ALEX©: a mobile adult literacy experiential learning application

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Abstract: An alarmingly high number of adults in the world's most developed countries are linguistically functionally illiterate. The research presented in this paper describes ALEX©, an ongoing attempt to successfully develop an innovative assistive, mobile, experiential language-learning application to support the daily literacy education and needs of such adults, anywhere, anytime. We introduce a set of guidelines we have collated to inform the design of mobile assistive technologies, introduce our application and describe the design activities to date that have led to the development of our current application. We present this overview in the hope that it is useful to others working in the fledgling domains of mobile assistive technology design and/or mobile experiential language-learning technologies.

Keywords: MLL; mobile language learning; experiential learning; functional illiteracy; assistive technology.

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1 Introduction

Basic literacy skills are the fundamental building blocks of any language learning. Unfortunately, nearly 25% of adults (16–65) in the world's most developed countries are reportedly *functionally* illiterate (UNSECO, 2002). The International Adult Literacy Survey (IALS) defines literacy as: "the ability to understand and employ printed information in daily activities, at home, at work, and in the community, to achieve one's goals and to develop one's knowledge and potential" (OECD, 1997, p.14). Based on this definition, adults who are *functionally illiterate* are defined as adults (18+ years old) whose current literacy skills in their native language limit their ability to understand, use, find, produce and benefit from printed/textual information required in daily activities at home, at work and in the community: "these people may be able to read and write in the strict sense of the term…but for all intents and purposes, they […] can't cope in modern society" (UNSECO, 2002). In Canada, alone, for example, over 40% of adults are below the "desired [literacy] threshold for coping with the increasing skill demands of a knowledge economy and society" (Statistics Canada, 2005).

The IALS identified that the native linguistic literacy (language) skills of individuals are a powerful determinant of a country's innovative and adaptive capacity (OECD, 1997). Despite being "a pre-requisite for enhanced capacity for individuals in employment, in education, in community participation, and as parents" (European Basic Skills Network, 1999, p.12), adult education to improve basic literacy or native language skills is, however, typically underdeveloped because it is seen as marginal to compulsory schooling and it is an invisible part of other activities. An investigation into how education can help functionally illiterate adults overcome the problems associated with social exclusion emphasised the importance of community and the need for literacy organisations to meet the needs of people *within* communities (OECD, 1999).

A community approach to adult linguistic literacy (basic native language) learning often works well but, equally, potential learners can be prevented from taking part in such programmes due to barriers such as job or money problems, lack of childcare and lack of access to affordable or convenient transportation (ABC Canada, 2005).

Studies have shown that, despite considerable investment of effort and resources, little overall improvement in adult linguistic literacy is evident (Statistics Canada, 2005). This suggests that current adult literacy support and resources, including existing e-Learning applications, are not having the extent of impact that was anticipated. This further suggests that there is a need to investigate an alternative approach to tackling adult literacy issues – namely, the use of pervasive and ubiquitous forms of computing to support *experiential* language learning amongst functionally illiterate populations. In other words, there is a pressing need to investigate how best to take advantage of recent developments in mobile and ubiquitous technologies in order to provide new learning environments for literacy (language) learning that extend beyond traditional learning paradigms (e.g. classroom-based learning) and embrace the notion of *experiential* learning. In our research, we define *experiential learning* to be learning that is acquired through the performance of everyday life activities (as opposed to formal, curricula-based learning) – learning through reflection in doing (in contrast to didactic learning) that focuses on the learning process of the individual as opposed to a transfer of knowledge from a teacher to a learner. In essence, in our context, it refers to the development of literacy skills and acquisition of knowledge (e.g. enhanced vocabulary) as it pertains to real-life tasks that are undertaken by learners. As it is noted later in this paper, literacy educators working in community-based literacy organisations identify this as being a powerful and beneficial way for functionally illiterate adults to increase their literacy skills.

Flexible access to handheld technology has been suggested as a means by which children can be provided with tools to construct knowledge throughout their daily activities (Soloway et al., 2001). The research presented in this paper looks at projecting this philosophy to support *experiential* adult linguistic literacy (language) education by observing the key principles of andragogy. Section 2 presents some background relevant to this research. Section 3 introduces the guidelines which informed the design and development of our mobile experiential learning application. Section 4 briefly introduces the current version of our application design and Section 5 concludes with a discussion of identified further work.

2 Background

Attempts to address adult literacy education need to accommodate the everyday context of learners' lives. Mobile technologies offer new, and increasingly affordable, community-based and context-sympathetic possibilities for adult literacy (language) education. In particular, they offer opportunities to engage in *experiential* learning, whereby the technology becomes a ubiquitous aspect of learners' daily existence, and supports learning during everyday life experiences. Literacy skills are like muscles – they are maintained and strengthened through regular use (ABC Canada, 2005) and so continuous, experiential learning is essential for the progress of adult literacy (language) students (Kadyte, 2004). Although formal adult literacy education programmes and associated software applications have a clear and important role to play in raising global

literacy levels, functionally illiterate adults also need to be supported in their daily literacy activities as well as given access to convenient literacy resources that bridge the typical barriers to community-based literacy education.

