ENABLING CONTEXTUAL MLEARNING: DESIGN RECOMMENDATIONS FOR A CONTEXT-APPROPRIATE USER INTERFACE ENABLING MOBILE LEARNING

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Abstract

Enabling Contextual mLearning: Design recommendations for a context-appropriate user interface enabling mobile learning

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The aim of this thesis is to provide design recommendations for a context-appropriate user interface enabling mobile learning (mLearning). mLearning applications are being used on mobile devices in classrooms with students of all ages.

How can the technology be merged within a device's operating system to help manage various phone events in order to aid in the management of learning activities. Participatory design was used and both qualitative and quantitative data was collected. Two interviews of 17 conveniently selected adult participants were performed which discuss time management strategies and specific uses of various technologies on mobile phones with participants.

I conclude that a mobile learning prototype should (1) be able to collect information autonomously; (2) should have a variety of functionalities; (3) should have modular functionalities in order to allow the user to customize the device; and (4) should have an interface as flexible as possible to cater to a variety of users.

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Chapter 1

Introduction

The aim of this thesis is to provide design recommendations for a context-appropriate user interface enabling mobile learning (mLearning). mLearning is a bourgeoning field and software applications are being used on mobile devices in classrooms with students of all ages for this purpose. However, how can the technology be ever-present instead of available only during some classes? How can it be more effectively integrated within user's lives in order to minimize the demarcation between learning and other daily activities. Furthermore, how can the technology be merged within the device's operating system to help in the management of various phone events in order to aid in the management of learning activities? These are the issues explored in this study.

Participatory design was used because it aims at involving the users at every stage of the design. More specifically, the collaboration between the designer and the users leads to data "co-constructed" by the participants and researchers. Both qualitative data and quantitative data was collected in this study. Two interviews were performed which discuss time management strategies and specific uses of various technologies on mobile devices with participants.

In the study, seventeen participants were recruited from within the university

context. Participants were chosen from different age groups and with various backgrounds. An important criteria was that participants should have a varied background. It was not required that participants currently owned a mobile phone.

I conclude, based on the results, that a mobile learning prototype should have the following software characteristics : (1) it should be able to collect information autonomously; (2) it should have a variety of functionalities; (3) these functionalities should be modular in order to allow the user to customize his or her device; and (4) the device interface and settings should be as flexible as possible to cater to a wide spectrum of user lifestyles.

This document is divided into five chapters including the introduction. Chapter 2 is an exploration of mLearning as both a technological and educational tool. It also provides an overview of user-centered design. Chapter 3 examines various methodologies possible in order to analyze the problem. Chapter 4 provides a description of the data collection process, followed by a discussion of the results in both qualitative and quantitative forms. Chapter 5 details the recommendations for an eventual design and the future work involved for this. Finally, conclusions will be provided in Chapter 6.

Chapter 2

mLearning

This chapter defines what is meant by mobile technology, introduces the concept of mLearning and the problems which must be considered, discusses preliminary mLearning pedagogy, and highlights projects exploring specific applications.

2.1 Mobile technology explored

According to Quinn (2000), "[m]obile learning is learning through mobile computational devices." Therefore, mobile learning (mLearning) can be thought of mobile computing combined with eLearning.

Mobile devices are small autonomous devices that are both personal (they can only be used by one person at a time) and mobile (they can easily travel anywhere the user chooses and used at any time). Anderson and Blackwood (2004) suggest that there are currently three major classes of products to be considered: (1) Personal Digital Assistants (PDAs), (2) Mobile (or Cellular) Phones, and (3) Personal Media Players (PMPs). I do not consider tablet and laptop computers in my definition because they give relatively the same functionality as desktop computers and are more portable than these but not mobile. We differentiate between tablets, laptops, and mobile devices in that they can easily be brought anywhere but not accessed

anytime because of encumbering bulk and relative start up time.

The line between types of mobile devices is becoming ever more blurred and many of them are now able to play games, keep an address book and schedule, play mp3s, and make phone calls. The current trend towards a single device being capable of handling multiple functions and media types is called convergence (MacManus, 2002).

There were 91 million mobile phone subscribers at the end of 2004, an estimated 1.5 billion mobile phones subscribers in June of 2005, and a predicted two billion subscribers to mobile telecommunications by the end of the year 2005, according to a recent study by Informa Telecom & Media (2005). Another prediction made was that by the end of 2010, over 3 billion people will be subscribed to mobile telecommunications services, a penetration rate of nearly 43% of the total global population.

The Mobile Technologies and Learning Report (Atwell, 2005) by the UK-based Learning and Skills Development Agency states that, in mid-2005, there were more than three times the number of cellular phones per person as personal computers (PCs), and today the most sophisticated phones have the processing power of a PC from the mid-1990s. This technology therefore presents an opportunity to affect more people in more aspects of their lives.

2.2 The potential impact of mLearning on education

With the advent of the Internet and the World Wide Web, there has been a push to support learning electronically. E-learning, as it is known, can occur anywhere as long as you have access to that specific device. The difference between eLearning and mLearning is an addition of capabilities and limitations in a more evolutionary than revolutionary fashion (MacManus, 2002).

mLearning support can be information seeking, content delivery, *ad hoc* questions

and answers, notes, comments among a learning community, or tasks related to learning administration (Vanska, 2004). mLearning can be an educational environment in which wireless technology is used to assist students in their studies – both inside and outside the classroom.

Essentially, mLearning resembles eLearning but with several key differences:

- **Interoperability:** Depending on the different devices, there are various features that are available as well as drastically different Operating Systems (OS) which can help or hinder certain software capabilities.

- **Miniaturization:** There are several important aspect of miniaturization to keep in mind:

    1. *Usability:* User Interface Design (UID) must be carefully considered because screens found on these devices can have pixel resolutions as small as 96x60 (a desktop PC has a minimum resolution of 800x600 pixels).

    2. *Portability:* To make the device lighter, less memory and limited processing power are used than in top-of-the-line desktop computers. The use of light components as well as small sizes lead to limited capacity which affects the software and services available to the learners.

    3. *Ergonomics:* With limited physical space on the device, there is a limit to the number of keys that can be used to control the software.

- **Quality of Service:** I must consider features and quality of service for any device that requires a connection to a larger network whether it is a Wide Area Network (WAN) or *ad hoc*.

- **Adaptivity:** Adaptivity goes beyond the personalization of a mobile device's look and feel. User identity is closely tied to the device so this makes it possible to create user-specific and profiled services (Sharples, 2000). This allows the devices to be adaptable to the learner's evolving skills and knowledge as well as

the context in which it is used. Is the device being obtrusive? How does each user in each environment effect the use of such technology?

Similar considerations were brought up by other researchers (Uther, 2002; Steinberger, 2001; Csete, Wong, and Vogel, 2003). We will spend some time considering these differences.

2.2.1 Interoperability

There are several operating systems available for mobile devices including:

- *Symbian OS*[1]: Symbian OS aims at lowering licensee development costs and accelerating time to market. The platform claims to be a robust product that is secure, open, and standards-based. The main companies currently using this OS are Nokia, FOMA, and Motorola.

- *PalmOS*[2]: Since its introduction in 1996, the Palm OS platform has defined the trends and expectations for mobile computing, especially in the business sector. The OS plans to stay true to its roots by continuing to provide ease of use while adapting to new technologies and features that are becoming prevalent in the mobile market. Besides PalmOne products, the PalmOS can be found in Samsung, Kyocera, and Sony devices.

- *Microsoft Windows Mobile*[3]: Microsoft Windows Mobile has a smaller footprint than its PC counterpart and is designed for specific use, not general purposes. It caters to mobile devices that require power management capabilities, that have limited memory and processing resources, or that require deterministic responses to interrupts in real-time. These systems are used by HP, Dell, and Acer devices.

[1] `www.symbian.com`
[2] `www.palmsource.com`
[3] `www.microsoft.com/windowsmobile/`

- *Linux*[4]: It is designed as an open platform, and although there are some drawbacks to using Linux on a mobile device, certain groups believe it is a better choice than most other operating systems because it supports numerous installation methods, works in many heterogeneous environments, and needs smaller resources. Some companies using Linux on certain mobile devices are Sharp, Motorola, Samsung, and NEC.

These operating systems not only have a drastically different look and feel, they also have different features that may help or hinder mobile learning. Can you access saved information on the device? Is it easy to install new software? Does the software run efficiently? These questions must be carefully considered when picking the system which will host mLearning.

Along with various operating systems, there are also a several application environments such as Bluestreak MachBlue Mobile[5], Macromedia Flash Lite[6] and Java 2 Platform, Micro Edition (J2ME)[7]. These are meant to deliver consistent experiences across operating systems, processors, and screen sizes. The possibility of using Java (J2ME) on mobile clients may also contribute to the success story of the new devices in the area of mobile wireless learning (Steinberger, 2001).

The use of open standards may be the key to interoperability between classmates using different devices.

