Adapting a novel public display system for an educational context

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Calvin Pedzai

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1. Chapter 1: Introduction

1.1 Introduction

Universities in developing nations are viewed as gateways to global knowledge and as the source of human capital for their countries' economies (Juma, 2008). However, these universities face challenges in accessing educational information over the Internet due to high bandwidth costs, low literacy rates and the difficulty of setting up expensive computer labs. For example, at the University of Cape Town, labs are often overcrowded and fewer learners gaining access to information. One innovative solution to this problem has been realized through the adoption of mobile phones as PC terminal replacements in developing countries. There has been a steady increase in the adoption of mobile phones due to their ease of use and affordability (Juma, 2008). By harnessing this technology's potential, we believe a sustainable and cost-effective solution to support student needs can be developed for universities in developing countries.

Developed by a PhD student at the University of Cape Town, the Snap and Grab board was created for a developing world context in order to provide free access to limited information (Maunder, et al. 2008). The Snap and Grab board is a public display that is connected to a computer which houses various media packages. Through the use of a mobile phone, users can access these media packages and freely exchange information with the board via Bluetooth. Such a system provides an ideal way for students to access information with the need to use a computer in a laboratory.

This project extends the Snap and Grab work and looks at how the board can be used to help support students access educational information by integrating it with a university's learning management system named VULA. The final system serves as an interactive alternative or extension to current methods of accessing educational material on VULA. Students will be able to store and review up-to-date educational material on their mobile phones. This chapter presents

an introductory and foundational overview of the project. It explores what the project is about, why it is important and its success criteria.

1.2 ICT in education

In order to participate in the global economy and ensure sustainable national development, developing countries need a functional education system. Information and Communication Technologies (ICTs) can be used to improve the quality of education by enhancing educational content delivery and supporting administrative processes (Neuman, 2007). Many of the early ICT projects in developing nations focused on ensuring people had access to information through the use of computers which meant the setting up of telecentres or community labs.

Low literacy rates in developing nations have resulted in very basic ICT skills; consequently, initiatives like telecentres are ineffective without support structures such as computer training programmes. In light of this point, it is important to develop technologies on platforms that can be easily understood by the target user group (Butcher, 2003). This means an emphasis needs to be on sustainable technologies that are affordable, have relevant content and can be easily integrated into the daily lives of the target community.

Compared to global trends, developing countries' educational progress lags behind (Butcher, 2003). Natural and human-made disasters have placed extreme pressure on already weak educational systems. Structural adjustment programmes and governance problems have led to cuts in educational expenditure thereby denying many individuals access to education.

The increased adoption of mobile phones in developing countries creates opportunities for information exchange on this platform that would impact a greater portion of the population than personal computers. Mobile phones are increasing becoming more affordable and popular with the youth in developing nations (Gray, 2008). It is a technology which already exists in the social structures of developing world communities, making it easier to be improved upon and adopted than new applications.

1.3 Current Accessing methods

Educational information can be accessed over the Internet by students in formats such as e-books, journals, encyclopedias, dictionaries, news articles, tutorials etc. Most universities and schools in Africa and other developing countries cannot afford to set up expensive computer labs to access this information or fill libraries with updated journals and textbooks. Emphasis has been on buying textbooks and printing educational material on paper but such material becomes obsolete after a couple of years if not months. Countries like Togo and Djibouti use radio broadcasts, audiocassettes, and printed materials to support students and teachers (Farrell & Issacs, 2007). Interactive radio instruction is used extensively in Kenya and several countries such as South Africa use interactive television shows as a medium for delivering educational content (Farrell & Issacs, 2007).

In addition to the cost of setting up expensive labs, universities in developing nations suffer from low bandwidth speeds and the high cost of Internet access (Song, 2005). The high cost of bandwidth is due to the cost of using fiber optics in transferring data, whilst low speeds are due to the low number of fiber optic cables currently being used (Juma, 2008). Until sustainable, low cost solutions are developed to remedy these challenges, it is imperative to look to alternative technologies to help deliver information in developing countries' universities. For this project the University of Cape Town is used as our context.

At the University of Cape Town (UCT), students access information through several mediums, one of which is the use of desktop computers to access course information and material over the Internet using a learning management system named VULA. The system is built on top of Sakai, an open source educational software platform used for teaching, research and collaboration at over 160 institutions (Sakai, 2009). All of the University's courses can be accessed by students through secure personal login accounts. From VULA students can access everything pertaining to their courses such as handouts, announcements, test dates, marks, assignments and exchange messages with lecturers and other students through chat rooms. Information on the site is regularly updated by course conveners and teaching assistants depending on the course schedules but is mostly done on a daily basis. Announcements in class are notably always repeated on

VULA to accommodate absent students. As a result students access VULA every day to keep track of their courses.

Not all educational information is accessed over the Internet. Information such as course schedules, events and marks are placed on notice boards or printed out. Notice boards are located in departmental buildings usually near the entrances or on the walls of the corridors or at reception areas (See figure 1). These hold information such as course description, staff names, staff offices number, tutorial sign-up list, test venues and results.

Figure 1 : Notice boards at entrances

Handouts such as readings and slide printouts can be obtained from departmental offices (Figure 2). This is a secondary source, so in effort to reduce the management of paperwork in such areas most course resources are usually found in a digital format online. Information put on notice boards and at reception areas is usually not time specific and may remain there for the whole semester unchanged.

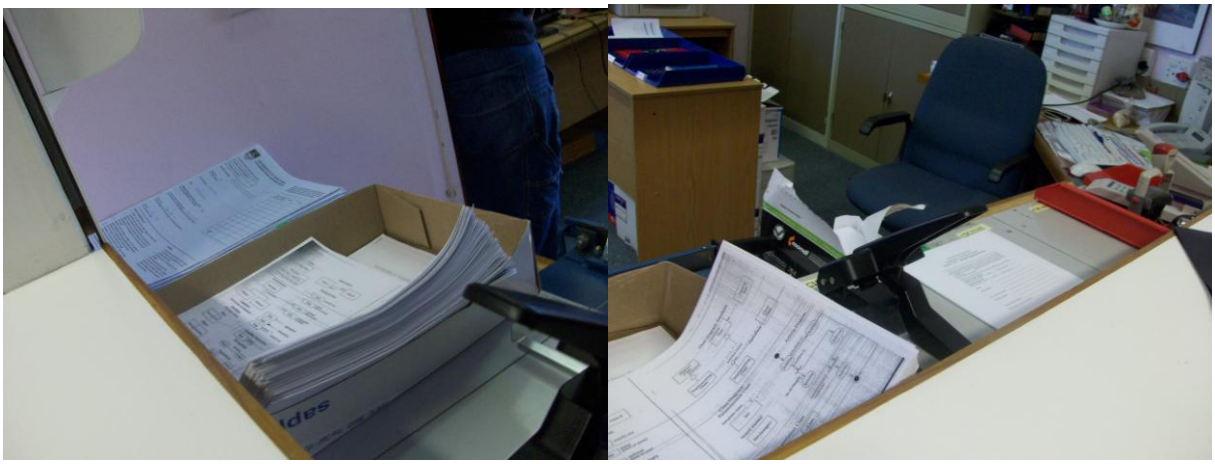

Figure 2: Notes and handouts found at a departmental reception

The general layout of each computer lab at UCT has computers arranged in rows across a room connected together through wires on a Local Area Network. Each computer lab comes equipped with a printer for student printing purposes as well. UCT has several computer labs allocated to its different faculties but still suffers from overcrowded labs.

Interviews with lab administrators revealed that labs are booked approximately two or three times a day for two to four hour tutorial sessions for different courses. This implies that other students would have to find an alternative computer lab or way of accessing course information and announcements at that time. However, there is time-specific information such as test, lecture or exam venue changes, query session venues which students may not be able to promptly access due to the lab being full or booked. Students either wait until the labs are free or try to get course information from alternative sources.

Receptions and notice boards usually contain reliable information but are not regularly updated to alert students to recent events. Verbal exchange between students is usually the best way to get such educational alerts. The informed students may have accessed the information before the lab became full or booked. Information exchange by word of mouth between students is not always reliable and there have been instances when students have ended up at the wrong lecture or exam venue. An alternative reliable means of accessing information to support time-specific tasks on VULA is clearly required. Such an alternative would lessen the dependence of accessing information in the computer labs and help in reducing overcrowding.

1.4 Scope and objectives

The increasing adoption of mobile phones in developing countries creates exciting opportunities for information delivery. Mobile phones are becoming more prevalent in developing countries because they are simple to use, but most importantly, affordable (Gray, 2008). This means the technology is increasingly becoming more available to everyone. The younger generation is naturally receptive to high-tech devices and university students in developing countries have access to mobile phones (Butgereit, 2008).

This project explores how educational material could be delivered to mobile phones allowing students to carry the material with them and review it later. Such a solution would help alleviate the overcrowding problem mentioned in the previous section by giving students an alternative means of accessing and reviewing information apart from the computer labs. Compared to desktop computers, the mobile phone can be accessed anytime and from anywhere. It is always with the user (Lehikoinen, et al. 2007). At UCT, more students own a mobile phone than a laptop/personal computer. Mobility makes education more adaptable, flexible and attractive to learners (Yordanova, 2007).

However, information exchange through the use mobile phones introduces new challenges. Information on mobile phones is either accessed over technologies like GPRS, to connect to the Internet or can come as a software application that needs to be installed on the phone. Therefore, students incur mobile Internet connection costs and mobile network charges, to access a particular piece of information. If the cost of accessing information is too much, no one may use the technology at all. The installation of mobile software can be tedious and lengthy, possibly putting off potential users as well.

The Snap and Grab board facilitates the transfer of free information and does not require the installation of additional software in order to function (Maunder, et al. 2008). Multi-media packs (this may be text, audio or video files) are transferred from the Snap and Grab board via Bluetooth, allowing information to be accessed without incurring connectivity costs or mobile

charges. This ensures that information is accessible to almost any user with a Bluetooth enabled camera phone. A user simply takes a photo of the desired media from the Snap and Grab board display, sends it to the board via Bluetooth for processing and receives the actual media files back. Figure 3 shows how a user can use their phone to get information from the Snap and Grab board.

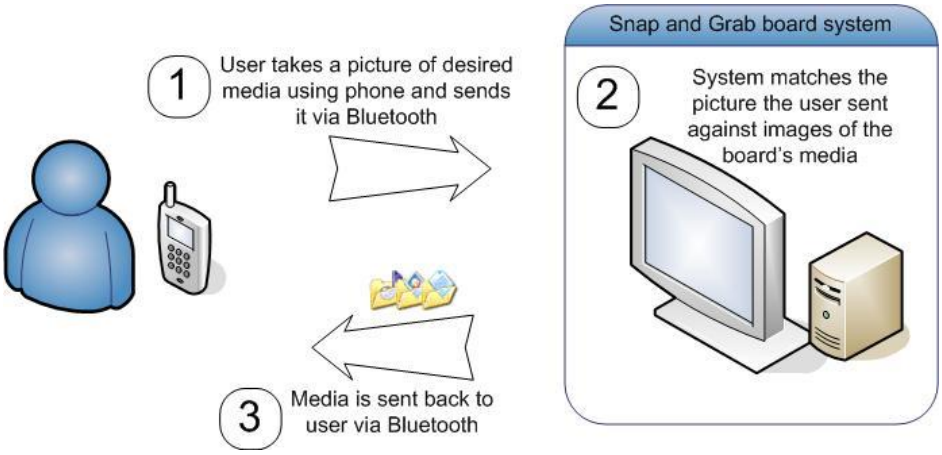

Figure 3: The transfer of information between user and the board

Information provided by the Snap and Grab board is currently very generic and may not be relevant to students, who are the project's target users. Therefore, the project looks at extracting educational information from the University of Cape Town's learning management system, VULA, to place on the board for mobile consumption. VULA is used by every student at UCT for looking up course information and communicating with lecturers and fellow students. By using the information on VULA, the project also seeks to extend the learning management system to have mobile access by integrating it with the Snap and Grab board. This lessens the students' reliance on using existing computer labs to access course information, thereby reducing the likelihood of overcrowded labs. This also allows access to information in areas with poor mobile network, without incurring connectivity costs or charges.

1.5 The Snap and Grab board and VULA

The following is a more detailed description of the two systems.

Snap and Grab board

Until recently, situated displays played a very passive role in society. They would display images and play videos. To make these displays more useful to the people who use them, researchers evaluated different user interaction techniques. One of the most promising techniques is the use of a mobile phone to interact directly with situated displays. The Snap and Grab board was developed to facilitate information sharing using a mobile phone with several key motivations. These are:

- The display system could be used as a free information hub for people requiring information but not willing to pay for it.
- Displays systems can act as limited information sources in areas where access to mobile networks is poor.
- Information transferred from the display to the phone could be taken away, reviewed and reflected upon later on.
- The system uses a Bluetooth exchange protocol that allows the users to use the technology without cost.

Figure 4: The Snap and Grab board use for a community project called Learn2Earn

Figure 4 shows the Snap and Grab board interface. Media on the board is represented by captions, numbered from 1 to 8. The instructions are at the bottom of the screen and the status of the system is displayed at the top. The interaction technique called 'Snap n Grab', allows users to select media for download from the display using a camera phone. A picture of the icon or portion of the display relating to the desired media is taken by the user's camera phone and sent via Bluetooth to the board. The display is connected to a computer server which processes the user's picture and sends back the related media. Not only can the system send media but it can also receive media from users. Media refers to content designed for mobile device platforms such as video (MP4, 3GP), audio files (MP3), image files (jpeg, etc), contact details (VCard) and text files (PDF, txt). The Snap and Grab display system can be managed via a remote server, due to the fact that it utilizes a Web-based architecture. Its content management system manages how the display presents the information, time-slot management and visual tag sizing.

The following is an example of how it may be used. A movie rental agency may want to advertise new movie stock and games. The store owner would create rich media packages related to the movies add them to the Snap and Grab system. Audio, video, photos, calendar entries and text files can be incorporated into the packages depending on what the store owner wants to advertise. Eye catching images for each package, can be placed on the board's display to entice downloads of the media packages. Drawn by the Snap and Grab board's display and content, potential customers will use their mobile phone camera to take a clear photo of the display image of interest and send it via Bluetooth to the Snap and Grab system. The submitted photo is processed and the media package associated with the photo image is then returned to the user's mobile device. The user can review the downloaded material or share it with friends. This gives customers a different way to engage with the shop's media and enhances their shopping experience without incurring additional costs.

VULA system

VULA is a learning management system built on top of Sakai used for teaching, researching and collaboration primarily in academic institutions. It includes many features common to course management systems, including resources section, a course gradebook, and discussion forums.

Other than the most simple, basic functionality, the system caters to different educational, administrative and deployment requirements. Figure 5 shows the VULA homepage when a student logs in. The student's courses are arranged at the top using tabs and the site's sections are laid out along side it.

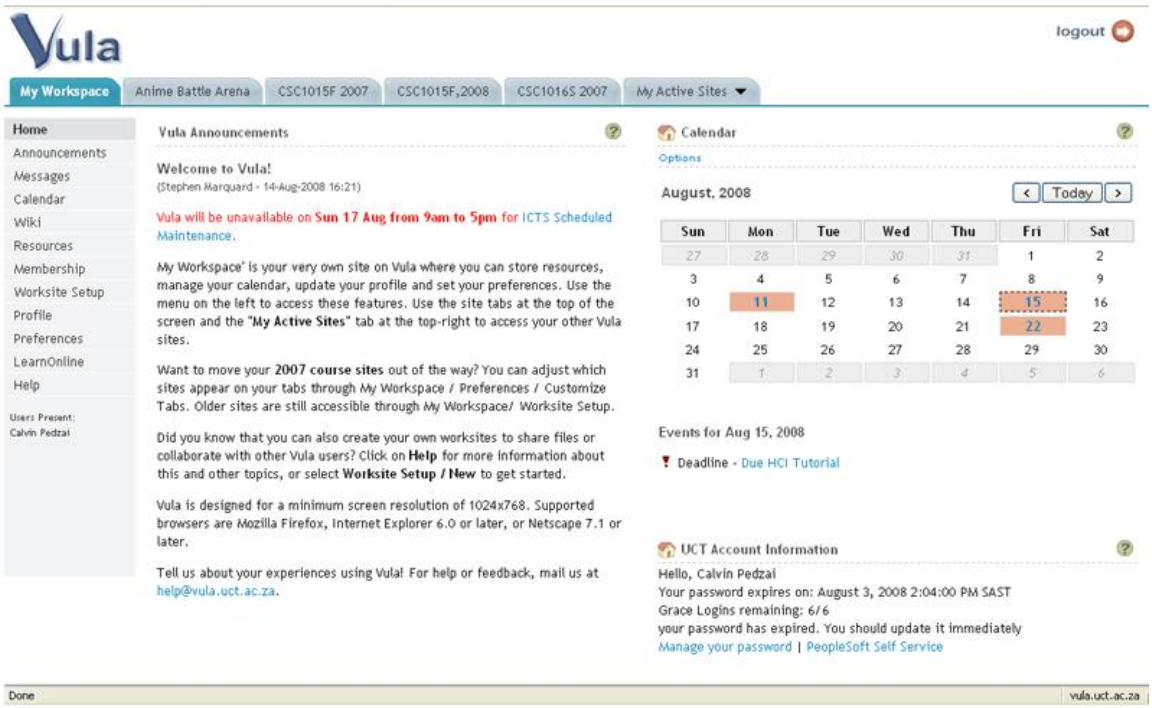

Figure 5: VULA system showing the home page

Some generic collaboration tools:

- Announcements - used to inform site participants about current items of interest
- Drop Box - allows instructors and students to share documents within a private folder for each student
- Email Archive - all messages sent to a site's email address are stored in the Email Archive
- Resources - shares many kinds of material securely with members of the site, or makes them available to the public
- Chat Room - for real-time, unstructured conversations among site participants who are signed on to the site at the same time

- Forums - communication tool that instructors or site leaders can use to create an unlimited number of discussion forums. See Figure 6.
- Presentation - allows a set of slides to be made available to many viewers
- Profile / Roster - displays the names, photos, and profiles of site participants
- Repository Search - searches content created by tools within a worksite or course
- Schedule - allows instructors or site organizers to post items in a calendar format

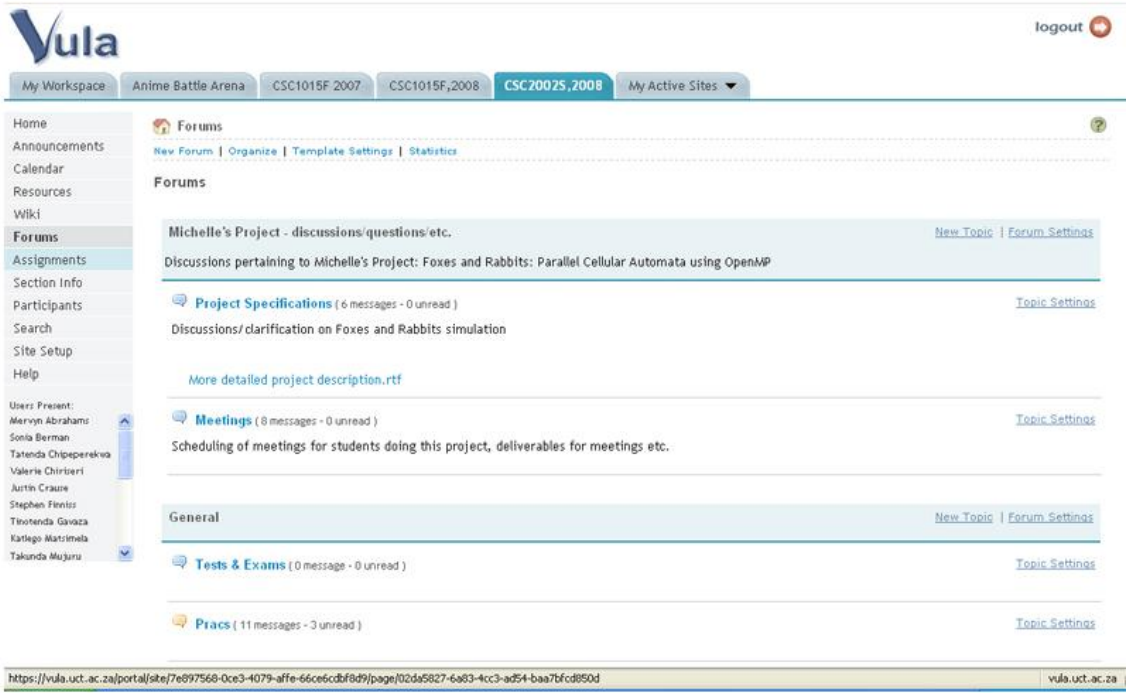

Figure 6: VULA system showing the forum section

At the University of Cape Town, VULA manages student records for all available courses offered. It provides login access for students to manage their degree courses. VULA also makes it easier for lecturer and heads of departments to track student progress, to effectively communicate with students and to provide relevant information in a timely manner. In addition, the system is online and therefore can be accessed at anytime.

1.6 Project aims

The main research objectives of the study are as follows.

i. To support student activities by adding mobile access to VULA through the use of the Snap and Grab board.

ii. To find out how the students will respond and appropriate this new paradigm of interaction.

The first project aim involves understanding student attitudes towards the current online learning management system, in order to get design ideas and requirements for the final system. The assessment focuses on student habits and practices with the current VULA system. By conducting interviews and surveys with the students, detailed insights into the usage the current system may be obtained as well as identification of activities to support.

The second project aim focuses on the evaluation of the system created to support the student needs identified in the first part of the research. It explores the students' response to the final display system and how they incorporate it into their lives. What do they do with it? Do they like it and does the system do what they expect it to do? What advantages does the interaction offer over current methods?

There are several research questions that need to be addressed. How do the design tradeoffs between VULA and the Snap and Grab board, influence the project outcome? Were the methodologies used effective in achieving the project goals? These are all important questions in evaluating whether or not the technology has been successfully implemented.

