EXPLORING THE USE OF MOBILE TECHNOLOGY FOR DELIVERING ELECTRONIC SUPPORT

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ABSTRACT

Mobile technologies in one form or another are having a significant impact on the way teaching and learning are delivered within all levels of the curriculum. Bearing this in mind, we have recently started to explore ways in which such technology (particularly, mobile phones) could be utilised in a university environment. A mobile phone application was implemented using principles of electronic performance support systems (EPSS). These principles state that human ability is inherently limited - cognitively and physically - and will benefit from external support usually in the form of electronic tools. These tools must be made available at the point of need, provide task-oriented support and should be tailored to the specific needs and skill-levels of their users in order to improve their task performance or cognitive ability. The application was designed to support learning, by university students, about how academic libraries organise their books using classification systems such as the Dewey Decimal Classification (DDC) system. Previous research has demonstrated the lack of knowledge and skills of our students in using the DDC, which our application aims to address. The application was adapted from a desktop EPSS tool previously built by the authors for use by first-year university students. The desktop tool was made up of a PowerPoint presentation which provided a tutorial on the DDC and decimal number system using text, images, audio, video and interactive elements. The tool also contained two computer games which provided a simulation for the students to practice what they had learnt from the tutorial. This paper briefly discusses the problems encountered in converting the desktop tool to the mobile phone platform. It also addresses some of the issues raised by students learning on mobile devices and presents the results of a preliminary evaluation undertaken with students studying at the University of Teesside.

INTRODUCTION

Mobile technology in the form of MP3 players, PDAs and mobile phones has become an important part of a student's learning environment. MP3 players, for example, can be used to play back recordings of lecturers and/or view sequences of course-related pictures. In a similar way, PDAs (and some mobile phones) can be used to send and receive email messages to and from tutors and colleagues. All these electronic devices have increased the range of tools at the disposal of students for learning. We have recently become involved in a programme of research that explores how mobile technology can be used to enhance teaching and learning processes - particularly, through the use of performance support techniques.

Electronic Performance Support Systems
The rationale underlying electronic performance support is the fact that human ability is inherently limited and many of these limitations can be overcome by the appropriate use of electronic tools. Some important characteristics of these tools are that they are available at the point of need; they provide task-oriented support and can be tailored to the specific needs and skill-levels of the users for which they have been designed (Gery, 1991; Banerji, 1995; Barker, 1995; Bezanson, 2002). Figure 1 shows typical skill-acquisition performance bands exhibited by novice and expert users. With time and continued

practice, skill levels continually increase to a certain innate capability level. However, beyond that point, the rise in skill level is not significant - as a performance plateau is reached. An important objective of electronic performance support is to help raise the performance plateaus of novice and expert users (as shown by the dotted lines) beyond what would be possible as a result of their inherent abilities.
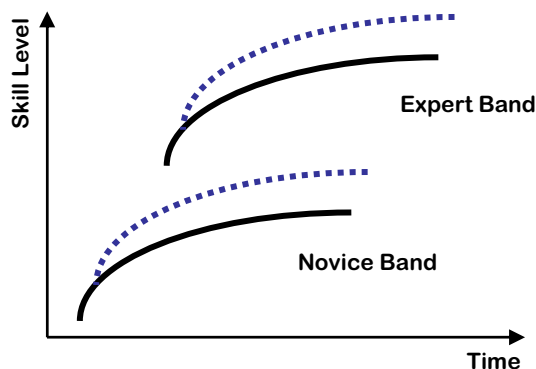

Figure 1. Performance Plateaus and Bands.

Some of the authors of this paper (PB and PvS) have been actively involved in the design and application of the theory and practice of electronic performance support for over a decade. Their recent research endeavours include: virtual study environments concerning distributed performance support (Beacham, 1998), information retrieval using search engines (Flinders, 2000) and the provision of support for students who want to use quantitative research methods (van Schaik *et al.* 2002).

Performance Support in Libraries
Over the years, many conventional libraries offering books, journals and other physical information-based artefacts have given way, in recent times, to the concept of a hybrid library. While these hybrid libraries continue to offer conventional services and facilities, they also provide access to numerous repositories of digital content and associated services (Leonhardt, 2006). Unfortunately, this has resulted in increased complexity and frustration for many library users (Cox, 2006; Hull, 2000).