2.2.2 Miniaturization

Nokia believes that "[t]he difference in designing [a user interface (UI)] for desktop environments versus phones is about quantity; desktops can accommodate more." (Lindholm, Keinonen, & Kiljander, 2003) When we delve a little deeper, however,

[4] tuxmobil.org
[5] www.bluestreaktech.com
[6] www.macromedia.com/software/flashlite/
[7] java.sun.com/j2me/

reducing quantity means that the quality of the content must be higher. PC interfaces do not scale downward; small interfaces are fundamentally different from larger ones. In educational environments, Kiili (2002) found that poor usability of mobile applications tends to disrupt the learning process, again supporting the importance of focusing on usability in the success of mobile applications.

Furuya, Kimura, and Ohta (2004) conducted a study in which they surveyed university students specifically regarding their study habits. Their results show that there is a shift from study inside the home and classroom to study outside these conventional places. With overextended functionality, usability becomes lost in feature-rich environments, portability is sacrificed, and ergonomics become too complex for the learners mental models.

2.2.3 Quality of service

There are several different types of networks that support a variety of types of data connectivity including Infra-Red (IR), Bluetooth, Cellular Systems, Short Message Service (SMS), Multimedia Message System (MMS), and Global Positioning System (GPS). The phone's functionality determines if these systems are supported.

These services can be considered in two different categories including pay services and proximity services. In both cases, there is no capability for constant connection to a larger network as we have become accustomed to with PCs. In the first case, the expense is too great for such a connection and, in the latter, mobility would be compromised.

Hoarding is when a set of documents are downloaded during idle times in order to allow reference to these when offline; this technique is especially useful with intermittent connections and is similar to caching or pre-fetching. One of the major considerations is memory limitations – the entire set of document cannot always be stored. A possible solution proposed by Trifonova and Ronchetti (2005) suggests using predictive algorithms to download information which the user might need in the

near future.

Another possibility is to use local *ad hoc* systems such as in Lonsdale et al. (2003). An *ad hoc* system is a self-configuring network of mobile routers (and associated hosts) connected by wireless links (Wikipedia, n.d.). This means that the nodes organize themselves arbitrarily and can receive and transmit data among themselves. These can be confusing and, therefore, specific user interfaces for these have been developed to aid in the use of these systems (Klein & König-Ries, 2002).

2.2.4 Adaptivity

Uther (2002) argues that some traditional usability guidelines relating to navigation, structure and error prevention can be applied to mobile applications. However, she believes that attributes such as limiting user input, displaying only minimal and relevant information on the screen, and the use of context, should be considered specifically from the perspective of mobile applications. Ryan and Gonvales (2004) suggest that this customization for web users may involve the ability of a site to automatically reconfigure based on predetermined requirements, while customization for a mobile user may be based upon geographical location or the physical environment. Because they are so portable, mobile devices can be used at home, at the office, or at school. There are some activities related to the location where the learners find themselves (Steinberger, 2001). How does each environment affect the use of such technology? And how does the ease of change between these different modes affect the learning outcomes? The following section identifies the possibilities these mobile devices provide for education.

2.3 Pedagogy of mLearning

New technologies bring forth new educational possibilities based on their unique characteristics and capabilities. From a pedagogical perspective, mLearning potentially

supports new dimensions in the educational process. Six characteristics of mobile learning can be identified (see Figure 1).

1. urgency of learning need;
2. initiative of knowledge acquisition;
3. mobility of learning setting;
4. interactivity of the learning process;
5. 'situatedness' of instructional activities;
6. integration into instructional content.

Figure 1: Characteristics of mLearning (adapted from Chan and Sharples, 2002; Leung and Chan, 2003).

These characteristics can be mapped to specific learning theories. There are many cognitivist concepts which lend themselves well to mLearning.

For example, situated cognition (Kirshner & Whitson, 1997) is based on the concept that knowledge will remain inert and unused if the context it is taught in is separated from the material being learned. Learning is greatly enhanced when it happens in a particular location or context.

Devices are becoming location-sensitive which enables location specific services (Sharples, 2000). Beyond Just-in-Time (JIT) learning, it has been suggested that Just-in-Location (JIL) learning could easily be initiated with mLearning (Vila & Wheeler, 2003). MacManus (2002) asks us to "[i]magine scientific field work or visits to historical landmarks as the context and think of how a mobile device could allow learners to access pertinent information, remediation, evaluation, or suggested further study as the learner comes in proximity to a location." The material to learn needed at a specific time, in an exact location, could be delivered to the learner.

Steinberger (2001) suggests that for mLearning to work, "[m]obile technologies could significantly augment some of these processes and support processes wireline

solutions can not support." The above theories suggest cognitivist approaches but mLearning could do a better job with constructivist approaches as well.

Another example is distributed cognition which explores the interaction of learners with one another, with their cultural and historical setting, and with the mobile technology (Laru & Järvelä, 2004). The theory emphasizes how cognitive efforts are distributed across artifacts (the technology), internal and external representations (mental models), and amongst individuals (groups of learners), and acts to dissolve the traditional boundaries between these. If a learner always has a mobile learning device in their possession, the learner and the device begin to interact, in essence becoming more than the sum of their parts as the learner offloads some of the cognitive effort onto the device, enabling the learner to free up more cognitive resources for learning (MacManus, 2002). The mobile devices can then distribute the load across the community it is connected to and, in effect, across the devices and individuals in this community to build a larger scale social construction of knowledge.

Table 1: Associating mobile technology to lifelong learning (adapted from Sharples, 2000).

Lifelong Learning	**Mobile Technology**
Individualized	Personal
Learner Centered	User Centered
Situated	Mobile
Collaborative	Networked
Ubiquitous	Ubiquitous
Lifelong	Durable

"Learning [is] a continuous, life-long process resulting from acting in situations" (Brown, Collins, & Duguid, 1989). In the end, it is important to consider that mobile learning is the first technology to integrate fully into everyday activities to support lifelong learning beyond the classroom, as can be seen in Table 2, no matter what specific pedagogy is used.

A case in point can be observed in Japan. Masayasu Morita, working with ALC

Press, evaluated the use of English language lessons formatted differently for computers and cell phones. He found that 90% of cell phone users were still accessing the lessons after 15 days, compared to only 50% of computer users (Morita, 2005). Although students are more willing to access the content after the lesson is over, it must be engaging and beneficial so that educators may take advantage of this effect.

2.4 Current mLearning applications

Many projects attempt to use mLearning to determine whether it is truly and realistically an option. However, very few of these projects are proposing innovative uses of mobile devices that go beyond standard use of basic features. For example, there are several projects that detail the mapping of PC-based eLearning portals to mobile device interfaces (Alamkäi and Seppälä, 2002; Scheele, Seitz, Effelsberg, and Wessels, 2004; Trifonova and Ronchetti, 2005; Xu, Fountain, MacArther, Braunstein, and Sooriamurthi, 2004; Hayes, Joyce, and Bergwall, 2004). However, there are interesting projects that push the boundaries by using mLearning in novel ways.

A group at the University of Paderborn, Germany, has developed a collaborative working environment using spontaneously connected devices with the option of accessing services in structured networks like the Internet. Their approach features distributed, cooperative knowledge spaces which specifically addresses conceptual issues, introducing the concept of so-called temporary knowledge areas and groups (Eßmann and Hampel, 2003; Facer et al., 2004). Their project is a PDA-based simulation of the African Savannah where a "virtual savannah" is mapped to a 100m x 50m playing field. Children used PDAs with headphones and GPS to explore the terrain and act as a pride of lions. After each game, the children return to the "den" to discuss their progress and develop strategies for the next iteration, helped by an interactive whiteboard.

A company in Colorado, AgentSheets[8], is exploring the use of distributed simulations in mobile devices. Their product, called C5 (compact, connected, continuous, customizable, collective simulations), enables users to connect to a centralized computer to combine results from their individual simulations for general comparison, reflection, and group analysis. *Mr. Vetro* is a simulated human being, developed for C5, whose organs such as the heart and lungs are distributed on client simulations running on handhelds. *Mr. Vetro*'s organs can be assigned to different groups of students, who are asked to simulate situations such as *Mr. Vetro* being a heavy smoker and trying to go for a jog.

Another interesting project is a mobile learning system for scaffolding students learning about bird-watching (Chen, Kao, & Sheu, 2003). The aim is to construct an outdoor mLearning activity using a wireless mobile ad-hoc network. Using a PDA and a wireless network, bird pictures and video files can be broadcast to a group so that every student gets an equal chance to observe a specific bird. Students can also produce bird query conditions, such as size and color of the bird, which are sent to a database which helps narrow possible results. A trace file is then created in the instructor's notebook to record all searching patterns during each bird-watching activity. Finally, the interface allows evaluation of students knowledge and progress. It was found that Japanese children who used the system improved their learning above and beyond what would normally be expected.

