive colour highlighting, only merit inclusion if the target device offers support.

- **Optimise navigation** – Simple navigation and text entry become critical when using small screen and keyboard with limited bandwidth. Clearly identified and consistent navigation mechanisms must be deployed, balancing trade-offs between having too many links on a page and asking users to follow too many links to reach desired resources. Uniform Resource Identifiers (URI's) need to be of minimum character length, accommodating users who have to enter page identifiers via a keyboard, avoiding assumptions that all application traffic directs solely from external hyperlinks.
- **Check graphics and colours** – Images, colours and styles all brighten content but require careful application. Devices may have low-contrast screens or may not support certain design formats. Large, high-resolution imagery with no specification of image markup properties will inhibit interface functionalities. Foreground and background colour combinations that exude poor contrast and readability will generate debased user interactions.
- **Keep it small** – Smaller applications enhance user experiences through reduced user interaction times. Terse, efficient markup with limits on scrolling and page size results in optimised application usage.
- **Use the network sparingly** – Web protocol features can help improve the user experience by reducing the impact of network bottlenecks and latencies. Every click can generate an HTTP request to the server. Caching control effectively resolves this situation, negating the need to reload style sheets, images and pages thus improving performance and reducing cost of use. Externally linked resources should be minimised thus reducing HTTP requests.
- **Help and guide user input** – Keyboards and other input devices can be tedious to use, so effective designs minimise their need. Minimising keystrokes, text entry avoidance and provision of pre-selected default values where text entry is a necessary aggregate to augment usability.
- **Think of users on the go** – Web users on the go want compact information when time is short and distractions are many. Short but descriptive page titles, clear simple language, clear meaning and limitation of content to that requested by the user ensure a usability experience maximising absorption of information by users.

Supplementary to the ten themes outlined by the W3C, the organisation provide development tools in the form of validation services pertaining to mobile web applications. W3C mobileOK Checker (W3C, 2011) facilitates analysis of web applications hosted both locally and remotely, rendering code and giving applications a percentage rating derived from the applications adherence to the ten provided themes. W3C Markup Validation Service (W3C, 2011 [B]) performs a more basic validation service gauging HTML and CSS 'correctness' with analytical software filtering code and validating content against W3C web programming standards.

Ballard (2004) underpins W3C mobile best practices, contributing additional design principles for mobile web applications explaining users expect web applications to be predictable on both desktop and mobile locations. Predictability accompanies features that match user tasks, providing the correct set of cues, guiding user expectations. Most desktop web applications are feature rich – mobile web applications restricted by context of use and display limitations, should not be. When a user performs tasks, a web application should demonstrate immediacy in response, even if the process is not ready to respond, as users

should always be aware of system status. Feedback should be given for user actions, but avoid interrupting the users mid-task to do it.

Outside of the entertainment domain, users are normally looking to accomplish singular tasks on a mobile web application and may be paying for the connection. Optimisation should target a specific device, a “one size fits all” approach will not work in most cases, browser-rendering differences require that computing practitioners design for a target device. Rotto (2006) reaffirms problems associated with smartphone usage in a pervasive environment stating, content must have value with minimisation of graphics and gimmicks. Supplementary commentary states connectivity is not always free. Most Wi-Fi spots are free of charge but networks such as 3G still require subscription. Operatives will appreciate minimising time spent accessing a web application.

Shresta (2007) undertook an empirical evaluation of a desktop web application viewed on a native desktop environment, then viewed on a mobile device. A key recommendation from the study concluded in order to avoid excessive page scrolling; implementing a ‘Search’ facility would reduce information retrieval time thus accentuating user experiences. Although a search facility would require textual inputs, evaluative statistical analysis revealed information retrieval emitted higher levels of efficiency through word searches than manual vertical scrolling.

2.2.1 Objective Summary

A comprehensive cross-section analysis of literature from both the W3C and accomplished academic researchers provides a balanced representation in determining web-based guidelines for good usability on a smartphone platform. Guidelines derived from investigations undertaken in this section will be applied directly to the primary research method cementing a robust engineering process, consequentially delivering a mobile web application yielding full-bodied usability. Investigative conclusions determining web-based guidelines for usability on smartphone platforms receive summarisation in the literature conclusion section.

2.3 Understand Mobile Specific Language Features of Web Scripting

This literature objective aims to understand web-programming languages available to the author involving an analysis of language suitability and performance in a mobile web application context. Users of web services have come to expect dynamic interaction with terminology switching from *Website* and coining a new phrase, *Web Application*. Web applications mimic desktop applications characterised in both aesthetics and responsiveness as opposed to traditional static text-image-hyperlinked HTML documents, which historically were the embodiment of the original WWW concept (Lawson & Sharp 2010). Users have come to expect a certain level of responsiveness across all computing but even more so whilst accessing information in a dynamic mobile environment.

Dale Dougherty is regarded as the practitioner who invoked the term *Web 2.0*, recognising traditional web services were transgressing to a new plateau of operability performed through web applications utilising a re-gurgitation of existent technologies, facilitating participatory information sharing, propositioning a new web ethos, shifting control of information from a powerful few to an empowered many (O’Reilly, 2005). Web 2.0 has provided a platform for Social Media, Blogging, User Generated Content, RSS feeds, Web Services and Mashups and

Rich Internet Application services. Aforementioned services see deployment in both a fixed desktop environment and mobile environment.

Tim Berners Lee who received coverage in the background section, contests in an IBM Developer Works interview with Scott Laningham (IBM, 2006), that Web 2.0 has no real meaning. Berners-Lee correctly observes technologies such as HTTP, XHTML, DOM, CSS, SVG and JavaScript utilised in Web 2.0, have existed as standards since the inception of Web 1.0. Berners-Lee additionally adds his vision for the original WWW was to encourage collaboration between individual parties directly manipulating web content, endorsed by Berners-Lee seminal browser-editor Nexus, supporting WWW viewing and HTML editing. The conceptual WWW vision experienced indistinctness in its relative infancy, but has been subject to a reincarnation as connectivity and a better understanding of how to apply technologies by practitioners to specific domains has proliferated web application development.

A literary exploration of standard web technologies in deployment scenarios will strategize usefulness within the primary research method. XHTML, CSS, XML, MySQL, DOM, JavaScript, AJAX, jQuery and PHP provide the touchstones for discursive analysis.

2.3.1 Extensible Hyper Text Markup Language

Extensible Hyper Text Markup Language (XHTML) is the principle markup language used in the construction of web pages with web browsers parsing XHTML code and displaying content to the user. Unlike Java or C#, XHTML is not a procedural programming language but a markup language specifying text formats to display. Linkage, ordered lists, forms, drop-down lists, radio buttons and metadata represent some functional characteristics provided by XHTML. Over time, XHTML standard has witnessed an increased demand by users, seeking a more sophisticated interaction with web pages to deliver user generated data. HTML5 is an incarnation of HTML more suited to the modern web (Lubbers et al., 2010) and more specifically the mobile web.

HTML5 specifies new Document Object Models (DOM) for drag and drop server-sent events (Pilgrim, 2010). HTML5 in a way returns to the original ethos of the web as an open standard, replacing proprietary technologies such as Adobe Flash or Microsoft Silverlight. HTML5 specifically addresses the shortcomings of XHTML in regards to supporting mobile web application development. HTML5 is a W3C working draft (W3C, 2011), which will receive a full standardisation soon but is still subject to syntactical changes. In light of this information, individual browsers across both desktop and mobile landscapes have customary page rendering semantics requiring verification of HTML5 processing before deployment.

A recent investigative study carried out by Hagood et al, (2010) into HTML5's usefulness as applied in developing a web mobile application operating on an iPhone which assists patrons with the language disorder, Aphasia, concluded - adoption of the emerging HTML5 markup standard significantly reduced overall development efforts citing the non-proprietary HTML5 as an emerging technology offering significant advantages to technology developers and researchers alike.

2.3.2 Cascading Stylesheets

Cascading Style Sheets (CSS) allow web authors to specify presentation of web page elements (e.g. fonts, spacing, and colours) separately from the structure of the document (section headers, body text and hyperlinks). Separation of structure from presentation simplifies the process of maintaining and modifying a web page and is especially useful for alterations to web applications with a large directory of pages (Cederholm & Marcotte, 2010). HTML dictates content and CSS dictates presentation of that content. CSS styles can be applied in line with HTML code, embedded within an HTML document header section or finally, contained externally with a call from within HTML to the stylesheet file. CSS is a W3C standard with version two rendered by most web browsers with version three a working document.

The Scottish Government (2011) web portal enlists CSS technology to improve accessibility for visually impaired users. Four variable font sizes appear in navigation hierarchy. Clicking on a desired font size will reduce or enlarge page text as required, achieved with user controlled selection of an appropriate stylesheet. Separating CSS code from HTML code permits mobile devices to cache stylesheets applicable to an entire web application avoiding additional parsing of code thus optimising web application functionality.

2.3.3 Extensible Markup Language

Extensible Markup Language (XML) is a language development created and overseen by the World Wide Web Consortium. XML is a widely supported non-proprietary technology format used to describe and parse data exchanged between applications over the Internet. XML vocabularies provide a means for describing particular types of data in standardised structured ways overcoming cross platform difficulties in data exchange allowing authors to customise structure and data presentation (Tatarinov et al., 2002). XML structure and content is both machine and humanly readable supporting web interactivity, which is reliant on relational database enterprises that can exchange stored information seamlessly, thus enhancing portability. XML files are written in a simple text editor and saved with a .XML file extension occupying minimal memory providing caching ability. Efficient parsing of small files makes XML suitable for deployment in mobile domains where efficient leveraging of processing power is of the essence.

2.3.4 Structured Query Language

Nearly all modern web Information Systems utilise databases to organise and store data. Database Management Systems (DBMS) provide mechanisms for storing, organising, retrieving and modifying data allowing access and storage of data without concern for the internal representation of data held in the database. Structured Query Language (SQL) is an international standard language commonly deployed to perform queries and manipulate data. Databases are simply tables comprising of rows and columns usually with each row comprising of a primary key that acts as a unique identifier to information in that row so once created it cannot be duplicated. MySQL is a popular example of a relational database management system (RDBMS), removing the need to store information locally and allowing users access to information stored remotely, across a network. MySQL is a multiuser, multithreaded (i.e. allows multiple simultaneous connections) RDBMS server that uses SQL

to interact with and manipulate data. MySQL web domain (2010) lists numerous benefits of MySQL. Scalability, high performance, robust transactional support, high availability strong data protection and comprehensive application development are key characteristics of MySQL, which make the open source software a popular choice for businesses, educational establishments and individuals. Dynamic information delivered to smartphone devices is normally stored remotely on a database and is retrieved through script requests across a network. In order to facilitate a pervasive computing experience database technology will be required to provide a high level of functional information services to end users.

2.3.5 Document Object Model

Document Object Model (DOM) provides access to all elements in an HTML web page with browsers viewing an HTML page as an object hierarchy. Identification of each element allows dynamic modification of page content via event-driven JavaScript codes to create, modify and remove elements accessed through *Element Nodes*. A basic tree structure describes relationships between elements such as *Root*, *Parent*, *Child* and *Sibling Nodes* (Deitel & Deitel, 2008). Historically browser semantics saw variations of how individual web browsers such as Netscape and Internet Explorer parsed the DOM model consequentially resulting in web programmers having to design browser-agnostic applications. In an effort to encourage cross-browser websites, the W3C created a standardised Document Object Model. Mozilla Firefox, Microsoft Internet Explorer and Apple Safari browsers now implement most of the features laid out in the W3C DOM, leading to less development work required to achieve cross-browser compatibility (Jianlei et al., 2004).

2.3.6 JavaScript & jQuery

JavaScript is a non-proprietary client-side dynamic scripting language, which facilitates a disciplined approach to designing programmes (scripts) that enhance the appearance of web applications made possible with portability and cross-browser acceptance (Fraternali et al., 2010). Powerful functionality is injected into the web architecture. Creation of a unique platform allows web programmers to improve user experiences through utilisation of client-side data computation, synchronous and asynchronous events, bidirectional client-server communication and rich interface widgets (Gosselin, 2008). The ability to respond to user input is where JavaScript enforces powerful operational events such as responding to mouse clicks (buttons) or rollovers. Control statements direct programme flow supported with algorithmic formula which process decision making regarding variable selection and manipulation of array elements. Random image generation, complex calculations and cookie session represent JavaScript versatilities essential to a rich internet web application.

jQuery (2011) is an open source, cross-browser JavaScript library designed to simplify the client-side scripting of HTML allowing developers to reduce the amount of JavaScript code implementation whilst retaining high-level functionality. JQuery library includes effective code snippets that detect differences between runtime environments such as variable web browser semantics in DOM parsing and remove the need for web applications to allow for such inconsistencies allowing quick assembly of dynamic pages by running event handlers (form posting/validation), inspection of DOM elements and animations (Wellman 2009).

2.3.7 Asynchronous JavaScript

Asynchronous JavaScript and XML (AJAX) illustrate a collective term for a group of technologies. Jessie James Garrett is accredited with defining the term stating AJAX comprising of “*several technologies, each flourishing in its own right, coming together in powerful new ways*”(Garrett, 2005). AJAX is responsible for web applications replicating richness and responsiveness characteristics of desktop applications with seamless updates to page information largely unnoticed by operatives due to low latency. Google Suggest (2011) and Google Maps, exemplify the seamless experience with suggested updates as users type and bi-directional scrolling respectively.

AJAX incorporates standards based presentation utilising XHTML and CSS. Dynamic display and interaction harness Document Object Models (DOM). Extensible Markup Language (XML) and Extensible Stylesheet Language Transformation (XSLT) facilitate data interchange and manipulation. Asynchronous data retrieval is performed through XMLHttpRequest with JavaScript binding all technologies together. The classic web application model in figure 1 illustrates user actions performed in the UI triggering an HTTP request to the server, which in turn returns an HTML page to the client. Latency in the classic convention is very noticeable incurring downtime for operatives.

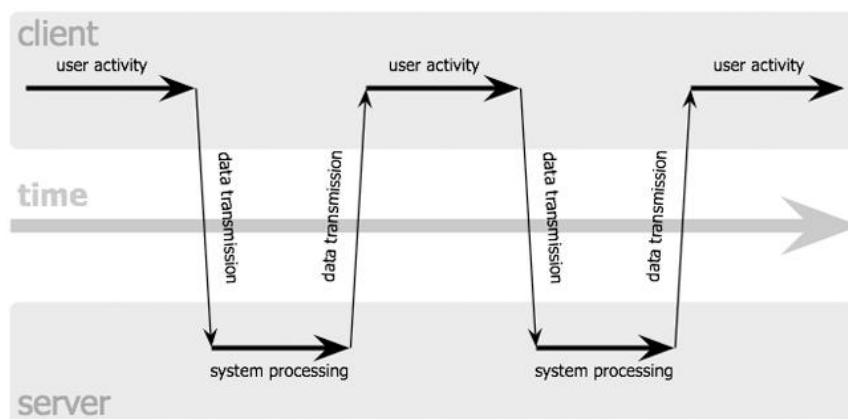


Figure 1 - Classic web application model (synchronous) (<http://adaptivepath.com>)

An AJAX application eliminates latency removing the start-stop nature of the classic web application model. The AJAX engine written in JavaScript acts as an intermediary between the client and the server and can be viewed in figure 2. HTTP generated user requests in the classic model are replaced with JavaScript calls to the intermediary engine. Responses to a user action that do not require information retrieval from the server, such as navigation and simple data validation are handled, solely by the AJAX engine. If the AJAX engine requires server assistance to a user response such as loading additional interface code or processing data submissions, an asynchronous XML request is undertaken by the AJAX engine enhancing application interactions. Conceptually AJAX operating in a mobile web environment would eradicate needless HTTP requests and responses thus greatly improving usability through enhanced responsiveness and minimal power drain on mobile device CPU's.

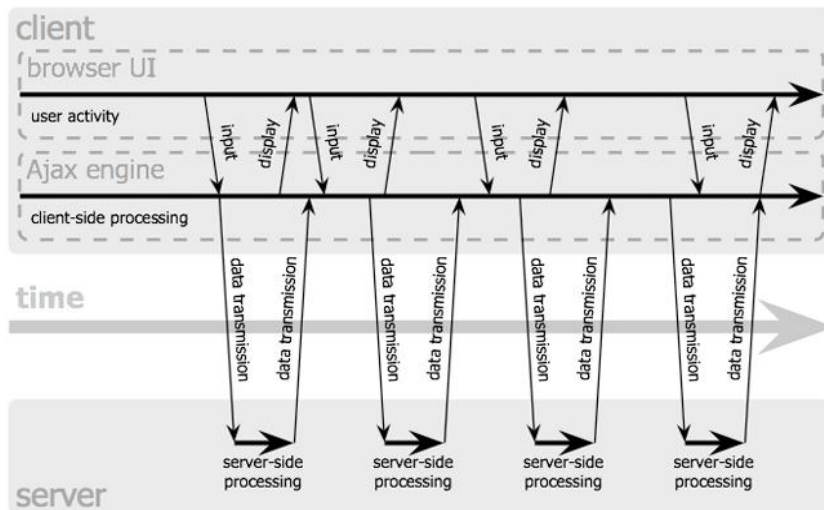


Figure 2 - AJAX web application model (asynchronous) (<http://adaptivepath.com>)

2.3.8 Hypertext Preprocessor

Hypertext Processor (PHP) is one of the most prevalent server-side scripting languages for creating dynamic web pages. PHP has been in use since 1995 and version five seen release in 2004. Thus far, most of the technologies investigated run on the client-side, PHP scripts can only be executed on the server-side. PHP history (2010) estimated in 2007, fifteen million domains included PHP technology into web applications accounting for 20% of web pages. PHP is commonly implemented as a retrieval service obtaining data from MySQL databases returning queries marked up in the *front-end* user interface with HTML5.

Factors such as open-source and operational support from developers and users has contributed to the technology's popularity. Platform independence provides implementations for operating systems such as UNIX, Linux, Mac and Windows providing developers with the freedom to develop one script, which will be interpreted unilaterally on all operating systems. PHP is highly adaptive allowing form processing and business logic through superglobal arrays reacting to user inputs such as \$_GET, \$_POST and \$_COOKIE. PHP scripts can be written into web applications detecting if the user is requesting web services from a mobile device, redirecting users as necessary to a mobile-specific domain.

2.3.9 Objective Summary

A formative literature analysis covering both available technologies and previous works carried out by fellow developers provides well-evidenced justification in understanding mobile specific features of web scripting. In order for scripting technologies to benefit any web application, rendering has to be affirmed with target devices. iPhone mobile operating system (iOS) and mobile Safari browser are capable of supporting and interacting with web-scripting technologies discussed. Application of web-scripting technologies in the development process will enhance usability. A detailed description of administering technologies to the project is contained in the conclusion section.

2.4 Understand the key characteristics of usability inspection methods as applied to mobile web application design and identify user inspection methods to use

Commentary in the Background Section introduced the concept of Interaction Design (ID), which focuses on the reciprocal actions of people and interactive products. A derivative of ID is Human Computer Interaction (HCI), which deals specifically with design, evaluation and implementation of interactive computing systems for human use. Jacob Nielsen provides a further refinement of HCI principles, introducing the concept of *Discount Usability Engineering*. The Nielsen concept counteracts traditional resource-intensive usability inspection and testing methodologies where software engineers and stakeholders may be intimidated by complex terminology and elaborate laboratory experiments resulting in abandonment of usability engineering methods altogether. Nielsen lists *User task observation*, *Scenarios*, *Simplified thinking aloud* and *Heuristic evaluation* as four key techniques to remove potentially intimidating usability testing methods. Applying all four methodologies to a web application would indeed form an all-encompassing approach. However, Nielsen states that a high volume of usability errors can be uncovered through selection of whichever method or methods best suit the project to be undertaken.

User Task Observation, Scenarios and Simplified thinking aloud are variants of Participatory Design (PD) involving users from an early stage of the design process and are common in the construction of bespoke systems (Kensing & Blomberg, 1998). However, PD is labour intensive for modest projects, even by Nielsen's standards and requires early input from both user and designer.

On the other hand, Heuristic Evaluation can be applied when a product or interface already exists, as in the case of the desktop Student Homepage. Hvannberg et al., (2007) performed Nielsen's heuristic evaluation techniques on an existing framework, concluding that the low cost evaluation techniques uncovered a reasonable amount of usability problems, assisting improvements in subsequent increments of the design. The journal findings state that heuristics evaluation should not replace end user testing, but in fact integrate with end user testing. An individual expert user, avoiding the need to involve human participation at early stages of development, can perform a heuristic evaluation. Developer-centred inspection will uncover usability problems in the current desktop Student Homepage and provide development guidelines that can be applied to the development of a mobile web application.

In order to structure the requirements, design and implementation a development lifecycle is required to support project activities with a framework suitable to the software engineering process. Murugesan (2008) provides an investigative journal exploring development lifecycles for mobile web applications concluding that an incremental development approach is required for the evolving nature of web applications, where core functional requirements of a system can be identified and manufactured as individual components with integration occurring during implementation stages of the lifecycle.

The background section introduced a high-level overview defining usability as much more than just a one-dimensional property. *Learnability*, *Efficiency*, *Memorability*, *Errors* and *Satisfaction* (Nielsen, 1992) were identified but Heuristic Evaluation and End User Usability Testing require a more detailed definition in order to conduct thorough inspections of both the current desktop web application by the developer and the mobile web application prototype by end users.

2.4.1 Heuristic Evaluation

Heuristic evaluation is the action of a systematic interface analysis where an individual evaluator decides on what is good design and what is poor design. An initial evaluative inspection of the user interface will clean up the interface and identify obvious usability problems. Incremental redesign of the mobile web application interface would receive a post-implementation heuristic evaluation confirming removal of identified poor usability features. Undertaking a formal heuristic evaluation requires the identification of heuristic criteria that can be applied to an interface. Nielsen (1994) outlines a collection of ten general heuristics.

- **Simple and Natural Dialogue** – User interfaces should have a simplistic layout, since each additional on-screen feature is one more item for the user to learn, one more item to possibly misunderstand and one more item to search through when users are looking for essential information. Furthermore, interfaces should appear natural and match the users task where mapping computer concepts and users concepts provides a low cognitive load on users and eases navigation. Graphic design and colour co-ordination provide further assistance to users. Clearly grouped navigation and colour themes for related objects aid user understanding of screen layouts. Identification of truly important information to the user will allow efficient performance of all tasks. Designing a single screen concept where additional information can be relegated to auxiliary screens will improve end user performance supporting the ‘less is more’ ideology introduced in the background section.
- **Speak the Users’ Language** – Interface terminology should be based on the users natural dialogue with avoidance of system-orientated terms. Nonstandard meanings and titles should be avoided and familiarity should be apparent to users of the system. Mappings and metaphors help users associate related material aiding easy discovery of services and information.
- **Minimise User Memory Load** – Users find it easier to recognise something that is shown to them as opposed to having to recall the information from memory without help. Interfaces founded on recognition rely to a large extent on the visibility of objects of interest to the users. On the other hand, displaying too many attributes may result in a relative loss of salience for the attributes of most interest to the user.
- **Consistency** – One of the most basic usability principles is consistency. If users identify that a specific command or repeated action will always have the same effect, they will have greater confidence using the system. Positioning of information and dialog boxes should appear consistent, facilitating recognition.
- **Feedback** – The system should continuously inform the user of processes to avoid misunderstanding of system status. 0.1 seconds is the limit where users feel that a system is reacting instantaneously requiring no special feedback. 1.0 seconds is about the limit for the users flow to stay uninterrupted, even though users may be conscious of a minimal delay. Normally feedback would not be required for such a short delay, but users lose the feeling of directly manipulating data.
- **Clearly Marked Exits** – Users do not like to feel trapped in a system. In order to enhance the users feeling of being in control of dialogue the system should offer the user a simplistic route out of complex situations. A basic principle of interface design should be to acknowledge that users will make errors no matter how good a design may seem and one should make it as easy as possible to recover from these errors.
- **Shortcuts** – General interface operation should be possible through the knowledge of a few general rules however; it should also be possible for experienced users to

perform frequently used operations especially fast, using dialogue shortcuts. *Type-ahead* is not a shortcut as such since it requires the user to generate a sequential input, but it can speed up interactions by allowing the user to get ahead of the system by not paying attention to all the steps in the dialogue.

- **Good Error Messages** – Usability is enhanced with the provision of good error messages. Clear language and avoidance of obscure codes will provide intuitive assistance to users if a problem occurs. Precision of error occurrence, rather than general system error status, a system error with location identifier would be more beneficial. Clear constructive polite error messages will help solve potential problems quickly and avoid intimidation to the user.
- **Prevent Errors** – Building on the last heuristic, even better than good error messages is to avoid error situations completely. Incorrect textual inputs are common system errors instigated by the user. An assistive mechanism in typing error reduction such as a word predictor available for the input type will help users find information quickly and avoid the need for an error response.
- **Help and Documentation** – It is preferable if a system interface is intuitive to use and no further help or documentation is required. The fundamental truth about documentation is that users do not always read manuals preferring to spend time on activities that make them feel productive and start using a system instantaneously.

All ten heuristics relate specifically to user interface inspections so the guidelines are ably suited to both desktop and smartphone interfaces. Flexibility in the guidelines allows for customisation where necessary for differing interface types such as icon or textual navigation inputs.

2.4.2 User Testing

End user testing provides checking for the incremental redesign and location of remaining usability faults that were perhaps not identified by the heuristic evaluation. Combining both inspection methods will locate distinct problems rather than leading to repetitive findings. User testing is still an essential part of usability engineering. Uncovering usability errors can assist functionality changes to a system. Hart & Portwood (2009) combined heuristic evaluation with follow up task-analysis with interviews and performance measures through group testing, documenting that both methods were an effective way to gather both qualitative and quantitative data. Table 2 provides a tabularised representation of Nielsen's evaluative inspection methods and associated users required for each method.

Table 2 – Usability Engineering Methods (Adapted from Nielsen – Usability Engineering)

Method Name	Lifecycle Stage	Users needed	Main advantage	Main disadvantage
Heuristic evaluation	Early design - inner cycle of incremental design	0	Finds individual usability problems & can address expert issues	Does not involve real users so does not find surprises relating to their needs
Performance measures	Competitive analysis, final testing	At least 5	Hard numbers, results easy to compare	Does not find individual usability problems
Thinking aloud	Iterative design, formative evaluation	3-5	Pinpoints user misconceptions. Cheap test	Unnatural for users. Hard for expert users to visualise
Observation	Task analysis, follow up studies	3+	Ecological validity – reveals users real tasks. Suggests functions and	Appointments hard to set up. No experimenter control

			features	
Questionnaires	Task analysis, follow up studies	At least 30	Finds subjective user preferences. Easy to repeat	Pilot work needed (to prevent misunderstandings)
Interviews	Task analysis	5	Flexible, in depth attitude and experience probing	Time consuming. Hard to analyse and compare
Focus groups	Task analysis, user involvement	6-9 Per group	Spontaneous reactions & group dynamics	Hard to analyse. Low validity
Logging actual use	Final testing, follow up studies	At least 20	Finds highly used (or unused) features. Can run continuously	Analysis programs needed for huge mass of data. Violation of users privacy
User Feedback	Follow-up studies	100+	Tracks changes in user requirements and views	Special organisation needed to handle replies

The three proposed usability inspection methods are highlighted with a light grey background. Heuristic evaluation identifies the process is undertaken early in the system development requiring no external users. Performance measures and interviews are usability inspection methods that occur after design and construction of a prototype.

Five evaluators will be required to conduct the end user performance measures. A count of five is a manageable amount of subjects that can provide meaningful degrees of variation in the competitive analysis results. Section 5.1 provides a detailed analysis and evidence to further support the selection of five evaluators. Quantitative data capture will be undertaken via like for like tasks based on user inputs for the desktop web application versus the newly developed mobile web application viewed on the iPhone. Quantitative data capture is an important tool in statistical analysis (Connolly, 2007) and will help to prove or disprove the hypotheses. Qualitative data will provide further understanding of the prototype system probing the *why* and the *how* of user decision making. A minimum of five users are required to provide substantial feedback on a system. However, to maximise the usefulness of end user participation, the ten participants deployed for performance measuring will undergo a short interview to gain an insight into their reasoning behind their decision-making.

2.4.3 Incremental Development Lifecycle

An incremental development approach allows cyclic development of a system where smaller portions of core functionality are identified and developed as individual components. Integration of components will output an evolving prototype of the overall system. Individual component based development allows practitioners to positively affirm if the engineering process for a particular phase has satisfied functional requirements thus increasing the probability of system acceptance by end users and avoiding potential usability inaccuracies which may only be identified in the later stages of implementation and end user testing. Heuristic evaluation operates in tandem with the incremental development process as a heuristic evaluative inspection on an existing interface will identify key areas of functionality feeding into the requirements analysis, which will outline individual components requiring inclusion in a new system. Larman and Basili (2003) provide a historical overview of incremental and iterative design approaches and identify four phases that slice system functionality into portions and are listed below.