A body of m-Learning research is emerging in response to the fact that desktop e-Learning applications are usually unsuitable for wireless handheld devices (Mitchell and Doherty, 2003). Handheld devices have been found to be capable of assisting learners' motivation, helping their organisational skills, encouraging a sense of responsibility, supporting independent and collaborative learning, acting as reference tools, tracking learners' progress and delivering assessment (Attewell and Savill-Smith, 2004). Since there are many opportunities in one's daily life to exercise and practice literacy skills (or, for that matter, many opportunities where illiteracy is a barrier to successful completion of other primary tasks), the portability and potential for ubiquity of mobile technologies makes these technologies ideally suited to supporting experiential literacy learning. Furthermore, financial support for *adult* literacy education typically takes a back seat to school age education, both from public funding sources and corporate philanthropy, which often see early literacy initiatives as delivering a higher return on investment (e.g. TD Bank Financial Group, 2007).

For these reasons, we decided to investigate the use of a mobile device to support *experiential* literacy (language) learning. During our investigation, we have worked – and continue to work – closely with functionally illiterate adults who are self-identified as such and who are/were enrolled in community adult literacy programmes, as well as literacy educators working within these programmes. To this end, we often refer to our functionally illiterate adults as *adult literacy students* – in essence, those adults who have acknowledged their literacy 'handicap' and who have taken measures to address it by enrolling in community adult literacy programmes. By actively involving adult literacy students and educators in an inclusive design process, we developed the concept of ALEX© – a mobile Adult Literacy support application for EXperiential learning (Leung et al., 2006; Lumsden et al., 2005). ALEX© has essentially been designed to facilitate, in a manner sympathetic to the needs of functionally illiterate adults (specifically, those enrolled in adult literacy programmes), a series of basic language-related *support tools* (such as a dictionary facility specifically designed to the needs of functionally illiterate adults, and pronunciation tools). Our ultimate goal with ALEX© is that it will provide practical support to functionally illiterate adults in their daily life experiences as well as in their more formal language education and, in doing so, allow such adults to push beyond their comfort zones (i.e. physical environments and/or practices with which they are confident/comfortable and which, as a result, present no challenges) to become increasingly literate and independent.

Although there is a growing body of mobile language learning (MLL) research, little research has been published on using mobile devices to help *functionally illiterate* adults. One notable exception has been the work by Attewell (2004) on using mobile devices to deliver literacy-building content (e.g. learning materials, mobile webpage builder and peer-to-peer communication channels) to disengaged young (16–24 years of age) adults. The majority of past MLL research has focused on second language learning. This research has used mobile devices in many innovative ways, such as delivering brief vocabulary lessons and quizzes to the learner's mobile phone (e.g. Thornton and Houser, 2005), capturing and sharing learners' experiences in practicing the language outside the classroom (e.g. Joseph and Uther, 2006; Paredes et al., 2005) and sharing location-specific knowledge with other learners (Ogata and Yano, 2004). ALEX© is distinguished

from past MLL work by its focus on *functionally illiterate adults* and supporting *self-guided experiential* learning. Further, ALEX© can provide learning support at all times because it does not rely on a teacher to deliver or structure learning activities (learning activities as prevalent to ALEX© include any daily activity of which literacy is a part) and does not require a wireless data connection (ALEX© has been designed as a stand-alone unit).

3 Guidelines for inclusive design of assistive technologies

Computer technology can, in an assistive capacity, play an important role in helping to enhance the standard of living for people with physical, cognitive, developmental, psychiatric, learning disabilities and other special needs, such as users with limited literacy skills. Technology in this genre is commonly known as *assistive technology*, and it is typically used to help individuals to overcome a specific disability. Despite the extent of functional illiteracy in the world's most developed countries, adult illiteracy retains an element of social stigma with the result that adults who are functionally illiterate are typically very private about their situation. In today's knowledge-intensive society, adults with limited literacy skills can be said to suffer from a *social disability*; they form a special needs user group characterised by the fact that members do not possess the basic literacy skills necessary to function easily or effectively in today's society.

With this in mind, we investigated and collated a set of design guidelines for inclusive design of mobile assistive technologies (Leung and Lumsden, 2008). A summary of these guidelines is provided below; more extensive information about the background to these guidelines and how we put all of the guidelines into practice during our research is available in a prior publication (Leung and Lumsden, 2008).

Guideline 1: Work with existing support organisations. For any given disability, it is often beneficial to work closely with organisations that are dedicated to supporting individuals with the disability (Moffatt et al., 2004; Wu et al., 2005). Not only does such a collaboration typically make recruitment of target users easier (individuals are usually more at ease within the organisation's facilities), but also support organisations are an excellent source of domain experts and people with expertise in working with individuals with the disability.

Guideline 2: Assess target users' and domain experts' needs, abilities and expectations. A thorough understanding of target user participants helps to determine appropriate levels of participation and to establish strategies to ensure the most effective means by which participants can participate (LoPresti et al., 2004; Wu et al., 2004). A thorough assessment of domain experts' abilities and expectations helps foster good working relationships, especially in terms of diminishing scope for mismatched expectations (Allen et al., 2008).

Guideline 3: Choose a design/evaluation technique and analyse its requirements. After choosing a technique, it is important to assess its cognitive and physical requirements in order to analyse the demands it is likely to place on the target users (Wu et al., 2004); based on the flexibility of a technique, it is possible to determine how best to adapt it to individuals with specific disabilities.