2.5 Beyond the classroom

The potential for mLearning goes beyond the classroom and extends into business training and job aids. As Elliott Masie (Sheperd, 2001) points out:

> “”The assumption here is to dramatically expand the accessibility of learning beyond the physical footprint of the PC. If we remember that over 50%

[8] `www.agentsheets.com`

> of the workforce does not sit at a desk, but instead is standing, walking or moving around a factory, we see the potential of breaking the tether of the Ethernet wire."

With innovative use of this technology, lifelong learning can become accessible to all.

Context of use is a recurring issue within most of the research discussed as well as managing personal knowledge and social knowledge. Ferscha, Holzmann, and Oppl (2004) expand on this idea:

> "Location has been proven to be one of the most important and effective contexts in many applications. Besides identifying the geographical position of the user, it makes sense to introduce some sort of meta-information that enables the system to distinguish between locations used for different purposes. In learning settings for example these "meta-locations" could be classroom, home or outdoor, thus enabling the system to adapt to the current learning situation."

Roschelle (2003) describes one of the key issues with mobile learning as being a mixture of complex views of technology and simplistic views of social practices. She believes that further research is needed to identify relevant pedagogical practice arising out of simple wireless and mobile technologies. I believe that further exploration of contextual research would fulfill this need.

I would like to add that location is not enough. Context, whether it is a location-specific or time-specific, is a key part of how technology can help us manage our lives more efficiently. Moving between work and leisure, cell phone users have not had much trouble being able to handle both. However, formal learning is becoming a greater part of users' lives. Whether they be students completing their first undergraduate degree or adults adding to their employability while taking care of their family, learners have more factors of which to keep track.

2.6 Context-aware mLearning

Assumptions about traditional stationary applications are being discarded because they no longer apply to the ever-increasing number of mobile devices. These devices are most often used in changing environments and the current interfaces and services do not adapt well to these changes. To further complicate this, a problem arises from accommodating users with different skills, knowledge, age, gender, disabilities, disabling conditions, socio-economic status, etc. Seffah and Javahery (2004) provide us with an example:

> "While walking down the street a user may use a mobile phones Internet browser to look up a stock quote. However, it is highly unlikely that this same user would review the latest changes made to a document using the same device. [Another example is] when a user is driving, he/she cannot use a PDA to reference a telephone number. It is not possible to make use of a traditional PC as one walks down the street. The same is not true for a mobile telephone." (Seffah & Javahery, 2004)

Context, as defined by Dey and Abowd (2004), is any information that characterizes a situation related to the interaction between users, applications, and the surrounding environment. The challenge is to create a system that will adapt to the set of constraints imposed by the corresponding context of use. These constraints are set by various internal and external factors or dimensions of context. Prekop and Burnett (2003) provide a thorough overview of what various authors have put forth (see Figure 2).

Lonsdale et al. (2003) have themselves investigated context awareness for facilitating mLearning. They provide a hierarchy with which to breakdown and identify contextual situations.

This hierarchy consists of Context, Context State, Context Substate, and Context Features (see Figure 3). Their algorithm uses a basic cycle of operation to determine

Internal Dimensions of Context:
Human Factors

1. users
   (emotional/physical state, personal events, beliefs, previous experiences)
2. social environment
   (work context, business processes, communication)
3. activity
   (goals, tasks)

External Dimensions of Context:
Physical Environment

1. conditions
   (light, sound, movement, touch, acceleration, temperature, air pressure, proximity to other objects, time)
2. infrastructure
3. location

Technological Dimensions of Context

1. device
2. product design

Figure 2: Overview of various internal and external dimensions of context (adapted from Prekop and Burnett, 2003).

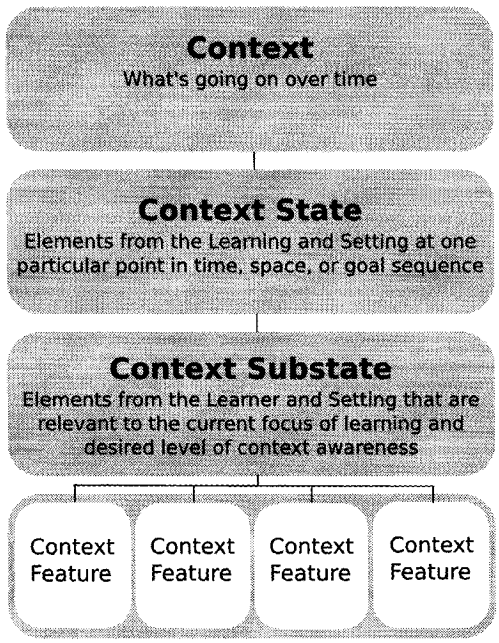

Figure 3: Hierarchy with which to breakdown and identify contextual situations (adapted from Lonsdale et al., 2003).

the context in which the system is operating. The cycle can be see, in Figure 4.

1. input – of context metadata;
2. construction – of context substate;
3. exclusion – of unsuitable content;
4. ranking – of remaining content;
5. output – of ranked list of content.

Figure 4: Basic cycle of operation for detecting context (adapted from Lonsdale et al., 2003).

Now that a method is provided in order to deal with contextual data collection, what data do we collect? The learning context as defined by Wang (2004) reads "any information that can be used to characterize the situation of learning entities that are considered relevant to the interactions between a learner and an application." He goes on to identify six dimensions that are relevant in computer-aided mobile learning: identity, spatio-temporal, facility, activity, learner, and community dimensions. In their approach, Ferscha et al. (2004) add team awareness as a seventh dimension to allow for team learning as a whole.

In computer applications, context is acquired either explicitly by requiring the user to specify it or implicitly by monitoring both the user and computer-based activity. It is most important to find the relationship between these variables, no matter how they are collected, so that the system can successfully determine how to react to different context.

Certain research groups have shown interest in the potential for user modeling systems to assist students in their learning, albeit in very different ways (Bull, 2003; Bull, Cui, McEvoy, Reid, and Yang, 2004; Stock, Rocchi, Zancanaro, and Kuflik, 2005; Joniken, Rissanen, Keränen, and Kanto, 2000; Becking et al., 2004).

Bull (2003) believes the solution to be in a location-aware system to offer easy access to the applications, files, and course materials commonly used by an individual in each of their frequently visited locations. She also believes that a mobile open learner model for consultation by a student after an interaction with the learning environment in which the model was created. So far, her participants have responded positively in favor of the proposed system.

However, no single strategy has been developed to accomplish this automatically. Instead, each research group carries on, hoping that their method will show promise. Most research groups propose few but powerful sensors like video or infrastructure based location-tracking (Laerhoven and Lowette, 2001; Schmidt, 2002; Schmidt and Beigl, 1998; Schmidt and Laerhoven, 2001). Feature extraction from different types of sensors has also been described in various publications (Clarkson, Mase, and Pentland, 2000; Brian, Sawhney, and Pentland, 1998; Clarkson and Pentland, 1998; Headon, 2003; Mäntyjärvi, Himberg, and Huuskonen, 2003).

Mayrhofer, Radi, and Ferscha (2003) aim towards developing a system that is reactive and proactive, using stored data to predict what the user may do in the future using an architecture based on feature extraction, classification, and labeling. Meanwhile, Mozer (1998) aims to learn user's habits in *The Neural Network House* to predict the likelihood that a zone is entered in the next few seconds using trained feedforward neural networks.

Dey and Abowd (2004) have suggested that there has been little advancement in context-aware computing over the past five years because of a poor understanding of what actually constitutes context. Although there have been many prototypes of location-based services, there are significant technology-centered and human-centred challenges. "We lack conceptual models and tools to support the rapid development of rich context-aware applications that might better inform the empirical investigation of interaction design and the social implications of context-aware computing" (Dey & Abowd, 2004).

Based on this review of context detection research, I believe that a context-aware mLearning system is possible which would integrate within the device's system allowing for transparent communication between detection devices, mLearning applications, and the mobile phone core services. However, despite having the push to profile learners and identify the context in which they find themselves at the time of access, pedagogical considerations are also important if learning is to occur.

2.7 Chapter summary

Mobile devices are becoming evermore commonplace and the quality and capability are increasing while costs continue to drop. Still in its early stages, mLearning using these devices is comparable to where eLearning was a few year ago. mLearning will not replace traditional methods but it does provide other ways of learning using new mobile technology. To do this, however, we must keep certain issues in mind such as interoperability, miniaturization (i.e. usability, portability, and ergonomics), quality of service, and adaptivity.

The increase in access and the flexibility associated with mobile learning will move students from passive to active roles using both situated and distributed cognition. While mobile learning research is still in its infancy, it is obvious that the trend towards ubiquitous computing needs to be matched with a sound theoretical model for educators to make the most of the new technologies (MacManus, 2002).

Through my search of the literature, I have found adaptive interfaces for various mobile applications. As I mentioned earlier, I have come to believe that context sensitivity is an important part of a successful mLearning device. Furthermore, I believe that mLearning applications will not integrate easily into student lives unless the entire mobile menu system helps manage their tasks and time. This concept would allow mLearning to be a holistic system which would not solely be dependent on any specific application; the concepts will be usable in any type of application.