- **Inception** – Identifies project scope, risks and both functional and non-functional requirements at a high level.

- **Elaboration** – Delivers a working architecture migrating the top risks and fulfils the non-functional requirements.
- **Construction** – Through an incremental approach, construction fills-in the architecture with production-ready code produced from analysis, design and implementation and testing of the functional requirements.
- **Transition** – Delivery of the system into the production-operating environment.

A methodical application of the four phases, highlights functional and non-functional requirements of a system facilitating designers with a vision of key components before any programming work would be undertaken. Once the entire functionality of a system is identified, programmers would then bring the functionality ‘to life’ with the application of key mobile web development technologies. A high-level overview of an incremental approach is detailed in figure 3.

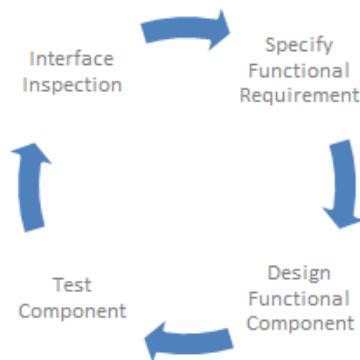


Figure 3 – Incremental Development

2.4.4 Objective Summary

The literature review for this section has provided an insight into usability inspection methodologies and listed benchmarked heuristics, which can be applied in full to the current desktop student web application for Caledonian University. An incremental development approach for software development underwent investigation. Furthermore, the type of end user inspection methods have been selected and will be covered in more detail in section 3.1.

2.5 Literature Conclusion

The literature review has met the objectives of the secondary research method. Exploratory research has discovered other experiments in similar fields of study. The project is justified by the references cited and confirms that migrating desktop web applications onto a smartphone platform throws up problematic usability considerations for users and developers alike alluding to the need for a custom-built application to successfully overcome mobile usability issues. HCI discoveries, developer-centred inspection methods and end user testing provide invaluable pointers to guide the remainder of the project.

HCI Characteristics of a Smartphone Platform

Literature reviewed in this section identified smartphones as offering increased computing ability over a standard feature phone. Complete operating systems and improved connectivity have facilitated pervasive computing operations in dynamic environments allowing users to continue with computational tasks away from desks and homes. Display sizes limited the amount of content on show to the user at any one time, with scrolling unpopular with smartphone users dictating thoughtful design of mobile web application information architectures is required to maximise usability. Any imagery and associated resolution used in a mobile web application should be carefully measured so as not to exceed device capabilities, doing so leads to bandwidth wastage. Smartphones with small keypads and micro joysticks require finite movements to input text accurately whereas the iPhone, which offers direct manipulation on the interface, facilitates textual input more readily, leading to a contrasting difference between the iPhone and first generation feature phones.

Smartphone computational power has improved, however the ubiquitous environment in which modern devices operate such as accessing small amounts of information quickly whilst in transit results in the user being exposed to external distractions such as fading light or auditory interference therefore requiring succinct and intuitive mobile web interfaces assisting efficient information retrieval. Network usage can be charged at premium rates for mobile devices so reducing HTTP requests and full-page refresh will result in lower costs and increased battery endurance.

Completing an investigative literature review into the identification of HCI characteristics of a typical smartphone platform draws distinct conclusions that can be adopted in the design process, influencing decisions regarding, display, input peripherals, context of usage and power consumption, with similar academic research in mobile computing affirming design semantics.

Web Based Guidelines for Good Usability on a Smartphone Platform

Literary investigations in this area established development guidelines are of paramount importance to successful mobile web applications improving both accessibility and interoperability, failure to apply guidelines to ensure good usability may result in users engaging with an alternative application due to failings on basic usability requirements. The World Wide Web Consortium has acknowledged that mobile web authors who design web applications with mobility in mind will undoubtedly provide an enhanced user experience. W3C's Mobile Web Best Practices 1.0 is a comprehensive document with ten themes that ensure browsing convenience on smartphone devices. All ten themes can be applied with ease provided they are utilised early in the development process.

Similar investigations by fellow practitioners reiterate W3C recommendations concluding that desktop web applications are feature rich whereas mobile web applications are restricted by context of use and display limitations and should therefore avoid rich features. Further conclusions are evident with investigations noting maximum optimisation of a web application is achieved by identification of the target device avoiding scenarios where a singular web application will operate on multiple mobile platforms. Additionally key analysis concluded a search facility on a mobile device supporting efficient textual input would overcome usability restrictions in relation to scrolling, assisting in efficient information retrieval.

Utilisation of the W3C mobileOK checker provides an effective validation service for developers and programmers alike, providing feedback and localising potential usability or network related frailties in the mobile design through a detailed console report.

Investigating and determining web-based guidelines for good usability on a smartphone platform has provided key components in the design process that not only relate to the target device but also improvements in network connectivity through common mobile web design standards.

Mobile Specific Language Features of Web Scripting

Understanding specific language features of web scripting was achieved through the extensive literature review. Previously technologies such as the ones investigated; XHTML, CSS, XML, MySQL, DOM, JavaScript, AJAX, jQuery and PHP were not all ensured to operate in certain mobile web browsers. Apple's Safari browser is capable of processing all the aforementioned technologies with browser processes greatly improved on smartphone devices especially the iPhone.

Adoption of all available scripting and markup technologies enhances the mobile user experience. Users do not need to view technologies (HTML) to witness the benefits. Responsiveness and ease of manipulation is primarily achieved with server side scripting (AJAX and PHP). It may seem like a wide array of technologies, but application of all will be required to assist in the development of a robust all-encompassing mobile web application that fits with the ethos of Web 2.0 supporting dynamic user generated content.

Utilising so many diverse technologies creates a complex and challenging development environment but through a rigorous literary investigation provided a coherent understanding of how the technologies will interrelate and the benefits they offer has been thoroughly understood.

Characteristics of Usability Inspection Methods as Applied to Mobile Web Application Design and Identify User Inspection Methods

Exploring usability inspection methods in relation to mobile desktop web applications uncovered Nielsen's Discount Usability Engineering approach to HCI. Heuristic Evaluation inspection techniques are a low cost methodology that can be undertaken by an individual operative and can be applied to an existing user interface systematically assessing what is good and what is poor usability design. Ten heuristics provide a benchmark in which to judge the existing web application. Nielsen lists four usability inspection techniques, but of the four, Heuristic Evaluation does not require participants throughout.

An investigative journal by a fellow researcher concluded that Nielsen's low cost evaluation techniques uncovered a substantial amount of usability problems to assist improvements in subsequent iterations of the design. However, journal findings stated heuristic evaluation should not replace end user testing, but in fact, both methods should be conjoined to locate distinct problems at different stages of development.

Adhering to an incremental development lifecycle will support an evaluative heuristic inspection of an existing web interface. Identification of key functional components provides developers with an insightful knowledge, which can be applied in the design phase of a project.

End user testing would require ten participants to undertake performance measurements in like for like tasks on both the desktop and mobile web version of the student homepage to generate quantitative data outputs that can be measured to prove or disprove both hypotheses. Interviews with the same participants will provide further feedback of a qualitative nature, which can also be analysed to test both hypotheses.

Understanding the key characteristics of usability inspection methods as applied to mobile web application design, identifying user inspection methods through a literature review has provided the author with a method in which to inspect the current desktop web application and a supporting development framework, then followed up latterly with a post implementation heuristic evaluation of the mobile web application finally leading to end user testing through performance testing and interviews.

3.0 Problems and Systems Analysis

The project aim is to investigate and measure how successfully a desktop web application can be redesigned for a smartphone platform using HCI developer-centred usability inspection methods. As stated in the background section, smartphone usage is increasing due to technological advancements in hardware and software supplemented through enhanced connectivity with nearly 80% of the world's population benefiting from mobile network coverage (Robbins et al, 2008). Ubiquitous computing provides smartphone operatives with the unique ability to undertake complex computational tasks in dynamic environments. Gartenberg (2011) observes smartphone development has progressed at such an exponential rate that desktop symmetry in relation to task performance can be replicated on a smartphone device, prompting the author to write, *'smartphones are really PC's that go in your pocket'*. However, the author observes, interactions through a reduced screen size provide the greatest operational difference between a smartphone and desktop environment thus, presenting unique usability problems in ubiquitous territories, a problem identified in the literature review in section 2.1.1 relating to smartphone screen displays. Rich processing abilities of smartphones allow users to access a wide array of web services delivered over the Internet, viewed through mobile web browsers. Assisted by increased processing power and adaptive technologies mobile browsers are capable of rendering complex web scripting languages thus removing web software processing restrictions which inhibited early feature phone usage. Web service delivery has leveraged this advancement leading to increased information retrieval through web interfaces meriting further exploration of usability issues in relation to web applications operating on smartphone devices. An exploratory study is required to seek new insights and assess usability phenomena of smartphone devices, shedding new light and contributing knowledge to a relatively new area of software engineering and HCI discovery.

The primary method used to evaluate the investigation into usability for smartphone devices was a develop and test project sometimes referred to as Action Research where primary research focuses on a new solution to an existent problem. As stated in the introductory section a suitable interface and smartphone needed to be identified, which resulted in the selection of the current Caledonian University student desktop web application and the iPhone respectively. Oates (2006) refers to evidence-based practice where he positively encourages researchers to analyse and evaluate the work of others. Information systems research findings provide evidence along with empirical evaluation to assist effective development of projects bearing the same characteristics. Following the writings of Oates, the develop and test project chosen has firstly performed a literature review that digests the work of researchers, drawing conclusions and secondly after applying developer-centred inspection methods on the desktop web application, empirical evaluation takes place at the later stages of the project with end user testing in the lab evaluation.

Develop and test approaches are common practices to test hypotheses. Tsiaousis & Giaglis (2008) conduct a mobile web usability study where both researchers develop empirically testable hypotheses through an end user evaluation. The Caledonian student homepage does not have a mobile version of their information portal. On completion of the project, a mobile web application will be constructed to operate on an iPhone. Whilst undertaking the literature review, evidence suggested that low budget usability studies could be performed by a developer on existing desktop web applications. Vredenburg et al., (2002) presents a case where the design is centred around the user throughout to assist in requirements gathering. A method of this type is acceptable when the design process involves a 'new build'. In the case of the existent desktop student homepage a low cost heuristic evaluation was performed by the developer to identify high-level usability problems avoiding the overheads of cost and

human services in the early stages of development. Fiotakis et al., (2009) support this view stating that heuristic evaluation resulted in low costs compared to the overheads of a field study. The researchers also noted that the field study did not uncover any subsequent usability issues compared to the developer-centred heuristic evaluation.

The project has been undertaken within the Computing Department of Glasgow Caledonian University. The mobile web application was targeted at students attending the university who utilise the current desktop web application. This section will provide an overview of the processes and methodologies associated with each of the three steps and justification of their inclusion, justified with research from practitioners in similar fields of study. Detailed accounts of the chosen Development Lifecycle (section 3.2) and the functionality derived through developer-centred interface inspections in the Requirements gathering (Section 3.3) are outlined in this section. Subsequent sections of the paper provide detailed examination with justification of Design and Implementation (section 4.0), End User Testing and Evaluation (section 5.0) and finally Discussions and Conclusions (section 6.0).

3.1 Overall Project Methods

To assist understanding of the stages and methodologies, content in this sub-section outlines and describes the significant work undertaken throughout the duration of the project contributing to the investigation, development and evaluation of the mobile web application for Caledonian University student homepage operating on an iPhone. Figure 4 provides an overview of the three main stages of the project – Requirements, Design and Implementation and Evaluation.

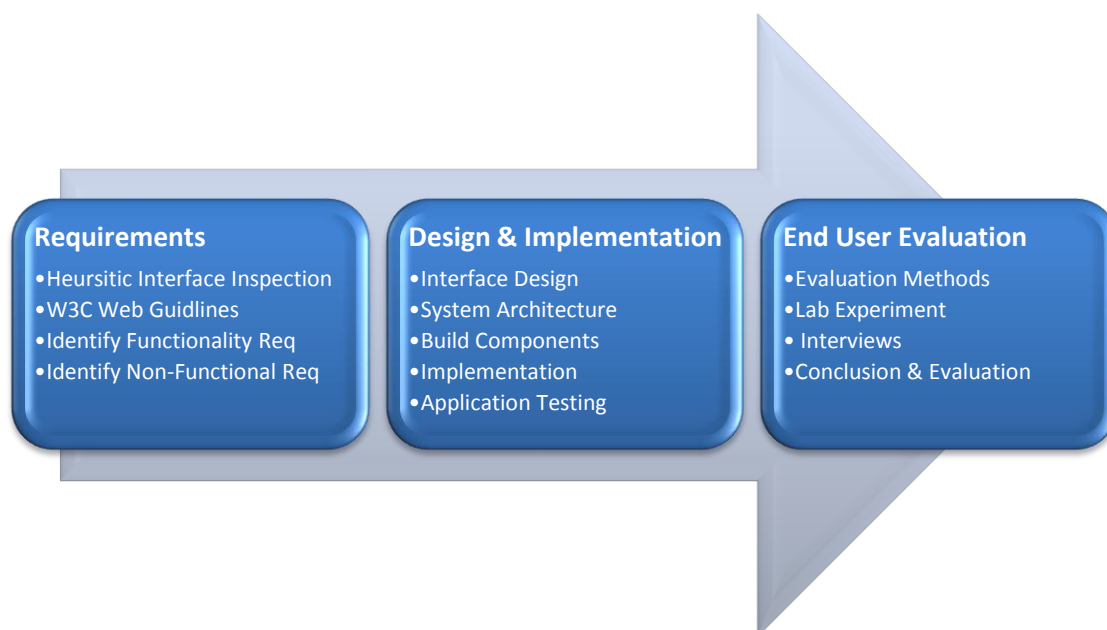


Figure 4 – Project Main Stages

3.1.1 Requirements

Requirements are the first phase of overall development. In order to avoid problems in the design process a full understanding of the current system is required. Requirements are statements about an intended system that specifically outlines what it should do (functional requirements) and how it should perform (non-functional requirements) with presentation occurring in an unambiguous manner. Accuracy in capture and analysis of system structures and interface semantics is of paramount importance, recognising that technology can only be successfully applied with an exact understanding of the context of use through (for this project) developer-centred inspection methodologies. This is not necessarily a binding document nor a fixed set of prescriptions, but designers need to be sure requirements will not be radically altered during the development processes as increased stability lays firm foundations for design activities. In general terms requirements gathering should progress in a sequential manner: firstly gather some data, then analyse and interpret data, then extract some requirements from it. Much has been written about IT failures and the significant cost of fixing errors late in software development lifecycle. Boehm & Basili (2001) present a top ten list of software defect reduction findings, stating, *'finding and fixing a software problem after delivery is often 100 times more expensive than finding and fixing it during the requirements design phase'*. Findings from this analysis present startling figures and enforce the theory that comprehensive requirements capture will consequentially lead to less errors and a more robust system with increased likelihood of acceptance from end users.

Understanding functional requirements for an interactive product such as desktop web application is fundamental, referencing Nielsen's usability principles outlined in section 2.4: learnability, efficiency, memorability, errors and satisfaction are core elements of successful interface design. To a certain extent data requirements and environmental requirements have a bearing on overall requirements capture with data types and product technologies feeding into the design processes.

Requirements analysis conducted through a heuristic interface evaluation of the current desktop web application ensured development of the mobile web application would include all of the basic functional prerequisites of the original desktop version through identification of poor usability. Lu et al (2010) in a journal titled 'a model based heuristic design of web user interface', conducted a heuristic evaluation on an existing web application with findings concluding that web designers can successfully build page presentations and interfaces through evaluative heuristic interface inspections. Although a redesign of the desktop web application is being undertaken, it is important to recognise core functional elements of the existing desktop application and thus include these elements in any new design. Investigative literary material especially in the area of usability heuristics (section 2.4) uncovered that an individual usability inspection of an existing interface would uncover a high correlation of faults thus improving requirements specification and ultimately increasing the likelihood of a comprehensive, intuitive mobile web application that will provide enhanced usability over the current desktop web application. A high-level overview is provided for each stage of the requirements gathering.

- **Heuristic Evaluation** – A systematic inspection of the current desktop web application is undertaken utilising Nielsen's ten usability heuristics as detailed in section 2.4.1

- **W3C Mobile Web Guidelines** – Findings from the heuristic evaluative inspection methods were compared with the W3C mobile web guidelines outlined in section 2.2 of the literature review.
- **State Requirements** – Results analysis from the findings in heuristic evaluation and W3C mobile web guidelines will provide functional and non-functional requirements

3.1.2 Design and Implementation

The second phase of the development process follows the requirements stage and now has to address the functional and non-functional requirements through component and overall application design. A modern information system such as a web application is not solely concerned with the design of the interactive system but the interaction itself, sometimes referred to as design interventions. Product creation is a design exercise where a developer intervenes to change the situation as it is with the view that any redesign will improve the current processes. Design is a balancing of goals and constraints which may require trade-offs to achieve the final goal with an understanding of both the human elements and computational elements involved in software design that meets all the stated requirements where possible. To improve user experiences the design principles of Nielsen in section 2.4 provide generalizable abstractions intended to orient designers toward creative thinking about various aspects of design. Kaindl et al (2008) provide an insight into methodologies for combining requirements into interaction design. Practitioners can harness abstract used cases through UML modelling with participatory collaborations. However, this is not an effective method for the mobile web application system as investigations have elicited requirements specifications through developer-centred design. A more effective method proposed by the journal highlights *symbolic modelling* where core functional elements of a system are highlighted and developed as incremental component parts which are derived in the requirements stage. Symbolic modelling can be integrated seamlessly into the incremental development approach detailed in the overall project development lifecycle detailed in section 3.2. Database interaction is a key component in the creation of dynamic web applications, with Andreica et al (2005) identifying symbolic modelling techniques particularly useful in XML representations of database structures and architectural modelling of web domains.

The second phase of overall development comprises of five key areas in the system development with screen design and layout (interface design) and navigation design (system architecture) comprising of what could be referred to as ‘front-end’ components visible to the end user using HTML5 and CSS. Replicating the iPhone native design characteristics in the mobile web application provides familiarity to the user utilising incremental development additionally incorporating evolutionary prototyping where a kernel is developed representing a model layout demonstrating the look and feel of the mobile web application which can be progressively built upon.

Functionality (build components), requires application coding which falls under the heading of ‘back-end’ programming. Some programming in the native web markup language, HTML5 styled with CSS will be required to achieve interface and component design with additional database interactions facilitating data retrieval and manipulation which will occur behind the scenes with dynamic scripts (PHP, JavaScript) and server programming, satisfying user interactions derived from the requirements gathering process.

Implementation is the activity associated with producing and integrating all the required software modules necessary to transform data and markup into a singular embodiment of the mobile web application running within the selected architecture incorporating AJAX technologies. Culmination of all the design activities output a fully functional mobile web application manufactured through evolutionary prototyping. Some pre-implementation activities had already been undertaken as interface design and core functional elements were programmed with the relevant technologies. Evolutionary prototyping ensures preservation of coding elements feature as composite components providing framework for the entire system. Deployment is achieved through hosting the mobile web application on a remote server. Utilising a 'live' hosting environment required the purchase of a domain name (<http://www.caleymobile.com>) and furnished the developer with substantial knowledge and expertise in FTP protocols with the added advantage of a fully accessible web application available for user testing and feedback in remote locations. Additionally, in order to test dynamic web scripting (PHP & JavaScript) and thus, functionality. A server is necessary to demonstrate database interactions, as a realistic accomplishment is unachievable in a 'local' environment.

Application testing can be divided into two distinct categories: verification with validation and unit testing with reference to bugs and errors. Verification is the process of affirming the development stages are undertaken in the desired fashion in relation to the development lifecycle with production outputting the correct component with appropriate quality. Validation checks that the system satisfies functional requirements suitably addressing the usability problems identified in the requirements specification. Di Lucca et al (2002) identify both methods require harnessing with the rapid diffusion of open standard technologies which must remain compliant in the areas of usability, reliability and operability thus, significant improvements can be achieved through V&V to meet these demands. Testing will occur at the unit level of each component, including individual web pages and dynamic functionality such as search facilities. To further define testing, categorising the process for the mobile web application would fall under dynamic *white-box* testing. Familiarity with the programming and structure of the code allows the developer the ability to test potentially error-prone parts of the system. Tonella & Ricca (2004) undertook experimentation with white-box testing in both the navigation model and the control flow model of a web application achieving high levels of error discovery recommending the methods suitability in accommodating dynamic code generation from both levels of abstraction.

A high-level overview is provided for each stage of the design and evaluation.

- **Interface Design** – Web page layout elements such as colour, size, style and positioning achieved through HTML markup and CSS stylesheets. Include user controlled auxiliary menu
- **System Architecture** – Overall hyperlinked navigation structure displaying page inheritance and database components.
- **Build Components** – Functional requirements transformed into functionality aided by symbolic modelling utilising server side scripts, PHP, JavaScript and MySQL.
- **Implementation** – Grouping of all component parts providing a final version, which will be remotely hosted on a server, providing a realistic testing environment with an accessible URL. The mobile web application will subsequently undergo a post implementation review by the developer

- **Application Testing** – V&V and white-box testing provide incremental testing capabilities at each stage of development reaffirming a mobile web application that meets requirements.

3.1.3 End User Evaluation

Primarily the author will perform testing of the web application during incremental stages, concluding overall development with a post implementation review with a heuristic evaluation of the redesigned interface. However, additional usability feedback from users of the system will give the project an insightful overview with participants who are unfamiliar with the Caledonian mobile web application outputting results gauging system performance in a realistic environment, consequentially proving or disproving both hypotheses stated in the introductory chapter in subsection 1.2.3. Justification validating end user evaluation is evident from Wong & Hong (2007) who identify a current situation where web content does not always support user needs acknowledging data and services do exist but are not always in a form amenable to users of a system. This case directly mirrors the desktop web application where information retrieval is inexplicably difficult to locate promulgated with a complex user interface.

Three distinct phases exist in the evaluative end user process. A lab experiment was constructed where the primary objective was to analyse like for like task performances on both the desktop web application and the mobile web application thus, in the process extracting valuable and measureable quantitative data. Berndtsson et al (2008) describe quantitative measures as being rooted in the natural sciences, concerned with understanding how an object is constructed/built/works additionally pointing out, *'repeatability of the experiments and the testing of hypotheses are vital to the reliability of the results'*. Results from this lab experiment specifically relate to the second hypotheses contained in section 1.2.3.

Interviews are a qualitative method of measurement, which has origins in the social sciences. Ribes and Khoo (2005) concluded through an investigative study into digital libraries that directly obtaining feedback and opinions from users would identify any perceived benefits from using a new system. Constructive feedback could influence design considerations in future modifications of a system through open ended conversation between evaluative participants and the author as opposed to questionnaires which are general rigid and 'closed' in nature offering little flexibility for individual opinion. Hypothesis number one will be answered through the collection of qualitative data, which specifies an overall improved user experience will be noticeable on interaction with the mobile web application

Finally, data presentation of end user testing must be succinct with a coherent appearance. While textual presentation of numeric results can often provide a *dry* interpretation of information obtained from the lab experiment and interview process, images in the form of graphs and charts provide a far more intuitive and holistic idea of what is going on. Bell (2005), states, *'a diagram can often simplify quite complex data which could take a paragraph or more to explain'*. With this statement in mind, data is presented with bar graphs and histograms. A high level overview is provided for each stage of the end user evaluation.

- **Lab Experiment** – Quantitative data capture from participants through a simplistic task based controlled lab experiment testing hypothesis number two contained in section 1.2.3
- **Interviews** – Qualitative data capture through open ended dialogue with participants testing hypothesis number one from section 1.2.3
- **Analysis of Results** – Final analysis of both evaluative methods will ascertain the mobile web applications overall performance and display results to potential readers of the paper in a succinct clear manner.

3.2 Lifecycle

As software systems were initially developed in the middle of the twentieth century they were constructed in a rather *ad hoc* manner without any reference to a structured development process. This undisciplined approach led to software systems that were poorly constructed and problematic to control. Knott & Dawson (1999) indicate that a formal development process was required to support software developers producing structured code by a manageable means with six distinguishable advantages –

- Partitions a large problem into easy-to understand tasks at each stage
- Project focus is sharpened
- Supportive of planning control thus improving time estimates
- Provides progress visibility
- Provides structure
- Leads to better coding and documentation

Rather than presenting an application towards the end of the project in one ‘big bang’ as conventional development processes do (stage-wise waterfall models), it is beneficial to deliver an application as a series of intermediary operational sub-systems over a period of development resulting in more functionality in each release cycle. This means a *kernel* is in place during the first phase of development with subsequent application parts brought on-line and released as the system progresses through development with a reduction in effort at each increment as only moderate changes should occur. An early indicator of the system’s capabilities is demonstrated providing a basic idea of what can be produced longer term and instils a sense of achievement leading to a clear understanding that progress is being made.

An Incremental Development lifecycle was adopted with evolutionary prototyping guided by the fact that system requirements will be clear (after a systematic heuristic interface evaluation) and the system can be partitioned into a series of intermediate deliverables derived from detailed requirements analysis. Vliet (2008) demonstrates that this development methodology is more suited to modern software development and error reduction is reduced as users and developers have exposure to the system and interfaces early in the development process to make comment. The development phases listed in figure 4 must be applied in an iterative and incremental manner, in which the various tasks are repeated and refined until results meet the mobile web application requirements.

Evolutionary prototyping differs from throwaway prototyping; instead of discarding models, the prototype evolves into the final product. Application development undergoes several

cycles of problem discovery/design refinement/implementation, with iterations producing a partial version of the system. Each iteration of the current version of the system is tested and evaluated, and then extended or modified. In this way, the application is seen to evolve from an embryonic core into the final system. Development durations are reduced as code is preserved; however, initial code produced must be well structured and commented, as it will feature in final application versions, avoiding major re-programming tasks. Ceri et al (2003) substantiate the lifecycle choice noting, iterative and incremental approaches are not exclusive to web application development, but appear particularly appropriate for this class of systems as web application interfaces are developed quickly to demonstrate an early working model.

The first stage of development was identification focusing on requirements for the mobile web application, produced via the heuristic evaluation of the current desktop web application. Output from the interface inspection provided both functional and non-functional system requirements. Requirements were then addressed in the design phase, seeing the development of interfaces acting as the kernel, overall system architecture specifications and functional components. After completion of the design phase, web technologies investigated in section 2.3 of the literature review were suitably applied in the implementation stage where coding processes created an initial prototype of the mobile web application, which was subsequently tested after the mobile web application was deployed on a web server. Following on from the coding process a post implementation review occurred. Evaluation took place on the 'live' mobile application through lab experimentation, interviews and compliance with the W3C mobileOK checker.

3.3 Requirements

Smartphone devices now offer greater functionality and computational power compared to their predecessor, the standard feature phone. As outlined in the report background section, both hardware and software technological advancements and improved connectivity have supported smartphone popularity. Improvements in these areas have seen sales and usage of smartphone devices increase on a global scale. Users have placed a greater reliance on devices to receive information whilst operating in dynamic environments away from fixed desktop localities. Identification of applications delivered over the web has been highlighted as a growth area in software development in the smartphone domain. However, literary material in relation to typical smartphone characteristics in section 2.1 revealed usability problems were prevalent when migrating a web application intended for desktop usage onto a smartphone device, presenting many usability problems for users due to reduced screen size and contextual use of devices, providing justification signalling that smartphone operating environments are completely different from desktop environments, necessitating the need for a custom built mobile web application to address usability issues in a mobile context. The mobile web application attempts to include all the functional requirements of the Caledonian student homepage whilst at the same time redefining layout, information architecture and navigation to improve overall usability for smartphone usage.

3.3.1 Heuristic Interface Inspection of Caledonian Desktop Web Application

To establish a suitable requirements specification the current Caledonian web application underwent a systematic developer-centred heuristic evaluation. As stated in section 2.4.1 Nielsen's discount usability engineering principles address previously resource-intensive usability testing methodologies, which may seem complex and elaborate, resulting in abandonment of usability testing altogether. The Caledonian University desktop web

application was inspected using Nielsen's ten general heuristic principles, which formed the basis of an interface checklist. Heuristic evaluation is a method that negates the need for user participation throughout and is appropriate for existing interfaces such as the desktop Caledonian University student homepage. The literature review conclusion in section 2.5 pertaining to inspection methods affirmed discount usability engineering methods uncovered a high correlation of interface usability errors, which can be addressed in the subsequent design process. Navigation, layout, colour, intuitiveness and domain architecture formed key components for inspection. Ultimately, a system should be *easy to learn*, *efficient to use*, *easy to remember*, *avoid errors* and be *subjectively pleasing*. The objective for this sub-section is –

- **Heuristic Evaluation** – A systematic inspection of the current desktop web application is undertaken utilising Nielsen's ten usability heuristics as detailed in section 2.4.