1.7 Sample Scenarios

A potential scenario for the final system is as follows: Each of the University's departments would have a Snap and Grab board displaying the department's courses. Considering the Snap and Grab board's size, up to eight courses can be shown on the display. Courses for the various year groups will be displayed on the board, differentiated by course code. A student wants to find out whether there is a test that week and if the course convener or teaching assistant has posted

an announcement about the test. The student is in a rush and does not want to bother waiting for a machine in the crowed computer lab.

The student will identify their particular course on the display; and take a picture of desired media caption related to the course using his/her mobile phone's camera and send it via Bluetooth to the Snap and Grab board. The display system will attempt to match the sent picture and if match is found, sends back course information, calendar events and announcements in three separate files for the user to accept. The student can review the files stored on their phone to find out the test date and latest announcements. He/she can decide to keep relevant information on the phone for later reference or to share with other students. When done with the information, the student can delete it or send it to another student via the handset's Bluetooth capability.

Another scenario is for a student who usually accesses course material such as assignments over the Internet on their mobile phone. Instead of using the Internet to access this information, the student would use the Snap and Grab board to select a particular course using their mobile phone camera. A picture of the caption for the desired course is taken by the phone camera and sent via Bluetooth to the Snap and Grab board. The Snap and Grab board will send back the information and the student can chose when to review the information. No connectivity costs are incurred and information is transferred rapidly.

1.8 Success criteria

The project will be deemed successful if

1) Students can still perform their daily activities/tasks more efficiently using the new medium of information exchange.

2) Students positively respond to using the system.

Drawing from the first point, a fast convenient method of accessing information from VULA could be used alongside other traditional information accessing methods. Key differences would

that the interaction would be faster and convenient due to its ability to store and retrieve information on a mobile phone. Currently information is either saved on a flash, memorized or noted down. Saving the information on the phone also allows the student to review it anywhere and anytime without having to use a computer. A good indication of a successful system would be if students can perform the same tasks they usually do with the new system.

The project not only investigates if the students can use the system, but how it is adopted. A successful evaluation would therefore be evidenced by positive responses in how they access the information and how they use the system over time. How the students respond and appropriate the system, could open up new unexplored areas of research – integration of new technologies in education, allows new types of knowledge and expertise exchange to emerge (Yordanova, 2007).

1.9 Significance of research

The final system will be one that can provide free up-to-date educational information in a fast and convenient manner to students' mobile phones. Internet connection costs and mobile network charges affect not only the quality of education delivered, but also affect how users access information through computers and mobile phones in the developing world. Because mobile use is not fixed to a certain location, offering educational information on mobile devices may alter student usage patterns of educational materials, contributing to better educational experiences for students. Information can be stored and reviewed anytime on the phone.

Adapting the Snap and Grab board for an educational setting would offer students a free and flexible alternative to accessing educational information. Such alternatives are much needed in developing world contexts where poverty, governance problems and budget cuts in education are strife. It also means a more significant number of students can be reached due to the high mobile phone adoption rate.

This project can identify the limitations of the Snap and Grab board in an educational setting for a developing world context and answer important research questions. For example: What type of

information suitable for the Snap and Grab board would be useful to students? What implications do tradeoffs in the design and interaction have on the overall interaction experience?

The project seeks to promote the development of technologies that have been adopted by society and shifts focus away from new technologies. The project also serves to promote the use of wireless technologies and mobile devices in the developing world by giving people the ability to obtain information without cost. We believe that this approach of using existing technologies will play a major role in bridging the digital divide between the developed and developing world.

1.10 Overview of project

Chapter two describes related work and applications similar to the project and the design implications that the work has on the project. Chapter three looks at methodologies that were used in the project at various stages, why they were used and how they used. Chapter four presents design framework and implementation in stages whilst Chapter five serves as a continuation of the fourth chapter, expanding on the experimental design for the project. Chapter six presents the results, analysis and findings from the evaluation of the final system and Chapter seven concludes the project by discussing what the results mean for the project goals, the project contribution and future work.

1.11 Chapter Summary

In this chapter, the project was introduced, explaining what it is about, why it is important and how it is to be carried out. The increasing adoption of mobile phones in developing world creates the opportunity of accessing educational information on the mobile platform and is likely to have an impact on a greater portion of society. The Snap and Grab board allows for the exchange of limited free information through the use of Bluetooth. By integrating a university's learning management system called VULA, with the Snap and Grab board, educational material can be transferred to students for free in areas where mobile network access is poor. The project has two major aims, the first of which is to support student activities by adding mobile access to VULA

through the use of the Snap and Grab board. The second aim is to find out how university students respond and appropriate the technology.

The next chapter presents related work that has been done around this project topic. The chapter initially looks at how ICT plays a crucial role in education especially in an African context. The chapter proceeds to present how mobile phones have been appropriated as educational tools. The next chapter looks at these areas of research and how each field plays a role in the development of this project's system.

2. Chapter 2: Literature review

2.1 Introduction

In the previous chapter, the project was introduced, focusing on what it is about and why it is important. This chapter presents related work around the project topic. The first part of the chapter touches on ICT and mobile phones and what it means for developing nations. The rest of the chapter looks specifically at the role mobile phones play in education and how mobile phones act as interaction tools for situated boards. This chapter attempts to draw comparisons with similar projects and explains how each study plays a role in the development of this project's system. The design implications drawn out from the related work are presented at the end.

2.2 ICT and mobile phones

ICT is any technology that enables communication and electronic capture, processing and transmission of information. Mobile phones, personal computers and the Internet all play central roles in making ICT available to everyone both in developed and developing world. ICT can also be used to improve the quality of education by enhancing educational content delivery and supporting administrative processes (Neuman, 2007).

However, the factors affecting the use of ICT applications are the same, in both the developed and developing world but differ in importance (Farrell & Issacs, 2007). The major constraints in the developing world are

- Low literacy levels
- Lack of money to buy ICT equipment such as computers
- Language barriers

- Lack of affordable access to connectivity with acceptable bandwidth

When accessing the state of the educational sector, literacy levels are a common starting point. Figure 7 shows how Africa lags behind the Asia and Europe in achieving basic literacy for all. Few countries in Africa have achieved universal primary education. Debt burdens, governance problems and cuts in educational expenditure have contributed to a low literacy rate despite making many gains in the past decade.

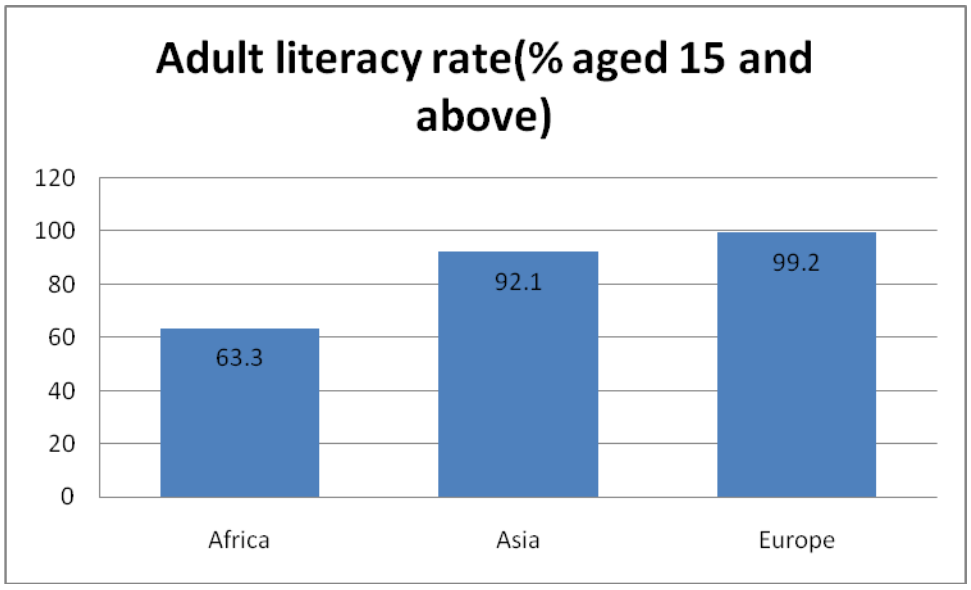

Figure 7 : Adult literacy rate, Human Development Report 2009 Data

The continent also has to deal with other problems such as HIV/AIDS which puts a strain on available human resources. Education systems are dependent on the supply of well-trained teachers, academic managers and support staff. There is need for replacement of teachers who have died of AIDS-related diseases as well as providing quality training for teachers.

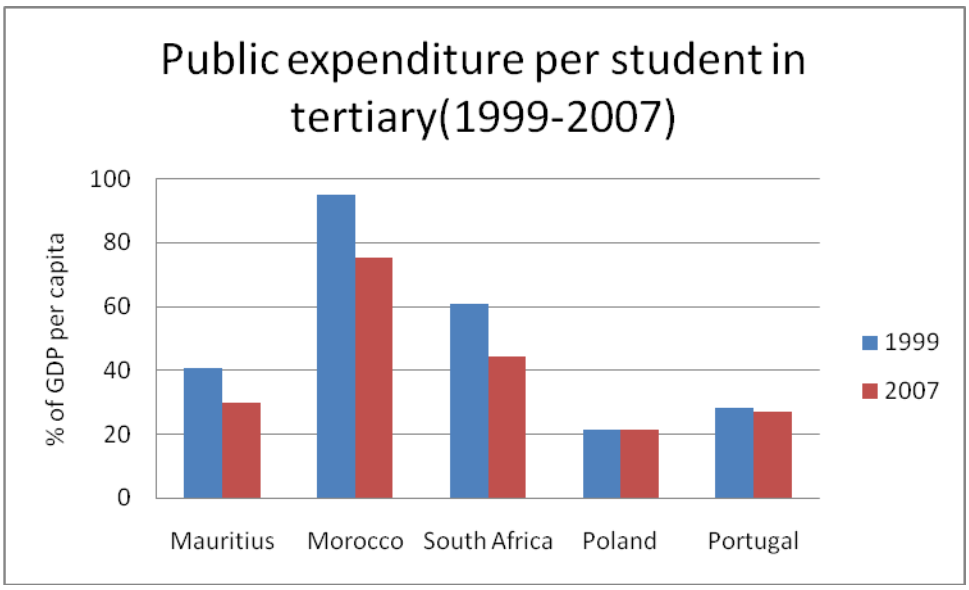

Figure 8 : Public expenditure per student in tertiary institutions

Figure 8 shows the public educational expenditure per tertiary student for three African countries and two European countries (ITU, 2009). It shows the varying amounts that countries spend on education at a tertiary level in 1999 and 2007. There is a marked difference in the decrease in expenditure over 1999 and 2007 for the African countries as compared to the European countries. This may be attibuted to African governments focusing bugets on regional problems such as food relief, AIDS and poverty. This means fewer computer labs, ICT initiatives and educational books for students.

Language also remains a barrier in implementing ICT in developing countries. In South Africa alone, 13 languages are considered as national languages. With a majority of ICT projects in English, it is easy to see why introducing ICT in these communities is difficult. Despite the challenges faced by developing countries there are successful initiatives. Alternative mediums have helped support education in native languages. In Guinea over 20,000 teachers and almost 900,000 students benefit from an interactive radio instruction program in native languages (Farrell & Issacs, 2007).

Guinea is just one of a dozen African countries using educational radio programs to support teaching and learning. In Botswana, Zambia and Tanzania the educational radio programmes are accompanied by simple printed materials, studied in controlled listening groups and involve

regular organized feedback (Farrell & Issacs, 2007). Mindset Network and the Learning channel in South Africa, the Talk Back TV in Botswana are some of the African television networks that act as a medium to deliver educational content in English and native languages (Farrell & Issacs, 2007). Madagascar is establishing "ICT villages" with digital classrooms and community ICT access (Farrell & Issacs, 2007). In Zimbabwe, mobile buses are used to bring computers and connectivity to schools in rural communities. Mozambique has community multimedia centers (See Figure 9) resulting from a merger between existing telecentres and radio stations (Farrell & Issacs, 2007).

Figure 9: A community multimedia center

The growth of mobile phone technology is viewed as the most promising enabling factor in the implementation of ICT in developing countries (Gray, 2008). The mobile phone is a technology used within the existing social structure of developing world communities and does not need to be introduced as an outside agent. It is fast becoming ubiquitous and a surprising number of the world's poor have access to it (Gray, 2008) (Yordanova, 2007). Therefore communities embrace mobile applications far easier than computer training programmes which may be difficult and expensive to set up (Farrell & Issacs, 2007) (Yordanova, 2007). Meeting the costs of maintaining

computer equipment, staff training and acquiring content materials are major challenges for other ICT initiatives.

People in developing nations have very basic ICT skills and low literacy rates and it is therefore important, to develop applications on platforms that can be easily understood and appropriated by local populations (Butcher, 2003). To bridge the digital divide between developed and developing nations, emphasis needs to be on sustainable technologies that are affordable, have relevant content and can be easily integrated into the daily lives of people (Maunder, et al. 2008) (Jones & Marsden, 2006) (Sharp & Rogers, 2007).

2.3 Mobile phones and education

Africa's mobile market has been the fastest-growing of any region over the last five years, and has grown twice as fast as the global market. Mobile growth remains strongest in the developing world. Mobile phones overtook fixed lines in 2001 and now outnumber fixed telephone lines by nearly seven to one, with 192.5 million mobile cellular subscribers in 2006 (ITU, 2009). This ratio is even higher in sub-Saharan Africa, where 9 out of 10 inhabitants with access to a telephone are using mobile cellular telephone. Mobile penetration tripled from 6.3 per 100 inhabitants in 2003 to 21.0 per 100 inhabitants in 2006.

By end of 2007, 45 out of 100 inhabitants in the developing world had a mobile phone (ITU, 2009). The following diagram, Figure 10, shows the growth of mobile telephone subscribers per 100 inhabitants from 1997 to 2007.

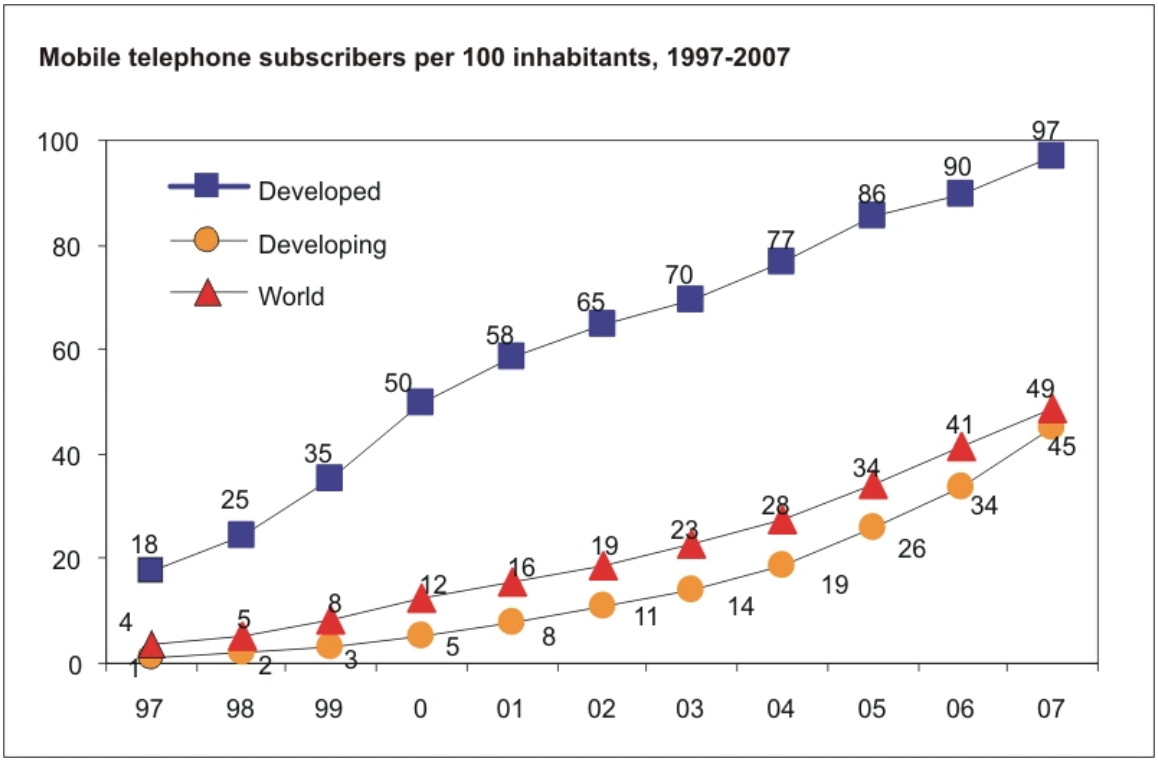

Figure 10: Mobile phone penetration per 100 inhabitants

These statistics indicate that the developing world is catching up with the rest of the world in terms of its adoption of mobile technology. Its adoption is at a higher rate than the developed world. These statistics encourage the creation of mobile applications for the developing world.

Katerina and Stephanos (Papanikolaou & Mavromoustakoos, 2006) identify and examine three major areas of critical success factors for the development of mobile learning applications which support educational purposes. The first explores the understanding of characteristics, peculiarities and constraints of the various mobile devices and technologies to be used in mobile learning. Not all phones are the same and neither do they have the same technology or applications on them. Mobile phones vary in size, cost and network capability.

The second area investigates a learner's needs and requirements. Do the applications meet the students' expectations? Do the mobile applications actually help or hinder tasks that students want to accomplish. The third area examines the quality components such as usability, functionality, reliability, efficiency, maintainability and portability, for the successful development of mobile learning applications. These factors were taken into consideration

throughout the project, but especially in identifying what elements of VULA to integrate with the display system.

Zhang et al (2006) built a Bluetooth-based e-learning system which would enable mobile learning from anywhere on a variety of devices including cell phones, PDAs and laptops. Mobile learning is learning that happens anywhere through the use of portable devices. Different from current e-learning systems which require access to the Internet, the Bluetooth-based system can establish a wireless network on the spot using a user's mobile device. To accommodate different portable devices, the system was designed for low power consumption and low cost learning. Instructors can receive instant feedback from students and check on students' performance at any time. At the same time, students can participate in the class and answer the instructor's questions in an easy way.

Brown et al (2006) designed their mobile learning environment by following a user-centered design approach. They explored understanding the work and work contexts of university students to design the system. The research was based in New Zealand and used students from the Massey University in Auckland. This research helps in identifying ways to elicit user needs and requirements using a user designed approach for an educational context.

Another example of how mobile phones have been used to support educational activities is found in a Wireless Course management system developed by researchers at Columbia State University (Zanev & Clark, 2005). The system allows the use of the wireless Web as a medium to develop, administer, and deliver course content. It also serves to support the taking of wireless course tests and student communication through the use of mobile phones. The use of email and discussion groups is already an important part of teaching environments and mobile phones enhanced student collaboration and communication.

The Math on MXiT (Butgereit, 2008) and the MobilED (Ford & Botha, 2007) Projects in South Africa are examples of how mobile phones have been used to support the educational process in Africa. MXiT is software that runs on mobile devices and allows users to exchange messages instantly at a very affordable rate. The cost factor makes the software very popular among the

young generation and is widely used in South Africa. According to the company's statistics, 45% of the users are aged between 12 and 18 (Butgereit, 2008). Math on MXiT takes advantage of the fact that students are already using MXiT and tries to incorporate discussion forums for students' mathematical concerns. The MXiT software allows users to talk with other instant messaging systems, on not just mobile devices but also desktop computers. Students can use MXiT to discuss their mathematical homework with an online volunteer tutor. Tutors are recruited from the University of Pretoria in South Africa on a volunteer basis. The project was successful in helping students with their homework due to minimal costs the student incurs when using the system and its high instant messaging speed.

MobilED (Ford & Botha, 2007) is a technology platform that provides a mobile-audio-Wikipedia functionality by using text messages (SMS). Implemented in a poor government school in Tshwane, South Africa, MobilED allowed students to search for terms sent by sms to a server. The server would call the user back and a speech synthesizer reads a related article from the Wikipedia. Uses of the technology included lessons on HIV/AIDS and a trip to a theme park. The results showed that it was not necessary to "teach" learners how to use a phone. Interviews also revealed that English was a preferred language choice for learning as it is seen as an "academic" language by the students.

What these studies show is the value of mobile phones in educational contexts. Some of the studies are in developed countries and some in developing countries. The studies also show how wireless technologies like Bluetooth, allow for cheaper solutions to be created. Focusing on mobile technology enables developers to develop more usable and personal applications because they are based on pre-existing social practices such as communication and sharing of information. However, no one is currently using a situated display and mobile phones to transfer educational material to students in developing world institutions. Despite this, we can draw valuable insights from these studies concerning the design and evaluation of our educational system.

The next section looks at how mobile phones have been used as interaction tools for situated displays.

2.4 Mobile phones and situated displays

Relatively there is a lot of work concerned with the feasibility of designing situated display systems that interact with mobile phones but, most systems lack a defined purpose of application (Juma, 2008) (Maunder, et al. 2008) (Martin, et al. 2006). Initially, situated display research work focused on promoting touch screen display systems. The Room Wizard (O'Hara, et al. 2003) is a touch screen based situated display appliance, designed to be mounted outside a meeting or conference room to provide a reservation management capability for that space. When multiple Room Wizards are mounted on the same network, they create a unified user-interface over the Internet allowing bookings for whole sets of rooms to be managed together in a convenient way.

In order to promote informal information sharing and to foster awareness of individual interests, a team based in America created Plasma Posters (Churchill, et al. 2004). These are plasma displays with interactive overlays that enable direct touch interaction for placement in public spaces. Plasma Posters are an enabling technology and no particular vision apart from information sharing was built into the display interfaces. What can be drawn from the research is that content types and styles were solely determined by users and emerged over time.

Touch screen based situated displays, however, limit the interaction the public can have and has opened the way for the use of mobile phones as interaction tools. Mobile phone based interactions which the Snap-Send-Grab board supports, can provide a number of advantages over physical interactions with a touch screen based situated board. One of the advantages of using mobile phones with displays is that more people that can interact with the system simultaneously. Another advantage is the ability of users to interact with the display regardless of its physical placement (e.g. height may be an issue for people in wheel chairs).