Chapter 3

Methodology

An analysis of context sensitive tasks linked to contexts such as work, leisure, and school is proposed. For this to be successful, it will be imperative to identify various types of time management tasks that users may complete with a device, and not simply with a specific application. It will then be determined how the device should handle these events by surveying users of mobile applications.

One way of involving users in the design process is through user-centered design (UCD). UCD is a broad term to describe design processes in which end-users influence how a design takes shape. It is both a broad philosophy and a variety of methods. To further pinpoint a methodology, I will be using participatory design (PD) for several reasons stated below.

3.1 Participatory design

Löwgren and Stolterman (2004) define participatory design as "...a process of mutual learning, where designers and users learn from and about each other. Truly participatory design requires a shared social and cultural background and a shared language. Hence, participatory design is not only a question of users participating in design, but also a question of designers participating in use." Bødker, Kensing, and

Simonsen (2004) state that designers need to understand the environments in which their design will function and users need knowledge about possible problems.

3.2 Design models

In their book, Human-Computer Interaction, Preece et al. (1994) provide an excellent review of various software design methods including the traditional 'waterfall' model of system development (see Figure 5). An important characteristic of this process is that validation is performed in order to verify that the client's requirements are met. This approach, however, does not begin to consider user requirements until the application is defined which, in turn, applies constraints. This means that the client's and designer's views of the system are considered first and bias all further design.

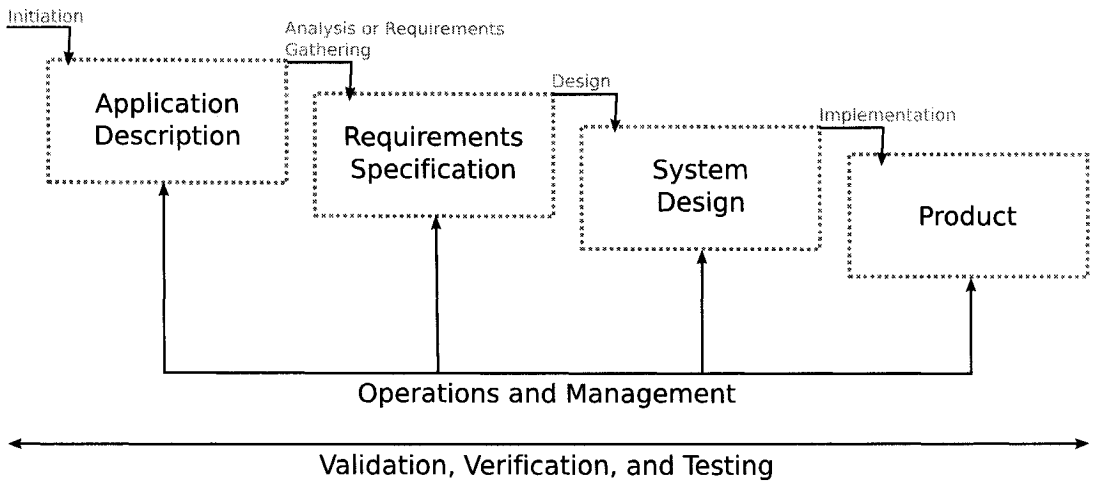

Figure 5: Traditional waterfall method (adapted from Preece et al., 1994).

Preece et al. (1994) believe that it is truly "...impossible to completely understand and express user requirements until a fair amount of design has been undertaking." This entails an iterative process. Because of the limitations, a number of alternate design models are presented in the review. I will examine the overarching themes of these models (see Figure 5).

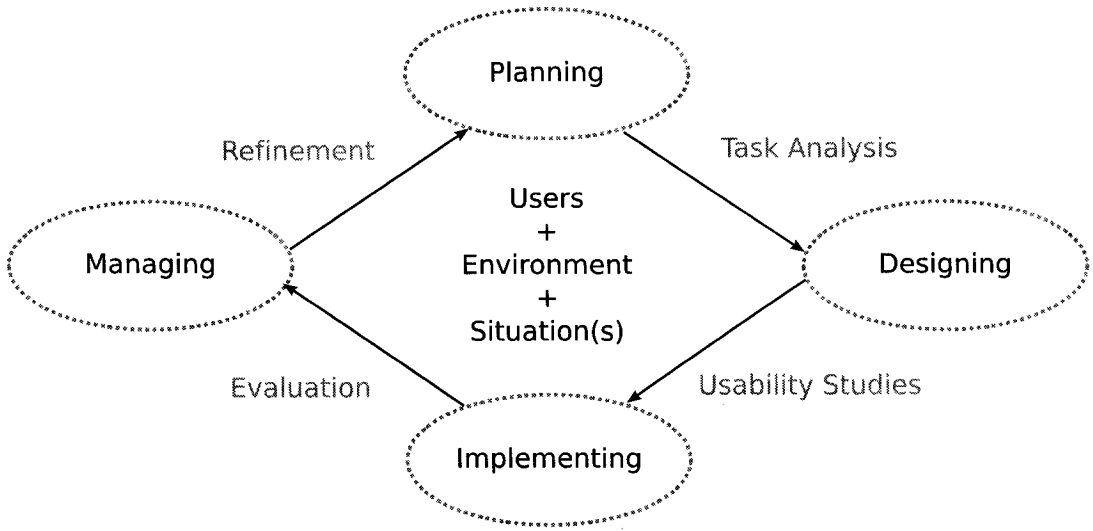

Figure 6: User-centered design method themes (interpreted from Preece et al., 1994).

In this study, no specific model was used because none truly fit the goals of the system. Instead, the trends brought up by Preece et al. (1994) were used to produce a set of specific tools for the initial stages of this study (planning and the beginnings of designing). These will be discussed further in Chapter 4.

3.3 Chapter summary

In summary, participatory design is an interesting methodology because it involves the users at every stage of the design. The collaboration between the designer and the users leads to data "co-constructed" by the participants and designers. This study would not be the first to use participatory design in this emerging field. Danielsson, Hedestig, Justin, and Orre (2004) used this method to develop a collaborative learning environment for university students.

Chapter 4

Data collection and results

To facilitate discussion, each stage of the data collection is explained and then followed by the results for that stage. Two interview sets are presented which discuss time management strategies and specific uses of various technologies on mobile devices with participants.

4.1 Participant selection

In the study, seventeen participants were recruited from within the university context. Posters were placed in strategic areas within the university advertising that volunteers were required to participate in a time management study. Participants were chosen from different age groups and with different backgrounds. An important criteria was getting participants who were in various stages of their lives (*i.e.* learners having recently finished high school/undergraduate degrees, adult learners, learners with a family, etc). It did not matter whether participants currently owned a mobile device or not since the former could provide information on how to improve current systems and the latter could explain how to make a mobile system more alluring and useful.

Participants were interviewed about their time management skills and their use of technologies, including mobile technologies. They were then asked how they think

a mobile device should act in certain contexts and during specific activities. Each interview was recorded to allow for accurate transcribing *post facto*. The procedure lasted no more than fifteen minutes for each interview.

4.2 Tool refinement

The tools used in this study were created first and were based on what information was needed for participatory design. The preliminary questionnaire (see Figure 7) was put online[1] in order to validate the choice of questions.

1. How do you manage your time?
2. Are you successful at managing your time?
3. What do you find difficult about time management?
4. Do you currently use a mobile phone? Why or why not?
5. Do you use your mobile phone as a time management tool? Why or why not?
6. If yes, what works well, what is satisfactory, and what is unsatisfactory?
7. Do you use any other technologies as time management tools?
8. If yes, what works well, what is satisfactory, and what is unsatisfactory?
9. Can you separate your daily activities into categories?
10. If yes, how would you identify these categories?

Figure 7: First iteration of the tool.

Participants from various sources were asked to fill out the survey anonymously. After reviewing the answers, the results were used strictly to improve the tools. The revised questionnaire is presented in the following section (see Figure 8). Allowing for clearer and more appropriate questions, themes were mentioned at the beginning of the interview to ensure that participants understood the goal of the session. The

[1] `www.surveymonkey.com`

second interview and the corresponding tool was added in order to provide more details as to how to develop storyboards for a prototype of an mLearning system (see Section 4.5). The process of refining the tool was published in Lavoie (2006).

4.3 First interview methodology

Once the participants were chosen, semi-structured interviews were conducted. This implies that broad questions were asked that did not require specific answers. Instead, answers were elaborated leading to a dialog to allow questions to build upon knowledge gained.

As can be seen in Figure 8, themes and questions were planned which guided the interviews. The themes ensured that participants understood the goal of the session. Bødker et al. (2004) recommends that interviews should not be scheduled right after one another to allow for some reflection by the interviewer. From experience, they have found that each interview will yield a wealth of relevant information that can be used in the next interview. For this reason, a period of approximately two weeks elapsed before the second interview was scheduled.