A grid view of the Caledonian desktop homepage in table 3 provides a basic representation of the user interface and navigation structure with hyperlinks and icon links listed.

Table 3 – Grid layout of Caledonian desktop homepage

Top Tier Navigation [3 Hyperlinks]			
Second Tier Navigation [1 Hyperlink]			
Main Navigation [8 Hyperlinks]			
Student Navigation [8 Icon Links]	Essentials [13 Hyperlinks]	Need a Hand [6 Hyperlinks]	Study [9 Hyperlinks]
News [15 Hyperlinks]	I Want to [4 Hyperlinks]	Jobs & Careers [10 Hyperlinks]	Computer Stuff [8 Hyperlinks]
	Life [11 Hyperlinks]	Official Things [6 Hyperlinks]	Resources [6 Hyperlinks]

Findings of the developer-centred heuristic evaluation of the user interface performed on the Caledonian desktop student homepage are detailed below -

Simple and Natural Dialogue

The interface layout is complicated and does not present a simplistic layout to the user. Each additional on-screen feature is an additional item to be learned resulting in one more item to possibly misunderstood. Presenting the user with one hundred and ten links on the first page hinders the ability to locate essential information quickly. Prioritisation of navigational elements is unclear increasing the cognitive load on the user. Colour co-ordination to group additional information has been utilised but is over-ridden by the wealth of linked information on the homepage. Important student information is provided in the Student Navigation area but the clarity of the icons leading to navigation or framed images results in uncertain clickability. Student Navigation conflicts with the Main Navigation resulting in dividing user attention and thus degrading user efficiency.

Designing a single screen concept where supplementary information can be relegated to auxiliary screens has been overlooked in the overall design and opposes the ‘less is more’ ethos which states that *less* irrelevant information will lead to *more* usable interfaces.

Inspection of the Caledonian University HTML code uncovered that an extensive use of tables was deployed for navigation layout as illustrated in figure 5. Navigation structures should be controlled with stylesheets. Tabular frameworks provide viewing limitations and restrictions for users when viewing web applications on smaller screen sizes such as smartphones.

```
<table class="mainTable" cellspacing="0" cellpadding="0" width="100%>
  <tbody>
    <tr>
      <td class="block_university_bar">
        <table class="block_university_bar_table" cellspacing=
          <tbody>
            <tr>
            </tbody>
          </tbody>
        </tbody>
      </td>
    </tr>
  </tbody>
</table>
```

Figure 5 – HTML table code for Caledonian homepage

Speak the Users Language

The desktop web application satisfies the criterion that interface terminology should be based on the users natural dialogue with avoidance of system orientated terms. University related terms such as ‘study’ and ‘careers’ are coherent terms relating to university related activities and provide familiarity. Mappings and metaphors help users associate related material assisting in simplistic discovery of university services. However, navigation links in the Main Navigation of the system is repeated on the same page, providing a duplication of links to the same resource. Duplicating links is sometimes a development method to increase web application traffic through search engine results but conversely the method increases page size leading to vertical user scrolling on the homepage to locate information in the bottom third of the interface. Literature uncovered in section 2.1.1 regarding displays concluded users avoid the extra effort of scrolling with 80% of participants concentrating on information and navigation above the ‘fold’.

Minimise User Memory Load

Interface attributes are overpowering which results in a relative loss of salience. Interfaces founded on recognition rely to a large extent on the visibility of objects of interest working on the principle that users find it easier to recognise something that is shown to them as opposed to recalling the information from memory without help. A search facility is available in the main navigation structure, which could assist users ‘foraging’ for information. However, the search facility is not openly viewable to users of the application resulting in redundancy of a key usability function.

Consistency

Navigation away from the homepage has the effect of losing the Student Navigation pane, which drops consistency of menu layouts. A major usability problem is apparent in the hyperlinked presentation of the navigation structure. Users need to understand where they have been, and which pages they have visited with nearly all web browsers displaying a

visited hyperlink in navigation structures with blue highlighting. The Caledonian interface violates this standard convention resulting in users having less mastery over page navigation with potential confusion arising in web application orientation.

Feedback

Improved usability is delivered through web application responsiveness. Delays in system processing exceeding a period of one second should be conveyed to the user. HTTP requests to the server can be timed using the Firebug Debug Console Application which provides developers with an accurate timeframe for each HTTP request. Figure 6 provides output from the console window illustrating download time from the server for the Caledonian University homepage.

Domain	Size	Timeline
gcu.ac.uk	19.3 KB	106ms
	19.3 KB (19.3 KB from cache)	106ms (onload: 402ms)

Figure 6 – Firebug console report for GCU HTTP request

An HTTP onload time of 402ms is reported for the request and retrieval of the homepage *index.html*. Nielsen’s recommendation requires that systems should only produce feedback if delays of more than one second occur. However, information retrieval from a database system is not taking place signifying that all web application content is ‘static’ and does not provide users with the option of data interchange or manipulation.

Clearly Marked Exits

Provision of clearly marked exits are implemented to allow users to undo actions and avoid the feeling of being ‘trapped’ in a system eroding user confidence in web applications. The Caledonian desktop web application displays inconsistencies in relation to this usability criterion. Figure 7 illustrates breadcrumb navigation viewable on the Registration web page but is removed when users click the Academic Registry page. Back button functionality can return users to previous pages however, simple navigation allowing users to return home in one click is basic functionality that merits inclusion in any web application design.

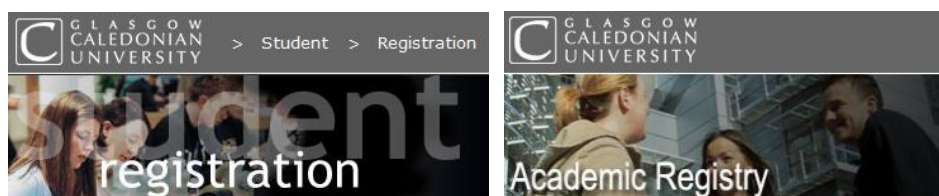


Figure 7 – Unclear interface navigation

Shortcuts

Typical accelerators include abbreviations, having function keys or command keys that package an entire command in a single key press or double clicking on an icon to perform the most common operation on it. Figure 8 demonstrates prioritisation of key components in the student homepage, providing essential information to students. Navigating away from the homepage loses these key components and alters the overall page structure throughout the application.



Figure 8 – Student navigation

Type ahead (providing textual prompts based on user interaction) is not really a shortcut as such but it can speed up interactions with the system and provide a succinct list of available navigation options or information selection available without much attention to spelling or exact wording required. The Caledonian ‘search’ facility does provide a search of the web domain but does not offer the type ahead functionality. Inclusion of such functionality would improve user confidence in the system with a more productive search capability.

Good Error Messages

The search facility outputs a corrective error message if a resource relating to the search cannot be found. Error messages should be human readable, precise, constructive and polite instructions which lead to error recovery. Minimal user input in the web application limits the amount of potential errors that could possibly occur.

Prevent Errors

Even better than having good error messages as stated, in the previous inspection criterion would be the avoidance of errors altogether. Avoidance of modes where users may be typing in upper-case when input should be carried out in lower case should not occur. Case-independent search facilities should be utilised, improving usability of web applications.

Help and Documentation

There is no help facility in the web application. Ideally help and documentation should be minimised for information systems. The web application does however contain a Frequently Asked Questions facility that provides partial assistance in system use. Ultimately the goal for users is productivity and the ability to readily interact with a system which consequentially instils confidence into the user experience.

3.3.2 W3C Mobile Web Development Guidelines

Applying Nielsen's usability inspection methods has identified current usability problems within the desktop application domain. To enhance and further refine usability for a smartphone platform requires the application of mobile specific web development guidelines. Literary investigation in section 2.2 identified W3C Mobile Best Practices 1.0 mobile web standards also comprising of ten themes. Guidelines are published by the Web Standards Organisation in acknowledgement to a growing demand for a quality mobile experience, noting that web authors who specifically design applications with mobility in mind will undoubtedly provide an enhanced user experience benefiting mobile users. The objective for this sub-section is –

- **W3C Mobile Web Guidelines** – Findings from the heuristic evaluative inspection methods were compared with the W3C mobile web guidelines outlined in section 2.2 of the literature review.

In conjunction with the textual themes for W3C mobile best development practices the organisation provide a programming code validation service as outlined in section 2.2 of the literature review providing additional technical detail regarding validity of code and operational capabilities in a mobile domain, displaying console listing errors with linkage back to the ten mobile themes. The validation service is provided as a web service, <http://validator.w3.org/mobile/>. Utilising the mobile validator can provide developers with a rapid formal inspection of a user interface in both a developer (localhost) and remote (HTTP) environment. The current Caledonian University homepage underwent validation via the W3C mobileOK checker <http://www.gcu.ac.uk/student/index.html>. A percentage mark is awarded against the ten themes for good mobile web practice with Caledonian desktop application awarded 21% as shown in figure 9.

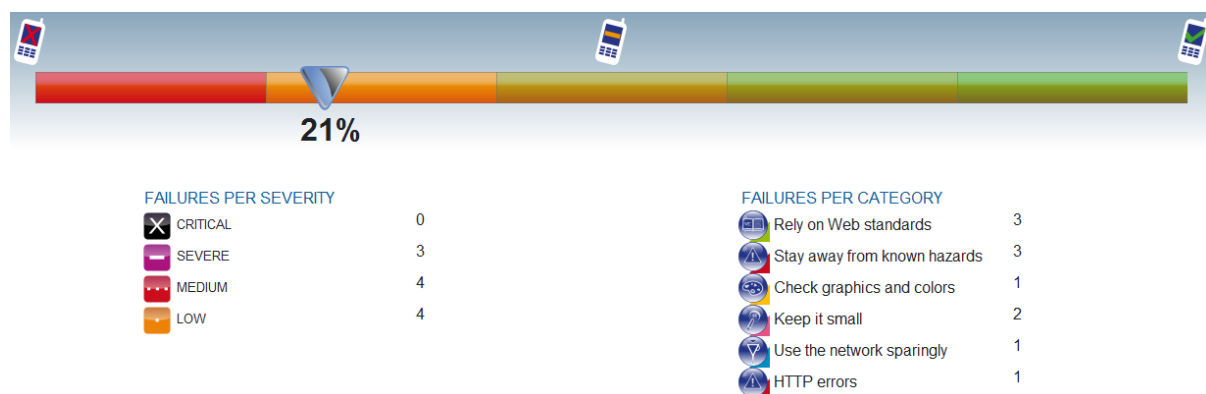


Figure 9 – GCU index.html, W3C code validation results

Results from the validation service confirm serious interface problems resulting from inadequate programming with eleven high-level errors meriting further investigation. Additionally console errors for the desktop web application detailed 'back end' server problems relating to internet protocols such as HTTP header information and meta data. This is an important area of discovery as initial interface inspections can only identify 'front-end' coding faults effecting usability. Network related problems could introduce latency into as system, directly effecting information delivery and responsiveness resulting in decreased

usability for the user of an application. In a method similar to the developer-centred heuristic evaluation, the ten W3C mobile development themes provide a checklist from which existing faults identified from the heuristic interface inspection in section 3.3 can be analysed through discussion, providing non-functional and functional requirements for a suitable mobile web application addressing usability faults, thus feeding into the development process. Themes are listed below with commentary and a recommendation that addresses the faults in a mobile operating environment.

Design for One Web

Thematic consistency is a convention the desktop web application does not adhere with. Inconsistencies in navigational layout and prevalence are evident, further degraded through the presentation of image navigation presenting the user with unclear clickability as the object may be construed as a framed image rather than an additional navigational resource. Content designed with mobile devices in mind will result in lower production costs, increase flexibility and satisfy the needs of more end users. Additionally application stability should be tested out with test suites in a realistic operational environment eradicating the uncertainties of device emulators.

Recommendations – Design consistent interfaces with well-bounded navigational options. Avoid clickable uncertainty, clearly defining all page objects. Use emulators to quicken the build and test process but deployment should take place on a remote web server to test system durability.

Rely on Web Standards

Code validation flagged up three errors relating to HTTP header information and UTF-8 character encoding which contravenes W3C web programming standards which are put in place to guarantee operability across mobile devices. An un-unified design approach is currently in operation. Style control seems so be embedded in the HTML code which should be controlled with CSS.

Recommendations – Deploy character encoding commonality utilising CSS for layout and positioning as this will provide a robust design approach. Correctly, nested HTML structural elements improve display if web pages need to be divided over several screens avoiding bloated interfaces. HTTP character encoding and metadata elements will provide a uniform approach consequentially leading to increased search engine visibility.

Stay Away From Known Hazards

Code validation flagged three errors in the programming of the desktop application. A usability problem identified early with the developer-centred heuristic inspection commented that table structures were in use for layout. HTTP DNS faults were flagged which is a server side problem that is otherwise impossible to locate through interface inspection alone.

Recommendations – Avoid tables and frames in mobile web development as the structures are not conducive to small device displays. More thoughtful layout and design will avoid these errors. DNS faults require web server access to view HTTP header information but can be programmed efficiently at the time of deployment.

Be Cautious of Device Limitations

This theme requires mobile web developers to ‘think ahead’ when initiating designs. In-depth understanding of smartphone capabilities is required as cookie sessions, scripts and stylesheets may not render correctly on first generation feature phones. Nearly all smartphones and certainly the iPhone have strong processing powers and highly adaptive mobile web browsers, which support a high percentage of modern web technologies.

Recommendations – Display size, input peripherals, power endurance and context of usage cited in the literature review in section 2.1 are all common characteristics of a smartphone platform influencing any intended developments.

Optimise Navigation

Of all the problems identified in the heuristic inspection, this rated as one of the most disconcerting. One hundred and ten navigation links were presented on the desktop web application resulting in the user having to process all the viewable objects and make a selection. Prioritisation of navigation is unclear with six areas occupying all screen space making selection of desired services extremely tenuous. Complex interfaces have the undesired effect of users having no confidence in the interface and thus, the application. Scrolling on the homepage resulted in the bottom third of the screen un-viewable. Several university resource links were duplicated on the homepage, which may cause confusion to users.

Recommendations – Design succinct navigation with user controlled menu options and a consistent homepage link where users are one click away from home. Increase usability with the deployment of a ‘search’ facility with prominent positioning so users show confidence in a system by being able to search for a resource if it is not clearly visible as stated laterally in section 2.2. iPhones support textual inputs with the user interface allowing for high levels of error free key entries. Careful consideration must be given not to exclude any content. Facilities not used by one user may be popular with others. Short URI’s should be a common feature in case users have to type directly into the browser address bar. This feature limits the amount of keyed inputs for an action, which is a benefit to users who may be operating in a challenging environment such as a train or a bus where motion may affect motor control. Screen real estate on smartphone displays is very precious and duplication of links to the same resource should be avoided even if it does increase search engine visibility. It is more important to provide good usability to a user who has already arrived at the web application than targeting potential customers.

Check Graphics and Colour

One error was returned in this category with the validation service flagging up an image problem. Image dimensions are not explicitly defined in this fault leading to screen dominance, overpowering mobile users with unnecessary graphics content.

Recommendations – Avoid large hi-resolution images with no specification and markup. Always stipulate image properties and if functionality can be delivered through alternative means, such as a textual hyperlink then it is worth consideration if both inputs achieve the same goal. Avoid weak colour combinations such as white on grey. Improved colour selection will improve readability and consequentially, usability.

Keep it Small

Three console errors are flagged in relation to this theme. Stylesheet size and large file sizes are responsible for this error. Information overload is apparent on the application homepage and each object represents precious memory usage and additional download times unsuitable for mobile computing environments. Scrolling pages are evident throughout the desktop application, most notably on the homepage.

Recommendations – Smaller applications enhance user experiences through reduced interaction times. Avoid scrolling where possible and design terse markup, thus optimising applications usage. Rather than displaying all the information available on a singular page, content could be designed as a database object. This process enables content to be stored as an individual component in a database and called over the network by the user. Presentation of information as individual units would not occupy as much screen space and could be user controlled through ‘drop down’ lists or ‘search’ facilities. In the current desktop application, ‘what’s new’ occupies two thirds of the left hand column. A more suitable solution would be for the deployment of a drop down list with dates which, when clicked by the user, would return data content from a database and display information corresponding to user input.

Use the Network Sparingly

Code validation generates two errors in relation to HTTP network requests. Caching information is not included in page headers requiring full-page load on each HTTP request. Network usage is increased on homepage load, as eleven of the image sources are located in another domain.

Recommendations – Caching header information improves web application performance assisting browsers that have previously rendered a returning visitor to the same location through header request/response functionality calling the web page from stored memory. Files for images and general content will improve download times if held on the same web server directory as the web page calling the resources. Resource requests over a network are inefficient, generating bottlenecks and latency where users can witness unresponsive system behaviour.

Help and Guide User Input

Heuristic interface inspection uncovered textual inputs required in the desktop search system, which supported basic error reporting but offered no type ahead facility.

Recommendations – User input, where required, can assist users locating a specific resource from the web application. W3C advise against textual inputs for mobile devices but some smartphones, especially the iPhone offer adequate support for textual input which is a stronger design option than page scrolling, hence improving the overall user experience.

Think of Users on the go

A lack of compact information, weak architecture and poor navigation make the desktop application cumbersome, providing inherent usability problems throughout the application.

Recommendation – Mobile web users require compact information whilst transiting dynamic environments as time is limited and distractions are many. Short but descriptive page titles, clear language and limitation of content to that requested by the user, collectively ensures a usability experience maximising absorption of information by users. The literature review in section 2.2 discovered web application content must have value with minimisation of

graphics and gimmicks. Interface inspection encountered difficulty in locating ‘timetable’ information. The navigational link to locate timetable information appears below the fold in the bottom third of the homepage and functionality in retrieving class information is poor. A user controlled feature such as a drop down list would provide an enhanced level of functionality. Additionally, observations noted that essential elements in the Student Navigation pane (Blackboard, Email, Library, My Caledonian and Service Desk) were only visible when viewing the homepage. Core functionality is delivered through this navigation pane and more precedence should be given when accessing these services in the navigation structure.

3.3.3 Identified Functional Requirements

Functional requirements address the essential functions that the web application should deliver to its users. The objective of functional requirements collection is to identify the processes that are supported by the overall application. A process can be described as a set of coherent activities, which must be performed by users interacting with the application. Developer-centred heuristic evaluation interface inspection and W3C mobile development guidelines have provided a practical way of gathering functional requirements. Symbolic modelling identified in section 3.1.1 represents a unit of interaction between the user and the web application describing the action of a well-defined business process, finalised by the accomplishment of a specific goal. The overall objective for this sub-section and the following sub-section is –

- **State Requirements** – Results analysis from the findings in heuristic evaluation and W3C mobile web guidelines will provide functional and non-functional design requirements

Data requirements describe the information assets a web application should manage to accomplish its goals. The objective of data requirements is identification of the data managed by the application. The starting point of data requirements collection is the investigation into exactly what point is content produced and consumed. At the requirements collection level, developers should focus on the definition of the main data elements, which will become the core concepts of the data scheme elaborated during design. Based on the outcomes from both interface inspection methods five principle requirements emerged from the observations:

1. Provide essential student services
2. Support user controlled auxiliary menu options
3. Locate a resource through searching
4. View timetable information
5. View events information

As stated previously, the new mobile web application is an information service for students. Core functional elements such as student services, timetables and events featuring on the desktop web application must feature in the mobile web application. A redesign of the desktop application is more appropriate than a reinvention of the application. Importantly, end users must have some familiarity with the new mobile web system with an intuitive

appearance. Literature in section 2.2 noted the user interface of a web application is its first impression and failure to ‘grab’ the user will result in disengagement. Additionally literature from the same section concluded web applications should be predictable through matching user tasks, providing the correct set of cues and guiding user expectations. Literature investigations also highlighted device constraints affecting how information is delivered to a smartphone device where optimisation must occur to address reduced display sizes. Utilising both the Nielsen developer-centred heuristics and the W3C mobile web development guidelines provided an evaluative framework in which a systemic inspection of the desktop web allocation could occur. At present, the current desktop application does present information to the user but it is delivered in an uncontrolled manner where every piece of information is displayed as HTML markup creating information overload in nearly every aspect of the interface. Development of controlled data objects and harnessing database technology allows the sequential storage of information which can be interchanged and manipulated through user input, supported with relevant technologies which the iPhone mobile Safari browser can support.

3.3.4 Identified Non-Functional Requirements

Non-functional requirements define all other requirements that are relevant for accomplishing user goals, but not specifically related to the system functions and relate to technical and communication issues. The core requirement of the develop and test method is to improve overall usability which is determined through the five Nielsen concepts of Learnability, Efficiency, Memorability, Errors and Satisfaction.

1. Intuitive interfaces
2. Availability of mechanisms to orientate the user
3. Responsive data retrieval
4. Interaction objects logically grouped
5. Enhanced user experience

Implementing the non-functional requirements in the design process will require combining all the collaborative technologies reviewed in the 2.3 of the literature review. Navigation structures need to be redefined, allowing the user great control over the selection of desired information grouping key components in a logical and structured fashion. Network frailties in the current system shall be overcome with the deployment of web standards increasing operability. The smartphone development environment is a challenging platform with typical characteristics for the target device discussed in section 2.1. Displays, input peripherals, context of usage and power consumption were identified as key limitations which need to be overcome in the design process to provide a suitable mobile web application, thus enhancing the overall user experience. Web technologies and mobile development standards will ensure a stable operating environment, consequentially outputting an all-encompassing mobile web application which provides a solution to all the identified problems discovered in sections 3.3.1 and 3.3.2

3.4 Conclusion

The extensive literature review and the developer centred inspection methods successfully contributed towards both the justification of the mobile web application and the selected choices of the systems intended characteristics. Knowledge gained in the literature review facilitated the author with an extensive understanding of key components and considerations for mobile web application development. Discoveries uncovered core functional elements and services the desktop web application should deliver with poor usability suitably addressed in the redesign process. Nielsen's developer-centred interface inspection heuristics are a robust set of criterion, which were subsequently validated with the W3C mobile web development guidelines. Interface design faults were identified in the current desktop web application to justify a develop and test project which addresses said faults. Additionally network protocol errors were discovered via the W3C code validation console providing guidance for the design process. The nature of web applications requires services to be accessed remotely with a stable client-server environment necessary to ensure operability.

4.0 Design and Implementation

This section details the choices made in the development of the mobile web application following on from the identification of the system requirements. The relevant phases: Interface Design, Build Components, System Architecture, Implementation and Application Testing are all detailed. Additionally the sections will display conformance to the development lifecycle detailed in section 3.2 which will allow the author to evaluate the application in a post-implementation inspection and draw appropriate conclusions.

4.1 Interface Design

This sub-section details the complete incremental development of the user interfaces, which were based on the requirements gathered in the previous section. In keeping with the incremental development approach, component parts underwent development individually including the interface design. Modelling interface designs can be achieved through various methods. A popular lo-fidelity approach requires the creation of screen layouts through sketches and drawings. Adopting this approach is useful in providing storyboard representations of simplistic systems but does not lend itself to the illustration of complex interactions such as database integration, and in some cases, it can be difficult to visualise a software system as merely a paper drawing. Most importantly, time spent on creating paper-based representations of a system can be counter-productive, as the drawings will never become physical parts of the system. A more efficient method of interface design adopts a high-fidelity approach utilising software that users would expect to see in the final version of the system, thus time spent developing prototype screens with code, is time spent building the actual system. An extensive exploration of literature in section 2.3 relating to web scripting technologies highlighted HTML5 and CSS as ‘front-end’ markup languages and will undergo deployment to construct the interface prototypes, which will evolve through incremental development into the main body of the web application. HTML5 is the latest W3C markup standard and as noted in the literature review the adoption of standards ensures operability of mobile web applications with a fellow practitioner noting that the adoption of this emerging non-proprietary technology significantly reduced overall development efforts. Adobe Flash is an alternative markup language (Adobe, 2011) but is a proprietary technology that does not render on the iPhone thus effecting operability. CSS styling is another W3C non-proprietary web technology standard. Where HTML5 controls markup, CSS controls styling of page elements such as fonts, colour and positioning. The console error report in section 3.3.2 flagged errors in the desktop application where style and markup program code featured in the same page. Developers should endeavour to embrace standards and thus separate markup from styling.

The first impression users perceive from a system is the user interface. Failure to ‘grab’ a potential user immediately regardless of content and processing capabilities may result in the user engaging in another web application. In section 2.2 of the literature review, investigations revealed web applications should appear native and predictable, providing the correct set of cues to guide and enhance user experiences. The first objective of the overall design process is -

- **Interface Design** – Web page layout elements such as colour, size, style and positioning achieved through HTML markup and CSS stylesheets. Include user controlled auxiliary menu

The iPhone has been chosen as the target device for the develop and test project and therefore all design is targeted towards device capabilities and where possible the mobile web application should replicate native styling to increase acceptance of the system. A basic text editor (Notepad 2, with syntax highlighting) was utilised to create markup and styling with front-end menus and *index.html* (homepage) rendered locally via Mozilla Firefox browser for local testing. Figure 10 [a] illustrates native iPhone styling, [b] contains unformatted HTML5 markup and [c] attempts to emulate the look of the iPhone native environment with the application of a CSS stylesheet.

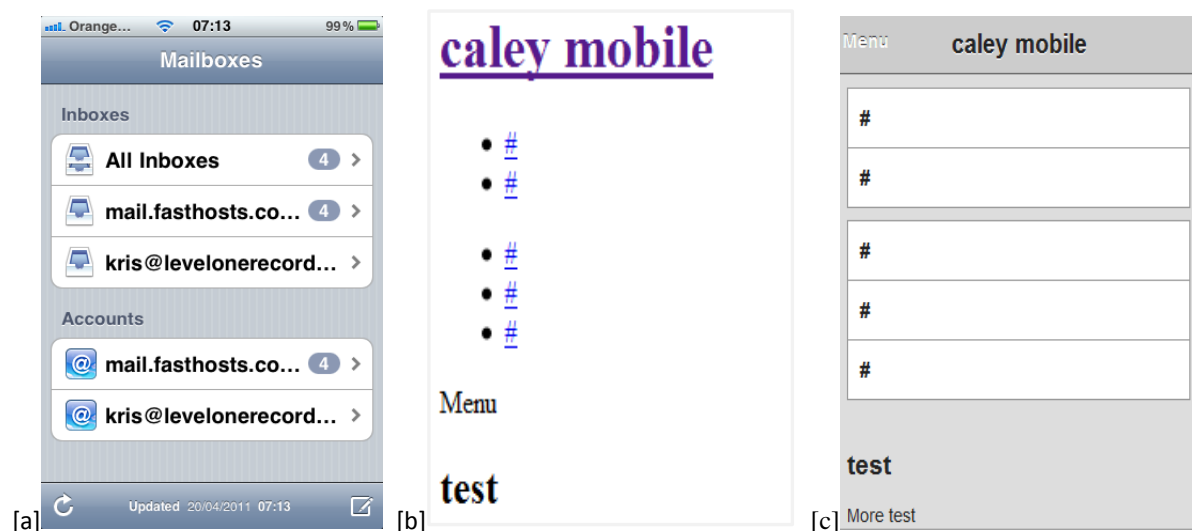


Figure 10 – Native iPhone styling / HTML markup (no style) / HTML markup with CSS styling

Verification and validation (V&V) took place throughout the component development. Identifying errors at the unit stage improves the quality of code whilst improving the overall quality of the product. As stated in the Lifecycle sub-section 3.1 V&V testing is well suited to incremental development, a view upheld by fellow practitioners referenced in the same section. The utilisation of stylesheets makes the application aesthetically similar to the native iPhone layout. Figure 11 illustrates a call from the *inex.html* header code to the stylesheet *iphone.css*, which is stored separately from the HTML5 code. A feature incorporated to improve usability is the restriction of the display size, which specifically targets the iPhone screen dimensions avoiding web application ‘bloat’ when displayed in the Mobile Safari browser. Separating style from content allows the mobile browser caching system to store individual page components thus reducing overheads and processing time when a user revisits a web application.

```
<title>Caley Mobile | Home</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-width: 480px)" />
```

Figure 11 – Fixed width attribute *index.html*

The first functional requirement in section 3.1.2 was to, *provide essential student services*. Student services form the core functional requirement of the student homepage and services were identified during the heuristic user inspection in section 3.3.1 featuring in the Student Navigation pane. Blackboard, Email, Library, My Caledonian, Service Desks, System Status

and Timetables are priority features of the desktop application and therefore feature in the mobile web application. One of the problems identified in the heuristic inspection noted navigation links were unclear because they bore a similarity to framed images, resulting in uncertain clickability. Redesigning the menu structure seeks to clarify any navigational confusion that may have arisen previously within the desktop web application. Figure 12 [a] illustrates the core navigation for essential student services with [b] implementing further stylesheet refinements with rounded menu corners and placement text above the navigation. It is important to note that CSS styling has created the tabular layout of the menu and not an HTML table tag. This was a problem in the desktop web application as tables have fixed width properties, creating poor interface displays on smartphone devices. An additional problem when performing interface inspections was the lack of consistent navigation. [c] Shows a small icon that will appear on every page allowing users to navigate to the homepage with one click, providing enhanced usability.