Guideline 4: Adapt the chosen approach to be sympathetic to the target users' abilities. It may not always be possible to adapt an existing technique and ultimately, obtain the same type of research data; it is often necessary to loosen some requirements that are typical of a controlled experiment and adapt experimental designs in accord with the target users' unique abilities and needs (e.g. Moffatt et al., 2004; Stevens and Edwards, 1996; Tee et al., 2005). Fundamentally, it is often only possible to recruit small sample sizes and so evaluations often have to be based more on qualitative results and case studies than quantitative results and statistical analysis. Despite this, however, evaluations conducted with members of the target user population typically return valuable insights, both about the population itself and the most appropriate means to improve a user interface design.

Guideline 5: Clearly communicate the nature of participants' involvement. It is essential to effectively communicate to participating target users the precise nature of their involvement in order to avoid mismatched expectations.

Guideline 6: Attempt and refine the approach. When a newly adapted technique is deployed, it is important to evaluate its effectiveness and revise and improve the technique, if necessary, based on what is learned in practice (Wu et al., 2004).

Guideline 7: Evaluate the technology in different contexts. Assistive mobile technology should, ideally, be evaluated in the many different contexts in which target users spend their lives (LoPresti et al., 2004). A combination of representative lab studies (e.g. Lumsden et al., 2006), field trials (Wu et al., 2005) and ethnographic studies (Davies et al., 2004) can be used to understand whether the technology will be usable and effective over the long term.

These guidelines are obviously generically applicable to the design of assistive technologies for many different disabilities; since functional illiteracy is essentially a 'social disability' it is, therefore, logical that the design of a MLL application targeted at improving the basic literacy skills of functionally illiterate adults in an experiential capacity should be approached from the perspective of an assistive device. We, therefore, adopted this set of design guidelines when developing ALEX©, our mobile experiential language-learning application for functionally illiterate adults. Our design process to date and our now-implemented application are described in Section 4.

4 ALEX©

From the outset of this research project, we have included functionally illiterate adults (specifically, functionally illiterate adults enrolled in community adult literacy programmes – i.e. adult literacy students) and educators in the design and evaluation process for ALEX©. In this section, we describe the various stages of our research (outlining the approaches adopted to achieve each and highlighting some of the strategies we adopted to work closely and successfully with our target users), before briefly describing the now-implemented version of ALEX©.

4.1 Our design and development approach

At the onset of our research, we contacted several local adult literacy organisations to engage their involvement in the project (*Guideline 1*). As a result, we have now worked with four literacy agencies which expressed interest and allowed us to recruit interested literacy students (i.e. functionally illiterate adults enrolled in their literacy programmes) and educators to participate in our research; this was done via in-person presentations in the research premises; three of the literacy agencies also allowed us to conduct aspects of our research on their premises (*Guideline 1*). Literacy organisations serve those adults who have acknowledged the need, and are actively seeking, to improve their basic language (literacy) skills. By working with literacy organisations, we were granted access to members of a population that would otherwise have been very hard to identify and recruit. Many adults with limited literacy skills prefer to remain within known comfort zones (Lumsden et al., 2005) and so by being introduced to potential participants in a familiar setting, as well as being able to conduct some of our research within the familiar setting, we feel that we were better able to put our participants at ease and thereby maximise their involvement and contribution to the project.

Informed by, and in accordance with *Guidelines 1, 2 and 4,* at all stages: we opted for in-person presentation of information rather than written content delivery wherever possible; we included, as far as possible, the educators in the processes of initially contacting, and delivering information to, potential participants; we paid particular attention to the process of gaining informed consent from the participants in each of our design activities; where written content was unavoidable, we were careful to restrict the complexity of the language used and to include as much imagery to supplement/replace text as possible; we kept group sizes small for group participation exercises to encourage all group members to participate equally; and we kept participation sessions to not more than 90 min to accommodate our target users' limited attention spans (which were under increased pressure given the unfamiliarity of the tasks in which we were asking them to engage).

4.1.1 Focus groups

We conducted a series of eight focus group sessions with six adult literacy students and three educators from the afore-mentioned local community literacy agencies. On the advice of the educators, the educators met as a group separately from the students in order that the students would not feel intimidated or embarrassed by the presence of their educator and would speak more openly (*Guidelines 2–6*). Each session was audio-taped and lasted between 60 and 90 min; to protect participants' identity, all subsequent transcriptions were anonymised. Prior to commencing the focus groups, we asked both the students (functionally illiterate adults) and educators to reflect on their thoughts about our stated project goals; additionally, we asked our educators (domain experts) to reflect on the number of years of experience they had accumulated supporting adult literacy students.

The principal intent of our focus groups was to profile our target users. We wanted to provide participants with an opportunity to talk about *their* personal perspectives on what kind of technologies *they* would like to see made available and, specifically, to gauge their receptiveness to the use of mobile technology for literacy support. Our focus group sessions with the literacy educators were designed to obtain their perspective on the

bigger picture of adult literacy as well as to elicit their ideas on beneficial applications to support their students.