4.4 First interview results

During the first interview, I asked participants to describe the strategies they used to manage their time. I found that certain themes and issues kept arising. The following collection of quotes gives a general overview and narrative of the themes discussed recurrently:

> "[I update my agenda] when I have time in the bus, cleaning the house, in the evening, on the bus or the metro." (P1, February 17, 2006)

> "[Making] lists is more of a psychological release just to put it down and see what I have to do." (P2, February 17, 2006)

Themes: Time Management, Mobile Phones, Technology Use
Questions:

I Introduction

(a) Tell me more about yourself...

a How old are you?

b What is your highest level of education? (High School/Cgep, Undergraduate, Graduate, Post-Graduate)

c Are you currently working? (Part-time, Full-time)

d Do you have children? (Yes, No)

II Time Management

(a) What strategy/strategies do you use to manage your time?

(b) Does your strategy/strategies ever vary? If yes, when do they vary?

(c) What do you find easy/difficult about managing your time? Are your needs fulfilled?

III Mobile Phone Use

(a) Do you currently use a mobile phone? Why or why not?

(b) If yes, do you use your mobile phone as a time management tool? Why or why not?

(c) If yes, what aspects work well for you, which are only satisfactory, and which are unsatisfactory?

IV Technology Use

(a) Do you use any other digital technologies as time management tools? Why or why not?

(b) If yes, what aspects work well for you, which are only satisfactory, and which are unsatisfactory?

(c) Do you use non-digital technologies as time management tools? Why or why not?

(d) If yes, what aspects work well for you, which are only satisfactory, and which are unsatisfactory?

V Time Management Revisited

(a) Can you categorize your daily activities? Explain.

(b) Do you prioritize your daily activities?

(c) Do you keep track of how long activities should take and how long they actually take?

(d) Do you schedule goals/milestones for activities?

(e) Do you look at your schedule one day at a time or one week at a time? Explain.

Figure 8: Second iteration of the tool used for the first interview.

"Part of it is just conceptualizing it in the sense of making it efficient to transfer what I need to do for the following day or the following week." (P2, February 17, 2006)

"The thing with lists is, it's great but then after a while I spend so much time renewing them and not getting things done." (P3, February 21, 2006)

"[The real issue is] procrastination but only for certain things. Certain things I don't have any trouble and other things, for some reason, once I've procrastinated once, it seems it's easier to keep [pushing them off]." (P4, February 17, 2006)

"I guess like anyone, it comes down to self discipline. Doing the things that you know you have to do but you don't necessarily want to. I think that making yourself do those things is probably the hardest thing to do when it comes to managing your time." (P5, February 28, 2006)

"Of course, things come up all the time so you can't really just stick to a schedule that's concrete." (P5, February 28, 2006)

Of course, there were differences among participants. One participant spoke of only doing certain types of activities in certain physical areas in order to mentally prepare himself:

"I think what's important for me, I've realized, is setting up environments for myself. To cue myself. I find that, for example, I can set aside time to do things but if I'm not in the right environment I won't necessarily stay on task." (personal communication, February 17, 2006)

A few participants spoke of a recurring cycle:

> "So when I'm busiest I HAVE to do something about it because I cannot function at all. But if I'm not that busy, I tend to put off things and I don't realize until I'm really busy again. [It's a cycle.]" (P3, February 21, 2006)

Some were anxious about letting duties fall through the cracks and responded by having a strict routine to ensure everything was managed efficiently:

> "[My strategy varies] based on how busy I am... I'm always doing the same routine to make sure that weeks are planned out properly. Some of my personal life is also reserved on specific days." (P6, February 21, 2006)

Also, a few participants were not native English speakers and needed to budget their time accordingly:

> "I need to distribute my time properly because I need to spend a lot of time reading. English is my second language and I changed my study area from undergraduate to graduate. So I need to read more and I need more time to understand [the terminology] because there are too many [professionally] specific concepts for me." (P7, February 28, 2006)

To analyze fully all of the comments provided by the participants, specific questions were asked during interviews. Table 2 lists both a set of generic strategies for time management and whether participants stated that they in fact did, or did not, use these strategies to manage their time. It also tries to identify under which category the tools they use to implement these strategies falls under.

Most of the participants use categorizing (13 out of 17) on a regular basis (see Table 3). Commonly recurrent categories included school (15), work (13), and home(4). There were also (9) other categories mentioned such as social life, meetings, and volunteering that came up only a few times each.

Table 2: Table of strategies and tools used in time management.

		Yes	No
Strategies	Categorize	**13**	4
	Prioritize	**11**	6
	Time Tracking	4	**13**
	Goal Setting	**10**	7
Tools	Mobile Phone	**9**	8
	Mobile Phone TM	5	**12**
	Digital TM	**15**	2
	Non-Digital TM	**16**	1

"[In terms of categories,] all school is very similar because you do it in the same place." (P8, February 28, 2006)

Table 3: Table of categorizing methods.

Categories	#
School	**15**
Work	13
Home	4
Other	9

Prioritizing (11 out of 17) was also popular. Several methods were identified (see Table 4). The first was most common (8) and relied on giving a higher priority to activities with looming deadlines.

"I say [I prioritize much more] by deadline but also how I'm feeling energy-wize." (P5, February 28, 2006)

Prioritizing based on how long an activity would take was used by five participants and prioritizing based on balancing one's life to include as much work-related and school-related activites as those axed towards social involvement was used by four participants.

> "During my undergrad I didn't realise how important it was to integrate that social componant. You get so wrapped up in your work that [you feel disconnected]. It's unhealthy to isolate yourself and your work is affected by it completely. Because without any kind of objective perspective on what your working on, I think that can be negative for the final product." (P5, February 28, 2006)

Some participants (3) prefered prioritizing based on location, which involves the optimization of a path to complete the most amount of activities tied to specific locations.

> "[When it comes to prioritizing,] depends on what kind of things I need to be doing. If there are thing that need to be done outside [of school and work], it totally depends on my path."' (personal communication, February 21, 2006)

> "If I don't have anything pressing, then it tends to be location." (P3, February 17, 2006)

Finally, a few participants (2) specified that they prioritized based on their life goals such as where they wanted to be in their careers.

> "I think probably the biggest problem is prioritizing things. What you end up with is a list, either on paper or on my PDA, of all the different deadlines but obviously some are much more important and some are going to contribute a lot more to my future than others." (P9, February 17, 2006)

The third was based on goal setting (10 out of 17) on a regular basis (see Table 5). Goal setting was specified to be used for projects (4), for long-term activities (2), for short-term activities (2), to specify when rewards for hard work were to be attributed (1), and to verfiy that involvement in a variety of different projects was achieved (1).

Table 4: Table of prioritizing methods.

Prioritizing	#
Deadline Based	**8**
Time Based	5
Balanced Life	4
Location Based	2
Goal Based	2

"[I set goals] for really important things. For longer term, bigger projects, yes. If I'm gonna vacuum the house, I'm not gonna have a benchmark." (P10, February 28, 2006)

"[I set goals and milestones], definitely. More personal than professional... It helps me stay involved in a wide variety of activities." (P6, February 21, 2006)

Table 5: Table of goal setting methods.

Goal Setting	#
For Projects	4
Long Term	2
Short Term	2
With Rewards	1
To Stay Involved	1

Time-tracking was only used by a few participants (4 out of 17). The most common reasons for not using this strategy was that it was depressing and frustrating to see that activities may take much longer than anticipated.

"If I put [my activities] into time, I would get depressed. So it's easier to have them as bullet points and just tick them off and be happy no knowing how long it took. It's completely un-useful [because you get interrupted]. It will take me as long as it takes me." (P1, February 17, 2006)

One of the reasons for not doing so was that some participants felt it prevented creativity and caused too much pressure.

> "In both my personal and professional life, there is just incredible amounts of creativity. I cannot restrict myself to [how long it SHOULD take]... I'll do it when it has to be done." (P6, February 21, 2006)

Others stated that it had never occured to them to track their time.

> "It just didn't occur to me to do that... I've always found it so hard to realistically predict how long things will take that I guess I've just decided that it's really not worth while [to stress over it]." (P4, February 17, 2006)

Two of the participants, however, felt it helped distribute their time accordingly and helped the billing process when presenting invoices to clients.

> "[I keep track of how long activities take and should take] with work I do because I have to keep track of my own hours. It's important for me to gage." (P2, February 17, 2006)

There was also interest in estimating how long an activity would take, tracking how long the activity actually took, and then comparing both time and reflecting upon the results in order to change their habits.

> "[Measuring how long activities actually take] would be interesting to do. I can see that being very useful especially in terms of development or design activities. Because, despite the fact that I've been given basic rules of thumb... I'd like to know how it works for me." (P9, February 17, 2006)

As for tools, almost all used both digital (15 out of 17) and non-digital (16 out of 17) time management options. Most of the participants used a combination of digital and non-digital tools (14 out of 17).