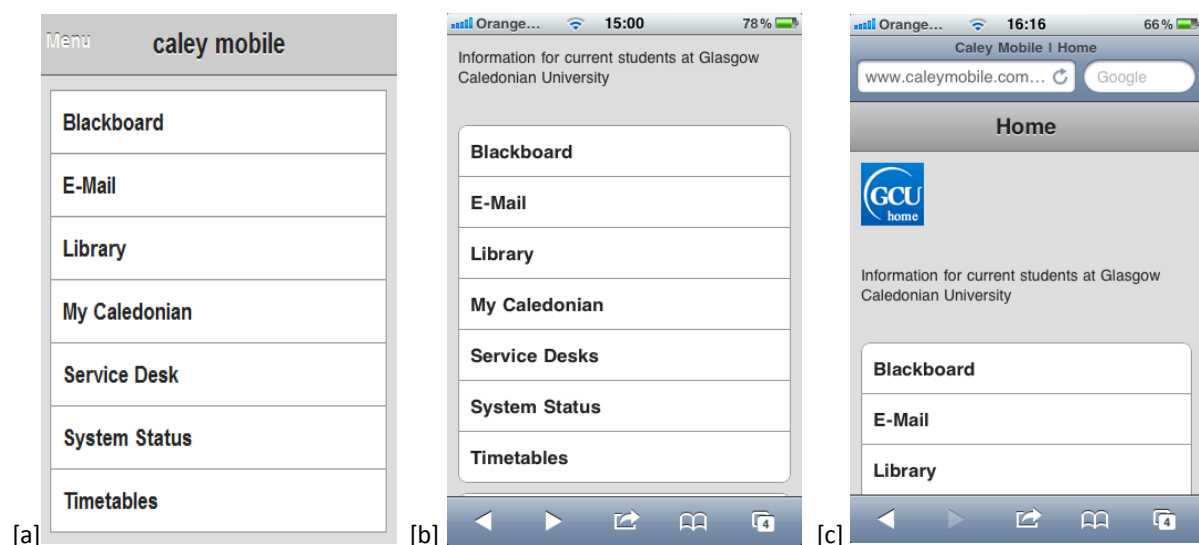


Figure 12 – Core navigation / Additional styling / Home button

The overall look of the interface and top tier navigation has been established, satisfying the first functional requirement, *provide essential student services*. The first six navigation options all link to external university resources. *Timetables* navigation has database functionality, which will be developed in section 4.3. Figure 13 shows the HTML code linking to external resources.

```
<div id="utility">
  <ul>
    <li><a
href="http://blackboard.gcal.ac.uk/webapps/portal/frameset.jsp">Blackboard</a></li>
    <li><a href="http://sn119w.snt119.mail.live.com/default.aspx">E-Mail</a></li>
    <li><a href="http://www.gcu.ac.uk/library/">Library</a></li>
    <li><a href="http://hp1.gcal.ac.uk/login.html">My Caledonian</a></li>
    <li><a href="http://isc.gcal.ac.uk/secure-login.htm">Service Desks</a></li>
    <li><a href="http://status.gcal.ac.uk/">System Status</a></li>
    <li><a href="timetable.html">Timetables</a></li>
  </ul>
</div>
```

Figure 13 – Homepage links to external resources

Heuristic inspection uncovered the problem of too many navigation links on the homepage with one hundred and ten links overwhelming users visiting the homepage. The second functional requirement, *support user controlled auxiliary menu options*, addresses the problem of overpowering navigation, relegating additional university resources to auxiliary page structures controlled by the user. Figure 14 [a] illustrates *More* option below the main menu structure, [b] has the auxiliary menu option in the top left of the pane and is user controlled, informing the user of additional university service available on ‘toggle’. [c] Illustrates the drop down menu with additional options replacing what would have been sub-navigation links in the desktop version. The menu in [c] is a JavaScript event handler which is fired when the user presses the button.

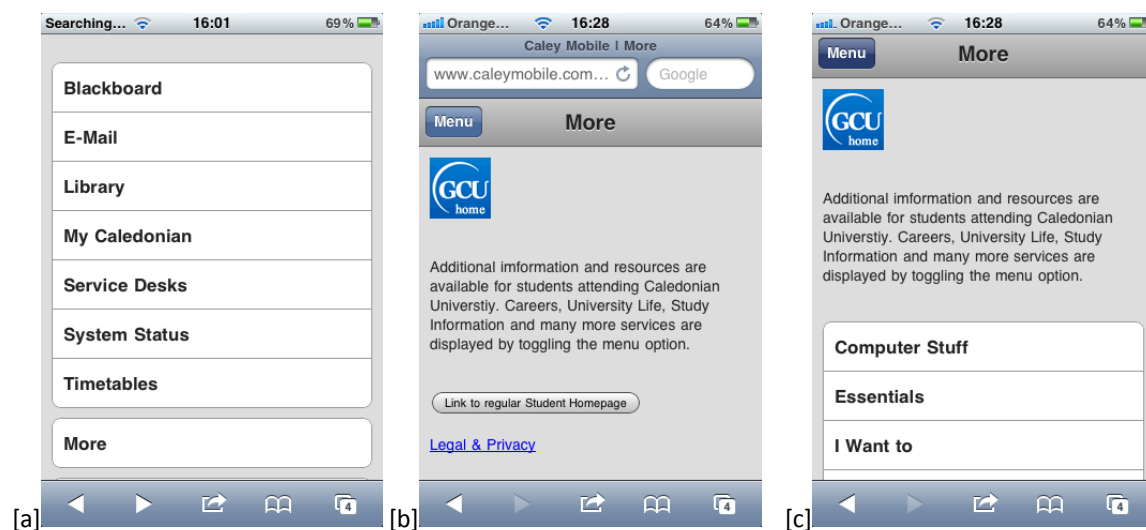


Figure 14 – Homepage / More (menu toggle) / Additional resources

Extensive scrolling has been removed from the mobile interface, which was a problem with the desktop application. Navigation links have been spaced adequately to remove the possibility of tapping the incorrect navigational link. The first objective of design and implementation has been completed resulting in the construction of a styled front page acting as a kernel from which the remainder of the application components can be added via incremental and iterative design. Completed requirements are detailed -

Functional Requirements Addressed

- Provide essential student services – Homepage with linked resources as the main menu option
- Support user controlled auxiliary menu option – Toggle menu facility contained in the More page

Non-Functional Requirements Addressed

- Intuitive Interface – Overall interface design replicates the native iPhone design.
- Availability of Mechanisms to Orientate the User – Robust menu options and a constantly visible home icon ensures users are only one click away from the homepage

4.2 System Architecture

The system architecture defines the overall hyperlinked navigation structure of the web application. *Index.html* provides the main portal to the entire web application and is represented in the top tier of navigation. *More.html* is the second tier of navigation and is accessible from the homepage with auxiliary information resources available through the user controlled menu toggle option. All additional information resources are contained in the third tier of navigation within the web application structure. The objective for this sub-section is –

- **System Architecture** – Overall hyperlinked navigation structure displaying page inheritance and database components.

Objects were grouped together in the mobile web application promoting trust in a system where users have a natural cue when viewing the new mobile web application. *Timetables.html* and *whatsnew.html* are both pages that will include dynamic content and interact with databases to deliver user generated content, the development of which are covered comprehensively in the following section. The second objective of design and implementation has been met in this subsection. A diagram illustrating system architecture is contained in Appendix A.

Non-Functional Requirement Addressed

- Interaction objects logically grouped – Familiar grouping of overall web application navigation options and information services.

4.3 Build Components

Inspection methods consistently noted information content and navigation structure on the desktop web application was overpowering. Too much information places a disproportionate cognitive load on the user who cannot identify information quickly, a key factor in mobile computing. Web 2.0 concepts were introduced in section 2.3 and the phrase represents the coming together of modern technologies and new ways in which said technologies can be applied in modern mobile web development. User generated content provides a dynamic platform, moving away from traditional ‘static’ web content, delivering powerful web services enhancing information systems performance and improving the user experience. The incremental lifecycle has included evolutionary prototyping and a symbolic modelling methodology. Key components underwent identification within the desktop web application, delivering increased functionality and responsive display characteristics. Identification of the key components that would overcome the cumbersome desktop environment were derived from the inspection methods undertaken in the Requirements in section 3.3. Transferal of information from static HTML markup to database objects allowed the author to interchange and manipulate data in response to user input. The objective for this sub-section is -

- **Build Components** – Functional requirements transformed into functionality aided by symbolic modelling utilising server side scripts, PHP, JavaScript and MySQL.

A problem highlighted through the inspection methods was the difficulty in finding timetable information for students. Navigation for timetable information was located below the fold and the system for extracting information was unclear. Additionally, investigations also noted that the placement of information for Caledonian student information titled, ‘whats new’, occupied a substantial amount of screen space. Listing of both, these elements are contained in the functional requirements from the previous section. In light of these situations, a key design decision was taken to convert information into data objects, migrating all course information and news information onto a database and access the course name and event date respectively in drop down lists. Figure 15 illustrates the drop down lists for timetables [a] and what’s new [b] respectively, both appearing on separate pages.

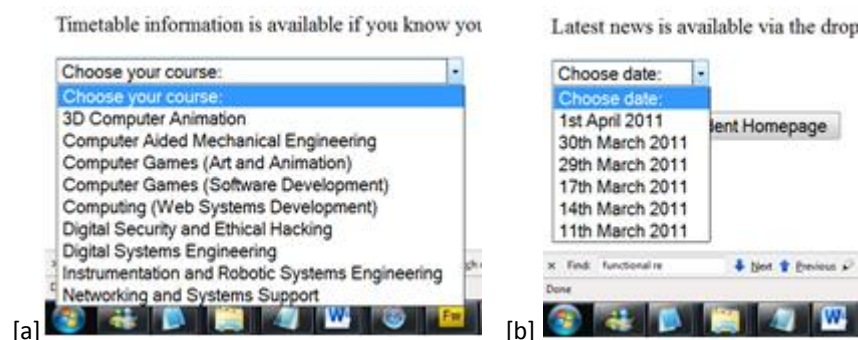


Figure 15 – Timetable and news drop down list prototype

At this point of component development, the model has only utilised HTML5 and CSS technologies to provide the menu options. A table was built utilising MySQL with course information contained in the relevant fields with the identifier being contained in course. The author gained an understanding of MySQL in section 2.3.4 and the technology’s inclusion is merited through its wider developer support and cross-platform capabilities guaranteeing stability and operability. Figure 16 illustrates the database structure for student timetables.

	<u>id</u>	<u>course</u>	<u>courseinfo</u>	<u>dayone</u>	<u>dayoneinfo</u>
<input type="checkbox"/>	1	3D Computer Animation	-	Monday 10.00-11.00 (M302), 13.00-15.00 (M606)	-
<input type="checkbox"/>	2	Computer Aided Mechanical Engineering	-	Wednesday 9.00-11.00 (M610), 12.00-13.00 (M622)	-
<input type="checkbox"/>	3	Computer Games (Art and Animation)	-	Monday 9.00-11.00 (M606), 11.00-12.00 (601)	-
<input type="checkbox"/>	4	Computer Games (Software Development)	-	Monday 12.00-13.00 (W417), 13.00-14.00 (W512), 14....	-

Figure 16 – Database structure for student timetables

Database technology operates on the server-side domain and the front-end HTML markup creating the drop down lists, resides on the client. An intermediary programming language is required to process the request between the two. PHP is a suitable webserver scripting language, which gained an introduction in section 2.3.8 with wide developer support, which can pass information between client and server. Figure 17 illustrates the ‘row calling’ method of the PHP script, which returns the corresponding information.

```
while($row = mysql_fetch_array($result))
{
```

```

echo "<ul>";
echo "<li>" . $row['course'] . "</li>";
echo "<li>" . $row['courseinfo'] . "</li>";
echo "<li>" . $row['dayone'] . "</li>";
echo "<li>" . $row['dayoneinfo'] . "</li>";
echo "<li>" . $row['daytwo'] . "</li>";
echo "<li>" . $row['daytwoinfo'] . "</li>";
echo "<li>" . $row['daythree'] . "</li>";
echo "</ul>";
}
echo "</ul>";

```

Figure 17 – PHP timetable script

An additional functional requirement relates to finding resources via a search facility. Including this component will assist efficient data retrieval and assist users unfamiliar with the web application. In order to represent the architecture of the web application to facilitate a search the author had to decide on a stable data storage technology but not necessarily a database. XML was investigated in section 2.3.3 of the literature review and was chosen as the language to present the architecture of the web application as it is lightweight and open source and both machine and human readable. The XML data structure links into the search box with an intermediary PHP script acting as a go between querying the XML structure based on user input, returning a page URL that allows the user to click and navigate to the page. Figure 18 illustrates the incremental deployment of the search bar [a] and partial XML code from *links.xml* [b].

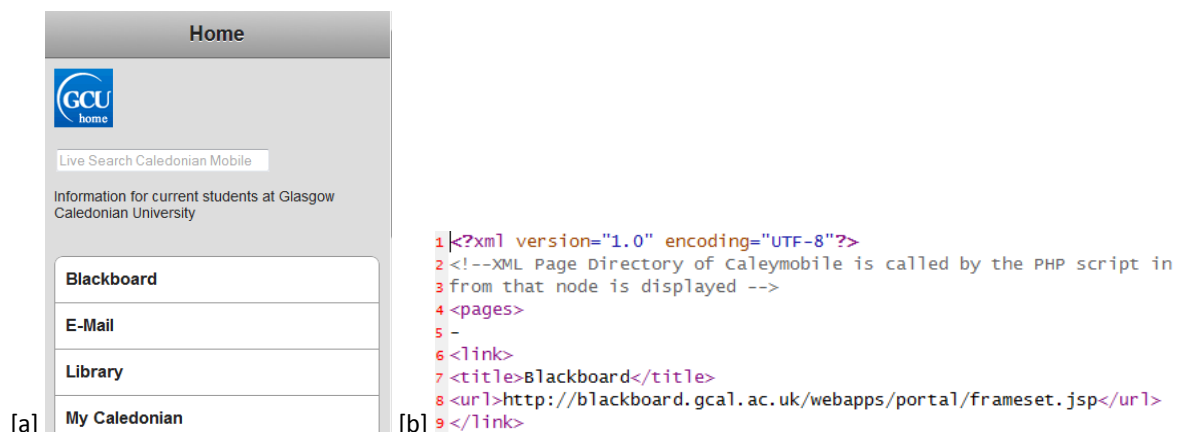


Figure 18 – XML code for links.xml

In building all the functional components with the relevant technologies, the objective for this section has been achieved. The kernel has transformed into a highly functional prototype, which undergoes implementation in the next phase of development. Completed requirements are detailed –

Functional Requirements Addressed

- Locate a resource through searching – Search box facility deployed on each page
- View timetable information – Drop down list and database integration provide specific timetable information from course lists

- View events information – Drop down list and data interchange with a database provide specific event information located through date

4.4 Implementation

This section reports on the integration of all the component parts. A large part of the system coding has already taken place and has evolved from an embryonic kernel into a highly functional prototype. One of the non-functional requirements necessitated responsive data retrieval. One of the major drawbacks with the desktop application was the high number of HTTP requests made to the server, resulting in full-page reload. Whilst a page reloads, the user has to wait for page refresh and furthermore they are unable to use the interface. Literary investigations into power consumption in section 2.1.4 gained insightful information into smartphone CPU performances. Evidence shows that smartphones are highly capable with powerful processing units, however battery life for devices depletes through repeated HTTP requests to the server, placing undue burdens on the CPU to handle such requests. Reduction in HTTP requests through AJAX technologies will improve smartphone performance and battery endurance. The literature review provided detailed understanding of both AJAX and DOM technologies in section 2.3. AJAX technologies provide a platform where partial page requests can be sent to the server for data interchange allowing returned information to be inserted dynamically into the HTML document negating the need for a full-page refresh. Implementation of AJAX provides an enhanced user experience where latency reduction occurs and web applications display higher levels of responsiveness. The objective for this section is -

- **Implementation** – Grouping of all component parts providing a final version, which will be remotely hosted on a server, providing a realistic testing environment with an accessible URL. The mobile web application will subsequently undergo a post implementation review by the developer

The AJAX engine acts as a partition between the client and the server and sends JavaScript code to build an XMLHttpRequest, which is a function triggered by an event. Once the event is triggered, in the case of live search a user enters an alphanumeric character (uppercase or lowercase) and a query is sent to the XML system architecture document and returns a suitable URL, which is clickable and takes the user to the desired page. InnerHTML replaces the onscreen URL suggestions with a different response and narrows the search as more characters are entered, in turn manipulating the Document Object Model and updating in real time. In the case of the drop down list, the same process occurs only this time information relating to news and student timetables is returned from a remotely hosted database and inserted into the DOM, an event triggered by the selection from the drop down list. Figure 19 illustrates the JavaScript code to implement the XMLHttpRequest in the livesearch facility.

```
function showResult(str)
{
if (str.length==0)
{
document.getElementById("livesearch").innerHTML="";
document.getElementById("livesearch").style.border="0px";
return;
}
if (window.XMLHttpRequest)
```

```

    { // code for IE7+, Firefox, Chrome, Opera, Safari
    xmlhttp=new XMLHttpRequest();
    }
else
    { // code for IE6, IE5
    xmlhttp=new ActiveXObject("Microsoft.XMLHTTP");
    }
xmlhttp.onreadystatechange=function()
{
    if (xmlhttp.readyState==4 && xmlhttp.status==200)
    {
        document.getElementById("livesearch").innerHTML=xmlhttp.responseText;
        document.getElementById("livesearch").style.border="1px solid #A5ACB2";
    }
}
xmlhttp.open("GET","livesearch.php?q="+str,true);
xmlhttp.send();
}

```

Figure 19 – JavaScript code implementing AJAX

A PHP script is required to assist in the server side processing of the AJAX request, illustrated in Figure 20.

```

<?php
$xmlDoc=new DOMDocument();
$xmlDoc->load("links.xml");

$x=$xmlDoc->getElementsByTagName('link');

//get the q parameter from URL
$q=$_GET["q"];

//lookup all links from the xml file if length of q>0
if (strlen($q)>0)
{
    $hint="";
    for($i=0; $i<($x->length); $i++)
    {
        $y=$x->item($i)->getElementsByTagName('title');
        $z=$x->item($i)->getElementsByTagName('url');
        if ($y->item(0)->nodeType==1)
        {
            //find a link matching the search text
            if (strstr($y->item(0)->childNodes->item(0)->nodeValue,$q))
            {
                if ($hint=="")
                {
                    $hint="<a href=' " .
                    $z->item(0)->childNodes->item(0)->nodeValue .
                    "' target='_self'>" .
                    $y->item(0)->childNodes->item(0)->nodeValue . "</a>";
                }
            }
            else
            {
                $hint=$hint . "<br /><a href=' " .
                $z->item(0)->childNodes->item(0)->nodeValue .
                "' target='_self'>" .
                $y->item(0)->childNodes->item(0)->nodeValue . "</a>";
            }
        }
    }
}

```



```

    }
  }
}

// Set output to "no suggestion" if no hint were found
// or to the correct values
if ($hint=="")
{
  $response="No search information found,please try rephrasing";
}
else
{
  $response=$hint;
}

//output the response
echo $response;
?>

```

Figure 20 – PHP code to implement live search

All mobile web application components and intended functionality underwent integration into one system and data was stored on a remote server. AJAX implementation occurred in the three functional components, timetable dropdown list, news dropdown list and search, which has evolved into a dynamic real-time search facility exuding high-level functionality assisting users who may have difficulty finding information. Achievement of the sub-section objective has been reached. Figure 21 illustrates livesearch [a], timetables [b] and what's new [c] which comprise of the final design.

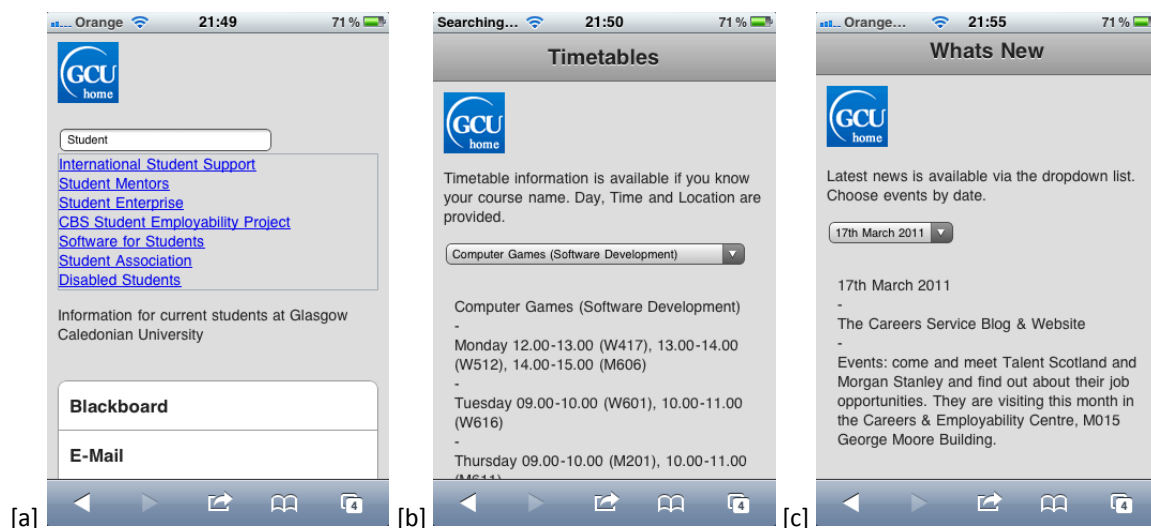


Figure 21 – Livesearch box / Timetables drop down / Whats new drop down – final designs

Hosting the mobile web application on a live server facilitates a realistic operational environment which allows both users and the author a platform on which to validate functionality and general performance capabilities. Experience gained in this part of the primary research method will prove invaluable and provide experience of web application deployment. Figure 22 shows the FileZilla FTP successful directory listing, the web application is hosted with a unique URL, <http://www.caleymobile.com>.

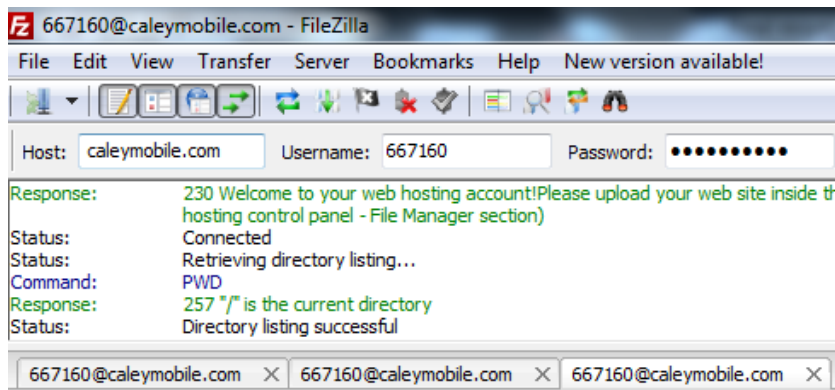


Figure 22 – FileZilla FTP directory listing for <http://www.caileymobile.com>

Post Implementation Review

Inspection methods employed on the desktop web application uncovered several high priority, usability and server-side scripting faults which had to be addressed in the redesign. In addition to these findings, the desktop returned a 21% score when code was validated against the W3C mobileOK checker, providing an indication that improvements in the current system were required. iPhones are capable of displaying desktop web applications providing restricted usability, but inspections confirmed, viewing the Caledonian desktop web application on the iPhone was severely inadequate providing justification that a mobile web version of Caledonian student homepage was required. System functionality derived from both functional and non-functional requirements underwent implementation in incremental stages with an evolutionary prototype acting as a kernel for development in the initial stages transgressing into the caileymobile web application. Thematic consistency was suitably addressed in the design phase with an intuitive interface, which employed native iPhone styling elements. HTML5 and CSS deployment ensured web standards were adhered to, ensuring operability across browser platforms. User controlled auxiliary menus for second and third tier navigation coupled with a livesearch facility harnessed modern technologies (PHP, JavaScript, DOM, AJAX, XML and MySQL) to deliver a highly functional mobile web application. Network wastage was avoided with terse markup and the avoidance of imagery. HTTP header information installs were undertaken where possible to assist mobile web browser caching. Design processes instilled confidence in the development with a functional prototype available early in development. Retrieval of information undertaken by end users will provide the basis for the lab experiment. More detail on the laboratory tests is provided in section 5.0.

Non-Functional Requirements Addressed

- Responsive data retrieval – AJAX and additional technologies have ensured data interchange and manipulation is efficient
- Enhanced user experience – Improved interfaces and navigation

4.5 Application Testing

As stated at the beginning of this section V&V was conducted throughout the incremental development where both program code and functionality were validated with each iteration of development. The author's familiarity with the coding enabled repeated testing of complex

functionality especially the livesearch component, utilising HTML5, CSS, JavaScript, AJAX, PHP, XML and DOM programming technologies. Incremental development supported unit testing where break points were inserted in the Firefox Debugger console to monitor both function and method parameters. A regression test specification can be found in Appendix B, providing a completed system test plan encompassing navigation and database interactions. As suggested in the W3C mobile development guidelines tests were conducted on the target device, the iPhone which removes uncertainties of a test-bed or emulator.

To check compliance with the W3C mobile development themes the URL <http://caleymobile.com> was parsed with the code validation service, scoring 83%, which is an improved validation rating compared with the desktop web application, which scored 21%. However, some errors do exist and they relate to server side scripting and HTTP requests, which the author was unable to correct in the given timeframe for the overall project. Figure 23 illustrates the console output window from the validation service.

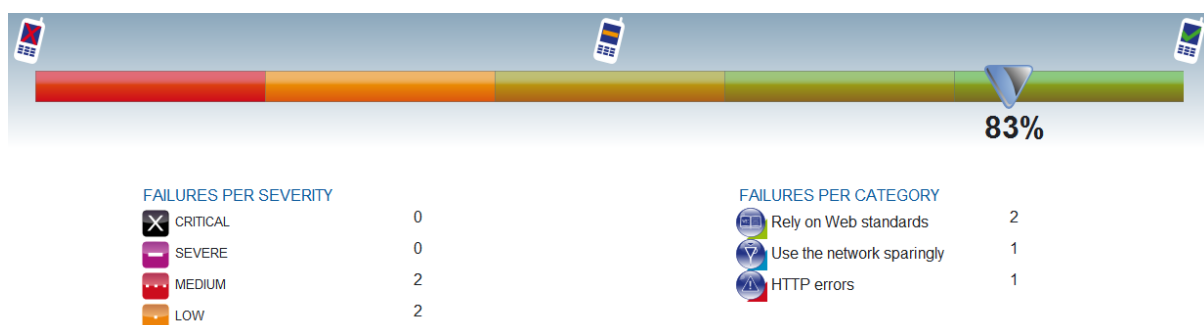


Figure 23 – W3C mobile validation result <http://www.caleymobile.com>

Another important service offered by the W3C is an HTML validator, which parses markup code for conformance to current web standards. HTML5 was utilised during the building of the mobile web application with code validated against the standard, improving overall operability. Figure 24 illustrates the validation for the mobile web application.