In research work reported by van Schaik *et al.* (2007), frustration and anxiety were also shown to be experienced - even by university students. They showed that many students had difficulties in using their university library and its services and a performance support tool for libraries - *Epsilon* - was developed and evaluated. The students involved in the study used libraries based at the University of Teesside and Northumbria University, both of which are located in the north-east of England. Another problem encountered by the students was gaining an understanding of the rationale underlying (and use of) the library's classification system which was based on the Dewey Decimal Classification system (DDC) (van Schaik *et al.,* 2006).

Mobile Technology in Learning
The area of mobile technology and its application in teaching and learning (m-learning) has been well documented in the literature. For example, Perry (2003) has focused on the impact mobile technology is having on schools and their curricula, but increasingly, research is concentrating on understanding how students and teachers interact with mobile technology. Furthermore, this research studies how mobile technology can be used to improve support and learning for students in contexts where conventional electronic learning aids such as desktop computers are not feasible (Rieger and Gay, 1997). Harley *et al.* (2006) discuss how the short messaging service (SMS) was used to reach out to first-year students by members of their faculty to help them settle into the university way of life and consequently improve student retention.

This paper discusses the outcomes of implementing a mobile phone application, which was based on a desktop tool, using the principles of electronic performance support systems (EPSS). The desktop application was designed as a pedagogical tool to support students' understanding of libraries and the services that they provide. With the increasing reliance on mobile technology, it is necessary to determine the implications and feasibility of providing just-in-time support through mobile devices such as PDAs and mobile phones. Of course, the effectiveness of such mobile solutions also needs to be evaluated.

SYSTEM DESIGN AND IMPLEMENTATION

This section describes both the design and the implementation of the prototype mobile EPSS application and the challenges that were encountered.

Design

Designing e-learning applications for mobile environments presents many challenges. Some of these have to be overcome at the mobile-device level while others have to be addressed during the development and/or adaptation of content. The challenges posed by mobile devices include: (1) small screen sizes with limited display resolutions, (2) limited input options - for example, a typical mobile phone only has about 12 buttons, (3) inadequate storage space for applications, (4) a lack of micro-browser software standards and a convenient means of ensuring the latest version is installed on the mobile device, (5) popular mobile devices in use today are limited to manipulating static text and images and (6) different application development platforms provided by each mobile-device vendor, making it difficult to support a wide range of features on these devices (Holzinger *et al.*, 2005; Tsvetozar *et al.*, 2006).

For the development and/or adaptation of content, the following issues had to be considered: (1) the optimization of the content to provide concise information for mobile users with limited time to spend in sometimes quite uncomfortable locations, (2) the delivery of content in a suitable format - extensible hypertext mark-up language-mobile profile (XHTML-MP) - that could achieve enhanced presentation across different mobile devices, (3) the re-formatting of graphics and sound material to ensure they would be understandable and would fit within the reduced memory and screen size of mobile devices, (4) the re-design of the navigation system for the content to ensure that users would be constantly informed of their location in the application and (5) the provision of hyperlinks on each page of information to allow users to trace their steps (Lum and Law, 2005).

Implementation

A prototype application was developed using a WAP server to host the *Epsilon* tutorial application, rather than a SMS or JAVA mobile edition application. This option was chosen because it offered the quickest route to demonstrate and evaluate the concept of mobile EPSS. The *Openwave* micro-browser simulator was used as the client browser, because the software was readily available and is widely used by mobile phone vendors. The application was developed using XHTML-MP and WAP CSS to ensure that the content could be accessed and viewed with improved visual aesthetics on a wide range of mobile phones. The Nokia micro-browser simulator was also used during the design phase to compare the performance and compatibility of mobile browsers in relation to the rendering of XHTML-MP with WAP CSS content.

Figure 2 shows a sample screenshot of the *Openwave* micro-browser displaying the menu page for one section of the *Epsilon* tutorial. When users navigate to a content page, they can select an audio icon to automatically start playing an audio file which is stored in the WAV file format. Though the images shown on a content page are small, users can select them and activate the zoom function. A larger image is then displayed on the mobile screen. Figure 3 shows a sample content page containing both audio content and an image. Note that in this diagram, the information in the heading is only partially displayed because of the scrolling effect - which allows more text to be shown than would be the case in a static display.
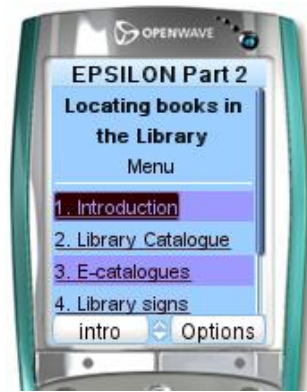
Figure 2. Page with menu items.