"If I'm in class, if I'm mobile, then I'll just use a student agenda. But if I'm at home in front of the computer, I'll tend to put it in Sunbird [right away]. And if it's something I have to do that day, I won't bother putting it in sunbird, I'll just write it on a piece of paper." (P8, February 28, 2006)

"Usually I use an agenda as a temporary recorder [until I put it in my PDA]." (P9, February 28, 2006)

It was stated that digital tools were prefered because those would reduce effort as well as mistakes.

"If I write something down in my notebook, when I go home, do I put it into [my computer] or just leave it in my notebook? But then I have two versions of my life that I'm trying to negotiate." (P2, February 28, 2006)

"I find I have too many kinds of lists. I have information in my notebooks from school, and I have information in another agenda... At a certain point, keeping that agenda up is more work than it's worth. I think that if I had more access to technology or more awareness of technology and found one [tool], than I would keep everything on that." (P11, February 28, 2006)

"Most important thing is that with a digital product, I can sync." (P7, February 17, 2006)

However, finding a digital tool that would suit their needs as well as be portable, efficient, powerful, and affordable was an issue. A definite concern is that finding an optimal tool and sticking with it is important because switching between devices is cumbersome.

"[My strategies] vary over time in that I'm always looking for [a tool that is] easier to actually use. Not necessarily more functional but easier to put information into." (P8, February 28, 2006)

"There is a certain inertia because you've already put the time into one technology... If you could export it to another application it would be great, transfer it between platforms." (P12, February 28, 2006)

One participant strictly used digital tools but, again, had not found one to answer all of his needs.

"I think the best part of my system is I can update it anytime and it's always pretty much [the same]. It's stays with me and I'm able to update it really quickly usually... Then I make sure it's synchronized with all my devices and computers." (P4, February 17, 2006)

"If need be, at pretty much any time, I can go back in my calendar two or three years if I wanted to which I couldn't do with a paper agenda. It's a little more flexible in that regard." (P12, February 17, 2006)

The most common digital tool used was a digital calendaring system. There are many reasons for this. These tools allow for easy input of new engagements, especially repeated activities and conditional activities. They usually include the ability to add notes to the engagements and the inclusion of these to To-Do lists. They could easily be referred to when looking for past or future engagements as well as be printed for mobility and portability, albeit no updating. Finally, most of these tools allow users to sign up to public calendars or ones held by one of their social groups.

Approximately half of the participants (9 out of 17) currently owned a mobile phone and of those only a few (5 out of 9) used some sort of time management feature. Unfortunately, their time management methods using a mobile phone could not be thoroughly analyzed since most (4 out of 5) strictly used the alarm system

and the fifth participant used a digital calendar that was an additional application on his device and so classified it as a digital tool.

Two participants strictly used non-digital technologies because they did not find that it had any disadvantages over non-digital technologies.

> "I tried [using digital time management tools]. The only thing I used it for is to print out monthly calendars to have it on the wall when I'm checking for assignments." (P1, February 17, 2006)

The most common non-digital tool used was an agenda. This was due to the fact that they were readily available at their place of schooling and usually were included in the price of their tuition. These agendas held calendars, were easily portable, mobile, and editable, and could be used for notes in a pinch.

Participants were also asked how they visualized their schedules (see Table 6) by identifying the time frame for which they look at their schedule, be it a day at a time, a week at a time, a month, or more at a time. In this case, participants were allowed to give more than one answer. The significant number of participants (12 out of 17) felt that they looked at their schedule a week at a time. A fewer number (9 out of 17) looked at their schedule a day at a time, and few (3 out of 17) looked at their schedule for a month or more at a time. This indicates that although participants felt that they needed to see what was planned for the immediate day, what they really wanted to know was what was coming up in the next week to make sure that they were prepared.

> "There is a micro and a macro [when I look at my calendar]. You do look at the day you are currently in (somewhere between a 24- and a 48-hour span) just so you know if you have something [the next day. However, u]sually my viewpoint is a week [so that I can prepare for what is coming up.]" (P8, February 28, 2006)

Several participants also mentioned that if a project was a semester long or more, they tended to break it down into smaller chunks in order to see the evolution and be able to track it every week or two.

Table 6: Table of visualisation methods.

	Day	Week	Month	Month+
Visualisation	9	12	2	1

During the first interview, it was important to understand the various viewpoints of time management. However, to have a clear idea of how this might be used on a mobile device, since most participants did not use one for such activities, it was important to have them project possible use.

4.5 Second interview methodology

A second session was scheduled with participants. This session included questions about hypothetical events. Answers were recorded on a grid where the horizontal dimension was context and vertical dimension was specific action-reactions. This grid aided users by allowing them to visualize the scenarios (see Table 7).

Each participant was asked how he or she would want a communication event, such as a call, a message using SMS or MMS, a schedule reminder, or an application reminder, to be treated by their phone from one context to another. The technique of prompted reflection is used when the concepts discussed are hard to grasp. Since there is no prototype for users to use and test, using such a grid helped sort out difficult concepts to grasp in order to discuss how the technology would work.

When responding, participants were told that the system could deal with each event in any possible way they wished. The participants, as a group, provided five different types of interactions for the system. The first was treated as (N)ormal. This would be defined as the default reaction of the mobile where the phone would ring or

Table 7: The answer grid.

		Work					Formal Learning					Leisure				
		N	S	D	A	X	N	S	D	A	X	N	S	D	A	X
Call	Work Formal Learning Leisure															
SMS	Work Formal Learning Leisure															
MMS	Work Formal Learning Leisure															
Reminders	Work Formal Learning Leisure															

make noise as a typical phone would do. The second was (S)ilent. Most participants assumed that the phone could display incoming events and vibrate to alert them only if it were appropriate. Having a (D)elayed interaction was also popular, especially when users would not want to be distracted or disturbed. For example, nothing is worse than being at work and seeing an SMS from a friend who is having a great time while you toil in a dark and smelly office. (D)elaying the interaction would mean that the phone records all calls and messages, but only displays them to you when you actively look in an inbox – the phone is still on but only some events get through the filter. Some also wanted an (A)utoreply feature saying messages such as "I am currently busy at the moment and will get back to you shortly" or "I am at work and do not reply to SMS during this time. Please call me at 555-555-5555 for emergencies." Finally, some users could not see themselves using certain functions or would actively choose not to use it and turn it off, hence, included was a lack of interaction title Do Not Use, represented by an (X).

Scenarios are important, in part, because they evoke reflection in the content

of design work, helping developers coordinate design action and reflection (Carroll, 1999). Carroll (1999) also states that scenarios promote communication among stakeholders and, therefore, ensures that the needs and concerns of the people who use the technology are fully addressed. In other words, it helps focus designs on the human beings behind the technology (Claussen, 1994).

4.6 Second interview results

During the second interview, fourteen participants were asked to describe their preference for how a context-aware system should act when, for example, they were in a certain situation and someone from their address book, labeled according to the specific context which the user interacts with them, attempted to communicate with them. Also, I was curious to see whether schedule reminders, again labeled according to the context of interaction, were treated the same way. The contexts used were generalized from the first interviews where most participants reported having a work context, a formal learning context, and a leisure/family context.

There were five events considered including an incoming call, SMS, MMS, and scheduled reminder. These were sent from and received in a combination of three different contexts including a work, formal learning, or leisure context. To simplify the analysis of this table, I have chosen to break it down based on events.

To begin, let us look at the first event: when participants receive calls (see Table 8). The table includes the following abbreviations: (N)ormal, (S)ilent, (D)elayed, (A)utoreply, and (X) Do Not Use. When calls received from work, at work, the majority of participants (11 out of 14) wanted the phone to act normally. When it came to calls from a formal learning context to a work context, participants were split. Almost an equal amount (5/4/5 out of 14) wanted a normal reaction by the mobile, a silent reaction, or a delayed reaction. This would indicate that participants found it difficult to prioritize between either work or school. I believe this is because both

may lead to improved career achievements.

When calls from a leisure context were received at work, half of the participants (7 out of 14) wanted these calls to be silent. This means that the calls would not interrupt. Instead, they could easily be seen in idle times in order to plan activities and, therefore, reward themselves after a hard day at work.

In a formal learning context, participants wanted silent calls from both work (7 out of 14) and leisure (7 out of 14) contacts. The most stated reason was that it is so hard to concentrate and get work done for school that distractions lead too easily to procrastination. The preference was less clear for formal learning calls in a formal learning context. Some participants (5 out of 14) wanted the event to be normal while others (6 out of 14) required silent actions. The justification was that these calls were from the same context, however, could be for a different topic and therefore could wait. One participant in particular, who wanted it to be silent, mentioned that if she was not working on a task, then it was not prioritized. Finally, in a leisure context, 6 out of 14 participants wanted work calls to be normal, while 5 out of 14 wanted work calls to be delayed. Some felt that their career came before anything else; these were mostly adult learners (5 out of 6). Some felt that outside of work, these calls were not important because they were not being paid at the time. However, in this context, formal learning calls were said to be normal because these were less linked to a specific schedule. For leisure calls in leisure contexts, almost all (12 out of 14) participants wanted this to be normal. I was surprised that two of the participants did not want this. However, I believe that this may be because they do not own phones and have a certain amount of technophobia.