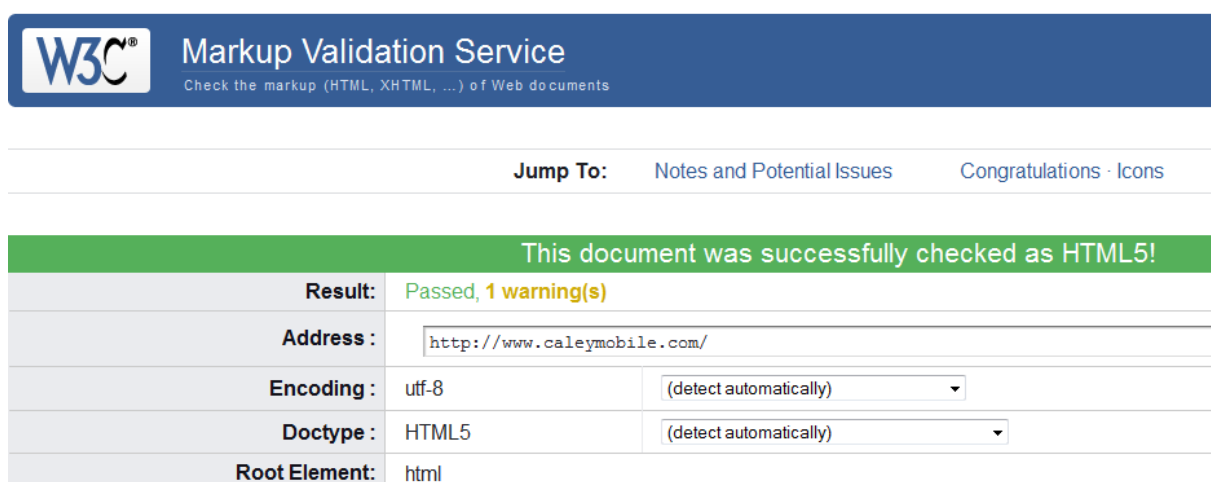


Figure 24 – W3C HTML5 validation result <http://www.caleymobile.com>

5.0 End User Evaluation

This section provides detail of the evaluation methods which were utilised in order to test the author's hypotheses. A lab experiment was undertaken, followed by interviews. The preparation, completion and outcomes of both scenarios will be explained and analysed. Outcomes from the findings of the evaluation methods will be presented with critical discussion taking place in relation to the project's overall aims and objectives.

5.1 Evaluation Methods

Participatory usability tests can reveal an immense amount of information about how people interact with a system. Usability testing is a quick and simplistic method to capture data that can be subsequently analysed. Usability testing is a structured approach, which focuses on specific features of an application. Testing an interface-based system is undertaken by evaluators providing output, highlighting successes, misunderstandings, mistakes and opinions. After a number of these tests have been performed, observations are compared and the most common issues are correlated into a list of functionality and problems. Developers can immediately see whether participants understand designs as they are supposed to be understood. A certain amount of usability testing occurred in the design phase through incremental development and evolutionary prototyping adhering to requirements gathered in section 3.3 reinforcing a deeper knowledge of the mobile web application and its intended functionality. However, evaluation was undertaken solely by the author and a more well bounded approach is required utilising participants who are familiar with the desktop application but not with the mobile web application. Examination of individual features and the way they are presented will locate potential misunderstandings or errors inherent in the way features are implemented which will in turn allow for an evaluation of the overall user experience. Gottschick & Restel (2010) investigated empirical evaluative studies in mobile web application systems focusing specifically on Rich Internet Applications with well-defined interfaces that provide semantic interoperability through data interchanges. Conclusions from the study strongly emphasised the assertion of usability studies through the collection of quantitative and qualitative data capture, led to overall improvements in design. Whilst noting the importance of empirical evaluative studies it is also important to outline the considerations of the initial hypotheses –

- H1 - *A mobile web application of the Student Homepage will offer greater usability to the end user compared to the desktop version when viewed using an iPhone.*
- H2 - *In performing like for like tasks, the mobile Web application will have a higher rate of successful end user interactions compared to the desktop version of the Student Homepage.*

Both hypotheses can undergo evaluation through the measurement gained in improved interface interactions by participants through two approaches. The two empirical evaluative approaches selected for the project are a lab experiment followed by interviews. The lab experiment allows collection of data within a controlled environment where individual evaluators can be monitored through realistic time and error based tasks on both the desktop application and the mobile web application. Interviews provide an additional evaluation

method whose aim is to achieve natural responses from evaluators whilst making sure responses are complete. Utilising both approaches removes any deficiencies that may occur through the deployment of an individual testing method, increasing the likelihood of a realistic outcome and a balanced set of results.

5.2 Lab Experiment

The lab experiment involved a time based and error checking evaluation method, which took place in Caledonian University. Quantifying user's performance is a dominant theme in usability testing where users are isolated from day-to-day interruptions providing insightful knowledge, enlightening the author as to whether overall usability has improved. The literature review relating to user testing in sub-section 2.4.2 explored Nielsen's usability engineering methods. Performing a heuristic evaluation by the author in a developer-centred approach was undertaken in the requirements section as literary findings revealed this was an effective method for uncovering a high percentage of usability faults, negating the need for participatory collaboration in the early stages of the development lifecycle. Utilisation of the developer-centred approach defined requirements, which in turn fed into the design and implementation phases of development resulting in a functional mobile web application prototype. An objective of this sub-section is –

- **Lab Experiment** – Quantitative data capture from participants through a simplistic task based controlled lab experiment testing hypothesis number two contained in section 1.2.3

Supplementary user-based inspection methods are also cited by Nielsen contained in the same sub-section, which support heuristic interface inspections. Performance Measurement is the quantitative element of the end user testing which is a traditional human factors research method outputting hard numbers, which can be analysed and used to compare two competing products, in this case, desktop web application versus mobile web application. Overall goals in usability testing can appear abstract so it is logical to break these goals into component parts. A balancing of the component parts has to be achieved and decide on the relative importance of each. To provide a quantification of a component a method of measurement must be introduced. Paithankar & Ingle (2009) identify that usability engineering is an indispensable feature of any interface-based software project validated through performance measurement in two categories, timed tasks and error rates. The following three sub-section identify participants and tasks with critical analysis provided.

5.2.1 Participants

A main pre-requisite regarding test users is that participants should be as representative as possible of the intended users of the web application. Adhering to the principles of discount usability engineering, careful consideration was given not to use outlier groups but care should be taken to involve average users. With this information in mind and the nature of the mobile web application, participants were recruited from departments within Caledonian University who were accustomed to the desktop interface. Nielsen & Landauer (2010) conducted research into the complexities and expense associated with conducting usability trials with a large number of users. Both researchers provided the following formula, $N(1-(1-$

$L)^n$) where n is the user and N is the total number of usability problems in the design and L is the proportion of problems discovered while testing a single user. Figure 25 illustrates the findings.

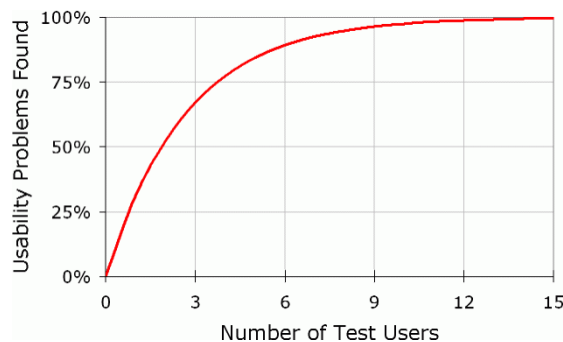


Figure 25 – Usability testing adapted from Nielsen <http://www.useit.com/alertbox/>

The typical value of L is 31% across the projects the researchers investigated with the plotting curve shown in the figure. This investigation reveals that in the initial stages of inspection error discovery rates are high but as more errors are uncovered, discoveries dip even with the application of additional evaluators. To locate all usability faults requires fifteen users with both researchers concluding more effective usability problems undergo discovery with the application of five users to three smaller tasks as opposed to channelling all resources into a singular test situation. Findings influenced the usability participant recruitment for the web application evaluation and five participants were selected for the testing phases. Recruitment of the participants was conducted through associates of the author who was mindful of the fact that multidisciplinary participants familiar with the system would provide a better cross-section of realistic results than if the tests were solely conducted on students from the computing department. Participants were recruited from the Psychology, Computing and Physiotherapy Departments within Caledonian University.

5.2.2 Tasks

The lab experiment conducted performance measurement and interviews in the same session with the details of the interview techniques and processes contained in section 5.3. To examine the second hypothesis the author had to extract data in relation to the anticipated improvements the mobile web application could potentially offer in comparison to the desktop application. Task duration and error rates were identified in literature earlier in this section as an effective means of performance measurement. To draw comparisons between like for like performance on a desktop and mobile environment tasks were identified for evaluators to undertake. Tasks were broken down into components, it is not effective enough to ask a user to test navigation, this term is too ambiguous and high-level to obtain any kind of meaningful data. A detailed list of the tasks is outlined –

1. Locate timetable information for Digital Systems Engineering
2. Locate news information for the 30th March 2011
3. Search for ARC health and fitness

All three tasks were intended to examine three main functional components of the mobile web application. [1] Dynamic timetable list [2] Dynamic dropdown list for news and [3]

Livesearch facility. Information gathered from the lab would be analysed and prove or disprove the second hypothesis.

The lab experiment involved four main stages: *preparation, introduction, the actual test and debriefing*. Testing sessions were carried out on an individual basis for two reasons. Firstly, logistically due to individual schedules, it was not convenient for all participants to attend the lab experiment at the same time as all students had timetabled classes in different departments. Secondly, the author had little experience in conducting group testing and to undertake the testing and recording of results accurately individual lab experiments would provide a controlled environment. Due to the authors inexperience in conducting lab experimentation a decision was made to conduct two pilot tests where a 'dry run' was undertaken with two classmates to ascertain whether the testing environment was appropriate for the experiment and to provide an estimated timeframe for the testing activities. Evaluators were informed by email of the room number and the date and time of the experiment and making them aware, lab tests and interviews would be conducted in the same session with a short break between both task based and interview methods.

Preparation

The lab equipment was set up before the evaluator arrived so that time was not wasted and the author could focus on the actual tasks. Equipment was checked to ensure a web connection on both the desktop computer and the iPhone was available. Screen savers were switched off and lighting was controlled to provide an adequate space for testing with signage on the lab door informing fellow students that the lab was occupied and currently being used for test purposes.

Introduction

The evaluator was welcomed and given clear instruction to the nature of the test and why it was being conducted. Conversation was of an informal manner to relax the evaluator, with the author avoiding technical jargon, speaking in clear unambiguous terms about the mobile web application. An explanation was given by the author that the purpose of the lab experiment was not to test the user but both desktop and mobile web applications. The author informed the user that test results would be confidential and that if he/she wished to withdraw from the lab experiment at any time, they were free to do so. Additionally instructions were provided to the evaluator that the author would not intervene at any stage to help with the experiment as this was against the principles of the usability testing, however questions could be asked at the start of the session to answer an uncertainties that may exist.

The actual test

The author refrained from helping the evaluator even when difficulties arose and set a maximum time limit of two minutes per task so as not to cause undue stress to users who had not completed the task in the given time. The author completed the task list as the evaluator moved through both systems.

Debriefing

A debriefing occurred after the lab test thanking users for taking the time to run through the interface usability tests. A short break was taken, then the author conducted a brief interview with the evaluator, which is covered in section 5.3.

Collecting quantitative data from evaluators has achieved the section objective and helps to prove the authors second hypothesis.

5.2.3 Task Results

The results obtained from the controlled lab experiment involving the five participants returned data of a quantitative nature providing results. Task duration, number of errors, number of steps and overall task success rate provide four key areas of analysis. The three specific task results were grouped to provide an overview measuring usability success through task competence. The bar chart displays mode, median and mean data analysis. A full breakdown of the tasks is contained in Appendix C.

Duration of Tasks

The first set of results relate to the amount of time evaluators took to complete a given task. A comparison is drawn with information taken from tasks performed on the mobile web application and the desktop web application with all five evaluators timed data processed. Mode, median and mean values are shown for each operating platform. Results in figure 26 illustrate that evaluators took longer to perform tasks on the desktop application compared to performing the same task on the mobile web application.

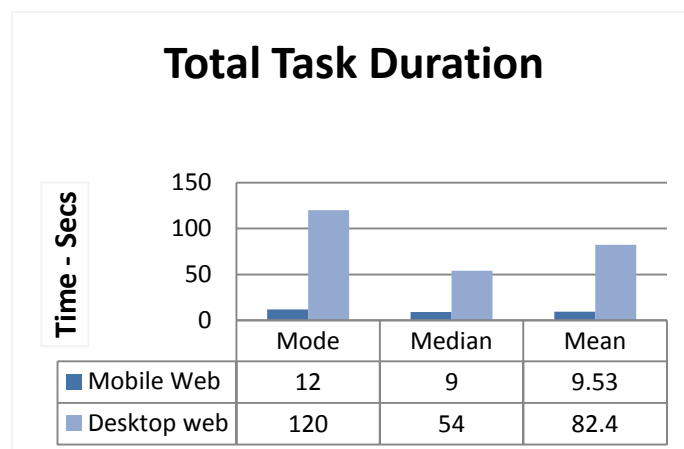


Figure 26 – Total task duration in seconds

In each category, it can be seen that task performances were more efficient on the mobile web application compared to the desktop application. The greatest difference is evident in the mode data with the mobile web application achieving 12 seconds and the desktop application returning a mode value of 120 seconds. The main reason for this difference being that retrieving timetable information was proving extremely difficult as the information is embedded deep within the desktop web application and the navigation link to reach the desired screen is below the page fold placed at the bottom of the menu system. A time limit of two minutes was set to prevent evaluators becoming frustrated if they could not locate a desired resource. All five evaluators were unable to locate the timetable information on the desktop application. It was anticipated that the mobile web application would provide efficient information retrieval compared to the desktop application, but results show a greater

difference than expected. Poor layout and navigation were identified in the developer-centred inspection of the desktop web application and results provide firm evidence that the mobile web application has addressed these problems. It is interesting to note that even though evaluators were not asked to use the livesearch functionality in this task, four out of five evaluators accessed the livesearch instantaneously to locate the timetable resource providing evidence that a search facility was fully justified.

Number of Errors

The bar chart shown in figure 27 displays the recorded values of errors which occurred in the three tasks performed on the desktop web application and the mobile web application. Information returned from the lab experiment has been grouped. The mobile web application does not feature on the chart because all three tasks performed by the five evaluators were performed without error. Information retrieval for timetables within the desktop application proved difficult as explained in the previous analysis and resulted in the high error rate. Timetable information features in the mobile web application main navigation structure, a design choice made in the requirements process, identifying the resource as core functionality. Error rates over four occurred in all desktop activities which highlights that information retrieval is un-natural to the evaluators. The drop down list provided efficient information retrieval for the relevant course. AJAX technology assisted evaluators with responsive data retrieval capabilities where they could manipulate data, facilitated through a key design decision in the requirements phase to convert information into data objects to be stored on a database and called when necessary.

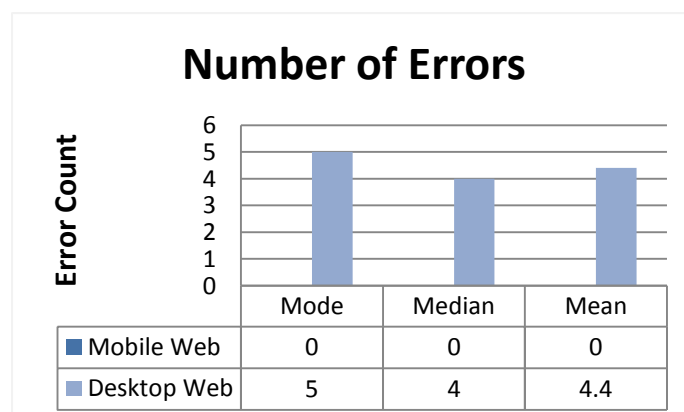


Figure 27 – Number of errors

Number of Steps

Number of steps was measured in ‘clicks’ or in the case of the iPhone ‘touches’, and returned data in relation to the total number of input actions the evaluator was required to make to achieve the desired resource on both the mobile web application and the desktop application. The livesearch facility and the intuitive layout are both providing efficient means for evaluators to locate resources quickly. Auxiliary menu systems are facilitating optimised performance results on the mobile web application. The desktop web application connects to the internet via an Ethernet cable whilst the iPhone connects through the GCU wireless facility. Fixed wiring cabling for internet and web access has a greater bandwidth than radio signalled wireless connections, however the mobile web application operating on the iPhone managed to outperform the desktop web application consistently through increased

functionality achieved through ‘front-end’ and ‘back-end’ web scripting technologies and web standards. The mobile web application has a small home icon located on each page providing users with a quick and easy option to return to main navigational structure, thus reducing the amount of clicks. Figure 28 illustrates the comparative difference in the step counts between mobile and desktop applications. A mean score average just below five is almost double the time taken by evaluators operating the mobile web application. Five clicks is acceptable in a desktop environment as mouse control allows for more precise movements, however due to input limitations and context of usage a smartphone needs to provide minimal inputs to reach a specific resource.

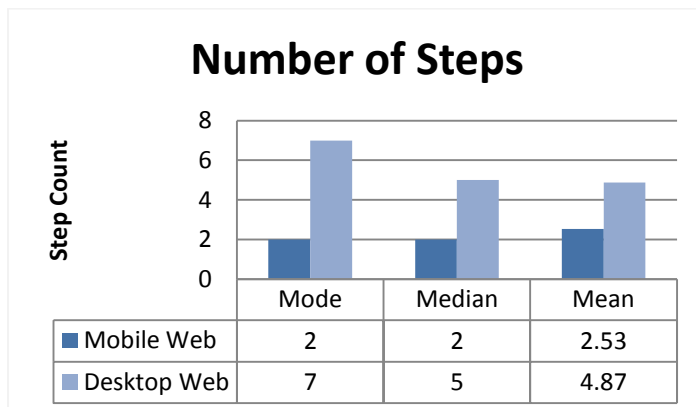


Figure 28 –Number of steps

Task Success

The final lab test performed by the evaluators was a comparison of overall task success. The mobile web application provided efficient means of information retrieval to all evaluators. Dynamic searching and information as data objects has delivered a successful mobile web application addressing key usability problems. Identification of limiting factors of a typical smartphone platform such as the iPhone, uncovered in the literature review, such as screen size and input peripherals have been addressed in the design process. Compact navigation structures and terse markup allow the application to operate successfully in dynamic environments. Figure 29 illustrates the overall task analysis.

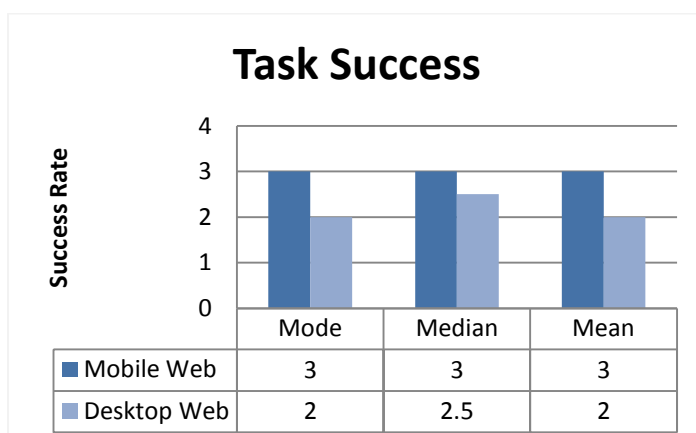


Figure 29 – Success

Conducting the lab experiment has satisfied the objective of this sub-section. Once evaluators had completed the evaluative testing they were given a short break and subsequently interviewed, this is covered in the next section.

5.3 Interviews

Interviews are an additional method for capturing systems information. It was decided to optimise the lab time the author had with the evaluators and conduct a short five minute interview. Questionnaires are often used in information gathering but can be difficult to distribute, collect and process with 'closed' questioning, which does not allow for free comment and a two way conversation. The objective for this sub-section is –

- **Interviews** – Qualitative data capture through open ended dialogue with participants testing hypothesis number one from section 1.2.3

Interviews were conducted after the lab experiment with the experience of using both the mobile web application and the desktop application, still fresh in the mind of the evaluator. The author prepared a short list of questions before the interview and encouraged an open-ended conversation. The questions were based on Nielsen's ten heuristics detailed in section 2.4.1 and focused on the mobile web application characteristics. All the relevant information from the transcripts is contained in the interview results section 5.3.1. The questions are detailed below -

1. *Simple and natural dialogue* – Did you feel the mobile web application had a simplistic layout and, additionally did the application feel native and intuitive to use?
2. *Speak the users language* – Did you feel the mobile web application used clear terminology and incorporated logical mapping?
3. *Minimise user memory load* – Did you feel overloaded with information whilst using the mobile web application?
4. *Consistency* – Did you think positioning of navigation and the consistent placement of the livesearch bar and the homepage icon aided your experience whilst using the mobile web application?
5. *Feedback* – Was the mobile web application giving you any indication of delays in information retrieval?
6. *Clearly marked exits* - Did you feel trapped or lost at any point using the mobile web application?
7. *Shortcuts* – Did you make use of any functionality, which you would consider a shortcut whilst using the mobile web application?
8. *Good error messages* – Did you receive any error messages whilst navigating through the mobile web application?

9. *Prevent Errors* – Did you perform any tasks to prevent an error occurring during the operation of the mobile web application?
10. *Help and documentation* – Do you think the mobile web application should include a help facility to assist users in their goals?

5.3.1 Interview Results

It was anticipated that results obtained through dialogue with evaluators would reinforce the author's design choices outlined in section 3.0. All five evaluators engaged in open conversation with the author regarding the ten heuristic-themed questions, which relate to the overall usability of the Caledonian University mobile web application. A summary of the information obtained through the interviews is outlined –

Simple and natural dialogue

All five evaluators agreed the mobile web application had a logical layout, which was easy to operate and required minimal inputs to locate resources. Familiarity was evident as the homepage contained the essential student services grouped in the same order as the desktop web application. Three of the evaluators currently owned an iPhone and comments were made regarding the similarity of the mobile web application design to the native device settings. All evaluators concurred that the overall system architecture and interface design was intuitive requiring minimal operational effort. Evaluators subsequently commented on the fact that scrolling was minimal which countered the problematic scrolling experienced whilst operating the desktop application.

Speak the users language

Evaluators conveyed that terminology used in the mobile web application was indicative of the desktop application and unambiguous terms had been avoided. Grouping of objects was logical and the auxiliary menu system for second and third tier navigation was a key component in the overall functionality of the mobile web application. Two participants enquired if the prototype would evolve into a 'live' application for real-context usage as they found the mobile web application was a useful tool for student services.

Minimise memory load

The group of evaluators acknowledged information architecture and presentation within the desktop web application was a major problem, increasing cognitive loads on users. Information gathered through dialogue with evaluators reaffirmed design choices to convert information into data objects as the user controlled the information on display, manipulated with the assistance of drop down lists and search facilities. All evaluators commented on the appearance of a 'clean' interface.

Consistency

All evaluators were unified in their opinions relating to the dynamic livesearch facility. Livesearch provided URL links to resources reacting to keyed user inputs. Consistent location of the search box in the header area of every page in the mobile web application

encouraged evaluators to use search for information utilising this function. Evaluators all agreed the livesearch facility was a key factor in their overall interactions with the mobile web application. Homepage icon was also cited as a useful tool to orientate users with the homepage and main menu structure.

Feedback

Evaluators commented no feedback was evident. However, evaluators commented on the responsiveness of the mobile web application, which reacted to their inputs instantaneously.

Clearly marked exits

All evaluators reiterated navigational structures and the clearly identified homepage icon facilitated a clear understanding of where they were and where they had been. None of the evaluators felt trapped in the mobile web application.

Shortcuts

Evaluators confirmed the adoption of the dynamic livesearch facility provided a shortened method for information retrieval if they were unsure how to locate a specified resource.

Good error messages

No errors were flagged by the evaluators.

Prevent errors

All evaluators agreed the layout and the additional functionality prevented error occurrence.

Help and documentation

All evaluators stated that no help facility was required and it was not a feature they thought should be include as interfaces were intuitive and simplistic to operate.

The collection of qualitative data through interviewing has achieved the section objective and assists the author in verifying the first hypothesis, discussion of which will take place in section 6.0.

5.4. Conclusion of Evaluation Method Results

The evaluative methods to collect quantitative and qualitative data through lab experimentation and interviews were successfully completed with the associated results recorded, analysed and compared. The outcomes of both evaluation methods provided a comprehensive interface and system inspection of both the mobile web application and the desktop application. The adoption of controlled data collection methods returned essential data reaffirming design choices regarding functionality and system architecture at the requirements stage in section 3.1.1. The objective of this subsection is -

- **Analysis of Results** – Final analysis of both evaluative methods will ascertain the mobile web applications overall performance and display results to potential readers of the paper in a succinct clear manner.

Performance measurement provided a clear indication that the mobile web application was consistently out-performing the desktop application in regard to information retrieval and overall usability involving the three performance tasks evident in the bar graph analysis. Interviews added to the performance measurements allowing users to speak freely about specific aspects of the mobile web application. Overall outcomes obtained through both data collection methods substantiated the main findings of the literature review and supported both hypotheses outlined by the author in section 1.0. Developer-centred inspection methods uncovered in the literature review and deployed in section 3.0 proved to be invaluable in identifying the overall usability problems associated within the desktop web application. System acceptance by the student evaluators supports design choices and inclusion of key functional components giving justification that an interface redesign was required and all design choices were both effective and appropriate in achieving the overall goal of improved functionality of a web application operating on a smartphone device. In completing both the performance measurements and interviews the information included in the section has achieved its objective.

6.0 Discussion and Conclusions

This section will contain the final overall conclusions of the project. A brief summary of the project outline is provided prior to the final discussion of the project and the results. This detailed discussion will present the author's findings in relation to the initial investigation and initial hypotheses. Consideration of the overall tasks undertaken to achieve project objectives will feature with a consideration of limitations and potential implications for the research area and future work also undergoing review.

6.1 Project Resume

Mobile phone development has undergone a radical transformation in recent years with technology and connectivity advancements combining to deliver smartphones. Smartphones differ greatly from standard feature phones as they provide powerful means of communication embracing Internet technologies, facilitating operations away from a fixed desktop environment whilst replicating many of the functional characteristics associated with desktop PC's. One of the most popular services accessed by smartphone operatives are web services. Wireless and 3G connectivity technologies have provided a platform where smartphone users can access web content anywhere at any time in dynamic environments. However, an extensive literature review undertaken by the author in the initial stages of the report concluded that device limitations such as display size, input peripherals (keyboards and micro joysticks) context of usage and power consumption were key factors influencing design considerations in the development of web applications intended for a smartphone device. Further investigations revealed migration of web applications intended for desktop usage provided inherent usability problems when viewed on a smartphone device, such as poor navigational controls and extensive scrolling. Kane et al (2009) provide an investigative journal, which concludes desktop, and mobile operational domains differ substantially, meriting an effective reworking of interface elements to eliminate the 'cumbersome' display characteristics associated with desktop web applications running on a smartphone. Additional studies revealed further research was required to investigate low cost, efficient usability inspection methods for desktop web application redesign to create a mobile web application that delivers an enhanced user experience in a smartphone domain. The aim of the project was to examine and answer the following research question -

Can a desktop website viewed on an iPhone, be reconstructed with the aid of developer-centred usability inspection methods, to produce HCI guidelines to develop an accessible mobile web application with an intuitive interface, enhancing usability whilst retaining core functionality?

Based upon this research question, the project's overall purpose was to evaluate to what extent the impact of developer-centred inspection methods deployed in the development of a web application would have in the redesign of the current Caledonian University student homepage desktop web application. This was completed through the undertaking of a develop and test project, creating a suitable mobile web application evaluated through performance measurement in a lab based experiment followed up with participatory interviews with evaluators of the new system. The mobile web application underwent development with an initial developer-centred heuristic evaluation of the current desktop interface with suitable application of W3C mobile web development guidelines, which in turn

led to a detailed set of system requirements feeding into the design process of the new application. The build process embraced web scripting technologies to create intuitive interfaces with a native appearance and a reworked architectural structure combining to facilitate the efficient retrieval of student related university resources. After the build process, a post-implementation inspection of the mobile web application prototype took place before the end user evaluation. The end user evaluation process returned data of both a qualitative and quantitative obtained through evaluation of both web applications, which was analysed and contributed significantly towards the author's conclusions relating to the initial hypotheses -

H1 - A mobile web application of the Student Homepage will offer greater usability to the end user compared to the desktop version when viewed using an iPhone.

H2 - In performing like for like tasks, the mobile web application will have a higher rate of successful end user interactions compared to the desktop version of the Student Homepage.

6.2 Final Discussion of Results

The main goal of the project was to measure the effectiveness of a developer-centred design approach in the identification of usability faults in a desktop web application negating the need for user participation in the early stages of requirements development. Knowledge derived from the literature review revealed previous work in the HCI field had employed a user-centred approach from the outset, which is labour intensive, requiring complex logistics and substantial resources. In order to evaluate the mobile web application, performance measures and interviews were conducted in a controlled lab environment with evaluators. The purpose of the end user evaluation was to provide measurable data that could test both hypotheses. Literature reviewed in section 2.2 revealed web application interfaces were the main entry point into a system and users who had difficulty in mastering an interface would disengage with the system regardless of content and processing capabilities. Furthermore a clear need emerged for a quality mobile experience from users of smartphone devices, thus designers should be mindful of device limitations and design mobile web applications accordingly utilising appropriate mobile web standards to ensure operability and ultimately acceptance by the end user. Results obtained from the end user evaluations produced vital qualitative and quantitative data, which was analysed with discussion of each method and how said methods assisted in the overall project objectives.

