"Showing off" your Mobile Device: Adult Literacy Learning in the Classroom and Beyond

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ABSTRACT

For a very large number of adults, tasks such as reading, understanding, and using everyday items are a challenge. Although many community-based organizations offer resources and support for adults with limited literacy skills, current programs have difficulty reaching and retaining those that would benefit most. In this paper we present the findings of an exploratory study aimed at investigating how a technological solution that addresses these challenges is received and adopted by adult learners. For this, we have developed a mobile application to support literacy programs and to assist low-literacy adults in today's information-centric society. ALEX© (Adult Literacy support application for EXperiential learning) is a mobile language assistant that is designed to be used both in the classroom and in daily life in order to help low-literacy adults become increasingly literate and independent. Through a long-term study with adult learners we show that such a solution complements literacy programs by increasing users' motivation and interest in learning, and raising their confidence levels both in their education pursuits and in facing the challenges of their daily lives.

Author Keywords
Mobile computing, interface design, educational interfaces, mobile learning, assistive technology.

ACM Classification Keywords
H5.2 User interfaces: Voice I/O, Natural language, User-centered design, Evaluation/methodology. K3.1 Computer Uses in Education: Computer-assisted instruction.

General Terms
Human Factors, Languages.

INTRODUCTION
In 2000, nearly 25% of adults (aged 16 to 65) in the world's richest countries were reported to be functionally illiterate [20]. In Canada, 50% of adults are considered to have low literacy skills [1]. For adult literacy students, understanding everyday items such as bus schedules, food labels, news articles, or medical information is a challenge. In addition to the impact on an individual's daily life, this has serious consequences for the economy – businesses are struggling to find local workers who have the basic skills necessary for the demands of today's workplaces. Community organizations offer resources and support to adults with limited literacy skills, but barriers such as work, lack of financial resources, childcare, and transportation often prevent potential learners from taking part in and benefiting from such programs [1].

During this study we worked closely with functionally illiterate adults who self-identified as such and who were enrolled in community adult literacy programs, as well as literacy educators working within these programs. In our research we often refer to these adults as adult literacy students – in essence adults who have acknowledged their literacy 'handicap' and who have taken measures to address it by enrolling in community adult literacy programs [14].

The portability and affordability of mobile devices offers a realistic opportunity to provide novel, context-sensitive literacy resources both within and, more importantly, outside community programs. By actively involving adult literacy students and literacy facilitators in a series of focus groups and participatory design sessions, we developed ALEX©, a mobile Adult Literacy support application for EXperiential learning (Figure 1 and detailed in [15]). ALEX© is designed to facilitate, in a manner sympathetic to the needs of functionally illiterate adults, a series of language-related support tools. Our ultimate goal for the system is that it will provide practical support to functionally illiterate adults in their daily life experiences and allow such adults to push beyond their comfort zones to become increasingly literate and independent.

BACKGROUND

Despite considerable investment of time, effort and resources, there is little improvement in adult literacy [20]. According to a Canadian Council on Learning Report, projections of literacy rates also reflect a virtually unchanged literacy level in Canada – by 2031, 47% of adults are predicted to have low literacy levels (below level 3). This percentage represents 15 million adult Canadians, and a 25% increase in low literacy levels from 2001 [6]. These projections, based on current literacy rates, suggest that current adult literacy support and resources are not having the impact that was anticipated. This further indicates a need to investigate alternative approaches to tackling adult literacy issues – namely, the use of pervasive and ubiquitous forms of computing to support experiential language learning amongst functionally illiterate populations.

Several solutions have been proposed that provide reading assistance to functionally-illiterate populations, ranging from audio-visual interfaces [10] to applications converting text into simpler forms. One example is Facilita, a reading assistance application, which is part of the PorSimples (Text Simplification for Digital Inclusion and Accessability) project in Brazil. This web application uses Natural Language Processing (NLP) operations to automatically adapt websites to assist low literacy level readers [24, 25]. However, solutions like this do not address the larger issue of literacy education. Economic analysis suggests that increasing adult literacy is essential to improving low-literacy adults' work performance and quality of life [7].

Researchers have developed mobile devices for language training; however, the majority of mobile language literacy research focuses on second language learning [14]. This research uses mobile devices in innovative ways such as: delivering vocabulary lessons and quizzes to the learner's mobile phone [21], capturing and sharing how learners practice language skills outside the classroom [13, 17], and sharing location-specific knowledge with other learners [16].