A situated public display named Joe Blogg was designed to receive both MMS and SMS messages (Martin, et al. 2006) from individuals. It allows participants freedom to direct the use and content of the system, thereby creating a collective narrative from individual contributions.

Joe Blogg had its content added to the system via SMS and MMS sent by mobile phone and passed to an external SMS forwarding service.

Unfortunately, the cost of SMS or MMS influences interaction with the situated display. A far greater barrier which was found during evaluation was the complicated procedure for enabling MMS services on participants' phones. A large number of users tried to send pictures but discovered the phone was not set up for this. Such studies have prompted researchers to look for cheaper alternatives to SMS and MMS such as Bluetooth.

The use of Bluetooth opened up the capability of interacting with displays without incurring connectivity costs. The CASIDE project (Cheverst, et al. 2005) used Bluetooth enabled camera phones to investigate how the deployment of situated displays can support the notion of community, both on campus and other settings. On exploring the use of Bluetooth equipped camera phones, the project planned deployment of the system alongside existing and more traditional notice boards. The display would prompt the users to send pictures or video footage from their mobile phone so that information could be shared with others. However, information cannot be downloaded but viewed on the display.

The integration of public displays with today's Bluetooth phones poses many challenges for a developer. The majority of the Bluetooth mobile phones do not support the Bluetooth API specification and this means that Bluetooth based displays can only support the newest phone models. Despite this, there is the belief that as Bluetooth matures and more new phones emerge, the current challenges will fade away.

By combining a touch screen display with a mobile phone to create audio-visual stories, the Storybank project (Jones & Marsden, 2008) incorporated the experiences of a rural Indian village community onto a situated display. Villagers access the content on the display using the touch screen, and stories of interest are downloaded to mobile phones via a Bluetooth wireless connection. Stories are created and edited entirely on the phone and uploaded locally or remotely. The methods of interaction (touch-screen and radio dial in Figure 11) the display supports, did manage to facilitate many interactions simultaneously.

Figure 11: The Storybank situated display in use in the community resource centre

Perhaps the closest system, in comparison to the Snap and Grab Board, is Hermes. The Hermes Photo Display (Cheverst, et al. 2005) is a public display application that enables users with camera phones to both send and receive pictures over Bluetooth. Both the Snap and Grab and Hermes rely on the Bluetooth personal area networking protocol for transferring content and do not require software to be installed on the client's device. Unlike the Snap and Grab board, the Hermes display utilizes a display panel with touch-screen input capabilities (Figure 12). Interaction with the Hermes board, involves the situated display receiving a picture from a user's phone and the ability for the user to select and receive pictures from the display using a mobile phone.

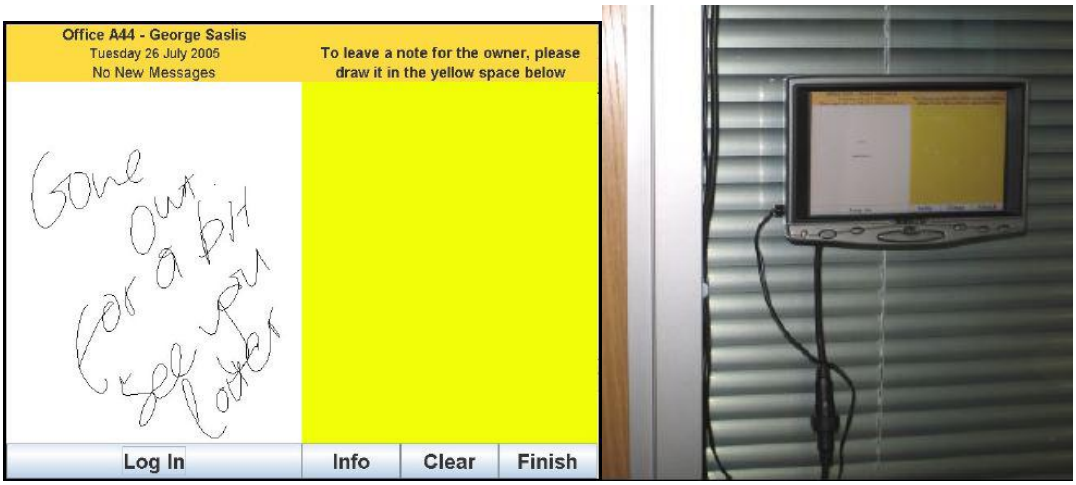

Figure 12: The Hermes II Office door display (taken March 2007)

An improved version of Hermes was developed in 2007 and supports the transferring of text messages. The Hermes II enables owners to receive visitor messages entered into the system via their mobile phones. Messages can also be left by scribbling a note of the touch sensitive screen. These messages can be viewed by the owner using the interface or if they are out of town, via email. The developers also hope to transfer video messages from visitors' phones to the owners' phones using the system while keeping the service free.

Situated displays were initially designed to support single applications, but multi-application situated displays have begun to emerge. Integration with a navigational system called GAUDI made the Hermes II system capable of allowing display owners to share control over their displays whilst supporting multiple applications (Kray, et al. 2006). This meant that users could control whether the navigational application or the message service application is active on the same display.

In summary, supporting group interaction was shown as being imperative in situated display evaluations (Hornecker & Stifter, 2006) (Kray, et al. 2006) (Maunder, et al. 2008). The physical setup of situated displays which provide visibility to interactions and handing over of control prove successful in supporting group experiences. The Hermes is not suitable for our educational context due to its inability to support group interactions. The size of the screen and its touch screen capability, limits the number of users who can use the system simultaneously. A Hermes user has to wait for their turn in order to use the system, and depending on the type of material

being transferred this may be hindrance due to the amount of time it takes to download material. Also, the touch screen means that the device must be in physical contact with the users, which greatly increases the chance of theft. The Snap and Grab board supports more media formats than the Hermes, giving the developer more media options for information exchange.

2.5 Design Implications

The following are design implications on the project that were drawn from the previous studies presented in this chapter.

Context

From looking at these existing systems, we can see that by making ICT solutions more sensitive to the local context, they are made more effective (Hagen, et al. 2005). Designing usable interactive products requires considering who is going to be using them, how they are going to be used and where they will be used (Sharp & Rogers, 2007). For this project, understanding how the user accesses educational information from VULA will be foundational to building a usable system. Computing applications should always start with a thorough understanding of how people behave in their natural settings, how they perform tasks and how these behaviors are influenced by technology (Intille, et al. 2003). Learners' needs and requirements need to be addressed in the final system. Does the system help or hinder tasks the student wants to accomplish?

Content

The use of mobile phones introduces tradeoffs in the design of the system and in what media can be used. Mobile content is different from stationery content on personal computers because quality is compromised (Lehikoinen, et al. 2007). Mobile phones have fewer pixels, less memory, small displays and small keypads guarantee cumbersome interaction. However, certain factors compensate for the loss of quality. It is smaller, lighter and is always with the user. Such factors play a role in what type of media should be extracted from the learning management system and put on the Snap and Grab board.

Content targeted for a mobile device has to be designed for short attention spans (Lehikoinen, et al. 2007) and should be relevant enough to prompt the user to use the system. It is not worthwhile building a very good system which no one will use because its information is

redundant. Providing information in text may not be appropriate or sufficient enough to keep the users interested in using the system. Use of video and image media may need to be incorporated. The Snap and Grab board facilitates the transfer of free information without connectivity cost or mobile charges. Extracting information from VULA allows students to access the relevant information through a different medium and allows the research to properly evaluate the benefits of the Snap and Grab board in an educational context.

People tend to be voyeuristic with large displays (Vogel & Balakrishnan, 2004). This raises concerns of publishing sensitive information from the VULA site on the Snap and Grab board for public consumption. Precaution has to be taken in what type of information is extracted so that it does not violate privacy issues. Therefore, private information like Gradebook and assignment marks cannot be published on the Snap and Grab board. The system should also be able to prevent other users from eavesdropping on a user's interaction (Vogel & Balakrishnan, 2004) by hiding personal information such as Bluetooth addresses.

Despite a large variety of student backgrounds and cultures, language is not a major barrier in educational contexts. For many academic institutions in Southern Africa, English is regarded as a universal language and students are required to have passed English in their secondary school before coming to university.

System

The final system should not be viewed as an end in itself, but should serve as an extension of the pre-existing VULA system with limited functionality but highlighting its advantages. Compared to the online version, the system is faster as no login is required to access information for particular courses. The speed, connectivity and mobile charge advantages that the Snap and Grab system offers, should stand out over the online version considering the same information can be accessed on both systems.

The colors, graphics and layout of information on the Snap and Grab board, may need to be adjusted to grab the user's attention. Care must be taken to avoid cluttering the interface with too much information. Information displayed by the display system must be comprehensible and

users should be able to discover its purpose through subtle interaction (Vogel & Balakrishnan, 2004). Text needs to be legible and distinguishable from the background.

The final system should allow users to carry out meaningful functions in brief periods of time (Lehikoinen, et al. 2007). Initiating and ending an interaction should be fast without requiring explicit login or logging-out (Vogel & Balakrishnan, 2004), especially considering that students can easily be put off by tedious interaction. Use of authentication by use a user's mobile phone Bluetooth ID to access personalized information would raise security issues. Phones can be borrowed or stolen. Whoever is in possession of the phone can then access the student's account and access private information.

Simultaneous interactions must be afforded by public display systems and relayed to the user in a visible manner on the display interface. The Snap and Grab board facilitates simultaneous interactions through the use of threads, but such information is not relayed in a coherent manner on the interface. The interface needs to be revised to convey the progress of multiple connections.

The Snap and Grab board uses a Bluetooth protocol to transfer information from the display to a user's mobile phone. However, the use of Bluetooth can only support the newest phone models, limiting the number of users that can use the system. There is a belief that as Bluetooth matures, more phones will emerge and the current challenges will fade away.

Evaluation

The educational sector is an area in which longitudinal studies most commonly occur (Hagen, et al. 2005). In order to understand how the final system will be appropriated by people, studies must take place over time. As with MXiT (Butgereit, 2008), cost savings for the user makes the software very popular among the younger generation but can the system remain relevant after the novelty factor is taken out of the equation? A non-intrusive study and questioning of the people who engaged with the display, is necessary (Jones & Marsden, 2008).

2.6 Summary

In this chapter, related work to the project was presented. ICT was touched on, and the benefit of low-cost technologies to developing nations was discussed. The chapter identified the limitations mobile phones have and the critical success factors for developing mobile learning applications. It presented research work and applications that enhance the use of mobile phones as learners' tools. The chapter then focused on how mobile phones have been used with publicly situated displays and interaction techniques associated with them. Comparisons and differences with the project topic were identified, and will aid in the development of the project. The last section looked at the design implications that the related work and applications have on the project. Implications for the context, content, the actual system and evaluation were presented.

The next chapter presents the methodologies to be used for the project.

3. Chapter 3: Methodology

3.1 Introduction

In the last chapter, research related to the project was examined. ICT and the use of mobile phones in developing countries were looked at as the most promising factors for bridging the digital divide. The increased adoption of mobile phones looks to promote the technology as an alternative platform in creating applications that will help people in the developing world. In order to adequately design and evaluate developing world applications, user centered techniques specific to the educational context need to be used. Lessons can be drawn from previous studies and the last section of the previous chapter presented valuable design implications for this project. These implications shape the methodologies presented in this chapter.

This chapter looks at the design techniques and methodologies, used at different phases of the project and explains why they were chosen. This project will be based on user-centered design techniques and this chapter explains the “how” or the framework in which this project will take place.

3.2 Interaction design

Following from the research studies described in the last chapter, a reoccurring approach used to design usable applications for the developing world, was interaction design. This design approach is also employed for our project. According to Preece (Sharp & Rogers, 2007), interaction design is about creating products to support the way people communicate and interact in their everyday and working lives. It promotes the use of a range of methods, techniques and frameworks in designing user experiences for all manner of technologies, systems and products.

In other words, it is about creating engaging user experiences with products by using knowledge of how people act and react to certain events in various contexts.

The process of interaction design

There are three main activities involved in the process of interaction design (Sharp& Rogers, 2007) (Jones & Marsden, 2006).

1. Identifying the needs and requirements of the users

2. Building interactive prototypes

3. Evaluating what has been built

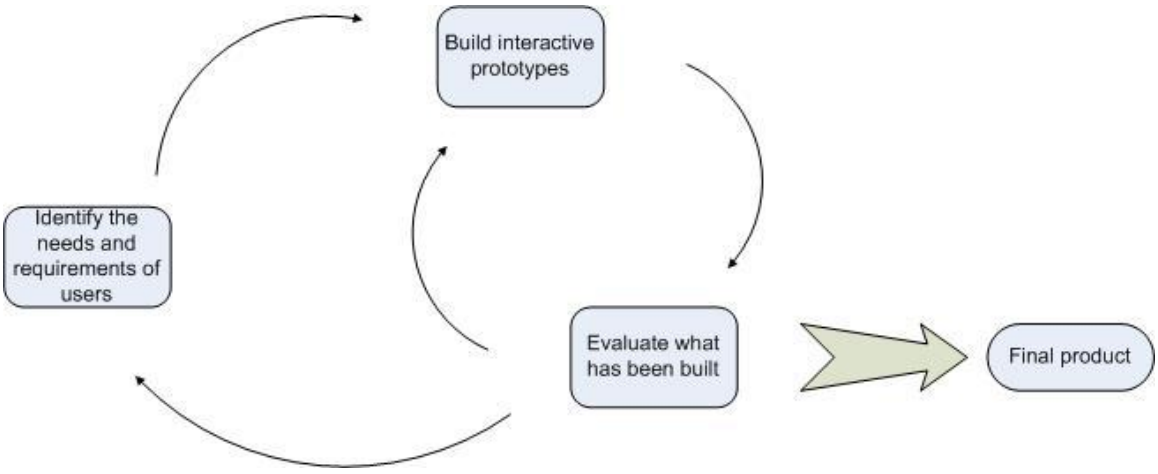

Figure 13: The interaction design lifecycle model for the project

In order to build a usable system, a user-centred approach which involves users from data collection through to testing, is used. Using this approach would mean involving a representative sample of users in the development lifecycle's three activities. The interaction design lifecycle (Figure 13) is complementary to the lifecycles models from other fields. Several lifecycle models were considered for the design, development and evaluation of the project's system. A waterfall

lifecycle model (Jones & Marsden, 2006) is a linear development model in which each step must be completed before the next step can start. However, for our project, where requirements may change over time, such a model is not appropriate. In addition, the model does not give the opportunity to review and evaluate with users. Figure 9 shows how interaction design is non-linear, thereby accommodating changes.

Though extremely flexible, the star lifecycle model (Jones & Marsden, 2006) does not specify any ordering of activities. In addition, evaluation is central to this model and whenever an activity is completed; its results have to be evaluated. Our project has limited resources and a specific time in which to be completed. The project's duration is over two years and has only one researcher. A star lifecycle model would not be suitable. In order to integrate changes that users relayed through their feedback, a rapid development approach (RAD) (Jones & Marsden, 2006) is adopted in order to iteratively develop the final system in a short period of time. It explicitly incorporates user involvement while reducing development time. Therefore an interaction design lifecycle with a RAD approach was used.

The following are the techniques that were used in the project for the three interaction design activities.

3.3 Identifying the needs and requirements of the users

Data gathering is a central part of identifying needs and establishing requirements. The purpose of data gathering is to collect sufficient and relevant data, so that a set of stable requirements can be produced. Identifying specific goals for each phase of the project shapes the nature of the data gathering, the techniques and the analysis to be performed.

The first project aim is to identify what type of information, from the VULA learning management system, could be adapted for the Snap and Grab board and mobile phones. There are several ways/techniques to elicit such user needs. This may involve observing users, talking to them, interviewing them or asking them to become co-designers.

In this project qualitative research is employed since it is very appropriate for exploratory study and development of new applications. Its emphasis is on the understanding of social contexts in which users live and work in; in our case the educational context (Jones & Marsden, 2006). Qualitative study focuses on the nature of something and can be represented by themes and patterns (Sharp & Rogers, 2007). Unlike quantitative research, a qualitative study is more flexible in exploring how a novel technology like the Snap and Grab board, can be used in a relevant and helpful manner for exchanging educational information.

In order to obtain qualitative data, the context or environment and people involved in the educational process needed to be identified and the tasks/activities conducted in the context need to be understood. The final system is a Snap and Grab board that can be used in educational institutions in the developing world to provide access to information through mobile phones to students. The University of Cape Town is used as the educational environment in which needs assessment could be obtained and evaluation could be carried out due to its accessibility and proximity to the author. The students act as co-designers and partners of the project due to their unique understanding of the educational process, activities and tasks involved in an educational context. Designers are generally more tolerant of technology than average users, so they are not representative of end users. The author is, however, also a student at the University and therefore has first-hand experience with the context. Our target users are the students at UCT for this project, also due to their accessibility.

As part of the Rapid Design approach, Rapid Contextual Design is used to understand the user's environment and their activities. Rapid Contextual Design (RCD) involves gathering data by conducting interviews with users, interpreting the data into themes and patterns, building affinity diagrams and finally prototyping and testing in short space of time. One-on-one field interviews are conducted with the users in their workplaces while they work, observing and inquiring into the structure of the users' own work practice (Holtzblatt, et al. 2004). This ensures that the project captures how students currently perform tasks and helps generate design ideas.

Interviews, questionnaires and observation are RCD data gathering techniques that can be used to obtain qualitative data from target users, the students.

Contextual interviews are conducted one on one with the students in their places of work, observing and talking about how they do particular tasks. What is important is observing first-hand how students perform their daily functions in their natural setting to gain a thorough understanding of the educational context and how it affects the user's behaviour. There are different styles of Contextual interviews relevant for this project, which are listed as follows.

Intermittent: The interviewer asks the user to save tasks they are going to do regardless of what time of the day the task is performed.

Uninterruptible: Tasks performed by the user cannot be interrupted. A pre-meeting about what is going to happen and a post-meeting about what was observed is required.

Environment centred interviews: Interviewing the environmental context by observing and talking to whomever comes to the location.

For this project a combination of all three is used. Intermittent because some tasks such as checking of announcements are done by students throughout the day whilst other tasks are only done at specific times of the day such as tutorial sessions. Some uninterruptible tasks may not be solely due to not being able to interrupt the student but also due to the student not communicating what they intuitively do. Therefore pre and post-meetings are needed. How students use the computer lab space influences how they access information therefore it is important to take into account the environmental context as well considering the social interaction between students towards information exchange. A major advantage of contextual interviews is that observations can be confirmed by users during and after the session.

It is crucial to get the best representative sample of students across all levels of study. It is also important to observe these students in their work contexts which will be different because they do not use the same computer labs. A RCD project with eight to 12 key users will reveal the

majority of the issues (Holtzblatt, et al. 2004) in the current use of the VULA system. Consolidation of the data gathered is done after a couple of interviews by building models and affinity which grow in detail as more data is collected. Early affinity can show holes in the data to guide further data collection whilst representing the key areas and distinctions for the project. From the affinity diagrams, themes and patterns can be drawn out which will influence the system design.

Interviews with the VULA administrator and lab supervisors provide information on how information is presented on VULA and how the environmental context affects the students' behaviour. These need not to be contextual but more one-on-one interviews with a structured open-ended questioning approach. Questionnaires are used to elicit information from students. This would help triangulate and confirm the results from the Contextual interviews.

The goals for the questionnaire are to find out what type of information students access from VULA often and how VULA facilitates a positive user-experience. The questionnaire is broken down into two parts. The first part of the questionnaire focuses on demographic information such as age, degree, year of study and experience with the VULA management system. Such background information is necessary for putting the questionnaire responses into context. This means answers may differ due to the student's level of experience.

The second section of the questionnaire poses open questions related to how often they use the VULA learning management system, what information they find useful, problems, favourable aspects and the user experience. The goals for the questionnaire are to find out

- How long information from VULA is relevant to students
- What information students find most useful
- To assess the favourable aspects and components of the online system
- What problems students experience with the learning management system

- Tease out any ideas the students may have

Likert and semantic differential scales are not used, in order to elicit in-depth qualitative data reflecting the students' opinions rather than restricting them to several choices or a scale. The aim of the questionnaire is not to measure the user attitudes, but to establish what information a student may want to access from the Snap and Grab board. Interviews may be more suitable in collecting such qualitative information but are too time consuming given the resources available.

3.4 Prototypes

Prototypes are a useful aid when testing out design ideas; for example, to test out the technical feasibility of an idea, to clarify vague requirements or to do user testing. The main focus of prototyping for the project is to create the best interface for the Snap and Grab board that would be suitable for an educational setting. The goals of the prototyping are to design a display that

- Supports interaction that is initiated and controlled by the user
- Supports multi-user interaction
- Generate appropriate feedback to user actions
- Accommodates educational material and makes efficient use of screen collateral
- Displays concise but understandable instructions

The resulting product is an interactive display that students can use.

The Snap and Grab board was designed for the generic purpose of exchanging free information and is not context sensitive. Its original purpose was to transfer media to and from the situated display and a user's mobile phone without incurring connectivity charges. To host information extracted from the VULA learning management system, the architecture of the Snap and Grab needs only to be adjusted to incorporate educational material.

A pragmatic design (Jones & Marsden, 2006) approach is employed to create an interactive prototype from the pre-existing Snap and Grab board and VULA. The VULA learning management system is currently used at the University of Cape Town and the Snap and Grab board is a novel situated display system, originally developed for the developing world context. Pragmatic design enables the developer to redesign existing technologies like the Snap and Grab board, to fit an educational context. In order to redesign the Snap and Grab board, co-operation from individuals involved in the educational process was needed. This suggests students coming together with the developer in order to design a usable system.

Low-fidelity prototyping is not required, because the aim of this stage is to redesign the interface of a fully functional Snap and Grab board for an educational context. Low-fidelity prototypes are for circumstances were the designer are starting from scratch and not modifying an existing product, which is the case for this project. However, this still implied the use of either inspection methods or predictive models, in order to analytically evaluate the original Snap and Grab board for redesign. Inspection methods analyse aspects of the interface and identify potential usability problems, whilst predictive models analyse the various physical and mental operations that are needed to perform particular tasks, in quantitative measures (Sharp & Rogers, 2007). Clearly, inspection methods are chosen on the basis that they are simple, do not require a lot of time to conduct and fall perfectly into the RAD approach for the project.