Lab Experiment Conclusions

The hypotheses of the project related to enhanced task completion and overall perceived usability benefits achieved with developer-centred inspection methods on the desktop web application producing specific mobile development guidelines to create an enhanced mobile web application. The lab experiment aimed to provide quantitative data to support the second hypothesis requiring evaluators to perform like for like tasks on both the desktop and mobile web application. Tasks were related to key functional components identified in the requirements section; Timetable information via a drop down list, news information for a specified date through database interaction and search utilisation.

The greatest deviation in test results was identified in the overall task duration, measuring evaluator times for completion of the three identified tasks. The mean completion time for the desktop application returned a time of 82.4 seconds whilst the mobile web application returned a time of 9.53. Performing tasks almost nine times faster on the mobile web application is a significant difference. Intuitive interface design and livesearch are responsible for improved task duration times on the mobile web application. Four of the five evaluators instinctively searched for resources via the livesearch function without encouragement from the author. In section 3.3.2 a recommendation suggested a search option to overcome crowded navigation, an observation made during the developer-centred heuristic evaluation of the desktop interface. Task analysis recorded a difference in error rates with the mobile web application returning zero errors across all three tasks and the desktop application averaging 4.4 errors. Maximum performance rates produced by the mobile web application provide further evidence that successful interactions occur in every task reaffirming observations that the interface is easy to use. Number of steps (clicks or screen touches) measured individual inputs required to locate a resource. The mean value for the desktop web application was 4.87 and the mean value for the mobile web application was 2.53, providing evidence the evaluators of the mobile web application can locate a resource in half the steps compared to the desktop web application. A key consideration uncovered in section 2.1 of the literature review recommended keystrokes be minimised for mobile users due to small screen displays making text entry difficult in dynamic environments, a problem addressed in the design phase of the mobile web application. Reduced scrolling has also been reduced in the mobile web application, a problem which was uncovered in the initial inspection with literature stating 80% of users do not search below the fold for information.

Interview Conclusions

Interviews were incorporated into the evaluation process to provide qualitative data returns. The lab experimentation provided numerical data which underwent analysis. However, this provided no insight into the actual user experience. Evaluators underwent questioning and encouraged to answer openly and completely. It was decided by the author to base questions loosely related to the ten heuristics used in the initial developer-centred inspection, as questions would evaluate the effectiveness of the mobile web application in terms of usability. Evaluators provided similar commentary regarding interface layout and navigation structure. Unanimous agreement was evident between evaluators regarding the implementation of the livesearch facility. Provision of the livesearch functionality was a pivotal design choice derived from evidence uncovered in section 3.3.2 where a recommendation was outlined in relation to information retrieval.

The literature review provided investigations into the importance of HCI in smartphone development and narrowed the focus on usability specifically. However, usability is still a broad term and was further sub-divided into five key areas by Nielsen; Learnability, efficiency, memorability, errors and satisfaction. Evaluative evidence has supported all five principles and provided a mobile web application that achieves highly in every category.

In relation to the original research question which drove the project, an accessible mobile web application has been created with an intuitive interface, that enhances usability and retains core functionality. Developer-centred usability heuristics supported an individual interface inspection, however the additional usage of the W3C guidelines and code validator proved essential in discovering network related faults such as HTTP header faults and Meta data errors. Nielsen's ten usability heuristics in conjunction with the W3C mobile web development guidelines, support an effective method of conjoined inspection methods, directly affecting the overall positive outcome of the project. Detailed descriptors contained

in the W3C themes are explicit in every aspect of interface, coding, context of usage and network related design considerations.

Identification of core functionality was achieved early in the inspection process, which formed the foundations for the requirements. Smartphone characteristics underwent extensive investigation in section 2.1 of the literature review, prioritising display size as a key consideration in the design process. However identifying usability problems alone will not deliver a robust mobile web application. An extensive knowledge of web scripting technologies was gained through the literature review in section 2.3, providing the author with a comprehensive understanding of required development tools and how to apply them. Hypothesis number one was proved by providing qualitative testing evidence supporting the view that evaluators of the mobile web application experienced usability enhancements. The second hypothesis was proved to be true also through quantitative data collection where the mobile web application out-performed the desktop application in all lab experiments.

6.3 Project Limitations and Future Work

The results from the evaluation methods proved to be supportive of both hypotheses however, there were factors which imposed limitations on the research undertaken to achieve the results. Recruitment of evaluators from other departments was decided upon, providing a fair representation of Caledonian students as opposed to five evaluators from the computing department who may be familiar with interface systems. Recruitment of evaluators was undertaken through associates of the author, therefore all five evaluators had prior knowledge that the system was designed by the author. This situation could generate tainted results in the interview techniques as evaluators may avoid criticising a certain feature so as not to upset the author. Another possible limitation in the testing scenario for task-based evaluation was the lab set up. Although the mobile web application was tested on an iPhone, the environment in which it was tested was static, more ‘natural’ results may have been gained if the evaluator was traversing a dynamic environment such as the Saltire Centre at the university where audio and visual distractions occur thus, providing more meaningful data.

Future usability projects assessing the effectiveness of a desktop web application on a mobile device may choose to ignore the manual methods of inspection by both Nielsen and the W3C mobile development themes and simply perform inspection through the W3C code validation service. This process allows web developers an efficient method to test both remote and locally stored web content whilst minimising overheads.

If resources were available to the author, it would be an interesting undertaking to develop the mobile web application further and launch as a real-time product offering information services to students. The W3C have now launched a Geolocation Application Programming Interface (API) (Pejic et al, 2010) that allows the retrieval of geographic location information on the client-side server. This service is representative of the general direction the web is heading. Users are demanding a higher level of interactions where a web service such as Google Maps is mashed up with the university mobile web application and an image tagging service. Caledonian University has many students and a mapping and tagging mashup combined with the mobile web application could provide essential location-aware services to assist student movements around the university campus. A large number of online services are utilising API's, providing web programmers with a platform to exert creativity and build evermore complex rich internet applications.

User evaluation illustrated the Caledonian University student homepage desktop application was consistently out-performed by the mobile web application. Scope exists for an additional

project addressing the usability problems associated with the desktop environment with a redesign targeting the native environment. Technologies deployed in the development process for the mobile web application can be adapted to provide the same livesearch functionality for the desktop application

6.4 Conclusion

The project was undertaken to investigate the extent to which developer-centred inspection methods could be used in the successful development of a mobile web application improving usability and retaining core functionality compared to the current Caledonian University student homepage viewed on the iPhone. Nielsen's heuristic evaluation methods were adopted together with the W3C mobile web development guidelines to provide a comprehensive list of requirements for the building of the mobile web application. The results gained from the evaluative processes of performance measurement in the lab experiment and the interviews supported both hypotheses that stated comparable task analysis between both desktop and mobile applications would result in the users performing more efficiently on the mobile web application with an overall improved user experience.

The project was initiated with the undertaking of a comprehensive and detailed literature review identifying key issues relating to characteristics of typical smartphone platform, web based guidelines for good usability on a smartphones, understanding web scripting for mobile devices and investigate key characteristics of a suitable HCI inspection method.

In the problems and systems analysis phase Nielsen's Heuristic inspection methods were used, supported by the W3C mobile development guidelines where a systematic evaluation of the current Caledonian desktop web application took place. Inspection methods uncovered several usability errors in the desktop web application assisting in the gathering of system requirements.

Design and implementation constructed a suitable prototype mobile web application that addressed usability problems in relation to the requirements gathering. The design process adopted an incremental development lifecycle, building each functional component separately and integrating with the kernel to form an evolutionary prototype with HTML5, CSS, JavaScript, AJAX, DOM, MySQL, XML and PHP. Inclusion of all languages assisted in creating a dynamic application that provided a livesearch option to assist web application navigation.

Evaluation results with end users occurred on the completion of the prototype mobile web application, which was hosted on a live server to provide remote access for testing and to measure usability in a real context environment with performance measures and interviews with five participants.

Overall, the project proved successful and the evaluation methods confirmed a robust and usable mobile web application had been created. However, lab experiments and interviews reaffirmed most of the design choices made by the author in the requirements stage of development and did not highlight any major errors or functional deficiencies. Developer-centred heuristic interface inspections are a simplistic, efficient method in which to inspect a current desktop web application and should be deployed in conjunction with the W3C mobile web development guidelines and assistive web scripting technologies.

7.0 References

- Agarwal, Y., Chandra, R., Wolman, A., Bahl, P., Chin, K. & Gupta, R. 2007, "Wireless wakeups revisited: energy management for voip over wi-fi smartphones", *Proceedings of the 5th international conference on Mobile systems, applications and services* San Juan, Puerto Rico, ACM, New York, NY, USA, pp. 179.
- Amazon 2011, [online]. Available at: <http://www.amazon.co.uk/qp/aw/d/> [Accessed 3/8/2011]
- Andreica, A., Stuparu, D. & Mantu, I. 2005, "Symbolic modelling of database representations", *Symbolic and Numeric Algorithms for Scientific Computing, 2005. SYNASC 2005. Seventh International Symposium on*, pp. 4 pp.
- Apple 2011, *iPhone 4 - Size, weight, battery life, and other specs* [online]. Available at: <http://www.apple.com/iphone/specs.html> [Accessed 2/3/2011 2011].
- Ballard, B. 2004, *Mobile Web Development Version 1.1 - in UI Design Guidelines for Mobile Web Development*, Little Springs Design, USA.
- Basili, V.R. & Boehm, B. 2001, "COTS-based systems top 10 list", *Computer*, Vol. 34, no. 5, pp. 91-95.
- BBC News 2010, *Apple iPhone beats BlackBerry as smartphone sales soar* [online]. Available at: <http://www.bbc.co.uk/news/business-11597782> [Accessed 2/2/2011 2011].
- Bell, J. 2005, *Doing your research project: A guide for the first time researchers in education, health and social sciences*, 4th edn, Open University Press, Maidenhead, UK.
- Berndtsson, M., Hansson, J., Olsson, B. & Lundell, B. *Thesis Projects - A Guide For Students in Computer Science and Information Systems*, 2nd edn, Springer-Verlag, London, UK.
- Berners-Lee, T. & Connolly, D. 1993, *A sample HTML instance: Hypertext Markup Language (HTML)* [online]. Available at: <http://www.w3.org/MarkUp/draft-ietf-iiir-html-01.txt> [Accessed 2/2/2011 2011].
- Berners-Lee, T. & Fischetti, M. 2000, *Weaving the Web*, Harper Collins, New York, NY, USA.
- Berners-Lee, T. 1996 [B], "WWW: past, present, and future", *Computer*, Vol. 29, no. 10, pp. 69-77.
- Berners-Lee, T. 2006, *Universal Resource Identifiers in WWW. 1994* [online]. Available at: <http://www.w3.org/Addressing/rfc1630.txt> [Accessed 2/2/2011 2011].
- Berners-Lee, T., Cailliau, R., Groff, J.F. & Pollermann, B. 2010, "World-wide web: the information universe", *Internet Research*, Vol. 40, no. 4, pp. 461-471.
- Berners-Lee, T., Fielding, T. & Frystyk, H. 2004 [A], *Hypertext Transfer Protocol 1.0 1996* [online]. Available at: <http://www.w3.org/Protocols/rfc1945/rfc1945> [Accessed 2/2/2011 2011].
- Blackberry 2011, *Curve 3G Smartphone - New BlackBerry Curve 9300 UK [A]* [online]. Available at: <http://uk.blackberry.com/devices/blackberrycurve3G/#!specifications> [Accessed 2/3/2011 2011].
- Bloomberg Businessweek 2010, *Tech Companies See Dearth of Mobile-Software Developers* [online]. Available at: http://www.businessweek.com/technology/content/oct2010/tc20101020_639668.htm [Accessed 2/3/2011 2011].

- Brewster, S.A. & Cryer, P.G. 1999, "Late breaking results: Overcoming human limitations", *Maximising Screen-Space on Mobile Computing Devices* Chicago, 1999, pp. 224-225.
- Carroll, A. & Heiser, G. 2010, "An analysis of power consumption in a smartphone", *Proceedings of the 2010 USENIX conference on USENIX annual technical conference* Boston, MA, USENIX Association, Berkeley, CA, USA, pp. 21.
- Cederholm, D. & Marcotte, E. 2010, *Handcrafted CSS: More Bulletproof Web Design*, 1st edn, New Riders, Berkeley, CA, USA.
- Ceri, S., Fraternali, P., Brambilla, M., Comai, S. & Matera, M. 2003, *Designing Data-Intensive Web Applications*, 1st edn, Morgan Kaufmann Publishers, San Francisco, CA, USA.
- Charlesworth, A. 2009, "The ascent of smartphone", *Engineering & Technology*, Vol. 4, no. 3, pp. 32-33.
- CHI '92: Posters and short talks of the 1992 SIGCHI conference on Human factors in computing systems 1992, , Monterey, California edn, ACM, New York, NY, USA.
- Chittaro, L. 2006, "Visualizing information on mobile devices", *Computer, IEEE*, Vol. 39, no. 3, pp. 40-45.
- Chun, B. & Maniatis, P. 2009, "Augmented smartphone applications through clone cloud execution", *Proceedings of the 12th conference on Hot topics in operating systems* Monte Verit\&\#224;, Switzerland, USENIX Association, Berkeley, CA, USA, pp. 8.
- Comer, D.E. 2000, *The Internet Book: Everything you need to know about Computer Networking and how the Internet works*, Prentice Hall, Upper Saddle River, New Jersey, USA.
- Connolly, P. 2007, *Quantitative Data Analysis in Education: A Critical Introduction Using SPSS*, Routledge, Abingdon, Oxon, UK.
- Deitel, P.J. & Deitel, H.M. 2008, *Deitel Developer Series - AJAX, Rich Internet Applications and Web Development for Programmers*, 1st edn, Prentice Hall, Upper Saddle River, NJ, USA.
- Di Lucca, G.A., Fasolino, A.R., Faralli, F. & De Carlini, U. 2002, "Testing Web applications", *Software Maintenance, 2002. Proceedings. International Conference on*, pp. 310.
- Dix, A., Finlay, J., Abowd, G.D. & Beale, R. 2004, *Human-Computer Interaction*, 3rd edn, Pearson Education Ltd., Harlow, Essex, UK.
- Ebner, M., Stickel, C. & Kolbitsch, J. 2010, "iPhone/iPad Human Interface Design", *HCI in Work and Learning, Life and Leisure*, Vol. 6389, , pp. 489-492.
- Eisenstein, J., Vanderdonckt, J. & Puerta, A. 2001, "Applying model-based techniques to the development of UIs for mobile computers", *Proceedings of the 6th international conference on Intelligent user interfaces* Santa Fe, New Mexico, United States, ACM, New York, NY, USA, pp. 69.
- Ekstrom, H., Furuskar, A., Karlsson, J., Meyer, M., Parkvall, S., Torsner, J. & Wahlqvist, M. 2006, "Technical solutions for the 3G long-term evolution", *Communications Magazine, IEEE*, Vol. 44, no. 3, pp. 38-45.
- Fiotakis, G., Raptis, D. & Avouris, N. 2009, "Considering Cost in Usability Evaluation of Mobile Applications: Who, Where and When", Vol. 5726, , pp. 231-234.
- Fraternali, P., Comai, S., Bozzon, A. & Carughi, G.T. 2010, "Engineering rich internet applications with a model-driven approach", *ACM Trans.Web*, Vol. 4, no. 2, pp. 7:1-7:47.

- Frederick, G.R. & Lal, R. 2009, "Enhancing Mobile Web Pages for Smartphone Browsers", , pp. 187-210.
- Garrett, J.J. 2005, *Ajax: A New Approach to Web Applications - Adaptive Path* [online]. Available at: <http://www.adaptivepath.com/ideas/e000385> [Accessed 3/19/2011 2011].
- Gartenberg, M. *Michael Gartenberg: Motorola Atrix smartphone has a usability vision that stands out - Computerworld* [online]. Available at: http://www.computerworld.com/s/article/9213740/Michael_Gartenberg_Motorola_Atrix_smartphone_has_a_usability_vision_that_stands_out [Accessed 4/22/2011 2011].
- Glasgow Caledonian University 2010, *The Saltire Centre, Facilities and Support* [online]. Available at: <http://www.gcu.ac.uk/study/part-timedegrees/whystudyhere/facilitiesupport/thesaltirecentre/> [Accessed 2/2/2011 2011].
- Google Suggest 2011, [online]. Available at: <http://www.google.com/webhp?complete=1&hl=en> [Accessed 3/19/2011 2011].
- Gosselin, D. 2008, *JavaScript*, 4th edn, Thomson, Boston, MA. USA.
- Gottschick, J. & Restel, H. 2010, "An Empirical Evaluation of the Quality of Interoperability Specifications for the Web", *Software Engineering and Advanced Applications (SEAA), 2010 36th EUROMICRO Conference on*, pp. 398.
- Hagood, K., Moore, T., Pierre, T., Messamer, P., Ramsberger, G. & Lewis, C. 2010, "Naming practice for people with aphasia in a mobile web application: early user experience", *Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility* Orlando, Florida, USA, ACM, New York, NY, USA, pp. 273.
- Hamer, C. & Davison, A. 2010, *Learn Blackberry Games Development: BlackBerry Application Basics*, Apress, New York, NY, USA. Available at: http://dx.doi.org/10.1007/978-1-4302-2719-9_2 .
- Hansmann, U., Merk, L., Nicklous, M.S. & Stober, T. 2003, *Pervasive Computing: The Mobile World*, 2nd edn, Springer, New York, NY, USA.
- Hart, D. & Portwood, D.M. 2009, "Usability testing of web sites designed for communities of practice: tests of the IEEE Professional Communication Society (PCS) web site combining specialized heuristic evaluation and task-based user testing", *Professional Communication Conference, 2009. IPCC 2009. IEEE International*, pp. 1.
- Holzinger, A. 2005, "Usability engineering methods for software developers", *Commun.ACM*, Vol. 48, no. 1, pp. 71-74.
- HTML5 - A vocabulary and associated APIs for HTML and XHTML (Editor's Draft 18 March 2011)* 2011, [online]. Available at: <http://dev.w3.org/html5/spec/Overview.html#introduction> [Accessed 3/19/2011 2011].
- Huitema, C. 2000, *Routing In The Internet*, Prentice Hall, Upper Saddle River, New Jersey, USA.
- Hvannberg, E.T., Law, E. & Lárusdóttir, M.K. 2007, "Heuristic evaluation: Comparing ways of finding and reporting usability problems", *Interacting with Computers*, Vol. 19, no. 2, pp. 225.
- Hwang, W. & Salvendy, G. 2010, "Number of people required for usability evaluation: the 10±2 rule", *Commun.ACM*, Vol. 53, no. 5, pp. 130-133.
- IBM Developer Works Interviews: Tim Berners-Lee* 2006, [online]. Available at: <http://www.ibm.com/developerworks/podcast/dwi/cm-int082206.txt> [Accessed 3/19/2011 2011].

- Inspiron One 2205 Desktop Details | Dell* 2011, [online]. Available at: <http://www.dell.com/uk/p/inspiron-one-2205/pd> [Accessed 3/18/2011 2011].
- iOS Overview 2011, [online]. Available at: http://developer.apple.com/library/ios/#referencelibrary/GettingStarted/URL_iPhone_OS_Overview/index.html [Accessed 3/3/2011 2011].
- Jianli, L., Jie, S. & Cuihua, X. 2004, "Segmenting the Web document with document object model", *Services Computing, 2004. (SCC 2004). Proceedings. 2004 IEEE International Conference on*, pp. 449.
- Jones, M., Marsden, G., Mohd-Nasir, N., Boone, K. & Buchanan, G. 1999, "Improving Web interaction on small displays", *Computer Networks*, Vol. 31, no. 11-16, pp. 1129-1137.
- jQuery: The Write Less, Do More, JavaScript Library* [online]. Available at: <http://jquery.com/> [Accessed 3/22/2011 2011].
- Kaindl, H., Constantine, L., Pastor, O., Sutcliffe, A. & Zowghi, D. 2008, "How to Combine Requirements Engineering and Interaction Design?", *International Requirements Engineering, 2008. RE '08. 16th IEEE*, pp. 299.
- Kane, S., Karlson, A., Meyers, B., Johns, P., Jacobs, A. & Smith, G. 2009, "Exploring Cross-Device Web Use on PCs and Mobile Devices", Vol. 5726, , pp. 722-735.
- Kangas, E. & Kinnunen, T. 2005, "Applying user-centered design to mobile application development", *Commun.ACM*, Vol. 48, no. 7, pp. 55-59.
- Karlson, A., Meyers, B., Jacobs, A., Johns, P. & Kane, S. 2009, "Working Overtime: Patterns of Smartphone and PC Usage in the Day of an Information Worker", Vol. 5538, , pp. 398-405.
- Kensing, F. & Blomberg, J. 1998, *Participatory Design: Issues and Concerns*, Springer Netherlands, USA.
- Kim, Y.B. 2010, "Real-time Analysis of Time-based Usability and Accessibility for Human Mobile-Web Interactions in the Ubiquitous Internet", *Journal of Universal Computer Science*, Vol. 16, no. 15, pp. 1953-1972.
- Knott, R.P. & Dawson, R.J. 1999, *Software Project Management*, Group D Publications, Loughborough, UK.
- Larman, C. & Basili, V.R. 2003, "Iterative and incremental developments. a brief history", *Computer*, Vol. 36, no. 6, pp. 47-56.
- Lawson, B. & Sharp, R. 2010, *Introducing HTML5*, New Riders, Berkley, CA, USA.
- Leichtenstern, K. & Andre, E. 2008, "User-Centred Development of Mobile Interfaces to a Pervasive Computing Environment", *Advances in Computer-Human Interaction, 2008 First International Conference on*, pp. 114.
- Lu, X., Wan, J. & Hou, J. 2007, "A Model Based Heuristic Design of Web User Interface", *Information Reuse and Integration, 2007. IRI 2007. IEEE International Conference on*, pp. 6.
- Lubbers, P., Albers, B., Smith, R. & Salim, F. 2010, *Pro HTML5 Programming: Powerful APIs for Richer Internet Application Development*, 1st edn, Apress, Berkely, CA, USA.
- MacKay, B., Watters, C. & Duffy, J. 2006, *Web Page Transformation When Switching Devices*, Springer, Berlin, Germany.

- Moggridge, B. 2007, *Designing Interactions*, MIT Press, Cambridge, MA, USA.
- Muhanna, M., Tackitt, B. & Dascalu, S. 2009, "Prototype details of the smartphone-based researcher's companion software (RCS)", *Journal of Computational Methods in Science and Engineering*, Vol. 9, , pp. 191-200.
- Murugesan, S. 2008, "Web Application Development: Challenges And The Role Of Web Engineering", , pp. 7-32.
- MySQL :: Top Reasons to Use MySQL 2010, [online]. Available at: <http://www.mysql.com/why-mysql/topreasons.html> [Accessed 4/8/2011 2011].
- Nielsen, J. & Landauer, T. 2010, *Usability Testing with 5 Users (Jakob Nielsen's Alertbox)* [online]. Available at: <http://www.useit.com/alertbox/20000319.html> [Accessed 4/24/2011 2011].
- Nielsen, J. & Molich, R. 1990, "Heuristic evaluation of user interfaces", *Proceedings of the SIGCHI conference on Human factors in computing systems: Empowering people* Seattle, Washington, United States, ACM, New York, NY, USA, pp. 249.
- Nielsen, J. 1992, "The usability engineering life cycle", *Computer*, Vol. 25, no. 3, pp. 12-22.
- Nielsen, J. 1993, *Usability Engineering*, Academic Press, San Diego, USA.
- Nielsen, J. 1994, "Enhancing the explanatory power of usability heuristics", *Proceedings of the SIGCHI conference on Human factors in computing systems: celebrating interdependence* Boston, Massachusetts, United States, ACM, New York, NY, USA, pp. 152.
- Nielsen, J. 1994, "Usability inspection methods", *Conference companion on Human factors in computing systems* Boston, Massachusetts, United States, ACM, New York, NY, USA, pp. 413.
- Nielsen, J. 2010, *Scrolling and Attention (Jakob Nielsen's Alertbox)* [online]. Available at: <http://www.useit.com/alertbox/scrolling-attention.html> [Accessed 2/3/2011 2011].
- Nielson, J. & Loranger, H. 2006, *Prioritizing Web Usability*, New Riders, Berkley, CA, USA.
- Oates, D., J. 2006, *Researching Information Systems and Computing*, 1st edn, Sage Publications, London, UK.
- Office for National Statistics 2010, *Internet Access 2010 - Households and Individuals* [online]. Available at: <http://www.statistics.gov.uk/pdfdir/iahi0810.pdf> [Accessed 2/2/2011 2011].
- Ong, C.S., Day, M.Y., Chen, K.T. & Hsu, W.R. 2008, "User-centered evaluation of question answering systems", *Intelligence and Security Informatics, 2008. ISI 2008. IEEE International Conference on*, pp. 286.
- Paithankar, K. & Ingle, M. 2009, "Characterization of Software Projects by Restructuring Parameters for Usability Evaluation", *Computer and Electrical Engineering, 2009. ICCEE '09. Second International Conference on*, pp. 436.
- , A. & C , Z. 2010, "Uses of W3C's Geolocation API", *Computational Intelligence and Informatics (CINTI), 2010 11th International Symposium on*, pp. 319.
- PHP: History of PHP - Manual [online]. Available at: <http://www.php.net/manual/en/history.php.php> [Accessed 4/8/2011 2011].
- Pilgrim, M. 2010, *HTML5: Up and Running*, O' Reilly Media Inc, Sebastopol, CA, USA.

- Pressman, R. 2010, *Software Engineering - A Practitioner's Approach*, 7th edn, McGraw Hill, New York, NY, USA.
- Raman, T.V. 2009, "Toward 2W, beyond
- Raman, T.V. *Toward 2(w), Beyond Web 2.0 Communications - February 2009 - Page 52-53-* [online]. Available at: http://mags.acm.org/communications/200902?pg=61&search_term=html5&search_term=html5#pg55 [Accessed 10/19/2010 2010].
- Ribes, D. & Khoo, M. 2005, "Studying digital library users in the wild: theories, methods, and analytical approaches", *Digital Libraries, 2005. JCDL '05. Proceedings of the 5th ACM/IEEE-CS Joint Conference on*, pp. 429.
- rich Internet applications | Adobe Flash Player* 2011, [online]. Available at: <http://www.adobe.com/products/flashplayer/> [Accessed 4/23/2011 2011].
- Robbins, D.C., Lee, B. & Fernandez, R. 2008, "TapGlance: designing a unified smartphone interface", *Proceedings of the 7th ACM conference on Designing interactive systems* Cape Town, South Africa, ACM, New York, NY, USA, pp. 386.
- Roto, V. 2006, "Web Browsing on Mobile Phones - Characteristics of User Experience", Department of Computer Science and Engineering, Helsinki University of Technology., Finland.
- S.L. Smith & J.N. Mosier. 1986, *Guidelines for Designing User Interface Software*. (MTR-10090), The MITRE corp, Bedford, MA, USA.
- Schaller, R.R. 1997, "Moore's law: past, present and future", *Spectrum, IEEE*, Vol. 34, no. 6, pp. 52-59.
- Scottish Government* 2011, [online]. Available at: <http://www.scotland.gov.uk/Home> 2011].
- Shrestha, S. 2007, "Mobile web browsing: usability study", *Proceedings of the 4th international conference on mobile technology, applications, and systems and the 1st international symposium on Computer human interaction in mobile technology* Singapore, ACM, New York, NY, USA, pp. 187.
- Sommerville, I. 2010, *Software Engineering*, 9th edn, Addison-Wesley, USA.
- Tarasewich, P. 2003, "Designing mobile commerce applications", *Commun.ACM*, Vol. 46, no. 12, pp. 57-60.
- Tatarinov, I., Viglas, S.D., Beyer, K., Shanmugasundaram, J., Shekita, E. & Zhang, C. 2002, "Storing and querying ordered XML using a relational database system", *Proceedings of the 2002 ACM SIGMOD international conference on Management of data* Madison, Wisconsin, ACM, New York, NY, USA, pp. 204.
- The W3C Markup Validation Service* 2011, [online]. Available at: <http://validator.w3.org/> [Accessed 4/19/2011 2011].
- Tim Berners-Lee: WorldWideWeb, the first Web client* [online]. Available at: <http://www.w3.org/People/Berners-Lee/WorldWideWeb> [Accessed 3/19/2011 2011].
- Tonella, P. & Ricca, F. 2004, "A 2-layer model for the white-box testing of Web applications", *Web Site Evolution, 2004. WSE 2004. Proceedings. Sixth IEEE International Workshop on*, pp. 11.
- Trevor, J., Hilbert, D.M., Schilit, B.N. & Koh, T.K. 2001, "From desktop to phonetop: a UI for web interaction on very small devices", *Proceedings of the 14th annual ACM symposium on User interface software and technology* Orlando, Florida, ACM, New York, NY, USA, pp. 121.