Having completed our focus groups, we quickly realised that it was not possible to describe a *typical* functionally illiterate adult. Unlike target users for many other educational software applications who can typically be homogenously characterised according to their technological or task-related goals, functionally illiterate adults who are seeking to improve their language skills cannot be characterised as a group due to the diversity of their learning styles, ages, literacy levels, technological literacy, technological needs and personal history and/or the circumstances leading to their functional illiteracy. Having said that we were able to identify two universal challenges:

1 adult literacy students typically struggle with the correct pronunciation of words which has a knock-on effect on their spelling capabilities

2 functionally illiterate adults often have poor handwriting and keyboarding skills (Lumsden et al., 2005).

Although the circumstances leading to their literacy difficulties varied considerably, all our student participants had developed coping strategies to enable them to function in today's society (Lumsden et al., 2005). It became clear, therefore, that any mobile application designed to support them in their language learning would have to be flexible and/or customisable to accommodate the diversity of its target users.

In terms of their use of technology, the frustrations of adult literacy students reflected those of most typical users; they were born out of a lack of *computer* literacy rather than basic *linguistic* literacy *per se*. Comfort with technology was, generally, a factor of age rather than literacy level – again representative of the general populous – but most students had no problem using ubiquitous technologies such as mobile phones and other household electronics.

The educators placed *immense* value on *experiential* – rather than formal, curricula or book-based – learning for their students. They were unanimous that one of the most beneficial methods of learning for their students is the ability to acquire, through day-to-day experiences, the skills necessary for tackling everyday life-centred and literacy-based activities. This sentiment was reflected in comments made by the students themselves, and set the direction for our mobile experiential language-learning application as described in Section 4.2.

All students commented that they would be keen to use a mobile device provided that it proved useful to them as individuals. The students cautioned that any mobile application could only be successfully adopted if support from educators and peers was readily available, if error messages were easily understood and that any tutorials were multimedia rather than text-based. Without exception, all the students could envisage themselves using a handheld device in public; some went so far as to comment that using such a device would be something of a "status leveller", putting them on a par with other members of their general community. In terms of the financial accessibility of mobile devices, discussion during focus groups generally pointed to a loan-based model whereby functionally illiterate adults enrolled in a community-based adult literacy programme would be able to 'sign out' an assistive mobile device; thus, the financial burden of ownership (i.e. the costs associated with the purchase of UMPCs) would not be placed on the users themselves (albeit, some who could afford a device of their own indicated a willingness to make such a purchase if it was proven useful).

4.1.2 Participatory design sessions

Our focus group sessions cemented in our minds the importance of placing adult literacy students (our ultimate, functionally illiterate adult end users) in a central, inclusive role in the design of our mobile application. With hindsight, without the benefit of such close involvement of members of our user group throughout our research to date, we would not have been able to relate to the specific problems, preferences and coping strategies of our target users. It was only through the ongoing direct involvement of our target users and educators that we were able to effectively assess their needs and expectations and design a MLL application to meet *their* needs.

Having elicited an extensive amount of information about our participants' requirements and associated abilities and constraints (*Guideline 2*), as well as determining clear backing for a mobile application designed to support experiential adult literacy education, we proceeded to design an initial prototype of such an application.

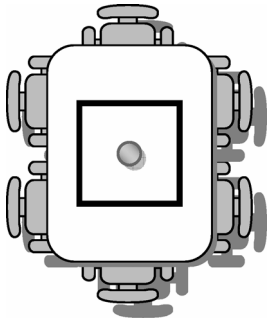
Given the limited language (literacy) skills of our participants, we selected the Plastic Interface for Collaborative Technology Initiatives through Video Exploration (PICTIVE) – participatory design method because its fundamental goal is to empower users to act as full participants in the design of systems that will impact on their daily lives (Muller, 1992). Via the 'imaginative' use of everyday office supplies to generate a paper prototype of a system, the PICTIVE method establishes an 'equal opportunities' design environment, where people who are not familiar with software prototyping can contribute on a par with the technology experts in the design team. Additionally, the approach has been found, on past commercial software development projects, to be enjoyable by all team members. As researchers, we wanted our participants to *enjoy* their design experience; we recognised that taking part in a design activity such as this would be a new (and potentially intimidating) experience for our literacy students, and we wanted them to feel relaxed, be able to participate, and empowered. We invited four literacy students (functionally illiterate adults) and one educator to participate in our design team, based on their level of input and group dynamics during the focus group sessions. Together with the researcher, the team comprised three men and three women.

We felt strongly that PICTIVE was the ideal participatory design approach for our purpose (*Guideline 3*). We did, however, make slight amendments or enhancements to the typical use of the approach in order to best accommodate our special needs participants (*Guidelines 3 and 4*). We were sensitive to the fact that the whole process of designing software was outside the comfort zone (realm of familiarity) of our participants and so made a concerted effort to regularly remind them that they were an integral *part* of the team and that we considered them as *experts* in terms of their daily contexts and needs (*Guideline 5*). Additionally, we continuously validated their ideas to provide ongoing encouragement, and relied heavily on graphics when communicating concepts and ideas to our participants. The design team was deliberately assembled with more participants than researchers (5 to 1 instead of an equal number of each) in the hope that the imbalance in participants' favour would help them feel more comfortable. These enhancements were identified as a result of the effort we invested in assessing our target users prior to their direct involvement (*Guideline 2*); furthermore, we continued to elicit information about participants' expectations and needs in relation to their abilities in an ongoing process of assessment as our activities proceeded.