Examples of language program software for mobile devices developed for learning English as a second language (ESL) include PALLAS, which is a mobile support system for language learning support that allows for personalization of learning resources [18]. Ally and colleagues [3] outline another mobile tool for training ESL learners which offers grammar and exercise books/content on mobile devices. However, this system lacks the ability to give feedback to students, who are unable to determine if an answer is correct, get advice from the system, etc. Another application for ESL training is "Mobile Mazes," an application for mobile phones that provides action reading mazes (much like a "choose your own adventure" book) [22].

Other mobile systems for ESL training involve the extensive use of images. For example, Hasegawa and colleagues created the Special Interested Group Material Accumulator (SIGMA) [11], a mobile learning system for second language learners. The system presents five second movies related to a word while displaying subtitles including the spelling and meaning as well as pronunciation of the word. Users register to access and create materials in order to release to other users. Likewise, Joseph and colleagues' PhotoStudy system, delivered via cell phones, allows ESL students to collaboratively build a system of image/vocabulary flash cards [12]. However, there is no pronunciation support in this system because of the expense of creating pronunciation content.

Most mobile devices assisting language learning are aimed at second-language learning. There is significantly less research published on using mobile devices to help functionally illiterate adults (literacy level 2), in comparison to research on mobile applications for basic adult literacy [14], with one notable exception; Attewell and colleague's 2004 publication [4] on using mobile devices to deliver literacy building content to disengaged young adults (16-24 years old).

Recent developments in mobile technologies need to be investigated in order to provide new learning environments for literacy learning in everyday environments by extending beyond traditional learning paradigms and embracing the notion of experiential learning. In our research experiential learning is acquired through the performance of everyday life activities that focuses on the learning process of the individual [14].

IMPLEMENTATION

ALEX© is a mobile application that is designed to assist adults enrolled in literacy programs or workplace essential skills training. It is designed to be used in an assistive capacity during everyday literacy-based tasks, in conjunction with formal adult literacy and workplace essential skills training. Example tasks range from more traditional scenarios such as classroom exercises and homework, to any other activity involving reading or writing, such as reading the newspaper, interpreting a safety notice posted in a public space, writing a letter, and filling-in documents at home.

ALEX©[1] is designed to help develop language skills and knowledge acquisition pertaining to real life by providing intuitive access to various language-based tools, as shown in Figure 1. Furthermore, it helps students develop other essential skills in conjunction with literacy skills, such as computer usage and information-focused thinking. The goal of this project is to increase students' independence, to empower learners outside of a classroom, and to adapt to and meet the different needs of different learners. It is a useful device not only for students, but also for teachers,

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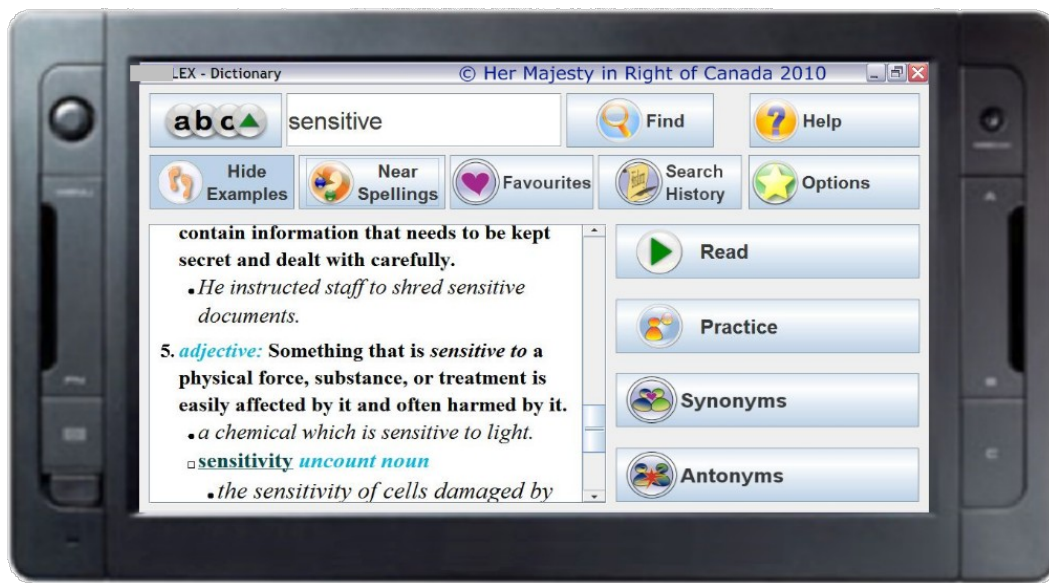[1]A complete description of the system can be found in [15].