- Tsiaousis, A.S. & Giaglis, G.M. 2008, "Evaluating the Effects of the Environmental Context-of-Use on Mobile Website Usability", *Mobile Business, 2008. ICMB '08. 7th International Conference on*, pp. 314.
- Tsiaousis, A.S. & Giaglis, G.M. 2010, "An Empirical Assessment of Environmental Factors that Influence the Usability of a Mobile Website", *Mobile Business and 2010 Ninth Global Mobility Roundtable (ICMB-GMR), 2010 Ninth International Conference on*, pp. 161.
- Vliet, H.V. 2008, *Software Engineering: Principles and Practices*, John Wiley & Sons Ltd, Cichester, West Sussex, UK.
- Vredenburg, K., Mao, J., Smith, P.W. & Carey, T. 2002, "A survey of user-centered design practice", *Proceedings of the SIGCHI conference on Human factors in computing systems: Changing our world, changing ourselves* Minneapolis, Minnesota, USA, ACM, New York, NY, USA, pp. 471.
- W3C 2010, *Mobile Web Best Practices (MWBP) Flipcards* [online]. Available at: http://www.w3.org/2007/02/mwbp_flip_cards.html [Accessed 2/3/2011 2011].
- W3C 2011, *CSS Current Status - W3C* [online]. Available at: http://www.w3.org/standards/techs/css#w3c_all [Accessed 2/3/2011 2011].
- W3C Mobile Web 2010, *Mobile Web - W3C* [online]. Available at: <http://www.w3.org/standards/webdesign/mobilweb.html> [Accessed 2/2/2011 2011].
- W3C mobileOK Checker 2011, [online]. Available at: <http://validator.w3.org/mobile/> [Accessed 4/19/2011 2011].
- Want, R. 2010, "iPhone: Smarter Than the Average Phone", *Pervasive Computing, IEEE*, Vol. 9, no. 3, pp. 6-9.
- Wellman, D. 2009, *jQuery UI 1.7: The User Interface Library for jQuery*, 1st edn, Packt Publishing, USA.
- What Is Web 2.0 - O'Reilly Media 2010, [online]. Available at: <http://oreilly.com/web2/archive/what-is-web-20.html> [Accessed 3/19/2011 2011].
- Wong, J. & Hong, J.I. 2007, "Making mashups with marmite: towards end-user programming for the web", *Proceedings of the SIGCHI conference on Human factors in computing systems* San Jose, California, USA, ACM, New York, NY, USA, pp. 1435.
- Wright, A. 2009, "Ready for a Web OS?", *Commun.ACM*, Vol. 52, no. 12, pp. 16-17.
- Xiao, Y., Tao, Y. & Li, Q. 2008, "Web Page Adaptation for Mobile Device", *Wireless Communications, Networking and Mobile Computing, 2008. WiCOM '08. 4th International Conference on*, pp. 1.
- Zepeda, J.S. & Chapa, S.V. 2007, "From Desktop Applications Towards Ajax Web Applications", *Electrical and Electronics Engineering, 2007. ICEEE 2007. 4th International Conference on*, pp. 193.
- Ziefle, M. 2009, "Visual Ergonomic Issues of LCD Displays - An Insight into Working Conditions and User Characteristics" , pp. 561-573.

8.0 Appendices

Appendix A System Architecture

Index

- Blackboard
- Email
- Library
- My Caledonain
- Service Desks
- System Status
- Timetables >
- More>
- University Homepage

More

- Computer Stuff >
- Essentials >
- I Want To >
- Jobs & Careers >
- Life >
- Need a Hand >
- Official Things >
- Resources >
- Study >
- Whats New >
- University Homepage >

Whats New [database interaction]

Timetables [database interaction]

Computer Stuff

- Computer Stuff FAQ's
- ICT Skills
- Software For Students

Essentials

- New2GCU
- Back2GCU
- Graduation
- International Student Support

I Want To

- Pay Tuition Fees
- Set Security Password

Jobs & Careers

- Careers Service
- Student Enterprise
- Careers Events

Life

- Student Association
- Accommodation
- Arc Health & Fitness
- Disabled Students

Need a Hand

- The Base
- Your Views
- Student Mentors

Official Things

- Guidelines & Policies
- Dignity at Work & Study
- Formal Complaints

Resources

- A-Z of School Services
- Maps
- Useful Contacts
- Semester Dates

Study

- Academic Development Tutors
- Effective Learning Service
- Exam Dates & Guides
- Improve Your Coursework
- English Language Support

Appendix B Test Results

Page	Test Objects	Expected Result	Actual Result	Comment
Index.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Blackboard.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Library.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Mycaledonian.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Servicedesks.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Systemstatus.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Timetables.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
More.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Universityhomepage.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Computerstuff.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Essentials.html	Home button	Navigate to	Homepage	All page items

	functionality. Livesearch Content display	homepage. Livesearch viewable and operational	navigation. Livesearch All page items passed typeahead.	passed
Iwantto.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Jobsandcareers.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Life.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Needahand.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Officialthings.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Resources.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Study.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Computerstufffaq.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Ictskills.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Softwareforstudents.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
New2gcu.html	Home button	Navigate to	Homepage	All page items

	functionality. Livesearch Content display	homepage. Livesearch viewable and operational	navigation. Livesearch typeahead.	passed All page items passed
Back2gcu.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Graduation.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Internationalstudentsupport.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Money.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Paytuitionfees.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Setsecuritypassword.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Careersservice.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Studententerprise.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Careersevents.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Getanindustrymentor.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Cbdstudentemployment.html	Home button functionality.	Navigate to homepage.	Homepage navigation.	All page items passed All page

	Livesearch Content display	Livesearch viewable and operational	Livesearch typeahead.	items passed
Studentaccommodation.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Accommodation.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Archealthandfitness.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Disabledstudents.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Thebase.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Yourviews.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Studentmentors.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Guidelinesandpolicies.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Dignityatworkandstudy.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Formalcomplaints.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Atozofschoolservices.html	Home button functionality. Livesearch	Navigate to homepage. Livesearch	Homepage navigation. Livesearch	All page items passed

	Content display	viewable and operational	typeahead.	
Maps.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Usefulcontacts.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Semesterdates.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Academicdevelopmenttutir.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Effectivelearningservice.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Examdatesandguides.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Improveyourcoursework.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Englishlanguagesupport.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Legalandprivacy.html	Home button functionality. Livesearch Content display	Navigate to homepage. Livesearch viewable and operational	Homepage navigation. Livesearch typeahead.	All page items passed
Whatsnew.html	Home button functionality. Dynamic dropdown list – 6 date options	Navigate to homepage. Items appear and clickable	Homepage navigation. All items in dropdown list active Dataset 200ok	All page items passed
Timetables.html	Home button functionality. Dynamic	Navigate to homepage. Items appear	Homepage navigation. All items in	All page items passed

	dropdown list – 9 course options	and clickable	dropdown list active Datase 200ok	
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Appendix C End User Testing

	Mobile web application			Total	University web application			Total
	Task 1	Task 2	Task 3		Task 1	Task 2	Task 3	
Evaluator 1								
Duration (seconds)	11	12	8	31	120	43	44	207
Number of errors	0	0	0	0	7	3	5	15
Number of steps	3	3	2	8	5	5	3	13
Successful yes/no	y	y	y	3	n	y	y	2
Evaluator 2								
Duration (seconds)	10	12	7	29	120	57	43	220
Number of errors	0	0	0	0	7	5	8	20
Number of steps	2	2	3	7	7	2	3	12
Successful yes/no	y	y	y	3	n	y	y	2
Evaluator 3								
Duration (seconds)	7	14	11	32	120	45	54	219
Number of errors	0	0	0	0	6	1	1	8
Number of steps	3	2	2	7	7	4	5	16
Successful yes/no	y	y	y	3	n	y	y	2
Evaluator 4								
Duration (seconds)	12	6	5	23	120	54	67	241
Number of errors	0	0	0	0	8	1	2	11
Number of steps	3	2	4	9	5	3	4	12
Successful yes/no	y	y	y	3	n	y	y	2
Evaluator 5								
Duration (seconds)	12	9	7	28	120	34	45	199
Number of errors	0	0	0	0	5	4	3	12
Number of steps	2	2	3	7	6	6	7	19
Successful yes/no	y	y	y	3	n	y	y	2

Appendix D Source Code Listings

academicdevelopmenttutors.htm

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Academic Development Tutors</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href="."/>Academic Development Tutors</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Academic Development Tutors</h2>
    <p>At Glasgow Caledonian University, it is recognised that life as a university
student can be demanding. In comparison to school or college, success requires a more
active role on your part and will require you to develop a range of academic skills
that are probably very new to you. All students at some point along the way need a bit
of assistance with developing these skills (nobody excels at everything!) Academic
Development Tutoring is a service designed specifically to help you develop academic
skills alongside an Academic Development Tutor (ADT).</p>
    <p>Each School has at least one ADT who understands the demands of student life
and is experienced in assisting students in achieving their academic potential. ADTs
adopt a flexible and shared approach that allows you to identify the skills that you
would like to develop and how you can work with the Tutor to do so. Such skills might
include, for example, planning essays, note-taking, interpreting coursework feedback,
balancing university with work and other commitments, and revising effectively for
exams. The service provided in each School across the University is slightly
different. This is because the service has been developed to meet the needs of
students and these can vary depending upon School and even Programme.</p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
</div>
```

```

        <div id="footer"> </div>
    </div>
</div>
</body>
</html>

```

accommodation.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Accommodation</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href=".">Accommodation</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
<br/>
        <br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <br/>
        <h2>Accommodation</h2>
        <p>If joining Glasgow Caledonian University means living away from home, you can
either apply for a place in Caledonian Court - our on-campus residences - or you can
rent accommodation in Glasgow from a private landlord. Our dedicated Student
Accommodation Office will help you find the perfect home from home.</p>
    </div>
    <div id="utility"> </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
        <form method="get" action="http://www.gcu.ac.uk/student/index.html">
            <input type="submit" value="Link to regular Student Homepage" />
        </form>
        <br/>
        <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

archealthandfitness.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | ARC Health & Fitness</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">ARC Health & Fitness</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>ARC Health & Fitness</h2>
    <p>ARC: Health and Fitness is a multi-purpose gym in the heart of Glasgow city
centre yards from Buchanan Street bus station and a short walk from Queen Street train
station. The gym, exercise classes and halls are available for anyone to use, you
don't need to be a GCU student or a member of staff, everyone is welcome!</p>

    <p>3 separate gym areas cater for all fitness interests and abilities, the upstairs
area is spacious and has plenty of equipment so no need to queue during busy times.
Downstairs there is a large range of free-weights equipment with olympic bars and
lifting platforms.</p>

    <p>To access the gyms you can pay-as-you-go or if you are plan on using the gym on a
regular basis we have monthly online memberships from just £25 with no contract.</p>

    <a href="mailto:arc@gcu.ac.uk">Contact the ARC</a></p>

  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

[atozofschoolservices.html](#)

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | A-Z of School Services</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">A-Z of School Services</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>A-Z of School Services</h2>
    <p> * Built and Natural Environment</p>
    <p> * Caledonian Business</p>
    <p> * Engineering & Computing</p>
    <p> * Health</p>
    <p> * Law and Social Sciences</p>
    <p>* Life Sciences </p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

[back2gcu.html](#)

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Back2GCU</title>

```

```

<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Back2GCU</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Back2GCU</h2>
    <p>1. Register online - You can now register for session 2010/2011 through the
registration portal.</p>
    <p>2. Apply for your funding - UK undergraduates: apply for funding to SAAS,
your LEA or Library Board.
    Scottish undergraduates: even if you don't want a student loan, you still need
to apply to SAAS for your tuition fees. They will pay them direct to the University.
If you don't apply to SAAS, we will bill you for your fees.</p>
    <p>3. Student loans and Bursaries - If you received a Student Loan for your
course at GCU in 2009/10, you do not need to bring your award letter or Student Loans
Company payment schedule letter to us to be scanned.</p>
    <p>4. Check your timetable - You can check Celcat from early September. Remember
to check back just before you start in case there have been late amendments.</p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

careersevents.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Careers Events</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />

```

```

<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Careers Events</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Careers Events</h2>
    <p>* News - all the latest news from the Careers Service now appears on our blog
page.</p>
    <p>* Employer visits - view the list of employer visits which have been
organised by the Careers Service, and sign up online to attend.</p>
    <p>* Careers Seminar Series - our NEW 30 minute sessions which will provide
advice & information on the main elements of the recruitment process. Open to all
current students & graduates.</p>
    <p>* Drop-in sessions - usually take place everyday, ideal for having a quick
chat with a careers adviser without the need to pre-book a place.</p>
    <p>* Recruitment fairs - check out the dates of local and national recruitment
events. </p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

careersservice.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Careers Service</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />

```

```

<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Careers Service</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Careers Service</h2>
    <p>* Current students - Vacancies and placements, employer visits, seminars,
advice and more.</p>
    <p>* Graduates - Information on finding work, postgraduate study, and graduate
publications.</p>
    <p>* Employers - Advertise a vacancy, arrange a presentation, and read our guide
to recruiting students and graduates.</p>
    <p>* GCU staff - Find out what the Careers Service can offer your students,
download destination stats, or arrange a group session.</p>
    <p>* Prospective students - Open days, undergraduate and postgraduate courses,
and different study options at GCU.</p>
    <p>* International students - Working in Scotland and International Labour
Market Information. </p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

cbsstudentemployabilityproject.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | CBS Student Employability Project</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>

```



```

<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href="."/>CBS Student Employability Project</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>CBS Student Employability Project</h2>
    <p>Simply put, more and more research suggests that getting a degree, and
putting a few letters after your name is just not enough to land you that plum job, or
to launch your career. What you need to do is to use your time at university to build
up a portfolio of employability skills</p>
    </div>
    <div id="utility"> </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
      <form method="get" action="http://www.gcu.ac.uk/student/index.html">
        <input type="submit" value="Link to regular Student Homepage" />
      </form>
      <br/>
      <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
  </div>
</div>
</body>
</html>

```

computerstuff.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Computer Stuff</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href="."/>Computer Stuff</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>

```

```

        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <p>You may want to help with topics related to your Glasgow Caledonian
Experience.</p>
    </div>
    <div id="utility">
        <ul>
            <li><a href="computerstufffaq.html">Computer Stuff FAQs</a></li>
            <li><a href="ictskills.html">ICT Skills</a></li>
            <li><a href="softwareforstudents.html">Software for Students</a></li>
        </ul>
    </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
        <form method="get" action="http://www.gcu.ac.uk/student/index.html">
            <input type="submit" value="Link to regular Student Homepage" />
        </form>
        <br/>
        <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

computerstufffaq.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Computer Stuff FAQs</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href=".">Computer Stuff FAQs</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
<br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <br/>
        <h2>Computer Stuff FAQs</h2>
    </div>

```

`<p>Additional print credits can be purchased online via the student printing tab located in My caledonian. Or by using the money boxes on the ground and 1st floor of the Saltire Centre.</p>`

```
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>
```

dignityatworkandstudy.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Dignity at Work & Study</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Dignity at Work & Study</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Dignity at Work & Study</h2>
    <p>Glasgow Caledonian University is committed to ensuring that it provides a
positive working and learning environment for both staff and students. This website
describes the ways in which we can achieve this, supporting our core values, which
are:</p>
    <p>* Excellence</p>
    <p>* Achievement</p>
    <p>* Leadership</p>
    <p>* Trust and Honesty</p>
    <p>* Diversity</p>
    <p>* Courage </p>
```

```

</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

disabledstudents.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Disabled Students</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href="."/>Disabled Students</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Disabled Students</h2>
    <p>GCU is committed to providing an inclusive student experience, which offers
all students the opportunity to achieve their full potential.</p>
    <p>The Disability Service provides advice, information and services to disabled
students and applicants. Each year, around 700 students are known to the Disability
Service and include students with long term medical conditions, sensory impairment,
mental health difficulties, physical disability, specific learning disabilities and
students on the autism spectrum. </p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">

```

```

        <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

effectivelearningservice.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Effective Learning Service</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href="."/>Effective Learning Service</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
<br/>
        <br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <br/>
        <h2>Effective Learning Service</h2>
        <p>In the Effective Learning Service, a team of lecturers works with students at
all levels on a one-to-one, small or large group basis to provide tailored support on
all aspects of academic study and learning. Support is specific to your degree
programme and includes advice on:</p>
        <p> * effective writing and reading for essays, reports, dissertations and exams
</p>
        <p> * demonstrating critical analysis</p>
        <p>* preparing for effective oral presentations </p>
    </div>
    <div id="utility"> </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
        <form method="get" action="http://www.gcu.ac.uk/student/index.html">
            <input type="submit" value="Link to regular Student Homepage" />
        </form>
        <br/>
        <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>

```

```

    </div>
</div>
</body>
</html>

```

englishlanguagesupport.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | English Language Support</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">English Language Support</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>English Language Support</h2>
    <p>Studying in a UK university offers you an important opportunity to develop
the language skills that are required for success in your academic programme and in an
English-speaking working environment. Both academics and employers expect you to
demonstrate knowledge of complex issues in well-structured and coherent spoken and
written formats. This is a powerful skill, and one that is highly valued by academics,
employers and colleagues and it is important that you take advantage of your time at
GCU to develop your language skills.</p>

    <p>Regardless of English language level, you will almost certainly find some aspects
of studying in a UK university challenging. This may be because the academic
environment is new and you are unfamiliar with teaching methods and the expectations of
your tutors; equally, you may find that you are not familiar with the language used in
academic study at university. If English is not your first language, academic writing
will probably present real challenges.</p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>

```

```

    </div>
</div>
</body>
</html>

```

essentials.html

```

<!DOCTYPE HTML>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Essentials</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Essentials</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <p>Information for current students at Glasgow Caledonian University</p>
  </div>
  <div id="utility">
    <ul>
      <li><a href="new2gcu.html">New2GCU</a></li>
      <li><a href="back2gcu.html">Back2GCU</a></li>
      <li><a href="graduation.html">Graduation</a></li>
      <li><a href="internationalstudentsupport.html">International Student
Support</a></li>
      <li><a href="money.html">Money</a></li>
    </ul>
  </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

examdatesandguides.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Exam Date and Guides</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Exam Date and Guides</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Exam Date and Guides</h2>
    <p>Whatever you need to know about exams, this is the place to start! Lots of
really useful information and advice about every aspect of exams, from start to finish
- right through to graduation.</p>
    </div>
    <div id="utility"> </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
      <form method="get" action="http://www.gcu.ac.uk/student/index.html">
        <input type="submit" value="Link to regular Student Homepage" />
      </form>
      <br/>
      <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
  </div>
</div>
</body>
</html>

```

formalcomplaints.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Formal Complaints</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>

```



```

<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Formal Complaints</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Formal Complaints</h2>
    <p>With over 15,000 students, hundreds of programmes and many different
services, Caledonian is a complex place. This page tells you what to do if you are not
happy with something we do. We need to know so that we can put things right.</p>

    <p>The Student Complaint, Mediation and Resolution Procedure is the formal route for
you to make a complaint about any service we provide. Complaints can often be dealt
with informally; you should use all informal routes before moving on to the formal
student complaint procedure.</p>

  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

getanindustrymentor.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
  <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
  <title>Caley Mobile | Get an Industry Mentor</title>
  <meta name="viewport" content="user-scalable=no, width=device-width" />
  <link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
  <link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
  <script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">

```

```

<div id="header">
  <h1><a href="."/>Get an Industry Mentor</a></h1>
  <div id="sidebar"> <a href="index.html"> </a>
<br/>
  <br/>
  <form>
    <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
    <div id="livesearch"></div>
  </form>
  <br/>
  <h2>Get an Industry Mentor</h2>
  <p>In this increasingly competitive employment market there is no substitute for
one-to-one advice from people who have been professionally successful.
  All students on the Peer Assisted Student Support (PASS) programme from
September 2010 will receive an alumni industry mentor as part of the PASS programme.
Mentors are also available for non PASS students and recent graduates via the Careers
Service.</p>
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

getnews.php

```

<?php
$q=$_GET["q"];

$con = mysql_connect('fdb3.awardspace.com', '667160_kk', 'oscarmya69'); // Connecetion
to database
if (!$con)
{
  die('Could not connect: ' . mysql_error()); // close connection on error
}

mysql_select_db("667160_kk", $con);

$sql="SELECT * FROM news WHERE id = '$q'"; //select first table element

$result = mysql_query($sql);

while($row = mysql_fetch_array($result))
{
  echo "<ul>";
  echo "<li>" . $row['date'] . "</li>";          //5 rows retrieve data from table
  echo "<li>" . $row['dateplus'] . "</li>";
}

```

```

        echo "<li>" . $row['title'] . "</li>";
        echo "<li>" . $row['titleplus'] . "</li>";
        echo "<li>" . $row['info'] . "</li>";

        echo "</ul>";
    }
    echo "</ul>";

    mysql_close($con);
?>

```

getuser.php

```

<?php
$q=$_GET["q"];

$con = mysql_connect('fdb3.awardspace.com', '667160_kk', 'oscarmya69');
if (!$con)
{
    die('Could not connect: ' . mysql_error());
}

mysql_select_db("667160_kk", $con);

$sql="SELECT * FROM timetable WHERE id = '". $q . "'";

$result = mysql_query($sql);

while($row = mysql_fetch_array($result))
{
    echo "<ul>";
    echo "<li>" . $row['course'] . "</li>";
    echo "<li>" . $row['courseinfo'] . "</li>";
    echo "<li>" . $row['dayone'] . "</li>";
    echo "<li>" . $row['dayoneinfo'] . "</li>";
    echo "<li>" . $row['daytwo'] . "</li>";
    echo "<li>" . $row['daytwoinfo'] . "</li>";
    echo "<li>" . $row['daythree'] . "</li>";
    echo "</ul>";
}
echo "</ul>";

mysql_close($con);
?>

```

graduation.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Graduation</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />

```

```

<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Graduation</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Graduation</h2>
    <p>Full time students - graduation registration will take place during the
April/May Examination Diet (18 April - 10 May 2011). Please come to Room M134 to
complete a graduation registration form and receive information on how to pay the
registration fee of £40. You must bring your matriculation card with you at the time
of registration.</p>
    <p>Part time, distance learning, placement, non attending students, (and
students who do not have examinations during the graduation registration session) -
graduation registration documentation will be sent your home address by mid April
2011. </p>
    <p>Please complete, sign and return the registration form to the Graduation and
Awards Unit. Once you have returned the completed form, you can then pay on line
(where appropriate) by 10 May 2011.</p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

guidelinesandpolicies.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Guidelines & Policies</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>

```

```

<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href="."/>Guidelines & Policies</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Guidelines & Policies</h2>
    <p>GCU is committed to providing an inclusive student experience, which offers
all students the opportunity to achieve their full potential.</p>
    <p>University Guidelines and Policies are available on request.</p>
    <a href="mailto:foi@gcu.ac.uk">Request Policies</a></p>

  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</body>
</html>

```

ictskills.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | ICT Skills</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href="."/>ICT Skills</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>

```

```

        <br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <br/>
        <h2>ICT Skills</h2>
        <p>To be effective as a student you will need to use Information and
Communications Technology (ICT) effectively. You will certainly use some general
applications such as word processing, email and the internet. Depending on your
programme, you may also use specialist technology and equipment. The Student ICT
Skills Unit can provide you with information and support in basic, general ICT as well
as helping you to gain more confidence to use ICT in other ways.</p>
    </div>
    <div id="utility"> </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
        <form method="get" action="http://www.gcu.ac.uk/student/index.html">
            <input type="submit" value="Link to regular Student Homepage" />
        </form>
        <br/>
        <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

improveyourcoursework.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Improve Your Coursework</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href="."/>Improve Your Coursework</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
<br/>
        <br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <br/>
        <h2>Improve Your Coursework</h2>

```

<p>These pages tell you how to improve your coursework, for example, about good writing and presentation techniques to help you get those extra marks! They also tell you other things you need to know, like how to cite references and what counts as plagiarism.</p>

<p>When you're given a piece of coursework it's important to be sure you know exactly what's expected of you and how it will be marked. Check your module handbook or any guidance notes you've been given. If you're still not sure, talk to your lecturer, and remember other support is available, just ask for help.</p>

```
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>
```

index.html

```
<!DOCTYPE HTML>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />

<title>Caley Mobile | Home</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<!--<link rel="stylesheet" type="text/css" href="desktop.css" media="screen and (min-width: 481px)" />
  [if IE]>
    <link rel="stylesheet" type="text/css" href="explorer.css" media="all" />
  [endif]>-->

<!--<script type="text/javascript" src="jquery.js"></script>
  <script type="text/javascript" src="iphone.js"></script>-->
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Home</a></h1>
    <div id="sidebar"> <a href="index.html"> </a> <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <p>Information for current students at Glasgow Caledonian University</p>
  </div>
```

```

<div id="utility">
  <ul>
    <li><a href="http://blackboard.gcal.ac.uk/webapps/portal/frameset.jsp">Blackboard</a></li>
    <li><a href="http://sn119w.snt119.mail.live.com/default.aspx">E-Mail</a></li>
    <li><a href="http://www.gcu.ac.uk/library/">Library</a></li>
    <li><a href="http://hp1.gcal.ac.uk/login.html">My Caledonian</a></li>
    <li><a href="http://isc.gcal.ac.uk/secure-login.htm">Service Desks</a></li>
    <li><a href="http://status.gcal.ac.uk/">System Status</a></li>
    <li><a href="timetable.html">Timetables</a></li>
  </ul>
</div>
<div id="nav">
  <ul>
    <li><a href="more.html">More</a></li>
  </ul>
</div>
<div id="nav2">
  <ul>
    <li><a href="http://www.gcu.ac.uk/">University Home Page</a></li>
  </ul>
</div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

internationalstudentsupport.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | International Student Support</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-width: 480px)" />
<link rel="apple-touch-icon" href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">International Student Support</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />

```



```

        <div id="livesearch"></div>
    </form>
    <br/>
    <h2>International Student Support</h2>
    <p>We would like to welcome you to Glasgow Caledonian University and into our
International Community. We provide support and advice for all international students.
We have daily drop-in sessions (no appointment required) where you can come and speak
to an adviser. Appointments are also available: please contact the base to book an
appointment.</p>
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
        <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

iphone.css

```

body {
    background-color: #ddd; /* Background color */
    color: #222; /* Foreground color used for text */
    font-family: Helvetica;
    font-size: 14px;
    margin: 0; /* Amount of negative space around the outside of the body */
    padding: 0; /* Amount of negative space around the inside of the body */
}
#header h1 {
    margin: 0;
    padding: 0;
}
#header h1 a {
    background-color: #ccc;
    border-bottom: 1px solid #666;
    color: #222;
    display: block;
    font-size: 20px;
    font-weight: bold;
    padding: 10px 0;
    text-align: center;
    text-decoration: none;
}
#header ul {
    list-style: none;
    margin: 10px;
    padding: 0;
}
#header ul li a {
    background-color: #FFFFFF;
    border: 1px solid #999999;
    color: #222222;
    display: block;

```

```

        font-size: 17px;
        font-weight: bold;
        margin-bottom: -1px;
        padding: 12px 10px;
        text-decoration: none;
    }
    #content, #sidebar {
        padding: 10px;
    }
    #footer {
        display: none;
    }
    #header h1 a {
        text-shadow: 0px 1px 0px #fff;
        background-image: -webkit-gradient(linear, left top, left bottom, from(#ccc),
to(#999));
    }

    #header ul li:first-child a {
        -webkit-border-top-left-radius: 8px;
        -webkit-border-top-right-radius: 8px;
    }
    #header ul li:last-child a {
        -webkit-border-bottom-left-radius: 8px;
        -webkit-border-bottom-right-radius: 8px;
    }
    #header ul.hide {
        display: none;
    }
    #header div.leftButton {
        position: absolute;
        top: 7px;
        left: 6px;
        height: 30px;
        font-weight: bold;
        text-align: center;
        color: white;
        text-shadow: rgba(0,0,0,0.6) 0px -1px 0px;
        line-height: 28px;
        border-width: 0 8px 0 8px;
        -webkit-border-image: url(images/button.png) 0 8 0 8;
    }
    #header div.pressed {
        -webkit-border-image: url(images/button_clicked.png) 0 8 0 8;
    }
}