Five design meetings were undertaken, each lasting between 60 and 90 min; this duration was less than originally intended, but after an initial longer session during which

we determined that participants' concentration span was not sufficient to accommodate a longer session, we reduced each session length (*Guideline 6*) – in all other respects, the approach proved successful. The design team met in a room which was set up as shown in Figure 1.

Figure 1 Participatory design environment



To capture an audio/visual design document of the design activities and results, a Logitech Quickcam Pro 4000 was suspended from the ceiling above the design workspace; the area captured by the camera was delineated in blue tape (shown as bold in Figure 1) on the design workspace in order to ensure that all relevant activities took place within camera shot.

Participants were asked to think of scenarios from their daily lives in which they felt a mobile application might be useful in supporting their literacy needs – that is, helping them to overcome the associated literacy challenges – and, in helping them to overcome these challenges, might help enhance their literacy skills; these scenarios then formed the basis of the discussions and focused activities during the design sessions. Scenarios ranged from assistance in writing a letter (incidentally, a common 'project' used by literacy educators to facilitate experiential learning amongst their students) to understanding ingredients on a grocery packet during a trip to the supermarket.

The participants identified a core set of functionalities that they felt would be useful in a mobile application and, during the course of the participatory design sessions, iteratively generated a paper prototype of an application that met their requirements. Centred around a larger-than-life template of a handheld device, the design team used a variety of common office supplies (e.g. paper, pens, highlighters, Post-it™ notes, etc.) to mock-up the graphical elements of the user interface. The result was a fairly comprehensive paper prototype of the kind of mobile application that functionally illiterate adults felt would be beneficial in helping them address their everyday literacy challenges. Table 1 maps the identified literacy challenges to suggested functionality with the tool.

Table 1 Literacy challenges mapped to suggested application functionality

Literacy challenge scenario	*Suggested supporting functionality*
Reading: a user is faced with text that he/she cannot read	A text reader using speech synthesis (text to speech – TTS) to help users to understand (hear) text that they cannot read
Reading: a user is faced with a word that he/she does not understand	A built-in dictionary tool to provide definitions of words. Definitions provided at an appropriate reading level for the user
Reading: a user is unable to determine which word is the correct word to use when faced with two similar sounding words (e.g. 'their' and 'there')	A built-in dictionary tool to provide (appropriately targeted) definitions of given words and help users differentiate between words that sound the same
Spelling: a user may want to use a word or look up a word but does not know how to spell the word	A speech recognition feature to help users enter words to look up even though they do not know how to spell them
Pronouncing: a user may have encountered a written word that he/she does not know how to correctly pronounce	A combination of TTS and speech recognition technologies to help users to hear and repeat the pronunciation of words, complete with appropriate feedback
Revising: a user is writing or editing a piece of text but does not know how to identify grammatical mistakes	An intelligent grammar-checker to highlight grammatical mistakes A built-in dictionary tool to help users verify correct usage of words
Revising: a user is editing or writing a piece of text and wants to change wording but cannot think of, or does not know, suitable alternative words	A built-in thesaurus tool to suggest similar words A built-in dictionary tool to provide definitions for previously unknown words provided by the thesaurus

The application at this stage was essentially a transcriber application that incorporated a range of support tools, namely:

- a *dictionary* tool that provided, for a given word, a definition, the word broken down into syllables and phonetic symbols, and, where applicable, images and examples of the word in use
- a *thesaurus* tool that provided, for a given word, lists of synonyms and antonyms of that word
- a comprehensive *help* tool that suggested alternative words/phrases to help the user correct mistakes in the text (e.g. grammar mistakes, spelling mistakes, transcription inaccuracies)
- a *punctuation* tool that allowed users to punctuate text by gesturing punctuation symbols inline with the text using the stylus and touchscreen
- a *my word list* feature that allowed users to record and list words that they want to keep track of and work on in the future.

Figure 2 shows some example 'screen shots' of the paper prototype at the conclusion of the participatory design process. It is worth noting, at this stage, that the participants' enthusiasm for the notion of a mobile application led them to suggest more extensive

functionality within such an application than we had originally anticipated – for example, they were keen to have the application assist in writing documents (i.e. to incorporate a transcription-based text editor). We were surprised that they would want to use a small handheld device to actually write documents and believe that the scale of our paper device template – a necessity to accommodate the design team in collaborative design activities – likely misled participants into believing that the physicality of the device itself would be more accommodating for such tasks.

4.1.3 Evaluation sessions

For the purpose of our first phase of evaluations (the first of an intended series of evaluations in different contexts – *Guideline 6*), we focused on one aspect of the functionality incorporated within the original, paper prototype-based ALEX© concept – namely, its ability to assist adults with limited literacy skills to write. We created a medium-fidelity prototype using standard web development languages (see Figure 3) which participants were required to use to attempt three lifestyle-related tasks:

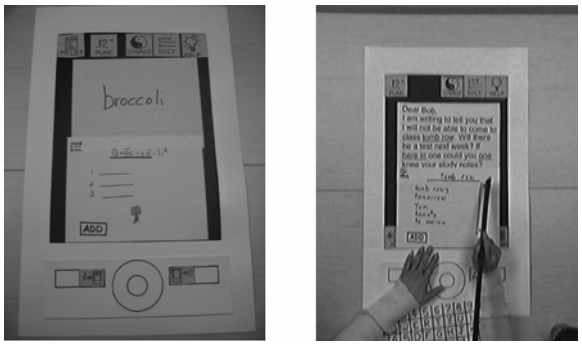
1 formatting a letter

2 correcting a letter

3 revising a letter.