Figure 1: The main interface and features of our system, running on a 7-inch Ultra-Mobile (Tablet) Device.

who gain an additional tool to enhance the classroom experience.

The interface was designed through a participatory design approach, involving teachers and students from the adult literacy classes. It was developed according to the guidelines for inclusive design of mobile assistive tools [14, 15]. The principles that were followed included multimodal output (text and speech), suggestive labels for buttons, instructions worded in simple language, soft keyboard with both alphabetic and qwerty layouts, and the use of a dictionary with definitions of appropriate literacy level for the target population.

The main feature of our language assistant is the dictionary look-up. For the study presented later in this paper we have partnered with HarperCollins Ltd, the publisher of a large-circulation English dictionary and thesaurus that were embedded on the devices provided to participants.

Text-to-speech functionality assists adult learners in reading definitions. Users can select a word or sequence of words to be read. If no words are selected, invoking the read feature will produce audio of the entire definition displayed at that moment. Text-to-speech is also enabled for buttons and menus. Once users become more familiar with the application, they can deactivate it from the "Options" panel.

In order to increase the portability of our application, a virtual keyboard is provided that can be accessed through the "abc" icon (top left corner of the main screen). Users can choose between a QWERTY layout and an ABC (alphabetic, vowel-aligned) layout.

Since many adult learners enrolled in literacy programs struggle with correct spelling of words, a near spelling feature that display words of similar spelling was introduced. Users typically invoke this when they look up a word that is incorrectly spelled for its intended use, but nevertheless forms a correctly spelled word. This is useful in both showing alternatives for misspelled words and presenting users with more choices when they are not sure of the correct spelling of a word. Spelling assistance is automatically activated for incorrectly-spelled words.

To facilitate a wider range of learning activities, ALEX© allows words to be saved in a persistent, favourites-type list. Users have full control of the list, being able to remove words and to perform most functions offered by the application directly within the list. A non-persistent list is also available in the form of a search history that displays the most recent word look-ups.

Our application can be customized to provide access to the various resources of the installed electronic dictionaries. For the current study, synonyms and antonyms look-up was provided, as activities based on these are an essential part of the adult literacy curricula.

Beside text-to-speech, ALEX© makes use of the built-in automatic speech recognition system to provide adult learners with a pronunciation practice feature. The practice allows users to first hear the correct pronunciation, then record their pronunciation and be informed of its correctness. Users can hear their own recording, and are able to compare their pronunciation with the correct one. Users are not given a numerical score for their pronunciation; a color-based dial is used instead, accompanied by positive reinforcement messages ("you did great", "try again, you're still doing great", etc.)

A MOBILE APPROACH TO ADULT LITERACY

The goal of this research project is to explore how adults enrolled in literacy programs and essential skills training

Participant	English first language	Age	Technology skills (*)	Literacy skills (*)
P1	yes	> 25	low	medium-advanced
P2	no	< 25	good	recent immigrant, poor language skills
P3	no	> 25	good	good conversational level
P4	no	> 25	adequate	good conversational level
P5	yes	> 25	very low	very low
P6	yes	<25	low	medium-advanced
T1	teaches the class with mostly older students			
T2	teaches the class with mostly younger students			

Table 1: Participants' demographic information (for participants that completed the final questionnaire – five users did not yet complete the interviews). (*) Note: skills are relative to average among students enrolled in the two participating classes.

can benefit from a mobile assistive technology that supports experiential learning, and furthermore investigate how the perceived usefulness and ease of use of such technology influences students' independence and confidence, as well as their motivation for literacy skills improvement.

We are located in the Canadian province with the largest percentage of adults with low literacy levels. As such, we have partnered with Government of New Brunswick's Community Adult Learning Services (CALS) to address the adult literacy problem in this province. CALS is an integrated network focused on adult learning services, including computer, literacy, and workplace training, operating under the relevant provincial education departments. This project is one of the outcomes of this ongoing research partnership.

Methodology
The main evaluation of ALEX© was carried out over six months in 2010. Each potential participant received one mobile device running our literacy application, and was instructed on the use of the device and of the application through a one-on-one session with the researcher, lasting typically one hour. After a review period of approximately one week, participants decided if they want to continue with the study. Researchers explained the details and objectives of the study and informed them of the details related to consent forms. The participants were given several days to review these details on their own, with family members, or with their teachers. Each participant received a $50 gift card as compensation for the study, independent of their completion of the study.