```

iphone.js

```

if (window.innerWidth && window.innerWidth <= 480) {
    $(document).ready(function(){
        $('#header ul').addClass('hide');
        $('#header').append('<div class="leftButton"
onclick="toggleMenu()">Menu</div>');
    });
    function toggleMenu() {
        $('#header ul').toggleClass('hide');
        $('#header .leftButton').toggleClass('pressed');
    }
}

```

iwantto.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | I Want To</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">I Want To</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <p>You may want to help with topics related to your Glasgow Caledonian
Experience.</p>
  </div>
  <div id="utility">
    <ul>
      <li><a href="paytuitionfees.html">Pay Tuition Fees</a></li>
      <li><a href="setsecuritypassword.html">Set Security Password</a></li>
    </ul>
  </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>
```

jobsandcareers.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
```

```

<title>Caley Mobile | Jobs & Careers</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Jobs & Careers</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <p>Glasgow Caledonian University offer on-campus careers advice to assist
students searching for placements or full time employment.</p>
  </div>
  <div id="utility">
    <ul>
      <li><a href="careersservice.html">Careers Service</a></li>
      <li><a href="studententerprise.html">Student Enterprise</a></li>
      <li><a href="careersevents.html">Careers Events</a></li>
      <li><a href="getanindustrymentor.html">Get an Industry Mentor</a></li>
      <li><a href="cbsstudentemployabilityproject.html">CBS Student Employability
Project</a></li>
    </ul>
  </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
  </div>
</div>
</body>
</html>

```

legalandprivacy.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Legal & Privacy</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-width: 480px)" />

```

```

<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Legal & Privacy</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Legal & Privacy</h2>
    <p>Glasgow Caledonian University is displaying this privacy statement in order
to demonstrate our firm commitment to privacy. The following discloses our information
gathering and dissemination practices for this website: gcal.ac.uk</p>
    <p>We use your IP address to help diagnose problems with our server, and to
administer our Web site. Your IP address is used to help identify you and gather broad
demographic information. Our site's feedback form gives users the option to enter
contact information (like their name and email address).</p>
    <p>We use user's contact information from the registration form to send the user
information about Glasgow Caledonian University. The user's contact information is
also used to contact the visitor when necessary.</p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

life.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Life</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>

```

```

<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Life</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <p>Information for current students at Glasgow Caledonian University</p>
  </div>
  <div id="utility">
    <ul>
      <li><a href="studentassociation.html">Student Association</a></li>
      <li><a href="accommodation.html">Accommodation</a></li>
      <li><a href="arhealthandfitness.html">ARC Health and Fitness</a></li>
      <li><a href="disabledstudents.html">Disabled Students</a></li>
    </ul>
  </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

links.xml

```

<?xml version="1.0" encoding="UTF-8"?>
<!--XML Page Directory of Calemobile is called by the PHP script in the Livesearch
document. <title> is searched by the script and the <url>
from that node is displayed -->
<pages>
-
<link>
<title>Blackboard</title>
<url>http://blackboard.gcal.ac.uk/webapps/portal/frameset.jsp</url>
</link>
-
<link>
<title>E-Mail</title>
<url>http://sn119w.snt119.mail.live.com/default.aspx</url>
</link>
-
<link>
<title>Library</title>
<url>http://www.gcu.ac.uk/library/</url>
</link>
-

```

```

<link>
<title>My Caledonian</title>
<url>http://hp1.gcal.ac.uk/login.html</url>
</link>
-
<link>
<title>Service Desks</title>
<url>http://isc.gcal.ac.uk/secure-login.htm</url>
</link>
-
<link>
<title>System Status</title>
<url>http://status.gcal.ac.uk/</url>
</link>
-
<link>
<title>Timetables</title>
<url>http://www.caleymobile.com/timetable.html</url>
</link>
-
<link>
<title>More</title>
<url>http://www.caleymobile.com/more.html</url>
</link>
-
<link>
<title>University Home Page</title>
<url>http://www.gcu.ac.uk/</url>
</link>
-
<link>
<title>Legal & Privacy</title>
<url>http://www.caleymobile.com/legalandprivacy.html</url>
</link>
-
<link>
<title>Essentials</title>
<url>http://www.caleymobile.com/essentials.html</url>
</link>
-
<link>
<title>New2GCU</title>
<url>http://www.caleymobile.com/new2gcu.html</url>
</link>
-
<link>
<title>Back2GCU</title>
<url>http://www.caleymobile.com/back2gcu.html</url>
</link>
-
<link>
<title>Graduation</title>
<url>http://www.caleymobile.com/graduation.html</url>
</link>
-
<link>
<title>International Student Support</title>
<url>http://www.caleymobile.com/internationalstudentsupport.html</url>
</link>
-
<link>
<title>Money</title>

```

```

<url>http://www.caleymobile.com/money.html</url>
</link>
-
<link>
<title>Need a Hand</title>
<url>http://www.caleymobile.com/needahand.html</url>
</link>
-
<link>
<title>The Base</title>
<url>http://www.caleymobile.com/thebase.html</url>
</link>
-
<link>
<title>Your Views</title>
<url>http://www.caleymobile.com/yourviews.html</url>
</link>
-
<link>
<title>Student Mentors</title>
<url>http://www.caleymobile.com/studentmentors.html</url>
</link>
-
<link>
<title>Study</title>
<url>http://www.caleymobile.com/study.html</url>
</link>
-
<link>
<title>Academic Development Tutors</title>
<url>http://www.caleymobile.com/academicdevelopmenttutors.html</url>
</link>
-
<link>
<title>Effective Learning Service</title>
<url>http://www.caleymobile.com/effectivetrainingservice.html</url>
</link>
-
<link>
<title>Exam Date & Guides</title>
<url>http://www.caleymobile.com/examdatesandguides.html</url>
</link>
-
<link>
<title>Improve Your Coursework</title>
<url>http://www.caleymobile.com/improveyourcoursework.html</url>
</link>
-
<link>
<title>English Language Support</title>
<url>http://www.caleymobile.com/englishlanguagesupport.html</url>
</link>
-
<link>
<title>I Want To</title>
<url>http://www.caleymobile.com/iwantto.html</url>
</link>
-
<link>
<title>Pay Tuition Fees</title>
<url>http://www.caleymobile.com/paytuitionfees.html</url>
</link>

```



```

-
<link>
<title>Set Security Password</title>
<url>http://www.caleymobile.com/setsecuritypassword.html</url>
</link>
-
<link>
<title>Jobs & Careers</title>
<url>http://www.caleymobile.com/jobsandcareers.html</url>
</link>
-
<link>
<title>Careers Service</title>
<url>http://www.caleymobile.com/careersservice.html</url>
</link>
-
<link>
<title>Student Enterprise</title>
<url>http://www.caleymobile.com/studententerprise.html</url>
</link>
-
<link>
<title>Careers Events</title>
<url>http://www.caleymobile.com/careersevents.html</url>
</link>
-
<link>
<title>Get An Industry Mentor</title>
<url>http://www.caleymobile.com/getanindustrymentor.html</url>
</link>
-
<link>
<title>CBS Student Employability Project</title>
<url>http://www.caleymobile.com/cbsstudentemployabilityproject.html</url>
</link>
-
<link>
<title>Computer Stuff</title>
<url>http://www.caleymobile.com/computerstuff.html</url>
</link>
-
<link>
<title>Computer FAQs</title>
<url>http://www.caleymobile.com/computerfaqs.html</url>
</link>
-
<link>
<title>ICT Skills</title>
<url>http://www.caleymobile.com/ictskills.html</url>
</link>
-
<link>
<title>Software for Students</title>
<url>http://www.caleymobile.com/softwareforstudents.html</url>
</link>
-
<link>
<title>Life</title>
<url>http://www.caleymobile.com/life.html</url>
</link>
-
<link>

```

```

<title>Student Association</title>
<url>http://www.caleymobile.com/studentassociation.html</url>
</link>
-
<link>
<title>Accommodation</title>
<url>http://www.caleymobile.com/accommodation.html</url>
</link>
-
<link>
<title>ARC Health and Fitness</title>
<url>http://www.caleymobile.com/archealthandfitness.html</url>
</link>
-
<link>
<title>Disabled Students</title>
<url>http://www.caleymobile.com/disabledstudents.html</url>
</link>
-
<link>
<title>Official Things</title>
<url>http://www.caleymobile.com/officialthings.html</url>
</link>
-
<link>
<title>Guidelines & Policies</title>
<url>http://www.caleymobile.com/guidelinesandpolicies.html</url>
</link>
-
<link>
<title>Dignity at Workd & Study</title>
<url>http://www.caleymobile.com/dignityatworkandstudy.html</url>
</link>
-
<link>
<title>Formal Copmplaints</title>
<url>http://www.caleymobile.com/formalcomplaints.html</url>
</link>
-
<link>
<title>Resources</title>
<url>http://www.caleymobile.com/resources.html</url>
</link>
-
<link>
<title>A to Z of School Services</title>
<url>http://www.caleymobile.com/atozofschoolservices.html</url>
</link>
-
<link>
<title>Maps</title>
<url>http://www.caleymobile.com/maps.html</url>
</link>
-
<link>
<title>Useful Contacts</title>
<url>http://www.caleymobile.com/usefulcontacts.html</url>
</link>
-
<link>
<title>Semester Dates</title>
<url>http://www.caleymobile.com/semesterdates.html</url>

```

```

</link>
-
<link>
<title>Whats New</title>
<url>http://www.caleymobile.com/whatsnew.html</url>
</link>

</pages>

```

livesearch.js

```

function showResult(str)
{
if (str.length==0)
{
document.getElementById("livesearch").innerHTML="";
document.getElementById("livesearch").style.border="0px";
return;
}
if (window.XMLHttpRequest)
{
// code for IE7+, Firefox, Chrome, Opera, Safari
xmlhttp=new XMLHttpRequest();
}
else
{
// code for IE6, IE5
xmlhttp=new ActiveXObject("Microsoft.XMLHTTP");
}
xmlhttp.onreadystatechange=function()
{
if (xmlhttp.readyState==4 && xmlhttp.status==200)
{
document.getElementById("livesearch").innerHTML=xmlhttp.responseText;
document.getElementById("livesearch").style.border="1px solid #A5ACB2";
}
}
xmlhttp.open("GET","livesearch.php?q="+str,true);
xmlhttp.send();
}

```

livesearch.php

```

<?php
$xmlDoc=new DOMDocument();
$xmlDoc->load("links.xml");

$x=$xmlDoc->getElementsByTagName('link');

//get the q parameter from URL
$q=$_GET["q"];

//lookup all links from the xml file if length of q>0
if (strlen($q)>0)
{
$hint="";
for($i=0; $i<($x->length); $i++)
{
$y=$x->item($i)->getElementsByTagName('title');
$z=$x->item($i)->getElementsByTagName('url');

```

```

if ($y->item(0)->nodeType==1)
{
    //find a link matching the search text
    if (strpos($y->item(0)->childNodes->item(0)->nodeValue,$q))
    {
        if ($hint=="")
        {
            $hint="<a href='" .
            $z->item(0)->childNodes->item(0)->nodeValue .
            "' target='_self'>" .
            $y->item(0)->childNodes->item(0)->nodeValue . "</a>";
        }
        else
        {
            $hint=$hint . "<br /><a href='" .
            $z->item(0)->childNodes->item(0)->nodeValue .
            "' target='_self'>" .
            $y->item(0)->childNodes->item(0)->nodeValue . "</a>";
        }
    }
}
}
}

// Set output to "no suggestion" if no hint were found
// or to the correct values
if ($hint=="")
{
    $response="No search information found,please try rephrasing";
}
else
{
    $response=$hint;
}

//output the response
echo $response;
?>

```

maps.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Maps</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
<div id="header">
<h1><a href="." />Maps</a></h1>

```

```

<div id="sidebar"> <a href="index.html"> </a>
<br/>
<br/>
<form>
  <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
  <div id="livesearch"></div>
</form>
<br/>
<h2>Maps</h2>
<br/>

<p> 1. Britannia Building (B) <br/>
  2. William Harley Building (H) and CPD Centre (CPD) <br/>
  3. Arc <br/>
  4. Students' Association (NH) <br/>
  5. Govan Mbeki Health Building (A) <br/>
  6. George Moore Building (M) <br/>
  7. Hamish Wood Building (W) <br/>
  8. Refectory Extension <br/>
  9. Buchanan House (K) <br/>
  10. Occupational Health Unit <br/>
  11. The Saltire Centre <br/>
  12. Charles Oakley Laboratories (C) <br/>
  13. Nursery <br/>
  14. Teaching Block (T) <br/>
  15. Milton Street Building (MS) <br/>
  16. Caledonian Court Accommodation <br/>
  A. Vehicle entrance from Cowcaddens Road <br/>
  B. Pedestrian entrance from Cowcaddens Road <br/>
  C. Vehicle entrance from North Hanover Street</p>
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

money.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Money</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />

```

```

<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Money</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Money</h2>
    <p>The information we have put on this site applies to most students, but if you
are not sure about your situation contact us for advice. There are also useful funding
information booklets available from Smarter Scotland. These booklets, along with our
own funding leaflets, are available from Level 0 in the Saltire Centre and the
Carnegie Suite.</p>
    <p>All universities charge tuition fees, so use this site to find out who will
pay yours. You can also find out about whether you can apply for a student loan. We
can tell you about different kinds of funding, and how to get help if you have
financial difficulties.</p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

more.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | More</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="stylesheet" type="text/css" href="desktop.css" media="screen and (min-
width: 481px)" />
<!--[if IE]>
  <link rel="stylesheet" type="text/css" href="explorer.css" media="all" />

```

```

        <![endif]-->
<!--<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>-->
<script type="text/javascript" src="jquery.js"></script>
<script type="text/javascript" src="iphone.js"></script>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href=".">More</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
        <br/>
        <br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>

        <p>Additional information and resources are available for students attending
Caledonian University. Careers, University Life, Study Information and many more
services are displayed by toggling the menu option.</p>
    </div>
    <div id="utility">
        <ul>
            <li><a href="computerstuff.html">Computer Stuff</a></li>
            <li><a href="essentials.html">Essentials</a></li>
            <li><a href="iwanttto.html">I Want to</a></li>
            <li><a href="jobsandcareers.html">Jobs and Careers</a></li>
            <li><a href="life.html">Life</a></li>
            <li><a href="needahand.html">Need a Hand</a></li>
            <li><a href="officialthings.html">Official Things</a></li>
            <li><a href="resources.html">Resources</a></li>
            <li><a href="study.html">Study</a></li>
            <li><a href="whatsnew.html">Whats New</a></li>
        </ul>
    </div>
    <div id="nav"> </div>
    <div id="nav">
        <ul>
            <li><a href="http://www.gcu.ac.uk/">University Home Page</a></li>
        </ul>
    </div>
    <div id="content">
        <form method="get" action="http://www.gcu.ac.uk/student/index.html">
            <input type="submit" value="Link to regular Student Homepage" />
        </form>
        <br/>
        <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

[needahand.html](#)

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Need a Hand</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Need a Hand</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <p>We are here to assist you in your time at Glasgow Caledonian University.</p>
  </div>
  <div id="utility">
    <ul>
      <li><a href="thebase.html">The Base</a></li>
      <li><a href="yourviews.html">Your Views</a></li>
      <li><a href="studentmentors.html">Student Mentors</a></li>
    </ul>
  </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

new2gcu.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | New2GCU</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />

```



```

<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">New2GCU</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>New2GCU</h2>
    <p>This website is here to give you all the help and advice you need in the run-
up to your first weeks at Glasgow Caledonian University and our new postgraduate
campus GCU London.</p>
    <p>It has all the latest news and events to do with registration, induction,
Welcome Weekend as well as useful links to school specific info that you need.</p>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

news.js

```

function showUser(str)
{
  if (str=="")
  {
    document.getElementById("txtHint").innerHTML="";
    return;
  }
  if (window.XMLHttpRequest)
  {
    // code for IE7+, Firefox, Chrome, Opera, Safari
    xmlhttp=new XMLHttpRequest();
  }
  else
  {
    // code for IE6, IE5
    xmlhttp=new ActiveXObject("Microsoft.XMLHTTP");
  }
  xmlhttp.onreadystatechange=function()
  {
    if (xmlhttp.readyState==4 && xmlhttp.status==200)

```

```

        {
            document.getElementById("txtHint").innerHTML+xmlhttp.responseText;
        }
    }
xmlhttp.open("GET","getnews.php?q="+str,true);
xmlhttp.send();
}

```

officialthings.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Official Things</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href=".">Official Things</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
<br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <p>Some serious issues you might want to utilise in your time at Glasgow
Caledonian University</p>
    </div>
    <div id="utility">
        <ul>
            <li><a href="guidelinesandpolicies.html">Guidlines and Policies</a></li>
            <li><a href="dignityatworkandstudy.html">Dignity at Work and Study</a></li>
            <li><a href="formalcomplaints.html">Formal Complaints</a></li>
        </ul>
    </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
        <form method="get" action="http://www.gcu.ac.uk/student/index.html">
            <input type="submit" value="Link to regular Student Homepage" />
        </form>
        <br/>
        <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
</div>
</body>
</html>

```

paytuitionfees.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Pay Tuition Fees</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Pay Tuition Fees</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Pay Tuition Fees</h2>
    <p>This applies only if you are paying your fees privately.</p>
    <p>If SAAS, your LEA or Library Board or another UK public funding body is
paying them, they will pay us direct. </p>
    </div>
    <div id="utility"> </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
      <form method="get" action="http://www.gcu.ac.uk/student/index.html">
        <input type="submit" value="Link to regular Student Homepage" />
      </form>
      <br/>
      <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
  </div>
</div>
</body>
</html>
```

resources.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Resources</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
```

```

<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Resources</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <p>Information for current students at Glasgow Caledonian University that may
make your time here more pleasurable</p>
  </div>
  <div id="utility">
    <ul>
      <li><a href="atozofschoolservices.html">A to Z of School Services</a></li>
      <li><a href="maps.html">Maps</a></li>
      <li><a href="usefulcontacts.html">Useful Contacts</a></li>
      <li><a href="semesterdates.html">Semester Dates</a></li>
    </ul>
  </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
  <div id="sidebar2"> </div>
  <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

semesterdates.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Semester Dates</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>

```

```

<div id="container">
  <div id="header">
    <h1><a href=".">Semester Dates</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Semester Dates</h2>
    <p>Trimester 2 Key Dates</p>
    <p>All Levels
      17th January 2011 to 8 April 2011 </p>
    <p>Spring Break: All Levels
      11th April 2011 to 15 April 2011 </p>
    <p>Exam Diet: All Levels
      18 April 2011 to 10 May 2011</p>
    <p>Inter-Trimester Break: All Levels
      11 May 2011 to 13 May 2011</p>
    </div>
    <div id="utility"> </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
      <form method="get" action="http://www.gcu.ac.uk/student/index.html">
        <input type="submit" value="Link to regular Student Homepage" />
      </form>
      <br/>
      <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
  </div>
</div>
</body>
</html>

```

setsecuritypassword.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Set Security Password</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Set Security Password</a></h1>

```

```

<div id="sidebar"> <a href="index.html"> </a>
<br/>
<br/>
<form>
  <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
  <div id="livesearch"></div>
</form>
<br/>
<h2>Set Security Password</h2>
<p>Many password enquiries can be broken down into two categories:</p>
<p>* You know your current password and want to change it to something else
  Select the system you wish to change from the green 'How to' section below and
follow the instructions listed.</p>
<p>* You do not know your current password
  Select the system you are having problems with from the red 'Problem' section
below and follow the instructions listed. </p>
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

softwareforstudents.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Software For Students</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Software For Students</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />

```

```

        <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Software For Students</h2>
    <p># For standard software like Word, Excel, Powerpoint or Access, it is best if you go along to an ICT Skills Drop-in Clinic</p>
    <p># RightAnswers is an online Software Help Provider, offering hundreds of thousands of solutions to more than 150 off-the-shelf applications. You can access it through myCaledonian. Log in and on the me(student) page there is a link to Right Answers (under Quickpicks).</p>
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
        <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

studentassociation.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Student Association</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href=".">Student Association</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
<br/>
        <br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <br/>
        <h2>Student Association</h2>
        <p>The main reason the Students' Association exists to represent the students at Glasgow Caledonian University. It is autonomous from the University and is democratically controlled by students at all levels. All Glasgow Caledonian University students are automatically members.</p>

```

<p>Glasgow Caledonian University Students' Association is a registered Scottish charity, number SC022887.</p>


```
<form method="get" action="http://www.caledonianstudent.com/">
  <input type="submit" value="Link to Caledonian Student" />
</form>
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>
```

studententerprise.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Student Enterprise</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Student Enterprise</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Student Enterprise</h2>
    <p>The Enterprise Society are the experts in enterprise and business start-up
here at GCU. Our events will help you realise your inner entrepreneur, boost your
employability skills and meet up with many great people.</p>
    <p>We have direct links to the Scottish Institute for Enterprise (SIE) who
themselves have a massive team of experts in business start-up and all the various
```


parts of start-up. They also run their own events, workshops and competitions which Enterprise Society members will be the first to know about.</p>

```
</div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>
```

studentmentors.html

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Student Mentors</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href=".">Student Mentors</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <br/>
    <h2>Student Mentors</h2>
    <p>Making the move to university is exciting and provides a fantastic
opportunity to meet new people, learn new things and get involved in a whole range of
activities.</p>

    <p>At university you may find that things are done in a different way from college or
school, but our mentoring scheme can help with ANY queries or issues you might have
and can offer re-assurance, practical advice, informal support, signposting to support
services, or just a friendly ear!</p>
  </div>
<div id="utility"> </div>
<div id="nav"> </div>
<div id="nav2"> </div>
```

```

<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

study.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Study</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href="."/>Study</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <br/>
    <form>
      <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
      <div id="livesearch"></div>
    </form>
    <p>Glasgow Caledonian University offer some helpful resources and support to
assist your studies.</p>
  </div>
  <div id="utility">
    <ul>
      <li><a href="academicdevelopmenttutors.html">Academic Development
Tutors</a></li>
      <li><a href="effectivelearningservice.html">Effective Learning
Service</a></li>
      <li><a href="examdatesandguides.html">Exam Dates & Guides</a></li>
      <li><a href="improveyourcoursework.html">Improve Your Coursework</a></li>
      <li><a href="englishlanguagesupport.html">English Language Support</a></li>
    </ul>
  </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>

```

```

        <br/>
        <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
</div>
</div>
</body>
</html>

```

thebase.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | The Base</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href="."/>The Base</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
<br/>
        <br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <br/>
        <h2>The Base</h2>
        <p>The Base is the enquiry desk on level 0 of the Saltire Centre. You can get
lots of information from the links below, and even more from the student home page,
but if you can't find what you need, please ask at The Base.</p>
        </div>
        <div id="utility"> </div>
        <div id="nav"> </div>
        <div id="nav2"> </div>
        <div id="content">
            <form method="get" action="http://www.gcu.ac.uk/student/index.html">
                <input type="submit" value="Link to regular Student Homepage" />
            </form>
            <br/>
            <a href="legalandprivacy.html">Legal & Privacy</a> </div>
        <div id="sidebar2"> </div>
        <div id="footer"> </div>
    </div>
</div>
</body>
</html>

```

timetable.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Timetable</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="stylesheet" type="text/css" href="desktop.css" media="screen and (min-
width: 481px)" />
<script type="text/javascript" src="timetable.js"></script>
</head>
<body>
<div id="container">
<div id="header">
    <h1><a href=".">Timetables</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
    <p>Timetable information is available if you know your course name. Day, Time and
Location are provided.</p>
    <form>
        <select name="users" onchange="showUser(this.value)">
            <option value="">Choose your course:</option>
            <option value="1">3D Computer Animation</option>
            <option value="2">Computer Aided Mechanical Engineering</option>
            <option value="3">Computer Games (Art and Animation)</option>
            <option value="4">Computer Games (Software Development)</option>
            <option value="5">Computing (Web Systems Development)</option>
            <option value="6">Digital Security and Ethical Hacking</option>
            <option value="7">Digital Systems Engineering</option>
            <option value="8">Instrumentation and Robotic Systems Engineering</option>
            <option value="9">Networking and Systems Support</option>
        </select>
    </form>
    <br />
    <div id="txtHint"><b></b></div>
</div>
<div id="utility">
    <ul>
</ul>
</div>
<div id="nav2"> </div>
<div id="nav"> </div>
<div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
        <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar1"> </div>
<div id="footer"> </div>
</div>
</body>
</html>

```

timetable.js

```
function showUser(str)
```

```

{
if (str=="")
{
document.getElementById("txtHint").innerHTML="";
return;
}
if (window.XMLHttpRequest)
{
// code for IE7+, Firefox, Chrome, Opera, Safari
xmlhttp=new XMLHttpRequest();
}
else
{
// code for IE6, IE5
xmlhttp=new ActiveXObject("Microsoft.XMLHTTP");
}
xmlhttp.onreadystatechange=function()
{
if (xmlhttp.readyState==4 && xmlhttp.status==200)
{
document.getElementById("txtHint").innerHTML=xmlhttp.responseText;
}
}
xmlhttp.open("GET","getuser.php?q="+str,true);
xmlhttp.send();
}

```

usefulcontacts.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Useful Contacts</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
<div id="header">
<h1><a href=".">Useful Contacts</a></h1>
<div id="sidebar"> <a href="index.html"> </a>
<br/>
<br/>
<form>
<input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
<div id="livesearch"></div>
</form>
<br/>
<h2>Useful Contacts</h2>

<p>The base is an essential part of Glasgow Caledonian University & can
assist you with all enquiries seven days a week tel - 0141 273 1000.</p>
</div>
<div id="utility"> </div>

```

```

<div id="nav"> </div>
<div id="nav2"> </div>
<div id="content">
  <form method="get" action="http://www.gcu.ac.uk/student/index.html">
    <input type="submit" value="Link to regular Student Homepage" />
  </form>
  <br/>
  <a href="legalandprivacy.html">Legal & Privacy</a> </div>
<div id="sidebar2"> </div>
<div id="footer"> </div>
</div>
</div>
</body>
</html>

```

whatsnew.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Whats New</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="news.js"></script>
</head>
<body>
<div id="container">
  <div id="header">
    <h1><a href="."/>Whats New</a></h1>
    <div id="sidebar"> <a href="index.html"> </a>
<br/>
    <p>Latest news is available via the dropdown list. Choose events by date.</p>
    <form>
      <select name="users" onchange="showUser(this.value)">
        <option value="">Choose date:</option>
        <option value="1">1st April 2011</option>
        <option value="2">30th March 2011</option>
        <option value="3">29th March 2011</option>
        <option value="4">17th March 2011</option>
        <option value="5">14th March 2011</option>
        <option value="6">11th March 2011</option>
      </select>
    </form>
    <br />
    <div id="txtHint"><b></b></div>
  </div>
  <div id="utility"> </div>
  <div id="nav"> </div>
  <div id="nav2"> </div>
  <div id="content">
    <form method="get" action="http://www.gcu.ac.uk/student/index.html">
      <input type="submit" value="Link to regular Student Homepage" />
    </form>
    <br/>
    <a href="legalandprivacy.html">Legal & Privacy</a> </div>

```

```

        <div id="sidebar2"> </div>
        <div id="footer"> </div>
    </div>
</div>
</body>
</html>

```

yourviews.html

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Caley Mobile | Your Views</title>
<meta name="viewport" content="user-scalable=no, width=device-width" />
<link rel="stylesheet" type="text/css" href="iphone.css" media="only screen and (max-
width: 480px)" />
<link rel="apple-touch-icon"
href="http://www.welcometoskye.com/images/caley/appletouchicon.png"/>
<script type="text/javascript" src="livesearch.js"></script>
</head>
<body>
<div id="container">
    <div id="header">
        <h1><a href=".">Your Views</a></h1>
        <div id="sidebar"> <a href="index.html"> </a>
<br/>
        <br/>
        <form>
            <input type="text" size="30" placeholder="Live Search Caledonian Mobile"
onkeyup="showResult(this.value)" />
            <div id="livesearch"></div>
        </form>
        <br/>
        <h2>Your Views</h2>
        <p>At Glasgow Caledonian University, our support services are committed to
providing you with access to the best advice and guidance available.</p>
        <p>To ensure we consistently offer you the best levels of service, we need your
suggestions, complaints and compliments on how we are doing.</p>
    </div>
    <div id="utility"> </div>
    <div id="nav"> </div>
    <div id="nav2"> </div>
    <div id="content">
        <form method="get" action="http://www.gcu.ac.uk/student/index.html">
            <input type="submit" value="Link to regular Student Homepage" />
        </form>
        <br/>
        <a href="legalandprivacy.html">Legal & Privacy</a> </div>
    <div id="sidebar2"> </div>
    <div id="footer"> </div>
</div>
</div>
</body>
</html>

```