Heuristic evaluation is a usability inspection technique developed by Jakob Nielsen (Nielsen & Mack, 1994) in which experts are guided by a set of usability principles known as heuristics, evaluate whether user-interface elements conform to principles. An expert refers to someone practiced in usability methods and has a background in HCI. Nielson recommended the use of 3 to 5 evaluators to catch 75% of total usability problems therefore, two Computer Science

Honours students are chosen to be experts along with the author. The students' Honours project focused on improving the usability and performance of the original Snap and Grab board therefore they are well versed with the system and its usability aspects. Only two Honours students are chosen because employing multiple experts can be too costly and because they already had specialized knowledge about the system.

Each evaluator will do several passes through the system, using the heuristics as guidelines. Afterwards, results would be compared, problems prioritized and solutions implemented. The final product is a redesigned interface for the Snap and Grab board.

3.5 Formative and Summative evaluation

Evaluation is integral to the design process (Sharp & Rogers, 2007) (Jones & Marsden, 2006) (Cheverst, et al. 2005). Evaluation is needed to check that the product does what it is supposed to do and that users can use it, particularly if the technology is new. The second project aim attempts to find out how users respond to their experience with the interactive prototype and how they adopt the system into their work and social lives. This project is very exploratory, in that it is a new paradigm of interaction in an educational environment. Therefore, the project evaluation explores what users do with the interactive prototype, what they like and what they do not like.

A formative and summative evaluation is required, to measure usability and adoption of the new technology. Therefore, the evaluation of the interactive prototype is done in two parts. There is a short/formative evaluation focusing on initial user impressions of the interactive prototype and a longer/summative evaluation done over two weeks. Using this approach, improvements identified by the short evaluation, could be incorporated before the long evaluation. Both evaluations are field studies conducted in a natural setting as opposed to a controlled setting such as a laboratory. This evaluation technique attempts to draw out what people do naturally and how the product mediates their activities (Sharp & Rogers, 2007) (Jones & Marsden, 2006). It facilitates the introduction of new application and helps identify opportunities for new technology.

The Computer Science Department's reception area is used as the test environment. This is due to its proximity to the author and accessibility. The final version of the Snap and Grab board represents a traditional notice board from which students can access course information for free. The only differences from using a traditional notice board is that a student has to access the information using a mobile phone and the information is very recent. However, hanging up the Snap and Grab board in the building's corridor would pose a security risk and is likely to be stolen; therefore the system is deployed at the reception area where it could be supervised by the receptionists throughout the day.

Short Evaluation

The goal of the short evaluation is to evaluate the users' initial impressions about the interactive prototype focusing on content offered and the interface. There are several evaluation methods that could be employed such as, observation of students, asking experts, asking users through questionnaires or interviews or modelling the users' task performance. Asking experts and modelling users' task performance, are not sufficient as they are analytical evaluation methods not done by users to predict the efficacy of an interface. Interviews would also not be suitable because they are too time-consuming.

Observation of users performing a task with the interactive prototype can be recorded to help designers evaluate if user requirements were met. Qualitative data can be captured which would give insights that other techniques cannot give. This technique gives the designer first hand opportunity to observe whether certain design ideas were implemented successfully and used correctly. Do users notice system cues and error messages? Are they enjoying interacting with the system? How far away from the board are they? Certain actions, like hesitancy to use the system and social embarrassment, can only be observed first hand. These could influence where and how the board is finally deployed and identify usability problems missed by the heuristic evaluation. These issues can then be addressed and the interactive prototype revised before the next evaluation.

Observation may not be sufficient by itself though. To reach a wider group of users, collect quantitative data and compliment observations, questionnaires are also employed. The

combination of observation and questionnaires allows qualitative and quantitative data to be obtained from participants, in a limited timeframe and enables the evaluator to measure the users' opinions, attitudes and response to their experience with the system. As explained before, questionnaires are cheap and easy to create and distribute. The purpose of this questionnaire does however differ from its use in the first interaction design activity. In the first activity, the questionnaire was used to elicit information about the VULA learning management system whereas this one was designed for evaluation of the interactive prototype. Therefore, the structure and content are different.

The questionnaire is based on the questionnaire that was used to evaluate the Hermes Photo Display (Cheverst, et al. 2005) because the two systems are similar. Two of the Hermes categories (Interface and Content) are used as guide posts for the structure and format of the questions. The project's questionnaire is broken down into four sections. The first section compromises of questions relating to the participant's background information. The last three sections are structured on a 7 point Likert scale, ranging from "strongly agree" to "strongly disagree". The second section is compromised of questions related to interface issues and the third section looks at the relevance of the information obtained from the system. The final section poses open-ended questions requiring participants' comments and recommendations. A Cronbach's Alpha test was done on the questionnaire to check its reliability. The Cronbach's Alpha gives a measure of correlation between particular questions and thereby inferring the reliability of responses given by the participants.

Long evaluation

A longer evaluation is necessary because the novelty of the Snap and Grab board could result in biased user responses. Students may be excited to use the system but not necessarily like the system. Whereas the short evaluation is used to capture the users' initial impression about the system and allow for small changes to the prototype, a longer evaluation produces further insights into the user's experience due to constant use. To capture insights drawn from the long evaluation accurately, interviews are used to elicit detailed responses. Observation of users would require constant monitoring of the natural setting where the interactive prototype was

deployed, through video recording and would then involve a lengthy reviewing process. This is time-consuming and undermines the RAD process adopted by the project. It is also difficult to validate video observations without users being present and poses the danger of the video equipment being stolen. Interviews are chosen over questionnaires because the goal of the evaluation is to gain in-depth qualitative data about the user's experience. Interviews are also more flexible in exploring a range of opinions whereas questionnaires are more rigid in that the interviewer is not present to ask specific sub-questions which result from the user's responses. Participants who took part in the longer evaluation are interviewed using semi-structured approach. The evaluation aims to get responses on particular design features without restricting the user's opinions so a semi-structured approach is used.

To enrich the evaluation, data logs/log reports are given to the participants to record their interactions with the Snap and Grab board on paper. Participants are scattered and unreachable to be interviewed every day therefore, data logs can capture what they did, when they did it and what problems they encounter. Logging of interactions is opted to be done on paper instead of on computer because of the convenience of allowing students to note down their experience directly after using the system without having to find a computer first. Students may also opt to write down their experience much later if they were using a computer and could forget some aspects of what happened. Log data would be more insightful as it captures information like the problems encountered in the participants' own words.

3.6 Summary

In this chapter, the project methodologies and techniques associated with them were presented. An interaction design process with a RAD approach was adopted and was broken down into three sections; identifying the needs and requirements of the users, building interactive prototypes and evaluating what has been built. The approach is user-centred implying the involvement of users from the start to the end of the project. To identify user needs and requirements, a qualitative research approach is employed using Contextual interviews with users and triangulating results with questionnaires. In building prototypes for the project, a pragmatic approach will be employed in conjunction with a heuristic evaluation. The final evaluation of the interactive prototype is split into two field studies, a short and long evaluation

employing the use of questionnaires, interviews and data logs. For each section the methodologies were defined, their use explained, how they were conducted and analysed. The next chapter describes in detail how these techniques were employed.

4. Chapter 4: Design and implementation

4.1 Introduction

In the last chapter, the project methodologies were presented. The chapter focused on the interaction design process of the project and how each methodology was to be used at various stages of the project. In this chapter, the project's design and implementation are presented in detail.

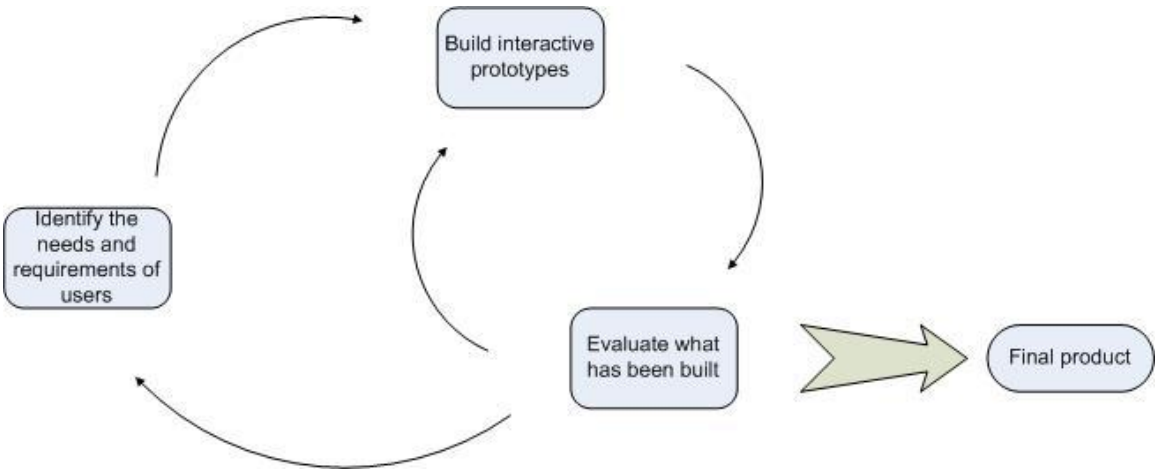

Figure 14: The project's interaction design process

The design process (Figure 14) of the project is broken down into three stages; identifying the needs and requirements of the users, building the prototypes and evaluating the prototypes. Each stage comprises of several user-centered activities. The following is the overview of the stages which are expanded on later in this chapter.

Stage 1: Identifying requirements of users

Activity 1, phase 1

Holding Contextual Interviews with a representative sample of the students from UCT, interpretation sessions and developing an affinity diagram to generate design ideas.

Activity 1, phase 2

A questionnaire is drawn up to assess students' attitudes towards VULA and confirm findings from the first activity. Open-ended interview sessions are also held with the VULA administrator and Snap and Grab board developer. This will provide expert information about the system, the context and the technology.

Stage 2: Build Interactive prototypes

Activity 2, phase 1

In order to create the best interface, it is necessary to rapidly iterate through many designs. By using a user-centered design approach, users can act as co-designers and work on the prototypes.

Activity 2, phase 2

Once the interface design is stabilized, computer-based interactive prototype are created for formative evaluation by users.

The prototype is intended to satisfy certain design criteria.

1. Architectural design, which involves mapping of requirements into the system architecture.

2. Navigational design, which involves the design of navigational pathways to enable users to access educational content.

3. Situated display interface design, which involves development of screen layout for effective communication between users and system.

4. Content design, which includes the design of the situated display content, in this case mainly text.

Stage 3: Evaluation

Activity 3

Having developed a complete prototype, it needs to be evaluated by users. Experiments are designed to evaluate whether or not the students respond positively or negatively to the final system.

In this chapter, activity 1 and 2 are looked at in detail and activity 3 is fully explored in the following chapter.

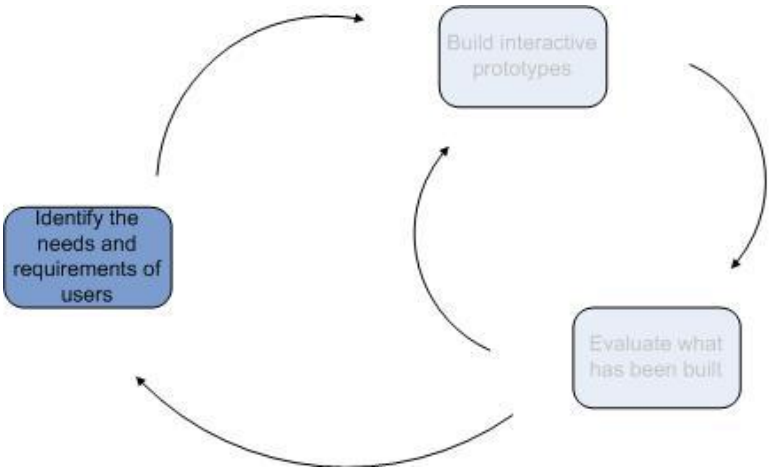

Figure 15: The first stage of the interaction design process

4.2 Activity 1, phase 1: Contextual Interviews

Aim: To observe how students currently use VULA and generate design ideas

The first stage in the interaction design process is identifying the needs and requirements of users (Figure 15). The involvement of users is crucial in the design process. The first step to designing a usable system is to consider who is going to be using it, how it is going to be used and where it is going to be used. A thorough understanding of how and where students at UCT currently use the VULA system will help in answering these questions and provide design ideas for the final system. As explained in the previous chapter, Contextual Interviews involve watching users and questioning them about how they perform tasks in their natural setting. Some key questions are

- What are the key work tasks students perform that the final system could support?
- Where are the tasks performed?
- What design ideas can be drawn from the interviews?

Participants

For Rapid Contextual Design, participant numbers are kept small due to short project time scope. Two or three different contexts are recommended having at least two participants representing each context. As explained in the previous chapter, eight to twelve participants are sufficient to reveal the vast majority of key issues for the final system. Eleven students (six male and five females) were interviewed. Students who participated in the interviews were studying IT, Molecular Biology, Social work, Civil Engineering, Genetics, IS, English and Biotechnology. Year of study ranged from 1st year to postgraduates.

Contexts

VULA is accessed from desktop computers in computer labs on and off the campus. Participants were picked through convenience sampling from four different computer labs;

- A computer lab off campus near student residences
- An Engineering computer lab
- A Science lab
- A Commerce lab

Each computer has a similar layout, with machines arranged in rows across the lab. Each lab also contains a printer. The computer lab off campus differed from the rest in that it had study rooms and a printing-credits machine as well. The Commerce and Engineering labs are larger and more spacious than the other two labs. It therefore accommodates a larger number of students.

Students were approached randomly, briefly informed about project and the Contextual design interviewing process. If they were keen to participate and could spare some time, confidentiality issues were explained and the participants' details such as their degree, year of study etc. are captured on paper. The participant is asked to describe and then perform a task using VULA that they habitually do. During the interview

- The participant is observed as they perform the task
- Each step in the task is captured

- Participant is interrupted by questions from the interviewer about what has been observed
- The interviewer's insights about the participant's behavior and actions are expressed and confirmed by the participant.

Observations and insights were noted down on paper. Design ideas drawn from the session were shared with the participant in order to get immediate feedback on the idea and how well the interviewer understood the participant's actions. After the interview, the session is summarized and related to the participant in order to check how correct the observations and inferences were. Finally the participant was thanked for their time.

Interpretation session

Data collected from the interviews was collected and rewritten on cards or affinity notes (Holtzblatt, et al. 2004) with the help of another Computer Science Masters student specializing in Interaction Design. Rapid Contextual Design interpretation recommends a two-person team both with user experience. The helper was made aware of the project's focus and the rationale for the data gathering. The author recounted the interviews guided by the paper notes, whilst offering insights and design ideas. The helper acted as the note-taker writing down informative affinity notes of the ideas and insights shared by the author. Each note was validated by both the author and the helper. These affinity notes capture observations, quotes, issues, questions, insights, design ideas and important characteristics of the tasks of the contextual interview participants. The following are two examples of affinity notes. One is a normal note and the other a design idea.

User Code10-3: Frustrated that there is no spelling check on VULA so as to edit Chat rooms comments on the society web site.

User Code09-2 Design Idea: Participant changes the view of the announcements from 20 to 50 to make it easier to search for the desired announcement.

Once the affinity notes were drawn up, they are grouped into a hierarchical representation of key issues for the students called an Affinity diagram (Figure 16). This grouping was done on a large

table. The affinity notes are grouped into key issues revealing students needs thereby showing common issues, themes and scope of student problems and needs. This was done by the author and the helper. All placements of affinity notes into columns is accompanied by justifications and double checked. Once columns start growing large, a label representing the common theme in the group is created. Once all affinity cards are grouped, the common themes/patterns and insights were noted down.

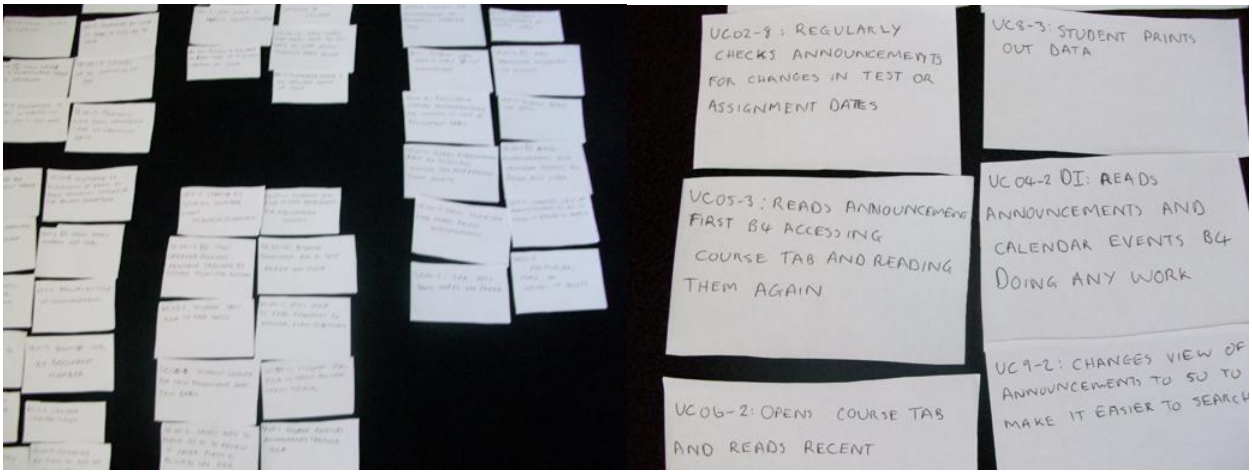

Figure 16 : Part of the Affinity diagram

Results:

- **All students check their announcements when they initially log on to VULA irrespective of the task they are performing.** Announcements were regularly changed throughout the day by lecturers and teaching assistants updating students about their courses. Most of this information is needed by students for completing of assignments, finding resources and even specifying what to bring for tutorial sessions. This is an important finding for the project related to the type of information students may want to access from the final system and is a key task students do on VULA. Currently this information is jotted down, memorized or saved to flash for later reviewing.

- **Most of the tasks involved using and searching for resources on VULA posted by lecturers and fellow students.** VULA has its courses arranged as tabs and each course has a Resources section. Resources were arranged by lecturer name, tutorial number and

week number. Resources were also saved to flash, printed or written down. This also answers the question of what key tasks the students currently do on VULA.

- **All students were frustrated by the time it took to log onto the UCT network then the VULA site to access their VULA account.** The UCT has a log on system which authenticates users when they sit at a computer through a username and password and then loads personalized settings and drives from a server. This is lengthy process as the machine's programs and user's account are loaded from the server as well. To compound the problem, opening an Internet browser results in a prompt for the user for authentication. This is done to regulate bandwidth usage and protect students from misuse of their Internet quotas by other students if they happen not to logout. Access of VULA is relatively fast but does slow when the numbers of users online increase.

- **VULA is used for non-academic purposes and extracurricular activities.** VULA allows students to create their own sites apart from the course sites available. Students can create society sites, project sites, voting sites and project group sites on VULA for extracurricular activities. Some of the tasks interview participants performed involved posting messages in Chat rooms and playing written dialogue driven games.

- **When labs were full or down, students either waited or accessed course information from reception, notice boards and friends.** This finding identifies key areas for the location of the final system. Students are knowledgeable about the locations and occasionally visit them to find information. They are currently used as alternative information zones for the students and hence take into account, space and interaction requirements. This point also stresses the need for an alternative means of accessing time specific course information.

  The reception has information about the course administrative details but very little about daily course events unless the lecturer had intentionally left a note with the receptionists. Notice boards held information which could stay on for weeks such as exam/test results, lecturer office numbers or faculty events and was not daily changed. Friends remained

the closest reference to time-specific information about the course. However, this information may be contradictory and unreliable.

Environment

Each lab has a printer for students to print out documents. Students use the printer for printing out assignments, articles, documents and the printer mainly fulfills the purpose of allowing students to review information in a paper format. The computer labs are spacious enough to accommodate movement of students. Computers are arranged on desks which occupy two-thirds of the room width as shown in Figure 17. The rest is used as a passage for students to come in and out.

Figure 17: Computer lab at University of Cape Town

Receptions have a similar approach in providing enough space to accommodate students. Reception areas however are comprised of the front desk, some chairs, tables and a printer. The printer is used by staff and the chairs allow reception visitors to wait. Enough space is created to accommodate movement of people whether they are using the printer, talking to the receptionists or waiting.

Figure 18: Notice board near a reception area

Notice board areas are located at entrances, receptions (Figure 18) and along corridors passages. Their location allows students to view information as soon as they enter the building or as they move around for lectures. However the notice boards along corridors can be problematic due to students blocking the passage for other students and staff as they review information on the board.

Verbal exchange about VULA content between students was found to be reliable only if credible sources could be found. Students trust information from lecturers, course conveners, teaching assistants or class monitors. Students revealed that friends may not properly remember test dates, venues etc. and therefore a more reliable information source must be consulted.

Design implications:

The final system could be designed to extract and house course announcements and resources for mobile consumption from VULA. Announcements and resources are regularly used on a daily basis and would contribute towards the final system's usefulness in offering daily updated information not provided by the reception and notice boards. The use of flash drives and note

books in nearly every task or activity observed emphasizes the need for students to capture information for reviewing later.

This falls in line with the project's use of the mobile phone as a tool for storing and reviewing information. The mobile phone can act the role of flash drives and note books in the students' tasks and offer the advantage of being able to review information anytime. Another design implication is that the content that the final system offers does not need to be purely academic but could be associated with student extracurricular activities. Student tasks were not limited to academic purposes but encouraged communication with other students and entertainment.

Clearly the need for a fast system or fast protocol in information exchange is also needed. Currently the process of accessing information is slowed down by authentication and loading personalized information. This implies that the final system might have to do away with student authentication. This insight also emphasizes the downloading information from the final system rather than uploading. Uploading tasks would require the student to be logged onto their personal VULA account and depending on the network speeds could result in slow transmission and a lengthy interaction.