Participants used ALEX© and interacted with researchers in two distinct settings. In the classroom setting, the researchers observed how students use the device in conjunction with the class exercises, and engaged with students in discussion about the use of the application. Outside the literacy classes, the participants kept their devices for the entire duration of the study, and were encouraged to use it outside classrooms in the same way as they use the support materials (e.g. dictionaries) when completing the homework or when reading a magazine, and explore ways to use the device in other situations.

Eleven participants in two classes (morning and evening) were enrolled in the study. Participation was entirely voluntary, and teachers did not pressure students to enroll. This was also ensured by the fact that adult literacy classes do not have a formal academic evaluation, and sign-up for these classes was not mandatory for any of the participants. All participants were of legal age (19 years or older) – only adults outside the K-12 education system are eligible for the literacy program. Table 1 briefly describes the participants' demographic information that is of relevance to this study.

Data was collected through several instruments: discussions with participants, direct observations, questionnaires (administered by researchers mainly as semi-structured interviews), and teacher interviews.

No hypotheses were formulated before the evaluation – this was an exploratory study to discover how this particular technology is adopted and the outcomes of using it in conjunction with adult literacy programs. We have defined several positive outcomes as measures of success: acceptance of technology, perceived usefulness in assisting with academic activities, ease of use, increased students' independence and increased confidence and motivation. We have also found several unexpected results, including the development of a personal relationship with the technology, evidence of collaboration and sharing, and pride in contributing to the project.

CHALLENGES
Most of the challenges encountered in conducting a comprehensive evaluation of our proposed solution are intrinsically tied to unique characteristics of our user base.

Literacy level
A typical student attending adult literacy classes has completed some years of formal schooling, usually up to the end of middle school, and works part- or full-time in a non-professional position (e.g. cleaning, farming). They are able to carry out non-complex reading and writing tasks, such as some newspaper reading or writing a very simple letter.

Low literacy levels make it difficult for researchers to conduct rigorous, structured data collection. Even

questionnaires that were phrased, with the help of teachers, at appropriate literacy levels, did not elicit meaningful answers. Instead, most of the data was collected either through direct, individual interactions with users during the longitudinal study, or prompted by the administration of the questionnaire at the end of the study. In particular, the final questionnaire was administered in the form of a semi-structured interview, with the researchers adapting the questions to the literacy level of individual participants. It was determined that this approach was more practical given the particular challenges posed by our user group – the narratives and direct observations provided researchers with an intimate understanding of both participants' struggles and needs, and how our system addressed these needs.

Beside data collected directly from participants, the researchers engaged in extensive on-going discussions with the two teachers, followed by an in-depth interview with them at the end of the study. This provided us not only with teachers' perspective on the use and acceptance of the technology, but also complemented participants' narratives. Students' daily interactions with teachers were an important source of information that could not always be captured by researchers since they were not present for extensive periods of time.

Class format
The adult literacy sessions are usually conducted in an informal setting resembling one-on-one tutoring. A typical class consists of several adult learners (maximum of eight, but usually three to four). There is one teacher per class. Students work independently on their assigned subject, making use of the support material (e.g. textbooks, dictionaries) provided to them by the teacher. The teacher moves between students' tables, assisting them or answering questions. Students are free to enter and exit the classroom at any time, as well as chat among themselves, occasionally helping each other with their work. In a given class, there could be students all studying the same subject, or each student studying a different subject. There is no formal evaluation of academic progress. The teachers' role is to facilitate the learning process and to guide students in their quest for self-improvement at the student's own pace toward their own individual goals.

Attendance and varying levels of motivation
Students do not attend classes on a regular schedule – even individual attendance varies with work and family commitments. Moreover, many students do not own a private vehicle – as such, weather, particularly in the winter, was an important factor influencing attendance. Attendance was one of the main challenges faced by researchers in collecting feedback and upgrading the system when necessary.

As attendance also fluctuates over the long-term (e.g. a student maintains a regular schedule for two-three months, then "disappears" for another two), collecting rigorous data

is difficult. Out of the initial 11 participants, we are still in the process of trying to reach 5 users that suddenly stopped attending classes.