SMS stands for Short Message Service. They are asynchronous text messages received by the phone's inbox. These are very popular among young people throughout the world because they are discreet and have a set cost, instead of per minute, so that they are cheaper than calls. Whenever a SMS (see Table 9) was received at work, from work, participants (9 out of 14) wanted these to be normal because they

Table 8: Results for second interview – calls.

		Work					Formal Learning					Leisure				
		N	S	D	A	X	N	S	D	A	X	N	S	D	A	X
Calls	Work	**11**	2	1	0	0	2	**7**	5	0	0	**6**	3	**5**	0	0
	Formal Learning	**5**	**4**	**5**	0	0	**5**	**6**	3	0	0	**8**	2	4	0	0
	Leisure	3	**7**	4	0	0	3	**7**	4	0	0	**12**	1	1	0	0

were in the right context. However, in the same context, participants wanted formal learning (7 out of 14) and leisure (8 out of 14) text messages to be silent so they could be reviewed at a later time. In a formal learning context, participants wanted SMS from work (5 out of 14), formal learning (7 out of 14), and leisure (9 out of 14) to be silent for the same reason. Looking at them at a later date means they are less intrusive but can be dealt with accordingly throughout the day. In a leisure context, participants wanted messages from work (6 out of 14), formal learning (6 out of 14), and leisure (9 out of 14) to come in normally. For calls, some participants preferred delaying work phone calls but for work SMS most participants were willing to receive them. I believe that this is because of the asynchronous nature of the message; they receive information but are not obliged to respond right away. The table includes the following abbreviations: (N)ormal, (S)ilent, (D)elayed, (A)utoreply, and (X) Do Not Use.

Table 9: Results for second interview – SMS.

		Work					Formal Learning					Leisure				
		N	S	D	A	X	N	S	D	A	X	N	S	D	A	X
SMS	Work	**9**	2	0	1	2	2	**5**	2	3	2	**6**	1	4	1	2
	Formal Learning	3	**7**	1	1	2	4	**7**	1	0	2	**6**	4	2	0	2
	Leisure	2	**8**	2	0	2	0	**9**	2	1	2	**9**	2	1	0	2

MMS stands for Multimedia Message System and is an asynchronous graphic,

audio, or video message received by the phone's index (depending on the device's capabilities). The responses for this category (see Table 10) were very similar to SMS but for one anomaly. In a work context, participants preferred normal responses for MMS messages from work (6 out of 14), but a silent response from formal learning (9 out of 14) and leisure (8 out of 14). In a leisure context, participants wanted work MMS (6 out of 14) and leisure MMS (7 out of 14) to be normal. The anomaly was found in MMS from formal learning in a leisure context. 5 out of 14 wanted these to be normal and 4 out of 14 wanted these to be delayed. I cannot propose a theory as to why that is other than that the participant perhaps did not understand the nature of MMS. In fact, most (8 out of 14) did not know what it was before starting the session. The table includes the following abbreviations: (N)ormal, (S)ilent, (D)elayed, (A)utoreply, and (X) Do Not Use.

Table 10: Results for second interview – MMS.

		Work					Formal Learning					Leisure				
		N	S	D	A	X	N	S	D	A	X	N	S	D	A	X
MMS	Work	**6**	4	1	0	3	2	**6**	2	1	3	**6**	1	4	0	3
	Formal Learning	0	**9**	2	0	3	1	**8**	2	0	3	**5**	2	**4**	0	3
	Leisure	0	**8**	3	0	3	0	**9**	2	0	3	**7**	1	3	0	3

For both SMS and MMS messages it was apparent that the younger participants felt a certain prestige in receiving messages during social situations, while older participants did not see it that way and wanted the messages to be silent or delayed.

As for schedule reminders (see Table 11), because most participants felt that these would be input by them and most likely relevant to their engagements, all of the preferences were that the reaction be normal in all context. The table includes the following abbreviations: (N)ormal, (S)ilent, (D)elayed, (A)utoreply, and (X) Do Not Use. In a work context, this reaction was preferred for work reminders (10 out of 14), formal learning reminders (9 out of 14), and leisure reminders (9 out of 14). In a formal learning context, a normal reaction was required for work reminders (9 out

of 14), formal learning reminders (10 out of 14), and leisure reminders (10 out of 14). The same was desired for work reminders (11 out of 14), formal learning reminders (10 out of 14), and leisure reminders (12 out of 14) in a leisure context. These results for reminders surprised me because it seems obvious to me that if a reminder is signaled at the wrong time, users may see it, however, they risk acknowledging it and promptly forgetting about it. When it is treated as any other interruption, users may ensure that it will be processed right.

Table 11: Results for second interview – reminders.

		Work					Formal Learning					Leisure				
		N	S	D	A	X	N	S	D	A	X	N	S	D	A	X
Reminders	Work	**10**	3	0	0	1	**9**	3	0	0	2	**11**	1	1	0	1
	Formal Learning	**9**	3	0	0	2	**10**	2	0	0	2	**10**	1	1	0	2
	Leisure	**9**	3	1	0	1	**10**	3	0	0	1	**12**	1	0	0	1

4.7 Chapter summary

In this chapter, the results of the first interview, which dealt with time management strategies, and the second interview, which dealt with specific uses of various technologies on mobile phones, were presented and analyzed. Statistics were provided along with quotes from participants.

In the first interview, typical time management strategies mentioned by participant included inputting appointments and deadlines when possible, mostly in order to conceptualize as well as to provide a psychological release. However, making lists is time consuming and can even be a form of procrastination. Accomplishments are achieved through self-discipline while still being flexible and managing change.

Most participants use categorizing (work, school, and home or other) to sort their tasks. Decisions were based on priorities and goal achievement. Most participants,

however, did not keep track of how long they thought activities should take as opposed to their actual length. The majority of participants usually viewed their schedule through a one-week window.

Almost all participants used both digital and non-digital time management tools. Just over half of participants used mobile phones and just over half of those used very basic time management features.

In the second interview, most participants required incoming calls to be silent or delayed in a work context, silent in a formal learning context, and normal in a leisure context. The majority of those interviewed wanted SMS or MMS messages to be silent in both work and formal learning contexts. They expected a normal reaction in leisure contexts. Practically all participants wanted reminders to act normally in all contexts.

Although these facts were interesting, they are not useful in their raw format to the design process. The following chapter distills this information in order to provide recommendations.

Chapter 5

Recommendations

Recommendations were elaborated in order to prescribe a course of action for future work. They are based on the first interview relating to time management strategies as well as the second interview relating to scenario preference. This information falls into three categories including (1) digital requirements, (2) functionality requirements, and (3) performance requirements as defined below.

1. **Digital Requirements:** Embedded functionality that is more or less invisible to the user.

2. **Functionality Requirements:** Specific applications and/or functionality available to the user.

3. **Performance Requirements:** Abstract descriptors of the functionality from the user's perspective.

5.1 Digital requirements

To begin, let us look at the digital requirements. As mentioned earlier in Section 2.6 Context-Aware mLearning, context-awareness will allow the device to easily identify context without user input. This will remove a step that may cause users to turn away

from such a system. The mobile could collect information using an intelligent user agent. Results from this data collection would allow such actions as modifying the interface in order to move menu items depending on how often they are used. Users should be able to have multiple profiles based on the context in which they are using their device to allow them to be more efficient in all aspects of their lives. Another important digital requirement is interoperability between time management systems. Allowing users to import or export events, contacts, etc., allows them a perceived notion of freedom. It eases their minds and encourages them to adopt technology more readily without feeling trapped. Finally, functionalities should be modular in order to easily turn on or off any unused features and reduce options in the interface and, therefore, unnecessary complexity.

5.2 Functionality requirements

In terms of functionality requirements, users should have the least amount of navigational steps in order to access time management features since this is the aim for the device. A variety of tools should be available. Most importantly, calendaring, and to-do lists were used most often by participants (15 out of 17). The ability to input repeat activities and conditional activities is absolutely necessary. Users should be able to customize the views of their schedule (i.e. daily, weekly, monthly). What I believe will be most useful, and has not been implemented broadly, is the ability to send events to contacts using SMS. Because of the social nature of devices, this would lend itself well to social calendars and group planning of activities whether for leisure, formal learning, or work. The ability to time track could also prove useful since many students needed to bill clients for contracts or wanted to time practical activities in order to have a better sense of time management in the work world.

5.3 Performance requirements

In relation to the previous points, performance requirements must be set. As much control as possible must be provided to the user. This flexibility is necessary because users do not yet know what they want because such technology does not exist and, therefore, hard to imagine various usage. Although users seemed interested and were willing to use such technology if it was released, it was hard to answer all of the questions put to them. Furthermore, participants risk changing their mind once they have used such technology.