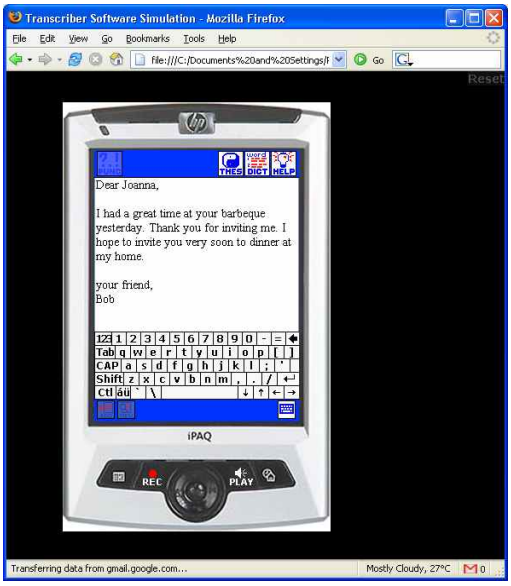
These tasks were identified as a result of the participatory design sessions. We used a combination of think-aloud and question-asking protocols to elicit and record user reaction to, and interaction with, the prototype (*Guidelines 3* and *4*). Six adult literacy students participated in our evaluation sessions, three males and three females. None had any prior involvement in our research project; all six varied in their literacy skills and technological comfort levels.

Figure 2 Paper prototype at conclusion of participatory design process



Given that our aim was to evaluate the ALEX© *concept* (at that time) prior to development effort, we decided to simulate the application on a tablet PC and use a Wizard-of-Oz approach to affect the speech-to-text and text-to-speech components of interaction. The simulation incorporated those features of ALEX© pertinent to the functionality we were evaluating – including a transcriber-based text editor with multi-line text, cursor positioning, text selection and scrolling as well as a fully functional QWERTY-formatted soft keyboard. ALEX©'s dictionary-related and help support tools were implemented and populated with entries for a limited (relevant to task) vocabulary. We mitigated against the influence of size difference between the tablet and a handheld device by confining participants' interaction with the touchscreen of the tablet to a small area of the screen representative of the size of the screen of a handheld device (see Figure 3). Participants evaluated this prototype seated at a desk, minimising the influence of device portability.

Figure 3 Medium-fidelity prototype used during evaluation sessions (see online version for colours)



Space does not permit a detailed account of the evaluation sessions; we would refer interested readers to a prior publication that was dedicated to this particular aspect of our research (Leung et al., 2006). Instead, we will highlight the key outcomes of our evaluation sessions.

For each participant, we generated a graphical content log of the participant's activities and commentary. Noticeably, most participants had difficulty using the soft QWERTY keyboard. Close analysis of the data revealed that participants' effectiveness with the keyboard did not correlate with their computer experience; their effectiveness did, however, improve with each subsequent task completed. Participants who came to our evaluation with higher levels of computer experience were substantially more productive compared to other participants. Debrief discussions with participants revealed that some participants were not sure how to use the soft keyboard and stylus and the text

editor as input technologies (e.g. they were unfamiliar with the fundamentals of using a text editor, such as placing the cursor where they wanted text to be inserted, and 50% of participants did not know what the *backspace* and *enter* keys were for).

After completing each of the three study tasks, participants were asked to use an adapted version of the NASA TLX (Hart and Staveland, 1988) to reflect on their subjective opinion of the workload associated with completing the task. Participants returned a wide range of overall workload scores, making it hard to generalise across the results, but reflecting the heterogeneity of functionally illiterate adults. Having said that, somewhat unexpectedly, participants generally rated their frustration levels as low which we attribute, at the level of conjecture, to an increased frustration threshold – developed as a result of facing so many literacy-based challenges in daily life – in this demographic. They also rated their performance very positively, which we would like to think is because ALEX© helped them feel that they had achieved something literacy-related for themselves.

In terms of general feedback, participants were positive about both the usefulness of the concept and the usability of the design. One participant went so far as to describe it as "a great product [which would] make a difference in people's lives"; this reflects the sentiment of the adult literacy students who designed the concept of ALEX© during the participatory design sessions. Participants thought that ALEX© was useful, interesting, and would motivate them to learn; some suggested the use of an alphabetical layout for the soft keyboard (hence, the design described in Section 4.2 and shown in Figure 5).

Prior to this evaluation, we had adopted a general assumption that a stylus is a natural interaction mechanism based on its similarity to pen and paper; for our users, however, this was not proven to be the case since writing was not a 'natural' activity for them and many of our participants exhibited poor hand–eye coordination. For this reason, we have designed the current fully functional version of ALEX© (see Section 4.2) to be usable with fingertip presses on the touchscreen – that is, we have endeavoured to make the design usable without the need for the stylus.