The mobile phone's Bluetooth ID could be used to authenticate users instead of a username and password. This would allow the user to access personalized by merely sending a picture of their desired media. Use of the mobile phone's Bluetooth ID to authenticate users, however, raises security risks. Mobile phones could be stolen or borrowed and whoever has possession of the phone could masquerade as the true owner and access private information. Depending on the tasks the system supports, student records could be captured, changed or even deleted.

This restricts the type of information the final system offers not to be personalized as it would also raise privacy issues. Students might not want to share course information such as their performance and course marks over the semester. The advantage of offering generic information would be that information can be extracted from VULA, cached on the system and refreshed occasionally instead of extraction of data on every student interaction.

Clearly the final system will not be a complete alternative to the computer based system as it will cater for some tasks and not all. Its role will be alongside the computer based system to provide access to generic information in fast and cheaper manner. As discussed in the last result, the final system could be located either where the notice boards or the reception are currently located. These are the alternative areas students visit to access information aside from the computer labs. Placing the final system alongside the notice boards in the passage or at an entrance will lead to the blocking of the passage and does not allow for much movement without bumping into someone else. Reception area seems the most viable option for the location of the system. There is enough space to accommodate movement of students and reviewing of information.

4.3 Activity 1, phase 2: Questionnaires

A questionnaire was drawn up to confirm the findings from Contextual interviews and assess VULA users' attitudes towards the VULA learning management system. This would help specify usability and user experience goals. It also aids in identifying what educational information users require from the VULA system and who to collaborate with on the project. Through the process of triangulation both qualitative analyses of the Contextual interviews and questionnaires can be combined in order to strengthen results.

Participants

Decisions on who would complete the questionnaire were based on availability and how often individuals use the VULA learning management system. University of Cape Town students were chosen because they are the end users of the final system (convenience sampling (Sharp & Rogers, 2007)). Professionals recommend 5 to 12 testers are enough, to evaluate a product extensively before similar results start emerging (Sharp & Rogers, 2007). Due to the number of students who were available at that time, 70 first years and 16 Honors students filled in the questionnaire. The more testers, the more representative the findings across the user population as race and gender had to be taken into account as well.

The first year group comprised of students who study Engineering, Computer Science and Humanities helping to get a broad base of opinions from students in different study fields. They

all used VULA on a daily basis and therefore had experience with the system. They would be able to give accurate and reliable assessments of their experience with the current VULA system. For the first years, similar results did start emerging after the first 20 students but the students were very eager to take part hence the large number. 16 Computer Science Honors students also filled in the questionnaire, on the basis that they have used different learning management systems apart from VULA and due to their computing background have slightly more insight into some technical aspects of the current VULA system such as usability and performance.

For the Honors students, similar patterns in response started emerging after the 15th student, hence only 16 were used. Only first years and Honors students were used because similar results emerged from their responses and we can reasonably infer that involving second and third year would not have yielded anything new. Participants were of both genders, from all cultural backgrounds and ranging from the ages of 16 to 22.

The questionnaire was broken down into two parts (See Appendix 1). First part of the questionnaire focuses on demographic information and the second consisted of open-ended questions related to their use of the VULA learning management system. The goals for the questionnaire was to find out

- How long information on VULA stays relevant to students
- What information students find most useful
- To assess the favourable aspects and components of the online system
- What problems students experience with the learning management system
- Tease out any design ideas the students may have

The questionnaire required students to fill in their answers instead of choosing a given option. This helps to get the students insights and opinions in their own words.

Interpretation

Data captured from the questionnaires was coded into themes. This is identification of passages of text and applying labels to them that indicate some thematic idea. This enables the rapid interpretation of all the text that could be associated with some thematic idea to be collected, examined together and different cases to be compared in that respect.

After analyzing the results of the questionnaire by grouping common concerns, the most prevalent issues are reported below:

What problems did you experience associated with VULA?

22 students said their main concern was the slow response of the system while navigating the online website. Several complained about how difficult it was to get out of particular sections on the system and the frequent occurrence of page timeouts. Page timeouts were due to the large number of students accessing VULA simultaneously, usually after a lecture or at lunch time. This demonstrates how overcrowded computer labs can affect the quality of education.

What elements of VULA are helpful in navigation and presentation?

Help options, colors, font, course tabs and the menu hierarchy were identified in the interviews as being the most helpful. This was because the colors and font are kept consistent throughout the site and the course tabs and menu hierarchy have a clear and coherent layout for easy navigation.

What do you like most about VULA?

7 students pointed out its accessibility as most desirable. Students access VULA from different computer labs located on and off campus. The user-friendly layout, informative content, discussion forums, chats rooms and consistency in the layout were amongst the other replies received from the students.

What information do you find useful?

Figure 19 shows how students rated the sections on VULA. 17 students mentioned announcements as being most useful; 16 mentioned resources; 15 assignment deadlines; 14 forum discussions and 6 calendar events.

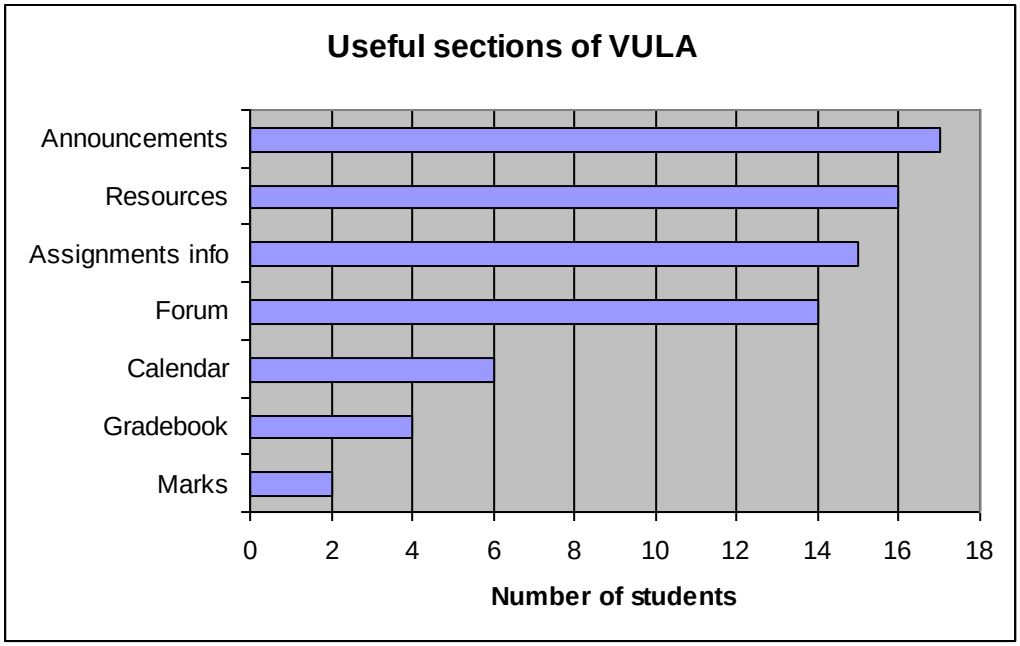

Figure 19: The useful sections of VULA

Design Implications

The results were collected and analyzed, to draw out design implications for the final system and to identify what type of information students would find useful on their mobile phones. The criterion used for the content to be put up on the Snap and Grab board was based on:

- Size of content (takes into account the phone's memory)
- How long the content takes to be downloaded (shorter time more preferable)
- Facilitates multi-user interactions (users should be able to obtain information and allow other users to interact with the display system)

From the Contextual Interviews, Announcements and Resources were identified as being most used sections of VULA to perform tasks.

However, Announcements and Calendar events are the most suitable for mobile development. Both could be represented in a text format which most phones support and are usually short in length making them small enough to be kept on the phone. Course details/information such as the ones found on notice boards and reception areas were also included as they contain information students need daily. These details are the course lecturer's name, lecturer rooms, times and venues of the course.

The timing of the provision of this information is very crucial to students to successfully complete their courses. Announcements are used by students to keep track of the daily updates on the VULA site whilst Calendar events help the student with the course scheduling for tests, exams, lab sessions, tutorials and assignment deadlines. This is representative of educational contexts in that students require updated information on the course to plan and coordinate their activities to successfully complete their studies. The method of delivery may vary due to different educational infrastructures and available resources.

Resources and assignment information were excluded due to the possibility that their sizes could exceed the mobile phone's memory capacity. Most resources on the VULA system exceed 3MB and this may be too large to store on students' phones. Another aspect is the amount of time the Snap and Grab board would take to transfer large files. A slow transmission rate would mean that the user spends more time downloading media. This could also deter those waiting for their turn, from interacting with the display. Forums were excluded because the entire topic has to be provided in order to understand comments made. This could take up too much phone memory, and requires users to spend more time in front of the board responding to an entry, thereby contributing to an unfavourable evaluation.

The Gradebook and Marks section were left out due to being sensitive information which could violate privacy agreements with student. These two sections are also accessed only when a student logs into their personal VULA account which requires authentication and this would result in a lengthy interaction with the final system.

Meetings with the VULA administrator at the University of Cape Town were conducted to confirm the findings and to decide on suitable software technologies to extract the information from VULA and place it on the Snap and Grab board. VULA tools are based on Java web services for adding, removing and modifying information. Therefore a set of Java web services needed to be written up to extract the Announcements, Calendar events and course detail information. A specific precompiled build of a learning management system similar to VULA, called Sakai 2.5x, was obtained for project development. It would serve as an offline VULA system on which development and testing could be conducted. Once the Java web services were developed and tested, they would be deployed on the actual online VULA site.

Regular meetings were also held with the Snap and Grab board's developer, to understand the system's architecture, how information is stored and how it's transferred from the Snap and Grab server. The pictures in Figure 20 show two images of the Snap and Grab board. On the left is the entire system comprising of an electronic board and a Mac mini. The picture on the right shows the Mac mini's connections. One is for the mouse, the USB flash, Bluetooth Transceiver v.3.0 dongle, display connection and the power supply. The Snap and Grab board runs on a .NET framework, uses a program called iView to do its image processing and makes Bluetooth connections through the Bluetooth dongle. The information is housed on the Mac mini in separate folders and referenced through XML scripts.

Figure 20: The Snap and Grab board consists of a display and computer hardrive with a Bluetooth dongle.

4.4 Activity 2, phase 1: Prototyping

Aim: Redesign the Snap and Grab interface

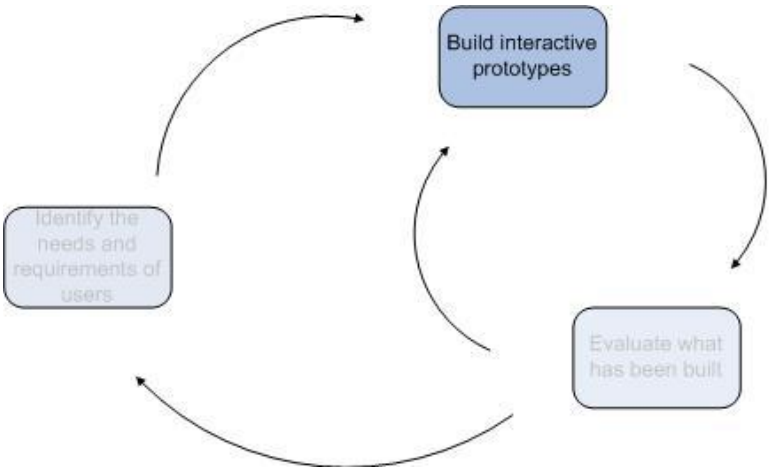

Figure 21: Second part of the interaction design process

As part of the Rapid Development approach, prototypes are a useful in rapidly testing out design ideas without implementing the full system. The main focus of the prototyping stage (Figure 21) was to create the best interface for the Snap and Grab board that would be suitable for an educational setting. The main goals of the prototyping, were to design a display that

- Supports interaction that is initiated and controlled by the user
- Supports multi-user interaction
- Generate appropriate feedback to user actions
- Accommodates educational material and makes efficient use of screen collateral
- Display concise but understandable instructions

The original interface is shown in Figure 22.

Figure 22: The original Snap Grab board interface

Low-fidelity prototyping was not required, because the aim of this stage was to redesign the interface of a fully functional Snap and Grab board for an educational context. Low-fidelity prototypes are for circumstances were the designer are starting from scratch and not modifying an existing product, which is the case for this project. Therefore, a pragmatic design approach (Jones & Marsden, 2006) was used to create new technology from a pre-existing application. This still implied the use of a heuristic evaluation in order to analyse aspects of the interface and to identify potential usability problems.

As explained in section 3.4, two Computer Science Honours students act the roles of evaluation experts along with the author because they are well versed with the system and its usability aspects.

Jakob Neilsen (Nielsen & Mack, 1994) describes eleven usability heuristics which were used as guidelines for the Snap and Grab board's interface design.

1. Visibility of system status - generate appropriate feedback in reasonable time
2. Match between system and the real world – use concepts familiar to the user
3. User control and freedom – allow users to quit interactions at will
4. Consistency and standards – design should follow platform conventions
5. Error prevention – prevent errors from occurring at all

6. Recognition rather than recall – make instructions easily available and all interaction
7. Steps should have independent information
8. Flexibility and efficiency of use – allow expert users to tailor frequent actions
9. Aesthetic and minimalist design – display only the required information in dialogues
10. Help users recognize, diagnose, and recover from errors – give users a solution when an error occurs
11. Help and documentation

Figure 23 shows the state diagram of the Snap and Grab system. The state diagram gives insights into various scenarios that could occur. This state diagram was used during the heuristic evaluation to identify all system cues during user interaction. Each expert did two passes through the original Snap and Grab board independently, carefully inspecting the product using heuristics for guidance.

The first pass was to feel for the flow of interaction and the product's scope. The second pass focused on specific interface elements in the context of the whole product such as the status bar and instructions. Problems were recorded on paper by all evaluators then a debriefing session was held to discuss the findings, pprioritize problems and suggest solutions. Most of the messages the original Snap and Grab board displays were not clear and had to be revised.

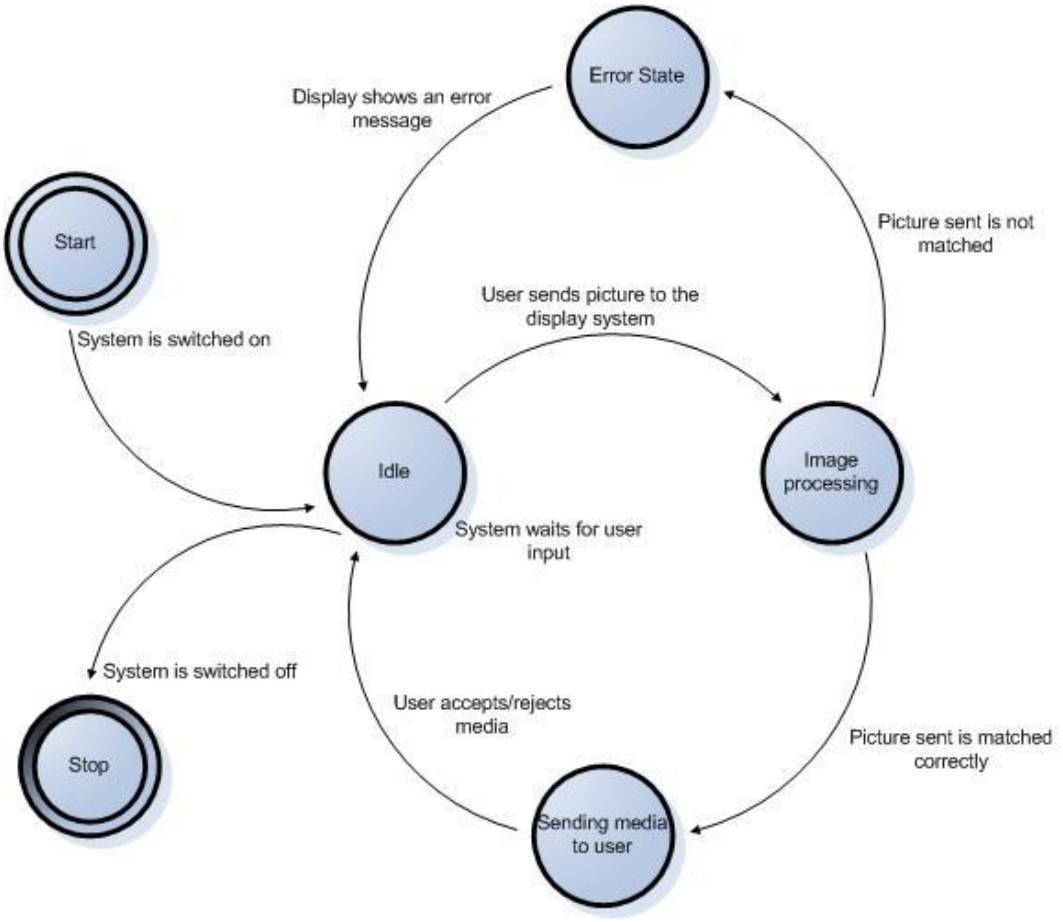

Figure 23: System state diagram

The evaluation drew out the following design improvements using the various states of the system:

Interaction that is controlled by the user

The user is meant to initiate interaction with the Snap and Grab board but this is not so obvious with the original display. The original display has the label "ready" displayed at the top of the screen, implying that the system is ready for a user to send a photo of their desired media. A status bar with an orange border was included at the bottom of the screen, displaying a clear message about how to initiate interaction with the board. When the Snap and Grab board is idle, the message "Ready to receive photo", is displayed in the status bar as shown in Figure 24. The orange color draws users' attention to the status bar as well.

Figure 24: The system's idle state

The support of multi-user interactions

The original Snap and Grab board supports multiple interactions but does not notify the users through the board's status. Instead, differently colored bounding boxes around the selected media captions on the display are used. The board's status was redesigned so that when multiple users interact with the system, they are identified by a unique number as shown in Figure 25. The status bar reads "Student 1" identifying the first connection with the board. Subsequent connections are assigned a number accordingly.

Figure 25: The status of the system when an image is sent by the user

Generating appropriate feedback

In addition to displaying messages related to multiple users and initiating a dialogue with the display system, the improved system displays appropriate feedback for each interaction in a polite and concise manner. Figure 26 shows the message status when the system is busy.

Figure 26: The status of the system when matching the sent image

Efficient use of screen collateral

The original Snap and Grab board has eight media spots on its screen at any given moment. The interactive prototype would be deployed in the Computer Science department as part of a field study therefore; it housed Computer Science course material. Computer Science courses were chosen due to the convenience of acquiring this course information. In total, there were five Computer Science courses running in the semester and therefore, five media spots were used with an additional media spot for Help or promotional media packages (Figure 27). Each spot

was assigned a picture from the online VULA management system and each media spot appropriately labeled. The layout of the courses helped to accommodate the status bar at the bottom and instructions on the right.

Figure 27: The layout of courses on the display

Concise but understandable instructions

Instructions were originally laid out across the bottom of the screen but users who evaluated the original board complained about not having seen the instructions because they do not stand out. For the improved version, instructions and the status were bounded by brightly colored orange borders and clearly labeled. To make the instructions more noticeable, they were arranged vertically on the right side of the display as shown in Figure 28.

Figure 28: The instructions

Microsoft Expression Blend was used by the author to redesign the original Snap and Grab display interface to satisfy the above design criteria. Microsoft Expression Blend runs on the Silverlite platform and separates the design information (XAML markup) from the application logic (C#, C++, etc).

The changes made on the interface were:

- Top banner identifies the department in which the board is used
- Instructions were moved to the right of the display and explained the purpose of the board.
- A status bar displaying helpful messages was created at to the bottom of the screen.
- Media spots were reduced to six, due to the number of courses available in the department.
- Orange bounding boxes were intentionally created to stand out from the rest of display and draw attention to the instructions and the status bar.

The final interface for the revised Snap and Grab board is shown in Figure 29.

Figure 29: The final interface

4.5 Activity 2, phase 2: Interactive prototype

Aim: Create a prototype that houses VULA information

The first step in this phase was extracting the relevant information from the VULA learning management system. After meetings with the VULA administrator, Java web services were created to extract course information, announcements and calendar events from the Sakai management system. The VULA system runs on top of Sakai, a Java based Open source learning management system. Development of the web services was done on a precompiled build of Sakai which acted as a proxy VULA management system until the web services were robust enough and thoroughly tested to be deployed on the online VULA learning management system.

Development of the application logic for the Snap and Grab board, was done in Microsoft Visual Studio 2005 on the Microsoft .NET 3 framework. The application logic of the original system had to be adjusted to cater for text and mobile game formats. Announcements, calendar events and course information were formatted into three text files which would be transferred to a user's phone for a particular course selection. C# was used to extract, format and store these files on the Snap and Grab board's repository.

What is important to note is that Announcements, Calendar events and course information represent three different tasks which students perform independent of each other. Some of the tasks observed in the Contextual Interviews were solely to read the latest announcements but not the calendar events. By splitting up the information into three files instead of one, users can chose which task/s they want to perform with the system.

The announcements web service extracts three of the latest course announcements from VULA and writes them to a file. Three announcements were chosen due to concerns about the information taking up too much mobile phone memory. In addition, the longer the announcements, the larger the resulting files therefore slowing down the file transfer to the user. Calendar events are summarized therefore all the events were extracted for the current month. The Course information file contains details such as the course pre-requisites, contact information and location of the lectures.

A web service client application was created to call the web services, which extract these files. Development was done on NetBeans, a Java IDE. There are two ways in which the web services could be called. The first involves calling the web service client every time when a user selects a particular media spot. This requires the Snap and Grab board to be constantly connected to the Internet. The obvious advantage of this approach is that the user obtains up-to-date information which is on the online VULA system at that precise moment. The disadvantage to using this approach is that there is a time lag introduced by the web service client logging into the VULA system, extracting and formatting information, before sending it back to the user. In addition, multiple user connections can only access the Internet one at a time through one socket address.

The second approach involves running the web service client only at certain times of the day when the display is idle and then caching information on the Snap and Grab board's server. The major advantage of this approach is its fast speed when exchanging information but suffers from the possibility that the information is not precisely up-to-date with information online depending on when the Snap and Grab board refreshes its cache. This approach was chosen due to its speed advantage and the likelihood of information on the VULA site not changing regularly. Figure 30 displays this approach.