In terms of demographics, attendance was more frequent for older participants than for younger ones, as illustrated in Table 2. Of the younger participants, the student with frequent attendance was enrolled in the literacy classes as part of the English program for new immigrants (participant P2). Of the older learners, the participant with infrequent attendance (participant P5) was enrolled in the program for a shorter period of time while attempting to gain employment – this participant also provided some answers to our final questionnaire through a proxy (the teacher) as he has left town for an employment opportunity.

		Attendance	
		Frequent	Infrequent
Age	Below 25	1	6
	Over 25	3	1

Table 2: Participants' attendance/age distribution.

A possible explanation for this distribution was given by one of the teachers: older learners are more aware of the positive impact that education has for employment, while the younger learners are more employable and thus willing to trade education for immediate (albeit often low-wage) employment. This was confirmed directly by researchers through discussions with younger learners – they have found it difficult to attend regularly, especially since they were, for the most part, working shift jobs.

Technology Acceptance
As expected, most of the participants, particularly the older ones, were at the beginning reluctant to use the technology or to fully explore its features. However, this reluctance subsided as the study progressed. Several minor issues that initially created anxiety for participants (e.g. accidental changes of various settings, both in our application and in the general operating system) were quickly addressed by researchers and provided participants with the reassurance that technology, especially software, is not threatening and can often be repaired.

Another challenge was the loan status of the devices. In some cases users were overly cautious with the devices. For example, one potential participant returned the device after a week of use and did not continue with the study. While initially he did not provide a reason, later he disclosed to researchers that he was afraid of losing the device. In other cases we had to repair devices or accessories such as headsets and chargers due to physical damage. Some participants went to great efforts to conceal accidents, despite our promises of no consequences for broken devices – for example, participant P4 returned the device to us after a week informing us that it stopped working. Upon further inspection we discovered super-glue inside the device, probably as a result of being dropped and subsequently

attempted to be repaired.

Overall we have discovered that ALEX© eased the participants' fears and facilitated their use of the technology. After the initial reluctance, students that were normally afraid of technology were, in the end, able to fully use the system.

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The system "is easy to use, it is not
scary or complicated" [T1]
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This finding complements the main reason for adoption of the system – its perceived usefulness – as it will be described in the following section.

OUTCOMES

The technology acceptance model (TAM) proposed by Davis [8] postulates that perceived usefulness of technology is the main reason for successful adoption. While perceived usefulness has been identified consistently by TAM as being important in attitude formation and use, support for perceived ease of use has been inconsistent and has yielded less significant results. A plausible explanation for this difference is that if the technology is perceived to be useful enough, than users will take the time to learn how to use it.

Given the particular challenges posed by our user group (low-literacy adults), we have extended TAM to further emphasize ease of use as a necessary criterion for the successful adoption of our mobile language assistant. As shown in this section, evidence from our longitudinal study confirmed that both usability and usefulness were important factors in the acceptance of ALEX© and in its positive impact as defined by the success criteria outlined earlier.

Our study was exploratory and no hypotheses were formulated a priori. To avoid the risk of post-hoc interpretation specific to qualitative studies with small samples [19], we have employed two mitigation strategies:

- Data was collected both by the principal researcher and by a developer associated with the project who acted as a more impartial observer. Care was taken to transcribe factual information and not interpret the observations during note taking.

- The transcripts were analyzed by a researcher not associated with the project by employing clustering techniques [19] to identify the main themes and outcomes of the study. This section describes these findings of our study, grouped according to the identified themes.

Usefulness for Homework

Participants appreciated the helpfulness of ALEX© for assistance with homework. Both teachers indicated that students employed it mainly for dictionary look-up but also for synonyms, antonyms, and to find the part of speech of a word – these were directly related to the goals of most exercises in the literacy curriculum. According to teacher T1, students often ask for help in the classroom, but at home they do not have any resource to help them with their homework. Our system was most effective in doing exercises at home.

Among other features that were found useful for homework were the Near Spelling and the Read function. Participant P3 indicated that hearing the pronunciation of new or difficult words helps her better remember how to spell that word. Teacher T1 indicated that most of her students had difficulty writing words they hear for the first time, and the Near Spelling feature helped them correctly spell the word – by typing in their best guess of the spelling and using the system's suggestions.

The example sentences that are included in the dictionary definition were also helpful. Participant P1 indicated that this was mostly helpful in understanding the meaning of words when the definition was too complicated, although she mentioned that sometimes this was not reliable, as some example sentences were used to illustrate only the proper usage of a word and not its meaning. Participant P2 used the example sentences to learn new words, which she found helpful for writing essays.