Figure 3. Sample content page with audio and graphics information.

Challenges Encountered

Various problems were encountered during both the design and the implementation of the prototype. These were caused by the inherent differences between desktop computers and mobile phones.

Limitations in the available memory capacity of mobile devices meant that the type and size of the application that had to be implemented was restricted. For example, the *Openwave* micro-browser could not play MP3 files successfully, so it was not possible to store the audio clips in a highly compressed format. The audio files thus had to be stored as WAV files - which require relatively large amounts of storage compared with compressed MP3 files. Consequently, it was necessary to reduce the quality of the audio recordings in order to reduce their file storage space requirements.

Because of the small screen size and resolution many of the images from the original desktop application could not be successfully displayed on the screen in the mobile application. Even though a zoom facility was available, it was still difficult to read the images. In addition, when the content was adapted for the mobile environment it was necessary to summarise or completely discard some information in order to reduce the amount of scrolling that users needed to perform.

SYSTEM EVALUATION

An evaluation was conducted to test the effectiveness of the mobile application for learning and to explore its usability and its acceptance by potential users.

Research Design

A pre-test post-test design was used to test the effect of the application on knowledge of the DDC. The outcome measures included both objective (knowledge, task completion, speed and navigation behaviour) and subjective data (confidence in knowledge and responses to questionnaire items). Further qualitative data were obtained from users while using the mobile application and through other responses on a questionnaire.

Participants

There were 21 participants; 10 were undergraduates and 9 postgraduates studying at the University of Teesside. Thirteen were males and their ages ranged from 18 to 42. Twenty had used mobile phones for over a year and all had used a mobile phone at least once a week.

Equipment

The WAP pages were displayed on the *Openwave* mobile phone simulator (Version 7) and participants' interaction with the WAP site was recorded using the *Camtasia* Studio software (Version 3). The tests were carried out on a personal computer (Intel Pentium 4 processor, 1 GB RAM, 80 GB hard disk drive) with screen dimensions of 800×600 pixels. However, the mobile phone simulator was used to display the WAP site contents with screen dimensions of approximately 128×128 pixels. A knowledge test was used twice (once as a pre-test and once as a post-test) to measure participants' knowledge of the DDC and their confidence in their knowledge.

An evaluation questionnaire was used to capture respondents' demographic details and mobile phone use as well as their perceptions of using mobile phones in general as well as the *Epsilon* tutorial. Seven-point Likert scales were used to measure perceived usefulness and intention to use the system (Davis and Venkatesh, 1996). In addition, the think-aloud method (van den Haak et al., 2004) was employed to capture the thought processes of participants while interacting with the WAP application.

Procedure

Each participant first completed the pre-test. This was followed by instructions to perform a familiarisation task using the mobile simulator. The main task then involved navigating the WAP site. During these tasks, participants were required to think-aloud. Following the post-test, each participant filled out the questionnaire.

Results

The difference between pre-test (mean = 56.19; SD = 20.12) and post-test (mean = 63.81; SD = 19.87) knowledge was not statistically significant ($t(20) = 1.73$, $p > 0.05$). However, the difference between pre-test (mean = 72.96; SD = (11.68) and post-test (mean = 89.75; SD = 8.61) confidence was significant ($t(20) = 5.56$, effect size $r = 0.78$, $p < 0.001$).

The self-efficacy scale was reliable, Cronbach's alpha = 0.70. Therefore, an overall self-efficacy score was calculated. With a mean of -2.30 (SD = 0.73) and $CI_{0.95} = [-2.63; -1.97]$, respondents' self-efficacy was high.

The intention-to-use scale was found to be reliable, Cronbach's alpha = 0.79. Consequently, an overall intention-to-use score was calculated. Respondents' intention to use the EPSS was high (mean = 1.57, SD = 1.06, $CI_{0.95} = [1.09; 2.06]$).

The perceived usefulness of EPSS scale was found to be highly reliable, Cronbach's alpha = 0.98. Therefore, an overall perceived-usefulness score was calculated. Respondents' rating of the perceived usefulness of the EPSS was high (mean = 1.89, SD = 1.33, $CI_{0.95} = [1.29; 1.50]$).