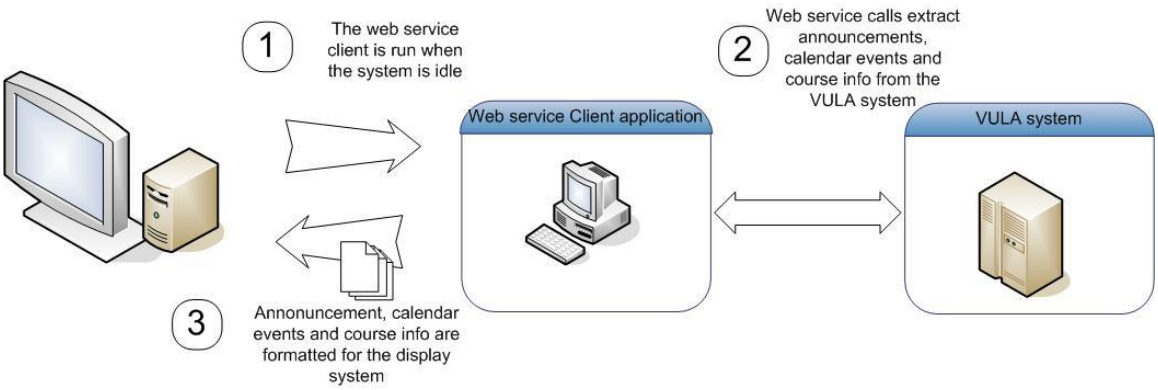

Figure 30: How the board calls its web services

The final system can display up to six courses for the corresponding department. A user would approach the display, take a photo of the media caption corresponding to their desired course and send it via Bluetooth to the display system. The caption is matched on the Snap and Grab board's hardrive and once correctly matched, Announcements, calendar events and course information files are transferred via Bluetooth from the Snap and Grab board's repository to the user's mobile phone. Each file requests the user to confirm whether or not they want to accept the files giving the user, flexibility in the choice of media they want to download from the display system. Users may want calendar events but may not want to receive course information. As mentioned before, each file represents a task students perform often. However not all tasks are done daily or at the same time thus a user would not need all three files from the system all the time.

4.6 Summary

This chapter covered the activities involved in achieving the first project aim. The first project aim involves creating mobile access to VULA information by identifying VULA's key elements that can be adapted the Snap and Grab board. The project was broken down into three activities with activity one and two having two phases each. The first activity consists of Contextual interviews and the drawing up a questionnaire to assess student attitudes about the current VULA and then validating the data collected. The second activity involves creating paper prototypes and interactive prototypes through a heuristic evaluation. The third activity, which will be discussed in the next chapter, describes the evaluation of the final system.

5. Chapter 5: Experimental Design

5.1 Introduction

The previous chapter described the project design and implementation process in detail. This chapter presents the evaluation of the project by going through its experimental design. The second project aim was to find out how the final users, the students, would respond to interaction with the revised Snap and Grab board and how they would appropriate the technology to their everyday life. Observation in a controlled environment followed up by questionnaires and interviews were chosen to evaluate the project. Using these different evaluation techniques, different perspectives about the system can be obtained. Each evaluation will tell a story from a different point of view and together, give a broad picture of how well the design meets the usability and user experience goals. Firstly we describe the final interactive prototype.

Figure 31: Final interactive prototype

5.2 The final interactive prototype

The final interactive prototype was run on a Windows XP operating system and connected to a plasma screen display (Figure 31). The size of the display allows multiple users to operate the system simultaneously. A Transceiver 3.0v Bluetooth dongle is plugged into the PC to allow Bluetooth connections to the Snap and Grab board and the transfer of media from the board to a user's mobile phone. Figure 32 shows an image of the final interactive prototype in its idle state. The status reads 'Read to receive photo', implying that the user initiates the dialogue with the display system by sending a photo. Each course is represented by a picture on the display and labeled accordingly at the bottom of each caption. A user takes a photo of their course's media caption and sends it to the display via Bluetooth.

Figure 32: The revised Snap and Grab board interface

The display system extracts the user's Bluetooth ID from the submitted photo and does image processing using iView software to match the submitted photo. The board's status notifies the user that it received a photo by writing 'Received photo from Student X' (X stands for the number of users currently interacting with the board). The iView software on the Snap and Grab board's server, does image processing by visually tagging areas of the light and dark areas of the

photo and then comparing these areas to the original photo. The status bar changes to 'Processing photo. Please wait', notifying the user that their photo is being matched.

If the photo is positively matched, the media spot on the screen is highlighted by an orange boundary (Figure 33). The status box reads 'Sending text back' indicating the transfer of media related to the media spot chosen. Announcements, calendar events and course information are sent back to the user's mobile phone in three separate files in the case of a positive match. If the was a negative result in the matching, an error message is displayed and then the system returns to its initial state.

Figure 33: A positive match continues with the transfer of media

The reception area was chosen as the ideal location for the evaluations. The area has space to accommodate the whole system and student interactions with the system. The reception also has receptionists on duty throughout the day making the system secure from theft. An ideal choice would have been closer to the Department's notice boards which were located in the corridors and building entrances. However the board would be unsupervised most of the time and thus be more susceptible to theft. Placement of the system in the corridors and entrances could also cause blocking of these areas when the system is being used by many students. The corridors are not

wide enough to accommodate student interactions with the board and movement of people passing by. Figure 34 shows the width of a typical corridor in the Computer Science building and the resulting blocking of the corridor when only three students view information on the notice boards. Placement of the system at building entrances would have caused a similar problem.

Figure 34 : Narrow corridor widths

5.3 Participants

The end users of the final system are university students. A key aspect of evaluating the interactive prototype was choosing individuals who are representative of the anticipated users of the final system. Participants were chosen from different fields of study at different levels of study. Students majoring in Mechatronics, Actuarial Science, Electrical Engineering, Computer Science, Social work and Biochemistry volunteered to take part in the study. Students had to be doing a Computer Science course (but not necessarily majoring in Computer Science) to take part in the evaluation because the prototype held information about Computer Science courses.

In total, 39 University of Cape Town students ranging from ages 16 to 22 took part in the evaluation. Professional evaluators argue that 5 to 12 testers are enough for an evaluation thereafter results would not yield anything new. An evaluation of a similar project involving the Hermes display used 17 students for the evaluation of their system. 39 participants were used to get a broad and unbiased view of the user experience. Each level of study had to be represented. Gender and race demographics also had to be catered for.

Students were recruited from Computer Science classes and computer labs. Figure 35 shows the breakdown of the participants involved in the evaluation. Ratios were dependent on the availability of each group.

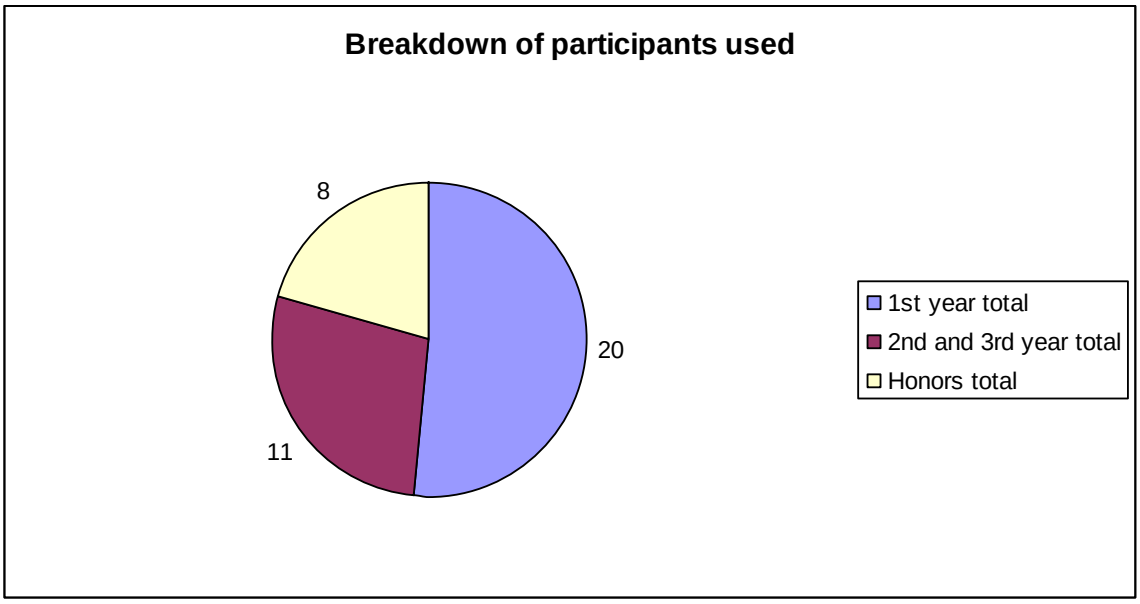

Figure 35: Breakdown of participants

5.4 Experiment design

The evaluation of the interactive prototype is done in two parts. This entailed a short evaluation and a longer evaluation in a natural setting. Participants were paid R20 for taking part in the short evaluation and R100 for the longer evaluation.

Short evaluation

Location: Computer Science Reception

Number of participants: 39

The participants were composed of students in their first, second, third and Honors year from different degree backgrounds. The only prerequisites were that they were studying a Computer Science course since the interactive prototype housed Computer Science course material and they had a Bluetooth-enabled camera phone. Users were asked to perform a task and thereafter fill in a questionnaire about their experience with the interactive prototype.

Procedure

Participants were briefed on what the project was about and asked to sign a consent form (Appendix 3), if they wished to take part in the evaluation. Participants were then ushered, individually and in groups, to the reception area, where the interactive prototype had been set up. Participants were asked to perform a task. The task required users to look over the display and thereafter, download desired course information from the board using their mobile phone. Participants were then asked to review the downloaded media on their phones. Users were allowed to ask questions about the system as well. Directly after using the interactive prototype, participants were asked to fill in a questionnaire (Appendix 2).

As mentioned before in Chapter 3, questionnaires were chosen because they are cheap, easy to create and can be distributed to many individuals. To prevent bias, the questionnaire was filled by participants randomly selected from classes doing a Computer Science course. Therefore participants differed in gender, age and degree majors, contributing to a rich evaluation.

The questionnaire was based on the Hermes Photo Display questionnaire (Cheverst, et al. 2005). Several relevant questions from the Hermes questionnaire were repeated in the project's questionnaire. These mainly queried Interface and Content issues of the user's interaction. The questionnaire was broken down into four sections. The first section compromises of questions related to the participant's background information. The section presents questions related the participants' degree, the model of mobile phone they are using, if they have used Bluetooth before, how often they use VULA and if they have previously participated in a similar study.

The last three sections were structured on a 7 point Likert scale ranging from "strongly agree" to "strongly disagree". The second section compromised of questions related to interface issues. Does the way the interface is designed, communicate

- The purpose of the system properly
- How to obtain information
- The use of Bluetooth
- Whether there is enough feedback from the prototype about what is going on.

The third section looks at the relevance of the information obtained from the system. Participants were asked to rate the usefulness of the media files, whether they had control over what they wanted from the board and if they could easily find their downloaded content from the board. The final section asked the participants if they had any particular comments and recommendations, pertaining to their experience with the interactive prototype.

Long evaluation

Location: Computer Science Department's reception

Number of participants: 20 students were used due to their availability over two weeks of evaluations.

The longer evaluation involved a field study over two weeks. Field studies are done in a natural setting as opposed to a controlled setting such as a laboratory. The evaluation attempts to draw out what people do naturally and how the product mediates their activities (Sharp & Rogers, 2007). It helps facilitate the introduction of new technology and helps identify further development opportunities for the Snap and Grab board. Evaluation was conducted during the exam season therefore few students were on campus.

The first years were chosen for this evaluation due to their availability during the exam period. The senior students were rarely on campus and opted not to participate due to not being available for two weeks of testing. Participants were paid for their time and their interactions with the system were recorded to ensure the collection of reliable data. The evaluation techniques used for the long evaluation were interviews and the use of data logs.

Procedure

Participants were given a brief introduction to the system beforehand, asked to sign consent forms (Appendix 3) and then proceeded to test the interactive prototype at the reception area. Here they conducted the short evaluation before receiving data logs and an interview schedule. The Snap and Grab board was deployed at the Department's reception for two weeks. No specific task was given to the participants apart from using the system. In fact, participants were encouraged to explore and test any aspect of the system they desired but to record their visits and

what they did on the data logs directly afterwards. The data log was done on paper and required the participant to fill in the time, day, problems encountered and type of content they downloaded every time they used the system. This would give useful usage patterns over the duration of the evaluation in the students. Paper based recording was opted over electronic due to the convenience of recording the interactions without need for a computer.

Interviews were scheduled with the participants on Fridays over the two weeks, to gain a better understanding of the user's experience over a period of time. The first Friday was used to draw out improvements and suggestions from users. The interview was also used to check that participants were using the data logs. The second Friday would evaluate whether these improvements made a difference in the user's interaction with the Snap and Grab board. Interviews were audio recorded so that they could be reflected on by the evaluator.

Privacy issues

In order to protect the rights of individuals and to avoid taking part in work they might not want to, privacy issues were written up into a consent form (Appendix 3) for the individuals to read and sign. These included agreement to compensation, taking part in recorded interviews and making sure their names are not used for any publications. A participant could not take part in either evaluation unless they signed the document.

5.5 The Novelty factor

It is necessary to evaluate public situated applications in its natural setting over several weeks (Maunder, et al. 2008). The novelty factor or initial gratification that the revised Snap and Grab board has, can wear off over time. Users need to be able to reflect on how beneficial such systems can be to them, take ownership and gradually integrate it into their lives. Therefore our display system was evaluated over two weeks. The length of the evaluation period could have been longer but due to the RAD approach employed for the project and availability of the participants, the system could only be evaluated for two weeks. It would obviously have given more data to run the trial for a longer period, but two weeks of consistent usage drew out enough data for us to act on.

The display system was to be deployed in the Computer Science Reception area for two weeks and participants were asked to use the system whenever they wanted to and however number of times. By so doing, participants had been given the freedom to use the display system as they would on a normal day to day basis. An alternative location would have been where the actual departmental notice boards are situated, in the corridors and main entrances. However, because of security concerns the reception area was preferred. Evaluation over a period of time removes the novelty factor of the system and allows for unbiased and correct views to be recorded.

5.6 Summary

In this chapter the experimental design for the evaluation of the project was discussed. The evaluation stage of the project addresses the second project aim since it explores how users will respond and appropriate the technology in their everyday lives. The experimental design outlined in this chapter builds the foundation in achieving this aim. The next chapter presents the results of the evaluation.

6. Chapter 6: Findings

6.1 Introduction

The last chapter discussed how the project was evaluated. The third project activity entailed setting up experiments to evaluate the final interactive prototype which was expounded upon in the previous chapter. This chapter discusses the results and findings of the evaluation of the interactive prototype.

6.2 Short Evaluation

The interactive prototype was set up in the department's reception area and participants were asked to complete an evaluation task. The task involved capturing a picture of desired media using a mobile phone, transferring the picture to the interactive prototype via Bluetooth and receiving media from the board. Users were also asked to find the downloaded media on their phone and to look over it.

Observation

Participants tried out the system either individually or in groups of five. Three groups of five were used with five users testing out the system individually. This was done intentionally in order to observe both individual and group behavior in front of the display system. The evaluator was present at the reception with the users to answer questions and direct the evaluation. Careful observation of participants using the system was noted down on paper. Individually, users were slightly intimidated by the presence of the evaluator but users in a group were not bothered.

Results:

It was observed that those who tested out the system individually took longer to interact with the system than those in a group. This may have been due to the presence of the evaluator thus making the user more tentative in their usage of the system. Social embarrassment is reduced in a

group context because individuals can ask others what they did or watch other people as they interact with the system.

The group evaluating the system would wait for someone to take the first step then everyone would either watch them or join in. When several of the participants could not either find their downloaded content on their mobile phones or switch on their Bluetooth, the other participants stepped in to help. Considering that the system was deployed with an educative context in mind, it was not surprising to find students who were curious about the display system and what it can do. Having finished their task, some participants explored the media contents offered by other courses on the Snap and Grab board. The general mood was excitement and users were clearly happy to have used the system.

Questionnaire

Directly after using the interactive prototype, users were asked to fill in a questionnaire. The questionnaire consisted of three sections covering background information, interface design and content relevance.

Reliability of the questionnaire

A Cronbach's Alpha test was done on the questionnaire to check its reliability. The Cronbach's Alpha gives a measure of correlation between particular questions and thereby inferring the reliability of responses given by the participants.

Question	Reliability coefficient
4 and 8 in the same section	0.5608
8 and 16 in different sections	0.2463
3 and 4 in the same section	0.8186

For a reliable questionnaire, the reliability coefficient for questions in different sections should be low implying the questions do not depend on each other and therefore a user's answer rating

for the questions would be different from each other. For questions in the same section the reliability coefficient should be closer to 1 to signify reliability.

Results:

First section: Background

All participants had some experience with using Bluetooth on their mobile phone and no one had taken part in a similar experimental study. The models of mobile phones used were Nokia, Samsung or Sony Ericsson. The phones also had to be Bluetooth enabled and equipped with a camera. Six of the participants responded to having used the online VULA system 2 to 3 times a day whilst the rest of the participants use it daily. This meant that the right participants with desirable criteria had been chosen.

Second section: Interfaces issues

56% of the students used the instructions to learn how to use the display system whilst 12 students did not agree to having learnt about the system using the instructions. This was mainly due to the pre-briefing about the project and the fact that participants could ask questions during the experiment. In addition, users in groups could ask each other or observe what others were doing.

Despite this, 87% of the students found it easy to get started with the system and 79% understood what the display system did. 85% positively agreed that it was clear how to get information from the display to their mobile phone and 90% of the students agreed that the display's design was visually appealing. During the evaluation, users were inquisitive about the system and asked to explore other courses on the Snap and Grab board. These observations are evident in the percentages.

Focusing on the interaction, 92% of the students found sending a picture over Bluetooth simple and straightforward. In terms of feedback messages about what the system is doing, 72% positively felt the system gave sufficient messages. In addition, 92% of the students liked the idea of being able to send pictures to a situated display on campus from their mobile phones.

During evaluation participants appeared to quickly grasp what they needed to do to get information from the interactive prototype. Figure 36 shows this distribution graphically. The graph is positively skewed emphasizing the positive response users had to their experience.

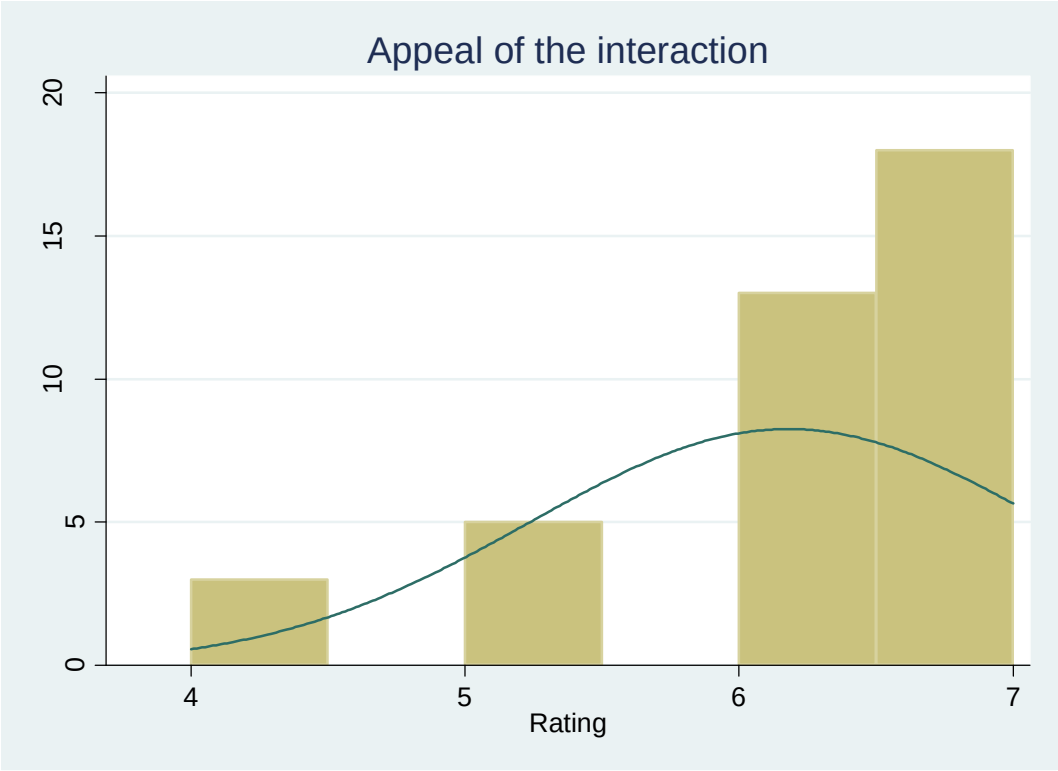

Figure 36: How users rated the appeal of the interaction

Third section: Content

72% felt they had control over what they wanted from the board. After having downloaded content each participant had to find the content on their phone. 79% said they easily found their downloaded content, 8% were unsure and 13% found it difficult. This was evidenced by how several students had problems finding their downloaded content during evaluation. This was mainly due to participants using phones which store downloaded media in the root folder instead of the media folders.

Figure 37 shows a positive skewed distribution of how users rated the control they had in the dialogue with the interactive prototype.