5.4 Opportunities for funding

Before further investigation, it is important to know the potential of developing such devices. Mobile manufacturers and service providers could market a mobile learning device directly to educational institutions. Enterprises already market credit cards, insurance, clothing, and other goods and services branded with the institution's names. These symbiotic relationships provide fundraising for schools and specific target markets to companies looking for a profit.

Why not consider this for mobile devices too? This would not only benefit the companies by ensuring sales and return customers (once the students graduate), it would also benefit the institutions who receive a cut of the profits as well as assume larger roles in aiding their students succeed. Additionally, once educational institutions initiate the students to this kind of device, lifelong learning and personal development could easily ensue helping students later in life. The devices could plug into learner and course management systems as well as student portals already put in place. Students would greatly benefit from having easy access to relevant information and could receive timely study materials and reminders through their instructors (*e.g.* notes, recorded lessons, class cancellations).

Beyond educational institutions, this could be useful for business training, personal development sponsored by companies, or distance education programs.

5.5 Future work

Although the review of user-centered design was useful in the design of the data collection tools, these methodologies are normally used within a business environment. This means that the the methods are used for existing products where the users already have an idea for an existing product. In this case, it was hard for participants to imagine such a tool fitting into their lives. A mobile learning management prototype should be developed in order to proceed with the following steps of user-centered design.

The imagined mLearning device, to be successful, should include what users normally expect from devices on the market such as MP3 capabilities and camera features (see figure 9). Although this may be considered as adding frivolous features, matching how the users would use the phone more closely would aid in guarantying its success. Furthermore, these tools could be integrated into the student's study habits. For example, the MP3 capabilities could be used to listen to recorded lectures and the camera functionalities could capture artifacts for further study or to share with classmates.

Such a prototype should have the following software characteristics based on the results. It should be able to collect information autonomously; it should have a variety of functionalities which must be modular in order to allow the user to customize his or her device; and, finally, the device interface and settings should be as flexible as possible to cater to a variety of users. The hardware should have added contextual buttons which could easily give access to the contextual tags within various functions of the mobile. It would also be branded with the desired educational institution (as described in Section 5.4).

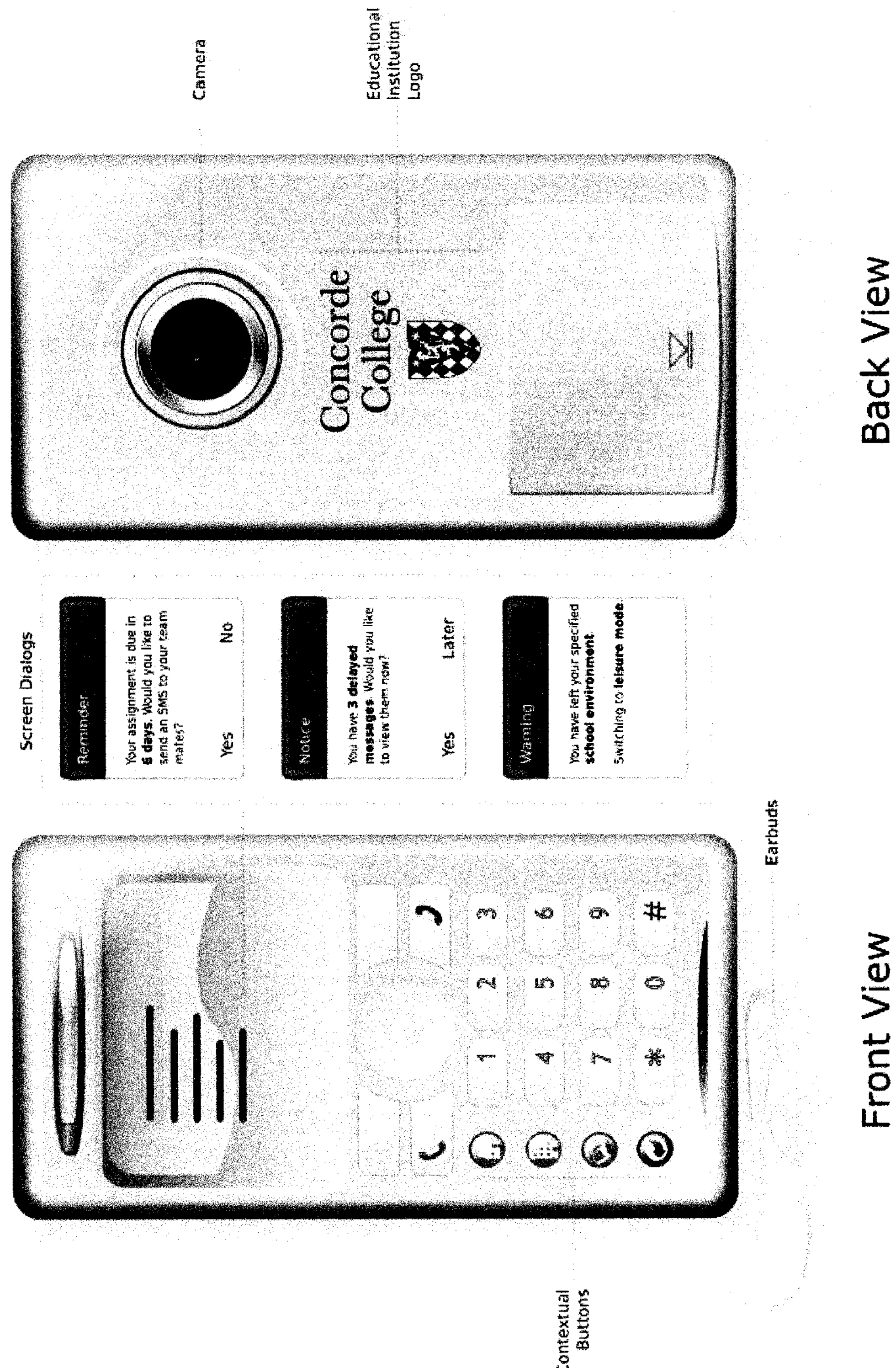

Figure 9: mLearning prototype as designed by the author

As for the participants, it would be preferable to use a larger set of test subjects including as many from this study as possible. This would allow for a refinement of the conclusions drawn in this work.

Finally, it would be useful to make a more detailed analysis of intelligent user agents in order to allow for a certain amount of automatic detection of context.

Chapter 6

Conclusion

Mobile devices are becoming evermore commonplace and the quality and capability is increasing while costs continue to drop. Still in its early stages, mLearning using these devices is comparable to where eLearning was a few year ago. MLearning will not replace traditional learning but it does provide other ways of learning using new mobile technology. To do this, however, we must keep certain issues in mind such as interoperability, miniaturization (*i.e.* usability, portability, and ergonomics), quality of service, and adaptivity.

The increase in access and the flexibility associated with mobile learning will move students from passive to active roles using situated cognition and distributed cognition. While mLearning research is still in its infancy, it is obvious that the trend towards ubiquitous computing needs to be matched with a sound theoretical model for educators to make the most of the new technologies (MacManus, 2002).

Also, potential for mLearning goes beyond the classroom into business training and job aids. As Elliott Masie (Sheperd, 2001) points out: "The assumption here is to dramatically expand the accessibility of learning beyond the physical footprint of the PC. If we remember that over 50% of the workforce does not sit at a desk, but instead is standing, walking, or moving around a factory, we see the potential of breaking the tether of the Ethernet wire." With innovative use of this technology,

lifelong learning can become accessible to all.

Context of use is a recurring issue within most of the research discussed as well as managing personal knowledge and social knowledge. Roschelle (2003) describes one of the key issues with mobile learning as being complex views of technology and simplistic views of social practices. She believes that further research is needed to identify relevant pedagogical practice arising out of simple wireless and mobile technologies. Contextual research would fulfill this need. Context, whether it is a location-specific or time-specific, is a key part of how technology can help us manage our lives more efficiently. Between work and leisure, mobile phone users have not had much trouble being able to handle both. However, formal learning is becoming a greater part of users' lives. Whether they be students in completing their first undergraduate degree or an adult learners adding to their employability while taking care of their family, learners have more factors to track.

Adaptive interfaces for various mobile applications exist, however, context sensitivity is an important part of a successful mLearning device. mLearning applications will not integrate easily into student lives unless the entire mobile menu system helps manage their tasks and time. This concept would allow mLearning to be a holistic system which would not solely dependent on any specific application; the concepts will be usable in any type of application. Users should be able to have multiple profiles based on the context in which they are using their device to allow them to be more efficient in all aspects of their lives.

Although there is still much work to be done, this study provided the groundwork for the development of a mobile learning management system. Such a system should be able to collect information autonomously; it should have a variety of functionalities; these functionalities should be modular in order to allow the user to customize the device; and, finally, the device interface and settings should be as flexible as possible to cater to a variety of users.

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