Ease of use

Overall, the main qualifier in terms of application's usability we have received was:

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"it was easier to use than a paper
dictionary" [all participants and
teachers]
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Participant P5 found ALEX© easy to use and less confusing than a traditional dictionary. According to teacher T2, P5 forgot how to properly use a traditional dictionary, but found our system intuitive. Furthermore, this has motivated him to look up even more words.

Teacher T1 indicated that ease of use is the main advantage of using ALEX© over a paper dictionary. She mentioned that with our system, students are more likely to look up words when they are in doubt about their use or meaning. With paper dictionaries, students often do not bother going through the trouble of looking up words and simply assume that their guess is correct. The ease of use of ALEX© facilitated the double-checking of words that otherwise would not have happened when completing exercises.

Participant P1 indicated that the Near Spelling function contributes to the ease of use. She often misspells words, and with a paper dictionary finding the definition of a word by guessing its spelling requires many tries. ALEX© allows her to find it after one try if using the Near Spelling feature.

Participant P3 mentioned that our system is easier to use than a dictionary since she can come back to the definition of a word she has difficulty with much easier than with a paper dictionary.

Saved Time

As previously mentioned, users found ALEX© provides

easier and much faster access to definitions, compared to traditional dictionaries. This has resulted in significant time saved while doing various academic and non-academic tasks. For example, participant P3 indicated that she has difficulty finishing her homework late at night after coming home from a full-time job and taking care of her children. However, with the help of the mobile language assistant she can finally complete her homework every day, and she is more confident that her homework is correct. Other students have mentioned similar benefits:

> "I can do my exercises like, two times faster now" [P1]

ALEX© was also appreciated as a time-saver by the teachers. Both have indicated that students are now less likely to ask for help with simple tasks – previously they even asked questions that could be answered by a dictionary. Instead, they now call upon the teachers only for more complicated tasks, such as understanding the meaning of a complete sentence after finding the meaning of individual words using the mobile language assistant.

Helped gain independence

One of the major goals of our project was to increase adult learners' independence outside the classroom environment, by assisting with everyday tasks, as well as encouraging the use of literacy resources beyond schoolwork or homework. Indeed, we have found that our application allows low-literacy adults to perform more independently.

Participant P5 has always felt embarrassed by his lack of literacy skills. He likes reading the newspaper but he was frustrated that he doesn't fully understand all articles. With a mobile language assistant, he started reading the newspaper and doing his homework at the coffee shop adjacent to the literacy centre. He felt that it is socially acceptable to use a mobile device in public, while maintaining privacy in terms of the purpose for which the device was used – the coffee shop is typically frequented by college students who study there and use their laptop and other mobile devices while reading books and writing assignments. Teacher T2 noted:

> "P5 would never buy a dictionary or want to be seen with one. I was surprised seeing him using ALEX at the coffee shop – he even used the [audio spelling] with his headsets on – I guess he felt it's cool to have them hooked to a mobile device like all the young students."

Participant P5 even reported using the device at a grocery store. In fact, teacher T1 mentioned that other students also took the devices while shopping and use them to write their shopping list – P1, P2, and P3 all indicated that it would be even more helpful it they could write entire recipes posted in the store and get definitions for the words.

Participant P3 also reported being interested in politics and finds ALEX© helps when she reads the newspaper, as she notices that there are a lot of difficult words in the political articles. Similar to newspaper reading, several participants mentioned using ALEX© when reading books at home.

Both teachers reported using the language assistant outside prescribed academic activities. Teacher T2 indicated:

> "P4 uses [the device] for everything!"

From students' narratives, we have also identified uses for situations where other assistive technologies would have been more convenient, yet for this particular group the ease of use and the fact they got accustomed to our language assistant prevailed. For example, participant P1 mentioned using the Near Spelling feature of our device to correct her spelling when chatting with friends through instant messaging, while participant P3 uses the same spelling feature when writing e-mails.

Participant P3 also reported using the device in social situations. In particular, she mentioned hosting a dinner with friends when a debate started about the meaning of a word. Despite her guests' disbelief, she claimed she knew the meaning, and when prompted to defend her claim, she used the language assistant.

> "It was cool to show off to my friends" [P3]

Increased confidence and motivation to learn

One of the most important findings of our study was the increase in learners' confidence and motivation to learn. This was both reported by teachers and self-reported by participants.

Participant P3 mentioned that she is now more confident that her homework is correct:

> "I see the word coming up on the screen and I know I got it right"

Participant P4 indicated that she likes to learn to increase her knowledge in general, and ALEX© provided her with the encouragement to carry out her pursuit at least with respect to the English language.