Users' usability problems were observed by means of an on-screen video and audio capture. The most common problems observed related to their use of a desktop mobile phone simulator rather than a real mobile phone. Most users had to adjust to interacting with a simulator rather than a real mobile phone.

Hence, interaction with the simulator was limited to the use of the simulator's alpha-numeric keys and buttons. Sometimes, use of the simulator caused confusion. For example, some users repeatedly clicked on the scroll bar on the mobile simulator's screen in an attempt to scroll down pages instead of using the simulator's up-arrow and down-arrow keys.

Another problem was related to sound, which was not synchronised with the text - thus causing it to stop functioning whenever a user tried to perform a new action while also listening to the audio narration.

In addition, some users experienced a loss of orientation. This was due to navigational problems caused by users' lack of familiarity with the simulator. However, fewer problems were observed in users' navigation after they had used the first part of the tutorial. Nevertheless, all users, except one, easily retraced their steps after a few clicks.

Other usability problems that were observed included: poor image quality, simulator errors and lack of interactivity. These were similar to the problems encountered during the design and implementation of the mobile application.

Participants reported the following strengths of the mobile application: its simplicity and ease of use, its organisational structure, the division of content into short paragraphs, its use of multimedia (image, text and audio) and the explanatory and educative nature of its content.

Participants most frequently reported the poor quality of images as a weakness of the mobile application. This was followed by lack of interactivity, simulator errors, small screen size, an over-abundance of text and a lack of animation. Regarding audio narration, the users who commented (all male) felt that a 'softer' female voice would have made the presentation more interesting.

Participants suggested that some changes should be made to the mobile application. Many suggested that animation should be included in the system to make it more interesting. Others suggested the inclusion of extra features - such as games to boost the interactivity of the system; and improving the resolution of images. Some participants wanted to see considerable increase in the use of colours in the interface. One of the reasons given for this was to enhance the system's appeal. Some other suggestions were also made that concerned the content of the EPSS tutorial - such as including information on how to find other library materials, for example magazines, audio-visual materials and course papers.

Furthermore, participants' comments as regards their intention to use and perceived usefulness of the mobile application varied. The most frequent comments were positive. The reason for this positive response was the portable and ubiquitous nature of mobile devices, which makes information readily available at any given time or place. However, a small proportion of users were negative in their response - either because they claimed to be already very familiar with the use of libraries or because of the limitations of mobile devices.

Discussion

Performance in the knowledge test, in terms of correctness of answers, showed only a marginal difference from pre-test to post-test. However, confidence in knowledge showed a marked increase. This may indicate that participants tended to develop over-confidence after using the mobile application. These results follow the same pattern as those obtained in previous research with the original desktop application (van Schaik *et al.*, 2006). Our positive results on perceived usefulness of the application are also in line with those for the desktop application.

CONCLUSION AND FUTURE WORK

The outcomes of this work are encouraging in terms of the use of mobile technology as a mechanism for providing electronic support for e-learning and other situations that require 'just-in-time'

performance-enhancing interventions. Our findings have also encouraged us to undertake further study in this area which would involve the use of other types of popular mobile device such as portable picture viewers and audio/video players such as the *Apple iPod.*

Electronic memory for mobile devices is now getting sufficiently capacious and cheap to support larger applications on these devices. This means that users can now download applications (including learning materials) into their mobile devices thereby allowing them to be accessed in an offline fashion. Consequently, the cost associated with using mobile phones for e-learning would be reduced as users would no longer need to maintain an active connection to a WAP server. The availability of larger amounts of storage space would also mean that higher quality audio files could be used - rather than the low-quality files similar to those that were used in our prototype.

Mobile-device manufacturers are continually increasing the communication facilities available with mobile technology. Many of these will allow external devices to connect to them. For example, modern mobile phones have Bluetooth and WiFi built into them. These allow mobile phones to communicate with other external devices such as audio headsets, keyboards and wireless local area networks (WLAN). Developments of this sort now make it possible for many of the limitations of mobile-devices, such as limited input options and small screen sizes, to be overcome. Also, we foresee the future availability of highly robust, foldable 'plastic' screens that could plug directly into a mobile phone - thereby enabling pictorial material to be viewed within a much greater display space than is possible with a conventional mobile-phone screen.

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