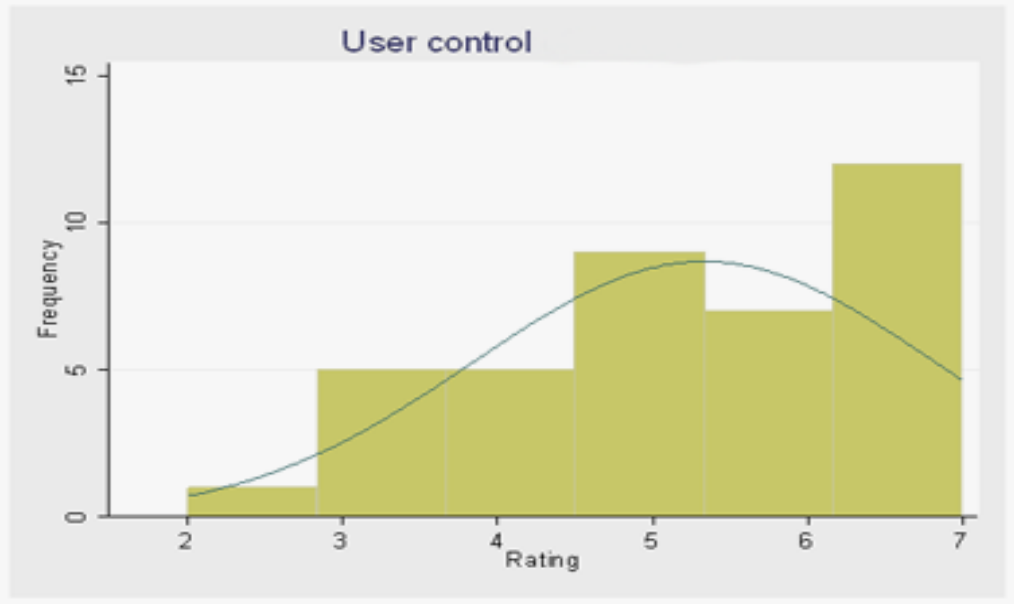

Figure 37: User control rating

Focusing on the relevance of the downloaded content to the participant, 92% said they found the announcements useful, 74% found the calendar events useful and 77% found the course information useful. This validates the initial questionnaire results, about the type of content from the VULA website that would be useful and suitable for mobile phones.

Figure 30 shows a box-and-whisker plot for file content against ratings given by the participants. The upper quartile of announcements and calendar events are the same as the maximum indicating a strong positive opinion about the relevancy of the content. Though having a shorter "box", course information has its whiskers between 4 and 7 implying that the worst opinion was "unsure" and the rest of the opinions were positive.

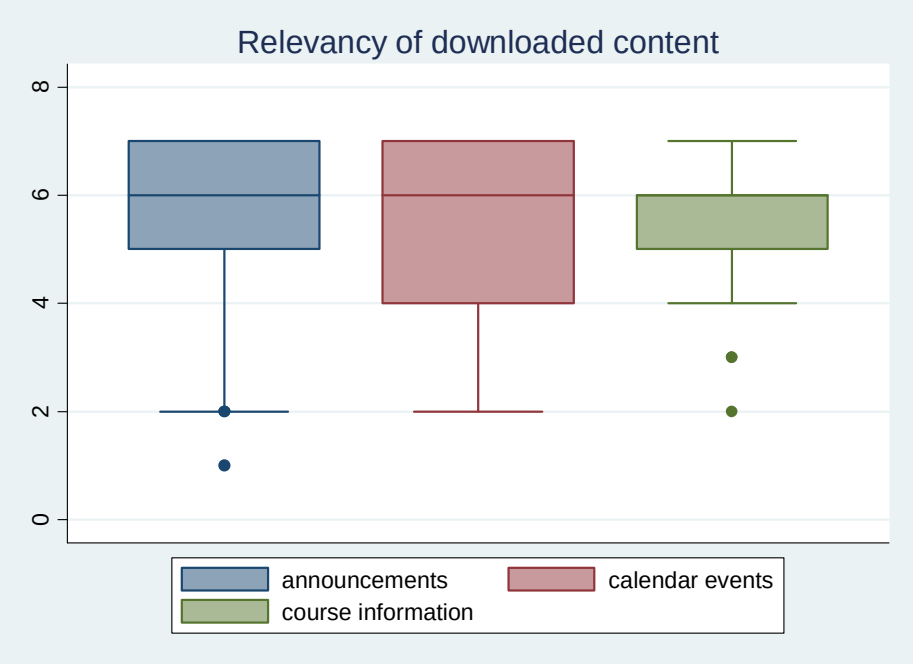

Figure 38: Relevancy of downloaded content

When asked if the participants would share information they downloaded with friends, 87% agreed that they would. Figure 38 shows the distribution of how the participants rated their overall experience with the interactive prototype. Apart from the outlier on the far left, the right-skewed distribution indicates that most viewers had a strongly positive opinion about their experience. Participants were glad to have used the system and were eager to take part in future studies. The box and whisker plot portrays the rating of the overall experience for the particular age groups. Overall, 97% of the students found the experience enjoyable. Figure 39 shows how strongly people positively found their experience. Figure 40 shows how the overall experience is distributed among the different levels of study. Each box and whisker is plotted against user experience rating. This diagram shows consistency of the opinions despite different levels of study. All groups had positive views about the system.

Figure 39: Overall experience

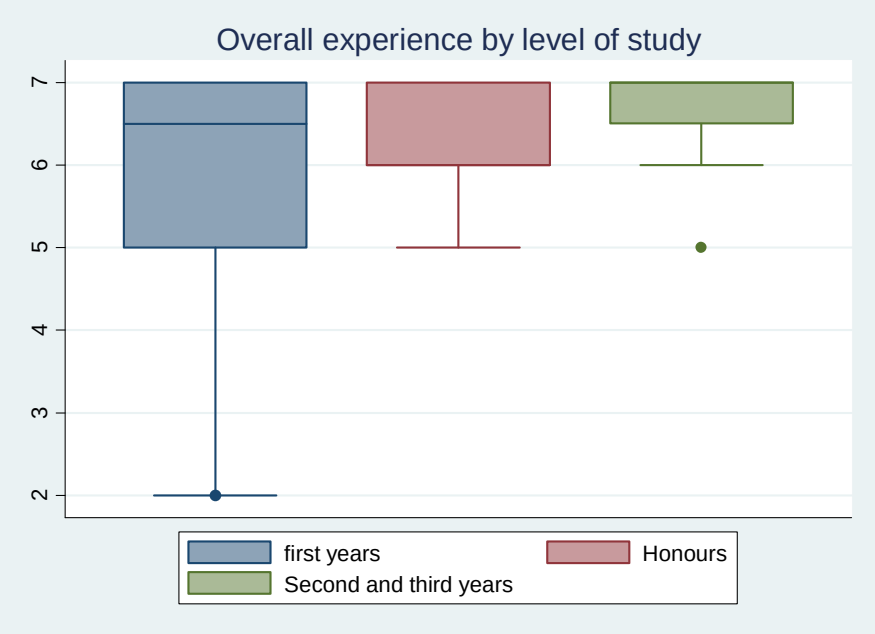

Figure 40: Overall experience by year of study

6.3 Findings from the short evaluation

Most of the phones that were capable of interacting with the interactive prototype were Nokia and Sony Ericsson phones. Since information was being transferred in a text format, some phones did not have text viewing capabilities and would store downloaded files transferred from the board in the inaccessible root directory. Apart from Nokia and Sony Ericsson phones only the Samsung e250 and Samsung p310 worked properly duration evaluation. These findings emphasized the limitations of the system, as not being accessible to everyone with a Bluetooth camera phone and defined the criteria for participants' phones taking part in the longer evaluation. Users noticed the status updates on the interface and clearly enjoyed interacting with the system.

Though instructions were not used by 44% of the users, this did not detract from a positive overall user experience. Usability problems were identified, such as incorrect delivery of media when a picture sent by the user is incorrectly matched and problems associated with the length of timeouts. These issues were resolved before the next evaluation was conducted. Positive responses were recorded in both the interface section and the content section.

Students expressed different ideas pertaining to the type of content they would love to have on the board. The original board had a video about how to use the system. Users came up with suggestions to include lecture videos, games and music. These ideas shaped some of the board's content for the long evaluation and would give insight into the use of multimedia alongside educational material. To get a more qualitative insight of the system's usage over time, a longer evaluation was conducted.

6.4 Long Evaluation

This evaluation was carried out over two weeks and the interactive prototype was set up at the Department's reception. Participants were asked to use the system whenever they wanted to, however many number of times they wanted to, but to make sure they recorded each visit on their data logs directly afterwards. Interviews were held at the end of the week on Fridays. Participants are shown in Figure 41 using the system.

Figure 41: Participants interacting with the system

Data logs

Data logs were returned by the participants after the two weeks of evaluation and helped in identifying usage patterns of the display system. Four slots were provided on the data log for participants to record the time, day, media downloaded and any further comments about the system. To ensure that participants provided reliable data, data logs were checked by the author after the first week and R100 was paid to each participant after the two weeks. The diagram below (Figure 42) shows how the system was used over the two weeks of evaluation. People who were not part of the evaluation were allowed to use the system as well therefore data logs gave an accurate measure of only the participants' activity. The diagram shows high activity during the first week (74 downloads) with the busiest day being Wednesday. The second week shows a decline in use (53 downloads) but a steady downloading pattern. This was a positive result because it shows a steady pattern of usage, but a longer evaluation would be needed to confirm these findings.

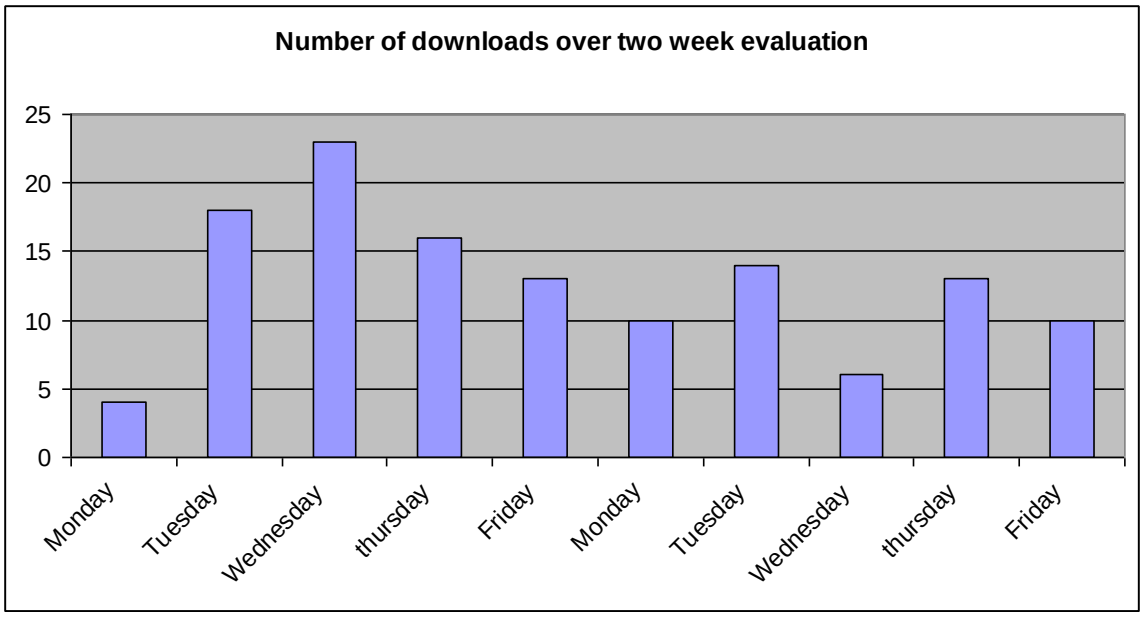

Figure 42: Number of downloads over the two week evaluation period

Figure 43 shows the times at which the system was most used over the two weeks of evaluation. Clearly, students used the display system more at midday. This is mainly due to the fact that most lectures would have ended and students have ample time to try out the system.

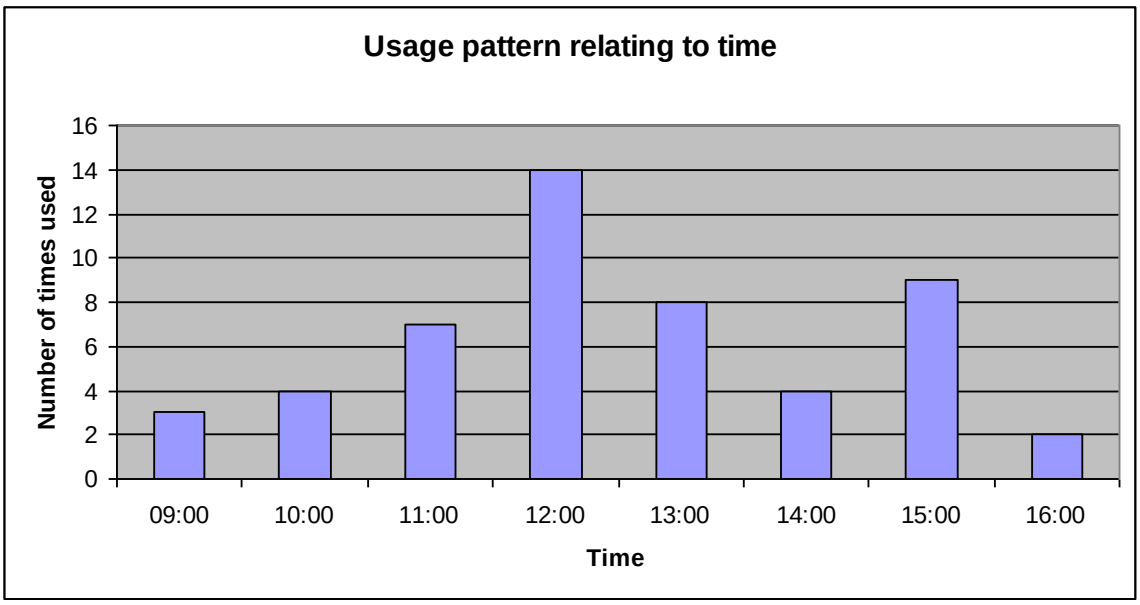

Figure 43: Usage patterns of the participants according to time of day.

Figure 44 shows all the content that was downloaded from the Snap and Grab board's repository. Downloads were related to what the users were studying and not surprisingly the first year media package, CSC1015F was downloaded the most (due to convenience sampling only the first year users did the long evaluation). The second most downloaded media was a BBC video about the power of computing. Despite being introduced after the first week following suggestions from users, it attracted a lot of attention indicating the other forms of media were greatly appreciated.

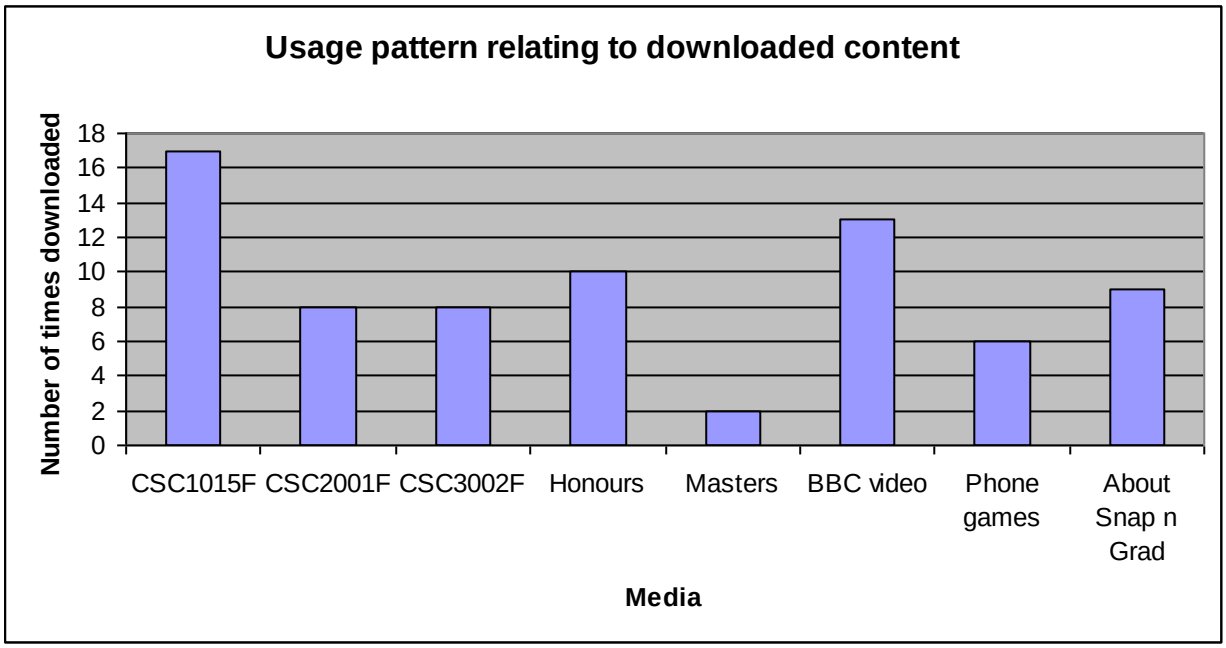

Figure 44: Usage pattern of participants according to content downloaded.

Interviews

Twenty participants took part in a longer evaluation which stretched over two weeks. At the end of each week, interviews were conducted with these participants concerning their experience with the system over the week. This would provide better insight and a more qualitative evaluation on students' opinions and feelings about the display system. A semi-structured approach was used consisting of open and closed questions.

Most interviews were held on a one to one basis and some interviews ended up combining into a session with 4 to 6 participants. This was to facilitate the students' conflicting schedules and availability. Several participants would be available at the same time and therefore were

interviewed together. Questions were still posed to each participant in turns. The following are some of the responses to questions asked in the interviews. Interviews were audio recorded and noted down on paper. The audio clips were reviewed and also noted down onto paper. Interpretation of the collected data was done through Coding to identify common themes in the students' responses. This was done by flagging key statements using labels in the margin or by highlighting the text. Sub-themes were identified and then explored in greater detail. Here are some of the responses.

Did you like the idea of sending pictures to a display and being able to select and receive info onto your phone? Why?

Most students answered yes because of convenience, the information is free, no typing is required and it's something new. One of the students said "Instead of logging in, you take a picture which is kind of fun and the information is something you want." Those who had reservations about the system gave the location as a major factor in them not liking the system. This was because the display system was deployed at the departmental reception area which is on the third floor. Another disadvantage that students pointed out was the limited range of phones that the interactive prototype supports.

What did you do with the information downloaded from the board?

Surprisingly, information that was downloaded from the display system was not deleted as often as expected. Only a few students said they would read through the information then delete it whilst some students would read the information and share it with their friends. Some kept everything and some kept information specific to their needs. For example, one student would keep the calendar events containing assignment deadlines and test dates, for planning purposes. Another student saved the course information for all the courses because it was relevant to their degree of study.

Would you rather use the web based system on VULA? Why?

Most students said they would rather use both. They pointed out that not everything that is online is on the board but the board is very quick and convenient for the content it has. One of the

students said "I see it as a fast food restaurant. If I want information on the go, I use the board but if I want detailed information I will use the labs. There is stuff you can do on a computer you cannot do with the board as well."

What did you like most about the system?

Participants liked that the system had a specific emphasis on offering information and the ease with which one can obtain it. Not having to logging in and the display system's response time appealed to the students as well. Some touched on the graphical look and feel of the system with one student saying "It's so colorful you can just stare at it." Several participants found saving the pictures of desired media on their mobile phones eliminated a step in the transfer of information. Participants would not need to take a picture before sending it to the board, but could send it directly from their gallery on their phones to the board. Two to three students liked the novelty of the system and the fact that it saves content to the phone.

What did you not like most about the system?

The majority of complaints were about the scalability of the display system. An initial evaluation of the original Snap-Send-Grab board suggested that up to eight people could use the system simultaneously. However, once the system was deployed, students not involved in the evaluation also took interest in testing out the system. Therefore, there were times when users flocked to use the system at once. The system would eventually buckle under consistent connections and disconnections from a large number of students and freeze up. Most of the participants found waiting for other users to complete their transfers similar to waiting in the labs for a free machine. Comments were also made concerning the lack of error messages when the system did not match a user's picture with the corresponding media image on the display's server. This was easily resolved after the first week.

Several students found taking a picture of the media they wanted tedious and preferred storing the picture on their phones. Some found downloading videos slightly more time consuming as compared to receiving text files from the display system.

What other media can be incorporated into the system?

Most of the male participants suggested information pertaining to sports news and results. News feeds and weather forecast media packs were also recommended. Due to the use of video media packs there were calls to get information about other Universities and their Computer Science departments. More insightfully one of the participants suggested mp3 versions of lectures and pictures of events and conferences that happen in the Department.

Other suggestions were:

- Music clips and music videos
- Themes and mobile games for phones
- Assignments and marks
- Promotional music clips and content as well as pizza offers
- News headlines from different news paper company.

Where can such displays be deployed?

Responses to this question were varied but back up with valid motivations.

- Cafeteria because students frequent these places
- At the building entrances and ground floor because they are easily accessible areas
- Shuttle stops because every student has to wait for their shuttle and they might want information whilst they wait
- At residences notice board because that is where students stay

6.5 Findings from the long evaluation

It became apparent during the evaluation, that a longer evaluation of the system is necessary to substantiate the usage patterns. Two weeks were used as part of the RAD process considering the project timeframe and due to the availability of the students. Usage of the system slightly decreased in the second week but was less erratic than the first week showing a consistent pattern of usage. Users appreciated variety in the content that was put on the board despite its primary goal being delivery of educational material. The basis for this inclusion was drawn from the earlier Contextual interviews at the start of the project. Some of the daily tasks students

performed on VULA were non-academic such as posting messages in society Chat rooms and playing dialogue driven games. The videos used were a short clip demonstrating how to use the Snap and Grab board and the other one was a BBC video based on the power of computing. Mobile phone games and videos attracted a lot of attention from users and maybe a worthwhile avenue for future work. Interviews with the participants proved very insightful in eliciting information about improving the system, the content and the delivery of information. There was a positive response to using the system over two weeks.

The evaluation was conducted near the exam period and therefore resulted in relatively less updates on the VULA system. This affected the usage of the system but did not deter students from using the system. An ideal evaluation period would have been at the start of a semester when students start new courses and require course information more regularly. However the exam period is part of the semester calendar and the evaluation still yields insights about the system in an educational context. This is a strong positive point in that the system was well received despite less updates to the actual educational content. The convenience of the system may outweigh how useful its content actually is. As suggested from the interview responses above, a common thread was how fast and convenient the system was relative to accessing the same type of information in the computer labs.