Both teachers reported that such a system provides an incentive for students to learn:

> " … reignite the spark when things are getting boring" [T2]

> " … made learning fun and was a real confidence-booster" [T1]

> "It was less hassle and less boring than a regular dictionary" [T2]

Teacher T1 also mentioned the case of a student (not a participant in the study) who was preparing for his GED exams[2]. He doubted his ability to study for these exams, but after using the device in the classroom he became confident

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[2]General Educational Development – in Canada, the equivalent of high school diploma for adults who have not completed the formal K-12 education. http://www.ilc.org/ged/main_what.php

that he can prepare successfully for the exams.

Teacher T1 also reported that students realized the importance of dictionaries – without our system, they never saw the value of traditional dictionaries and lacked the motivation to use them. Furthermore, the occasional failure of ALEX© to find the complete meaning of a word prompted discussions about the inherent limitation of dictionaries. For example, students started comparing the electronic dictionaries with the various editions of paper dictionaries available in class – teacher T1 believes that this increased students' interest in the learning process.

UNEXPECTED FINDINGS

Building a personal relationship with the technology
Several students appeared to develop a relationship with the software and the device. When speaking to researchers they would phrase their statements as if ALEX© was a person (perhaps this was also influenced by our choice of a proper name as an acronym for the system). This was projected outside the classroom as well – participant P2 received a small pocket translator as a gift and named it "baby ALEX".

The personal relationship with this technology was also projected in the classroom – student attributed human-like characteristic to the device. In teacher T1's class, students often shared the device when doing group exercises – during these exercises, they drew a human shape on the whiteboard adjacent to the table and named it after the device and left empty the space on the table facing the whiteboard.

Sharing the system
For the entire duration of our study, we found that participants shared their devices with friends and family. All participants that had school-age children reported lending them the devices for the purpose of homework. P2 mentioned sharing the device with her sister in order to help her improve her English. P3 indicated that both her children used it for schoolwork – her 8-grade son, struggling with academic English, found it easy to use and helpful for his essay writing, while her daughter even demanded she purchase a device for her.

> "[My son] finally found something he is interested in … he doesn't care for books at all" [P3]

One participant (P6) even wanted to share the device with her preschool-aged son to teach him new words, but did not proceed for fear of her son damaging the device.

Sharing also occurred inside the classroom environment. Other students not enrolled in the study started using the teachers' device, and some participants shared their devices with others in the class. Participants P1 and P2 reported introducing the technology to other students and explaining them how to use the device:

> "I don't even have to explain [to new students] how to use it, [P1 and P2] are doing it. This is a good learning experience, when one student explains something to another one." [Teacher T1]

Pride in taking part in the study
Even at earlier stages in the study, we have found that participants understood the process of validating technology through evaluations with real users. Once the study progressed and students became more comfortable with the researchers, they became less shy in providing feedback and criticism. They took pride in being part of the study by identifying issues and suggesting solutions. They liked the fact that someone was listening to them in a field that they have not contributed to before, and felt that it was important to tell us about problems that they found. Some participants even spent time looking for such problems – unfortunately, it was difficult for the researcher to properly instruct the participants in identifying application-specific issues from hardware issues (e.g. battery life or screen brightness in sunlight) or from dictionary limitations (e.g. a word they've found in a paper dictionary that have more definition entries than in our electronic dictionary).

Teacher T1 reported that students were anxiously waiting for researchers' visits so they can tell them about something new they've discovered while using the device. Teacher T2 mentioned that students felt that someone was listening to them and to their needs and struggles, and that they can contribute to something that would help others like them. Furthermore, the study helped them realize the range of opportunities that exist to support them – that there are other organizations interested in providing help.

UNFORESEEN FACTORS

Demographic factors
As described earlier, demographic factors, such as age and employment opportunities played an important part in influencing adult learners' motivation for and interest in improving their education. Further investigation is needed to fully understand the correlation between these factors. However, anecdotal evidence collected in this study indicates that the younger, more employable, learners would use such an application if it was offered in a different format, such as a smartphone app. As teacher T2 noted, almost all students in her class (predominantly young adults) owned a smartphone – some despite not having the financial means to comfortably purchase one.

Literacy levels
Both teachers agreed that such a mobile language assistant is most useful for adult learners that are "in the middle" with respect to their literacy skills. Observations from the study indeed confirmed that most students that were at advanced level did not benefit much from the device, beside the convenience of not having to use a paper dictionary. The

exception was participant P1 who has a personal ambition of completing her GED and applying for university admission to further study English literature.