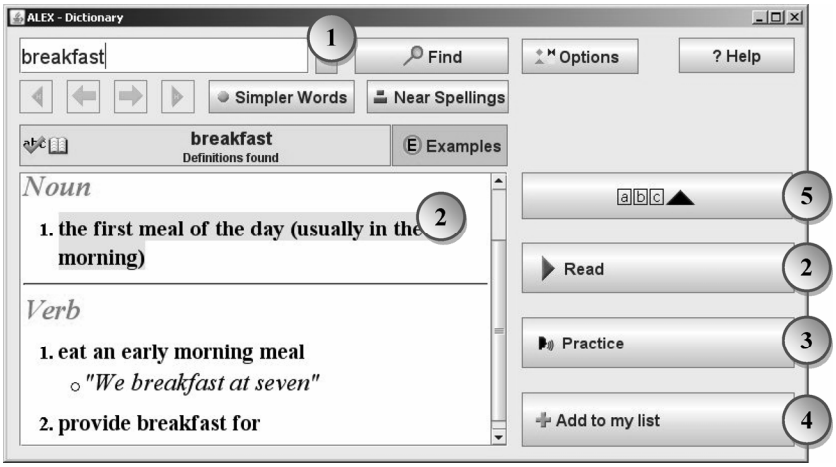
Most adults with limited linguistic literacy skills find it hard to convey ideas in writing; this difficulty can often be caused by difficulties with the fundamental mechanics of writing such as handwriting or typing and spelling (MacArthur, 1999). Our evaluation sessions brought these issues into focus for us; in so doing, they led us, in part, to focus on support for *spelling* – given its ubiquity and the suitability of mobile technology to support this aspect of literacy – as opposed to trying to resolve issues of text editing in a format (i.e. on a mobile device) which could only exacerbate the difficulties. In short, we took from our evaluation sessions a valuable lesson in terms of learning what is, and what is not, perhaps, appropriate for delivery to our target users on a mobile device. We have subsequently reduced and refined the incorporated functionality to a subset of the functionality that was included in the original paper prototype; the system as described in Section 4.2 introduces our *actual current functional implementation* and focus. In essence, we felt that our reduced scope was more appropriate as an *assistive* technology for *experiential* language learning; ALEX© can, in its current (reduced) form, be used anywhere, anytime, including in parallel with other more extensive applications designed to teach language students to structure and compose documents (i.e. specialised text editors). We felt that the observed complexities of text editing would obscure the true, easily accessible, benefit of ALEX© as an *assistive* technology designed to enhance spelling/vocabulary and pronunciation skills.

4.2 A brief overview of ALEX©

ALEX© has been designed such that it can run on either a desktop PC or on a handheld device; to date, we have focussed our development work on porting ALEX© to a Samsung Q1 ultra mobile PC (UMPC) running Vista. ALEX© is a stand-alone application, which does not rely on the availability of an internet connection.

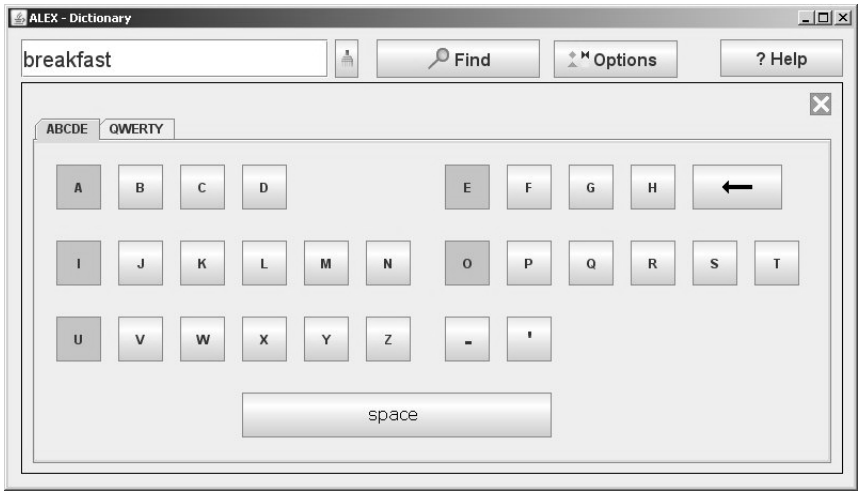
Figure 4 shows an annotated screen shot of the main user interface to ALEX©. The functionality supported by ALEX© centres around that of a dictionary. In essence, ALEX© provides a tailored facility for looking up words (see (1) in Figure 4), interacting with, and listening to, the definitions of words (see (2) in Figure 4) and practicing the pronunciation of words (see (3) in Figure 4); the latter is a key difficulty experienced by many functionally illiterate adults and so it is supported with both audio and visual feedback within ALEX©. In every aspect, ALEX© has been designed to provide standard (e.g. definitions) and enhanced (e.g. pronunciation practice) dictionary functionality targeted, in terms of content, interaction, and presentation, at the identified needs of functionally illiterate adults. It incorporates a range of functionality to enable a functionally illiterate adult to successfully look-up and understand definitions, including parts of speech; additionally, it allows users to personalise the system to their own set of preferences/skill levels.

Figure 4 Annotated screen shot of main ALEX© interface



Source: Copyright © Her Majesty in Right of Canada (2009).

Figure 5 Soft keyboard showing alphabetical layout



Source: Copyright © Her Majesty in Right of Canada (2009).