How did the system make the students to be more efficient?

After lectures are done, students would usually go to the computer labs and access VULA information. This would usually be around lunch time when all the lectures are done and students have sufficient time to access VULA. In between lectures students do not have enough time to log onto a computer and read recent announcements. Figure 35 shows how the system was used in the morning in between lectures. This can be accredited to the system's fast speeds in information exchange. One of the participant related how he would quickly get information from the Snap and Grab board before his Computer Science lecture and was therefore up-to-date with the course's recent events.

Another student related how receiving Calendar events helped them schedule their week. Due to assignment extensions, deadlines change and the student found it easy to keep track of such

changes with the download they received from the Snap and Grab board. What was particularly helpful was that they could review this information on the phone anytime without requiring the use of a computer.

Course information holds the names, locations and availability times for the course convener, lecturer and teaching assistant. One student related how they missed a test query session but were able to find the course teaching assistant and query their test paper with the help of the information provided by the system. Having the information on their phone was particularly helpful because they were able to review it as they were moving across campus doing other activities.

Previously students had to ask credible sources or friends to get reliable information by word of mouth. With the introduction of the system, students shared reliable information from VULA with friends with the use of their phone. Students would either show other students the content they got from the system or transfer it via Bluetooth to their friend's phone. This helps with the distribution of reliable educational information and keeps students well-informed through pre-existing social interactions.

6.6 Summary

This chapter described in detail the analysis carried out on the quantitative and qualitative data obtained from the evaluation. It touches on the observation, questionnaire, interview and data logs techniques used to evaluate the project and the responses received from the participants who took part in the study. The next chapter discusses what these results and findings mean and concludes the project.

7. Chapter 7: Conclusion

7.1 Introduction

The previous chapter presented the results of the evaluation of the interactive prototype. Results from each evaluation technique were discussed, and the quantitative and qualitative data was analyzed through the use of charts and graphs. This chapter concludes the project with a discussion of how the results satisfied the project aims.

7.2 Project Aims

The project sought to explore a solution for some of the educational challenges experienced by a tertiary institution in the developing world. These challenges were the high cost of bandwidth for Internet access and lack of money for building new computer labs resulting in overcrowded labs and fewer learners gaining access to information. The solution explored was one which would provide a reliable means of accessing time specific tasks for students through the use of existing technologies. The University of Cape Town was used as a study case and technologies explored were the Snap and Grab board and mobile phones. The Snap and Grab board is a public display that is connected to a computer which stores various media packages. Through the use of a mobile phone, users can freely exchange information with the board via Bluetooth. This project looked at how the board could be used as an educational application by integrating it with a university's learning management system. The final system serves as an interactive alternative to current methods of accessing educational material. The main research objectives of the study were:

- To support student activities by adding mobile access to VULA through the use of the Snap and Grab board.

- To find out how the students will respond and appropriate this new paradigm of interaction.

Stemming from the project's first aim, students' daily activities had to be supported by the system. By using a user-centered approach and contextual interviews, students' habits and what they accessed was carefully noted down and mapped onto the final system. From the evaluation it was noted that students used the information they got in their daily activities. They used it to plan for assignment deadlines and test dates, shared it with friends and kept up-to-date with their courses. To emphasize this point most students kept the downloaded files on the phone and did not delete them. This enabled them to review the information anytime. Furthermore, students felt comfortable enough with the information to share it with friends.

Usage patterns showed how students accessed the system in between lecturers whereas before they could only access VULA on a free period or lunch time. A recurring theme in the responses received from the long evaluation was the system's speed. The faster the system, the less time students spend accessing information making them more efficient. Currently students take from 5 to 10 minutes to get onto the VULA site using a computer at a lab. Contextual Interviews were filled with complaints about the lengthy time and for someone accessing VULA three times a day; this could amount to 30 minutes spent logging in. The final system took up to two minutes (depending on the size of media) to exchange information with a mobile phone user. The project successfully produced a system that provides a reliable and fast means of accessing time specific information.

7.3 Research Questions

How did the design tradeoffs between VULA and the Snap and Grab board, influence the project outcome?

The integration of VULA and Snap and Grab board introduced tradeoffs in design of the final system. The Snap and Grab board imposes constraints associated with the mobile phone which limits the amount, size and type of information, that can be used from VULA. Content targeted for a mobile device had to be designed for short attention spans and had to be relevant enough to prompt the user to use the system. The information also had to be suitable for most mobile

phones despite differences in size, screen resolutions, cost and network capability. Therefore, text files were used. Early in the design stage there were concerns about how much phone memory the media should take up. However, throughout the evaluation, no one complained about the media taking up too much memory. It could therefore be worthwhile to explore the exchange of different media types such as Word Excel of PDF format. The only restriction in this regard would be the mobile phone capabilities.

The use of the Snap and Grab board restricts usage to those who have a Bluetooth enabled camera phones. In addition, Bluetooth based displays like the Snap and Grab can only support the latest phone models. However, Bluetooth and camera functionality is becoming more ubiquitous with all the new models being introduced by phone companies.

The Bluetooth architecture for the Snap and Grab board can only support up to eight individuals (this is a limitation imposed by the Bluetooth standard). If there are more users the board would freeze up due to so many connections competing for the same media. Resource locking mechanisms and timeouts were used to deal with this problem but more testing needs to be done in supporting larger groups of users.

People tended to be voyeuristic with large displays. This raised concerns of publishing sensitive information from the VULA site, on the Snap and Grab board for public consumption. Precautions had to be taken in what type of information was extracted so that it did not violate any privacy issues. Phone security would have been a key concern for the system if more sensitive data was published on the Snap and Grab board. Stolen and borrowed phones could be used to access sensitive data.

When the participants were asked if they would rather use the display system over the PC based LMS, they said they would rather use both. One of the participants said “I see it as a fast food restaurant. If I want information on the go, I use the board but if I want detailed information I will use the labs. There is stuff you can do on a computer you cannot do with the board as well.” This implies that the display system should be deployed alongside tradition information systems and should not to be treated as a complete alternative but an extension/support system.

Were the methodologies used effective in achieving the project goals?

The first project aim focused on adding mobile access to the VULA learning management system by identifying information that would be suitable for the Snap and Grab board and mobile use.

The use of interaction design facilitated engaging user experiences, by using knowledge of how people act and react to certain events in various contexts. The use of a rapid development approach alongside interaction design was necessary to reduce development time, given the project timeframe of over two years. Changes could then be easily implemented as the project progressed.

Contextual interviews proved extremely useful in gaining understanding of how students currently work in the educational context. Students were observed whilst performing tasks they do on a daily basis in order to pick up on problems, design ideas and insights. Coupled with questionnaires, the project was able to confirm observations and findings from the contextual interviews. This also provided the project with clear and concise system requirements which took into account the user, the user's tasks and the environment.

User-centered design ensured that the prototype incorporated user affordances specific to the educational context. Meetings with the VULA administrator and the Snap and Grab board designer were very helpful to understand how each system works and how they could be integrated. A pragmatic approach proved ideal in the redesigning of the Snap and Grab board from being a generic information exchange application to be one which caters from educational tasks in an educational context. In order to test out design ideas prototyping was used to iterate through several designs rapidly and redesigning of the Snap and Grab board. A bigger heuristic evaluation group than three could have been used, to pick up on usability problems and to enable more users to be co-designers of the final system. However, more experts were not available.

By using pragmatic design and user-centered approach, the project was successful in integrating VULA and the Snap and Grab board for an educational context.

The second aim was to gain insights into the students' response to the final display system and its novel interaction. From observing the participants using the interactive prototype, users responded positively to their experience and users were sufficiently interested to ask questions from other users about the system. All participants were enthusiastic about using the system and had a general idea about its purpose. For some, it was only after receiving the educational media from the board, that they realized that up-to-date course information from VULA had been transferred to their mobile phone using Bluetooth.

Interviews were the most insightful in gaining an understanding of the users' experience in their own words. Most of the participants' motivation for using the system was its convenience. The information is free, no typing is required and the system is fast. Participants loved the novel aspect of interacting with a public display system and only had reservations about the board's location and the types of phones it could support. From the data logs, the novelty of the system seemed to last for the first week and thereafter evened out over the remainder of the evaluation period.

7.4 Design lessons learnt

Computing applications should always start with a thorough understanding of how people behave in their natural setting, how they perform tasks and how these behaviors are influenced by technology. Learners' needs and requirements had to be addressed in the design of the interactive prototype.

Interface issues

Care was taken to avoid cluttering the interface with too much information (Sharp & Rogers, 2007). Information displayed by the system must be comprehensible and users should be able to discover its purpose through subtle interaction (Vogel & Balakrishnan, 2004). Simultaneous

interactions had to be afforded by the display system and relayed in a visible manner on the display interface for multiple users.

Approximately half the participants in the short evaluation did not use the instructions on the screen but relied on what the evaluator had mentioned beforehand about the display system and also how other students interacted with the system. This reemphasizes the fact that people do not read but scan information.

Despite this, 87% of the students found it easy to get started with the interactive prototype, 79% understood what the prototype did and 85% found transferring information from the Snap and Grab board easy.

With regards to the feedback that the interactive prototype returned, 72% positively felt that the system gave sufficient messages about what was happening and 79% of the users positively felt that they were able to easily find the downloaded media on their phone. This gave the user a sense of control and confidence to engage in a dialogue with the system.

Content

The initial survey indicated that Announcements, Calendar events and Course information were the most suitable content for the Snap and Grab board. This was drawn from how students perform their daily tasks in an educational context. Information captured by student from the VULA system was saved onto flash drives, noted down or printed to review later. Allowing students to download the same information onto their phones enabled them to review it anywhere and anytime they had their phone. Participants were asked about the relevance of the information they received from the Snap and Grab board and these were their responses.

92% of the participants found the announcement useful

74% of the participants found the calendar events useful

77% of the participants found the course information useful

This indicates that the results from the Contextual Interviews and questionnaires were accurate in determining the types of educational information students might want to have on their mobile phones. The majority of student daily tasks involve getting the latest announcements of their courses and the results underline the point. Calendar events helped with tasks such as scheduling of assignment hand-ins, tutorial sessions and even exam timetables. These help students coordinate their activities and having the information of the phone made it easier as students always have their phones with them.

Course information specifies venue of daily lectures, course details, lecturer's name and office number. Instead of logging onto the computers in the labs, this information could be looked up from one's phone. The high percentage could be accredited to the convenience of having the information on the phone and not having to look it up on notice boards. With regards to sharing information with friends, 87% of the participants strongly agreed that they would and some mentioned that they already had. Figure 45 shows the overall enjoyment of the experience for all the participants. The experience entails what participants thought of the location of the system, the use of mobile phone as an input tool, the feedback of the system and the relevancy of the content received. The chart clears shows a positively skewed graph indicating a strong positive opinion about the usage of the interactive prototype among the participants.

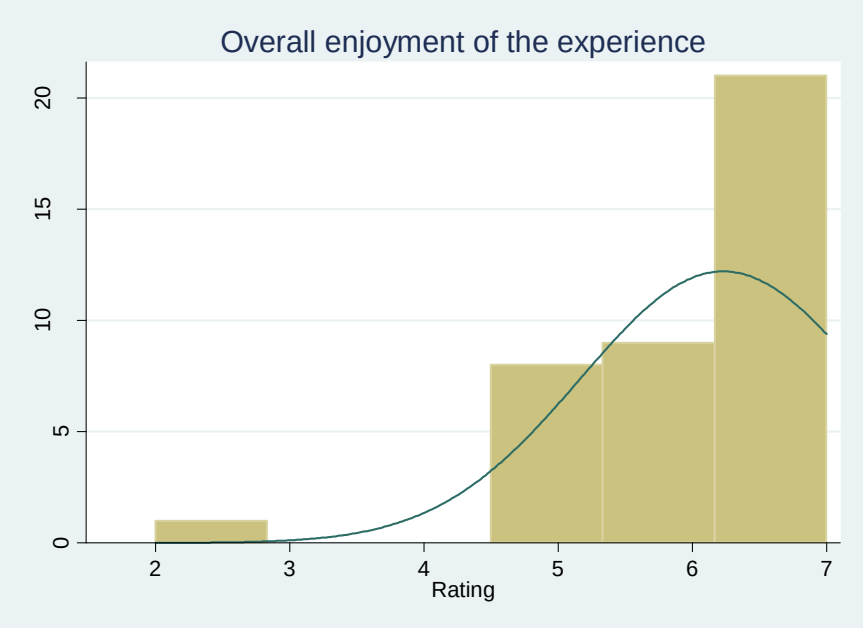

Figure 45: Overall rating of the experience

From the data logs, useful usage patterns were obtained that were valuable, in understanding the user's behaviour towards the final system. Due to availability, all of the participants who conducted the long evaluation were in first year and as expected, the media which got the most downloads was the first year course media pack. However participants were voyeuristic with the board and explored other courses for which they were not registered for. Over the two weeks of evaluation, the use of the system slightly decreased but evened out. The evaluation period was defined by the availability of users as the semester was nearing the exam period. To make the evaluation more thorough and reliable a comparison of usage in the data logs could have been opposed to the log files on the Snap and Grab board. This was a major oversight as the option used for updating the interactive prototype's cache, meant that log files were overwritten every time the media files were updated.

During the long evaluation a video about the Snap and Grab board, a BBC video and mobile phone games were put up on the board because this was suggested by the students and the current VULA system supports non-academic activities as well. This was drawn from the questionnaires and Contextual Interviews at the start of the project. The BBC video was about the power of computing and the games were intended for recreational activities. The response was overwhelming as users who were not part of the evaluation also engaged with the system

and got to download media. There were several instances where the interest in the board was so great, that the reception area where the board was deployed would become flooded with students. It might be worthwhile to explore using more Bluetooth receivers or access points to accommodate more users.

From the data logs, the novelty of the system seemed to last for the first couple of days and then evened out in the second week. New ways of interacting with the system were developed over time, as students began storing images of desired content on their phones therefore removing the need to take a photo to begin interaction with the system. They would merely send their stored photo to the system to initiate a dialogue. Some would interact with the board from outside the reception area making full use of the Bluetooth range. This shows how users can define new ways of interaction which is different from what the developer originally envisioned.

In an ideal world, the system would have been evaluated over a full year and the long term study used to triangulate the results obtained from this project. However this is beyond the scope of the project whose aim was to investigate use of the Snap and Grab board in an educational context.

7.5 Future work

There were scalability issues related to how many users the system can support simultaneously. Scaling the system represents a significant challenge mainly because this depends on the Bluetooth architecture and its maturity in the coming years. Another point of further investigation would be to use of more Bluetooth receivers around the display system in order to support more users and to support a larger range.

There were participants who initially thought the display was touch screen orientated and did not notice the instructions despite the use of brightly coloured boundaries around the instructions. Future work may explore the use of animated instructions which depicts how one would get media from the board. There also remains room for the use of different types of media formats of educational material such as video or audio recorded lectures. There are, however, several challenges to these media formats such as how information would be accessed, size of the files and the acquiring of camera equipment to record lectures. There are also concerns that stem from

availability of such media which could lead to students not attending lectures. Though an exciting prospect, such work would need to be carefully thought out.

The Snap and Grab board does support the uploading of information but this facility was left unexplored because uploading content would have required students to authenticate themselves by logging into their personal VULA account then transferring content from their phone to the board. Clearly this would be a lengthy process due to the slow network speeds involved during authentication and the size of the data being uploaded. This would deter students from using the system as they would have to wait for a while before their turn thus defeating the original motivation behind the system of providing a fast, convenient way of accessing time specific educational information.

Opportunities for exciting interactions remain untapped but could be explored in a future study of the Snap and Grab technology. Another untapped capability was the content rotation function that the Snap and Grab board possesses. This function would allow the display system to display more information by rotating media on the screen after a specific amount of time. For this project, the Computer Science courses were put up on the board's display but did not exceed six in number therefore there was no reason to use this functionality.

There are business opportunities for the providers of information as advertisements can be put up on the board alongside educational content. So not only will students be receiving information for free but the information providers will be receiving advertising revenue from interested companies. This makes the system very marketable and sustainable for institutions in the developing world.

It is worthwhile noting that over time the interaction method may grow from exciting to tedious. The user has to make sure they get a good picture of their desired media, looks for the picture on their phone, switches their Bluetooth on and sends the picture to the board then receives the media. This is evidenced by how students short-circuited the process by saving media images on

their phone during the long evaluation. Furthermore the novelty of the system resulted in the reception area being flooded by students implying the need for the interaction time to be shorter.

Another project has begun focusing on short-circuiting this process to one of receiving the media from a Bluetooth access point without any interaction with a display system. In this approach students would initially register their Bluetooth Ids to interact with the system and sign up to receive updates on particular courses. Bluetooth wireless points would be strategically placed around a department. Any time there is an update, the new content is pushed to the mobile device. This may prove a much more feasible approach to realistically implementing the system in schools. The cost of a single Snap and Grab board can be viewed as slightly expensive and most schools in developing countries would not be able to afford such a system for each department. The majority of that cost is the use of a large screen that can accommodate all the courses offered.

7.6 Contribution

Chapter 2 touched on how developing countries have had to cut back on education expenditure over the past decade. This is due to governments focusing on other challenges such as natural disasters, poverty and unemployment. This means less money will be available to spend on education and is likely to have an adverse effect in developing nations in the years to come. More institutions will find themselves with fewer educational resources such as computers and illiteracy rates will continue to climb. The educational Snap and Grab board shows how existing technologies can be properly designed using user-centered techniques to produce cost effective solutions applicable for the developing world. This is achieved by

- Using pre-existing technologies such as mobile phones and situated public displays to access educational information
- Removing any cost or mobile charges incurred by the user when interacting with the system through the use a Bluetooth protocol to transfer information
- Removing connectivity costs to Internet to access information

- Ensuring the support of multi-user interactions which is especially important in an educational setting

The educational context aided the acceptance of the new technology. For instance, at UCT more students own a mobile phone than a laptop. They use mobile phones in their daily activities to communicate and exchange information. This made it easier for students to use the system as the interaction was not completely novel. Students are also naturally curious and drawn to high-tech devices and did not have to be asked twice to use the interactive prototype. Once such systems are set up universities in developing nations may then be able to channel funds to other areas that need improvement. The technology is still relatively hard to adopt considering its limited phone support but could pave a more fruitful path to the development of sustainable technologies in the developing world.

In the introductory chapter it was stated that focus needs to be on sustainable technologies that are affordable, have relevant content and can be easily integrated into the daily lives of people. The use of wireless technologies and mobile devices, offers cheaper solutions for the developing world. Mobile phones have high level of adoption in the developing world and present a viable and sustainable alternative to current information accessing methods. Clearly, mobile phone technology is the most promising enabling factor in the implementation of ICT in developing countries and will play a major role in bridging the digital divide.

7.7 Summary

This chapter had concluding remarks about the project. Project aims were revisited and the evaluation results cross-matched to determine if the project was successful. Research questions touching on the tradeoffs and methodologies used were expounded upon. The chapter then went on to describe the design lessons learnt, future work and the project's contribution.

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9. Appendix 1: Needs assessment questionnaire

VULA is a new open-source learning, collaboration and research content management system. It is being built on a technology developed by a consortium of universities including UCT, MIT, Stanford, the University of Michigan and Indiana University, among many others around the world.

Survey

Section A:

Age:

Degree:

Have you used VULA before: YES / NO

Section B:

1. **How often do you use VULA?**

2. **What information do you find useful?**

3. **What do you like most about VULA?**

4. **What elements of VULA are helpful and aid in navigation and presentation?**

5. **What problems do you experience most from VULA?**

6. **What information would you like to be on VULA?**

10. Appendix 2: Evaluation Questionnaire

Questionnaire for VULA notice board

Section 1: Background information

1.1) Degree of study

1.2) Make and model of phone being used.

1.3) Have you previously used Bluetooth on your mobile to send/receive a file?

1.4) Have you previously used or participated in a similar study on an interactive notice board?

1.5) How often do you use VULA

Section 2: Interface issues

2.1) I used the instructions to learn how to use the board

Strongly disagree Strongly agree

1 2 3 4 5 6 7

2.2) Getting started with the task was easy

Strongly disagree Strongly agree

1 2 3 4 5 6 7

2.3) It is clear what the system does

Strongly disagree Strongly agree

1 2 3 4 5 6 7

2.4) It is clear how one goes about getting information

Strongly disagree Strongly agree

1 2 3 4 5 6 7

2.5) I found the colours and pictures used visually appealing

Strongly disagree Strongly agree

1 2 3 4 5 6 7

2.6) Sending a picture over Bluetooth was simple and straightforward.

Strongly disagree Strongly agree

1 2 3 4 5 6 7

2.7) There is enough feedback from the system about what's going on

Strongly disagree Strongly agree

1 2 3 4 5 6 7

2.8) I like the idea of being able to send pictures to a situated display on campus from my phone.

Strongly disagree Strongly agree

1 2 3 4 5 6 7

2.9) Overall I enjoyed engaging with the system

Strongly disagree Strongly agree

1 2 3 4 5 6 7

Section 3: Content

3.1) I had control over what I wanted from the board

Strongly disagree Strongly agree

1 2 3 4 5 6 7

3.2) The downloaded content was easy to find on my phone

Strongly disagree Strongly agree

1 2 3 4 5 6 7

3.3) I found the content transferred very useful

a) Announcements

Strongly disagree Strongly agree

1 2 3 4 5 6 7

b) Calendar events

Strongly disagree Strongly agree

1 2 3 4 5 6 7

c) Course information

Strongly disagree Strongly agree

1 2 3 4 5 6 7

3.4) I would share the information obtained from the board

Strongly disagree Strongly agree

1 2 3 4 5 6 7

11. Appendix 3: Consent form

Consent form

I understand that:

I may choose to withdraw at any time from the study task.

I may ask questions at anytime, before, during, or after the study.

No record of my name will be attached to the data I provide.

I will not be identifiable in any reports or publications.

My participation in this study will not affect my grade for any course in any way

I will compensated for my participation in this study

Signed …… Evaluator……..

Date……