However, both teachers reported that students at lower levels of literacy, and immigrant students struggling with English were also intensive users of our language assistant.

POTENTIAL APPLICATIONS

Several improvements were suggested by both teachers and directly by students that could increase the use and effectiveness of such technologies in conjunction with adult literacy programs.

Games

Allowing students to complete homework directly on the device was one of the natural next steps we have envisioned. However, through the questionnaire administered at the end of the study, as well as through the interviews conducted with teachers, it became evident that exercises would not be welcome by students, and that the "fun" aspect would disappear. Teacher T2 notes:

> "Students would just start hating [the devices], like they hate doing homework."

However, both teachers agreed that exercises in the form of games would be well accepted by students.

Math support

Almost all participants have indicated they would like to see some form of math or arithmetic help included in our system. Indeed, both teachers confirmed that, while students' literacy levels vary significantly, they all struggle with math.

Extended language support

Participant P2 indicated that she would like to see a bilingual translator integrated into the English language support offered by ALEX©. This would help her understand some complex words – often she did not fully understand the meaning and had to ask the teacher for help.

Other students mentioned the need for more complex language support, ranging from grammatical help (e.g. assistance with parts of speech, as this is a common theme of the exercises handed out to students), to full semantic processing (e.g. provide the meaning of an entire sentence). As participant P3 described:

> "I want to get the same help as [our teacher] gives us."

Integration

Both participant P3 and P4 stated that they would like to see an "all-in-one" device, in which the application is integrated or tightly connected to common applications such as e-mail. Participant P2 also described her efforts of writing essays in English and how such integration with a text editor would be very helpful.

Participants familiar with the Internet indicated that they would like to be able to access it from our system – they are accustomed to using search engines to find answers to different questions related to their assignments.

Most participants in teacher T1's class suggested integrating encyclopedic resources in ALEX©. Particularly, some users were somewhat disappointed that the dictionary look-up is not able to find names of geographical entities or correct the spelling of proper names. Participant P4 mentioned that she is using our system to prepare for her Canadian citizenship test, and would have liked to get help finding information about and properly spelling the names of Canadian historical figures.

FUTURE DEVELOPMENTS

As mentioned earlier, math support is one of the most desired features to be added to ALEX©, as all participants felt they struggle with basic math. Since lack of numerical skills is often cited as a significant problem for improving the competitiveness of today's workforce 7, we have adapted our system to workplace essential skills training. We are currently evaluating this iteration in the context of a program addressing on-the-job essential math, writing, and science training, and that will ultimately enable the development of language and math mobile aids to be used in the workplace. In fact, even during the current study we have found evidence of the suitability of such technology for the workplace. Participant P3 indicated that she wanted to use the device at work to help her when she doesn't understand clients' request (but was prevented from doing so due to her employer's workplace policies), while participant P4 mentioned that she would like to use ALEX© as a helper at work if her job was not fast-paced.

CONCLUSIONS

The current literacy levels of working adults do not meet the demands of today's information-centric society. In Canada, existing literacy programs only reach a small number of those who would benefit from them 7. As such, there is a need for novel approaches to adult literacy training. In this paper we have investigated how a technological solution can address this need. For this, we proposed a mobile application that enables adults to improve their language skills outside the confines of literacy programs, and bring them closer to functional literacy and independence. The encouraging results of our study warrant further investigation into the use of mobile language tools to assist low-literacy adults.

The analysis of semi-structured interviews with participants, recorded narratives, and of the interviews with teachers, have revealed that ALEX© is well received by adult literacy learners. Students perceived the device as helpful in the classroom when working on exercises that involve the use of language resources (e.g. dictionaries, thesauri), as well as with the pronunciation of difficult words, which is an essential component of literacy

programs. The system also provided them with assistance when doing homework. Furthermore, our study has revealed that our mobile language assistant is being used outside prescribed academic activities in an exploratory manner. The ease of use of ALEX© and its perceived usefulness contributed to the students' independence with respect to activities requiring the use of literacy skills, increased students' confidence in their own capabilities, and increased their motivation to learn.

Our future work will continue to build upon the findings of this study, while enlarging the scope of our project to include other adult learning areas, such as numerical literacy or workplace skills training. We also plan to conduct further studies to determine how such technologies can fully assist adult learners in functioning independently in today's society.

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