ALEX© also permits users to maintain a list of words specific to their needs (see (4) in Figure 4). This essentially allows users to record words that they wish to study in the future and/or words with which they would like assistance from their educator.

Finally, ALEX© provides both a traditional QWERTY soft keyboard and an alphabetical soft keyboard layout (as shown in Figure 5) such that users can interact with whichever layout they prefer; this is accessed by clicking on (5) in Figure 4. We had, initially, only thought to provide the standard QWERTY soft keyboard layout; in response to our observations during our evaluation sessions (see Section 4.1.3) in which we witnessed users' inability to locate letters on the QWERTY keyboard layout with which they were unfamiliar, we decided to include the more intuitive alphabetical layout shown. This layout is pared down to only those keys necessary to interact with ALEX© (i.e. letters plus backspace, space, dash and apostrophe) and distinguishes vowels from consonants.

It has been suggested that interaction with mobile technologies via their touchscreens is an appropriate mechanism for people with limited literacy skills (Bridges.org, 2001); transcription has also been found to be helpful to users with limited linguistic literacy skills (e.g. MacArthur, 1999; Raskind and Higgins, 1997; Reece and Cummings, 1996). Together, touchscreen technology coupled with text-to-speech/speech-to-text capabilities would seem to present the most appropriate interaction mechanisms for adult literacy students using an m-Learning application whilst, at the same time, avoiding the many limitations found with interfaces that use speech alone (Huang et al., 2001; Shneiderman, 2000). For these reasons, we have relied heavily on these interaction paradigms in the design and development of ALEX©.

Additionally, we have designed and developed ALEX© to accommodate *truly* novice computer users; we have attempted to strike a balance between using intuitive interaction metaphors and using accepted computer metaphors (e.g. navigation based on browser controls) in order to additionally help users learn some transferable computer literacy skills. We have typically used a combination of icons and labels on controls; the icons to

enhance initial usability, the labels to provide additional opportunities for users to practice their literacy skills.

Finally, sensitive to the confidence levels of our target users, we have aimed to use positive and encouraging feedback at all times, and to minimise negative language and imagery wherever possible.

5 Conclusions and further work

In this paper, we have presented the design, and described the process of designing according to specified guidelines, an innovative experiential, mobile, ubiquitous application that supports language learning in the daily lives of functionally illiterate adults. The effectiveness and success of each of our approaches thus far is testament to the applicability of the guidelines we proposed and followed (see Section 3). At the time of writing, we have completed the development of ALEX© and are working towards establishing a longitudinal study protocol that will see ALEX© reach the hands of functionally illiterate adults who are enrolled in literacy programmes in our region, and thereby allow us to observe its use and impact in the field (*Guidelines 1* and *6*). Based on the design guidelines outlined in Section 3, our aim is to carefully structure the protocol to allow us to effectively engage functionally illiterate adults in an extended study that will allow us to gauge:

1 typical users' immediate reaction to ALEX©

2 their opinion of ALEX© after extended periods of use

3 usage patterns amongst our target user population – for example, for what purposes, and in what contexts, do users engage ALEX© as an assistive MLL technology

4 to what extent ALEX© impacts users' basic literacy skills (compared to their progress in literacy programmes without the ubiquitous use of ALEX©).

Prior to commencing the longitudinal study, we will engage in some basic usability studies to validate (and improve on, if necessary) the user interface design of ALEX©. The outcome of such studies, together with expert reflection on the process adopted, will additionally help us further validate our approach, and thereby the guidelines, that we followed in designing ALEX©. The results and observations ultimately returned as a consequence of completing the longitudinal study itself will help us evaluate the extent to which ALEX© will help target users improve their literacy; in so doing, the results will be used (in a process of expert reflection) to further validate and elaborate (if necessary) the guidelines as they relate to designing assistive mobile technologies for adult literacy education. We are also in discussion with local agencies/companies to evaluate the potential for using ALEX© to address other basic (essential skills) learning activities; we hope to similarly evaluate the use of ALEX© and the design guidelines in such contexts.

To date, we have demonstrated that, with careful thought and adaptability to the needs, abilities and expectations of our specific special needs target user population (i.e. by following the guidelines outlined in Section 3), it has been possible to effectively engage them in the design and development of an assistive mobile, experiential, language (literacy)-learning application. We have highlighted that not only would our target users be comfortable using mobile technologies for mobile experiential language learning in

their daily lives, but also they additionally perceive such technologies as status levellers – an advantage in terms of technology adoption. Finally, we have touched on a number of the usability issues of concern to our target users when faced with using mobile technology for learning.

Albeit beyond the scope of language learning, and therefore the focus of *this* paper, our focus group participants were prolific in terms of the learning uses to which they could see mobile technologies being put; we have incorporated most of their language-related suggestions within ALEX©, but they additionally suggested a number of lifestyle-related possibilities which could benefit from the targeted application of mobile ubiquitous technologies.

Research in both the fields of designing assistive technologies with and for special needs users, as well as designing *experiential* mobile learning tools for language learning, is in its infancy. The overview we present in this paper serves merely as a mechanism to reflect on our experience in the hope that it is useful to others working in this domain. To quote one of our participatory design group participants: "as a group, we achieved something good that will help a lot of people". We sincerely hope this to be the case as we embark on our longitudinal study.

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