Adventures in the mobile learning toolbox

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ABSTRACT
As educators and technologists we have various views on what may constitute a useful mobile learning application, but this is typically from a teacher's perspective. In this paper, we review some mobile learning applications developed by some postgraduate students, who were free to explore their own ideas about mobile learning. Reviewing the range of applications developed, and the mix of implementation technologies chosen, demonstrates that these learners' perspectives go beyond simplistic categorizations of mobile technologies and associated learning applications. Rather, they use a blend of technologies and pedagogical approaches to meet the requirements of each learning context.

Author Keywords
Java Micro Edition, mobile learning applications, student projects

INTRODUCTION

Mobile learning applications vary widely in the technologies that they use and the learning content that they attempt to deliver. Prensky (2005) summarized what technical features could be used for learning on mobile devices, and what types of application these technical features could support (Table 1). Whilst this categorization has some utility terms of specifying fundamental requirements, it provides a somewhat narrow view of the relationship between a particular technology and a specific type of application.

Technical Feature	Sample Applications
Voice based	Languages, literature, public speaking, writing, storytelling, and history
Short Message Service (SMS) Text Messages	Behavioral reminders, voting, quiz games
Graphical Displays	Animations in subjects such as anatomy and forensics, sign language, mobile manga
Downloadable Programs	Applications combining voice, text, graphics
Internet Browsers	Research tool
Cameras and Video	Data collection, observation, journalism (gathering evidence)
Global Positioning Systems (GPS)	Augmented reality tours, geography

Table 1. Technical features and related mobile learning applications (from Prensky, 2005)

In this paper we review a number of mobile learning applications developed by postgraduate students from a course on mobile application development. These students were given the opportunity to develop applications under the general category of 'mobile learning', but were not constrained in terms of what types of applications they developed. This provided an opportunity to find out what these learners considered to be useful mobile learning systems. Given that the software platform taught in the course was Java Micro Edition, students were given the option of developing either thick client or smart client applications (a thick client does not require external connectivity to function, whereas a smart client requires some form of connection, which may use SMS, the web, Bluetooth or some other communication channel). A number of application areas were available to be explored by the students, so those who developed applications in the mobile learning area had chosen to do so. The purpose of this paper is to, somewhat informally, review a representative sample of the students' work to see if we might learn anything from them through their perceptions of mobile learning applications. It should be noted that the applications presented here were at the proof of concept stage, rather than being fully developed, so it was not possible to perform user evaluations of the applications. Rather, we attempt to summarise and categorise their features and concepts in the context of the technology to application mapping described in Table 1. Although the applications here are described in the voice of the researcher, it should be noted that most of the

motivations and concepts referred to were drawn from the students own project reports. The students concerned are individually credited in the acknowledgements section and have given permission for their work to be featured in this paper.

THE MOBILE LEARNING APPLICATIONS

In this section we describe a representative sample of the students' mobile learning applications, generally categorised under the headings of quizzes, games and puzzles, and contextual learning.

Quizzes

Quizzes are popular components of learning systems, which can help the learner to improve their personal knowledge and problem solving ability (Yokomoto, 2000). These may of course address many different types of learning. One such quiz is the 'World Geo-Quiz' which asks geography questions at varying levels of granularity and difficulty (Figure 1). This system takes advantage of the graphics processing abilities of the Java client to display a range of map types at various zoom levels. After the user gives their answer, the country's flag along with further information about it are displayed, thus giving two levels to the activity, both testing existing knowledge and providing the opportunity for further learning.

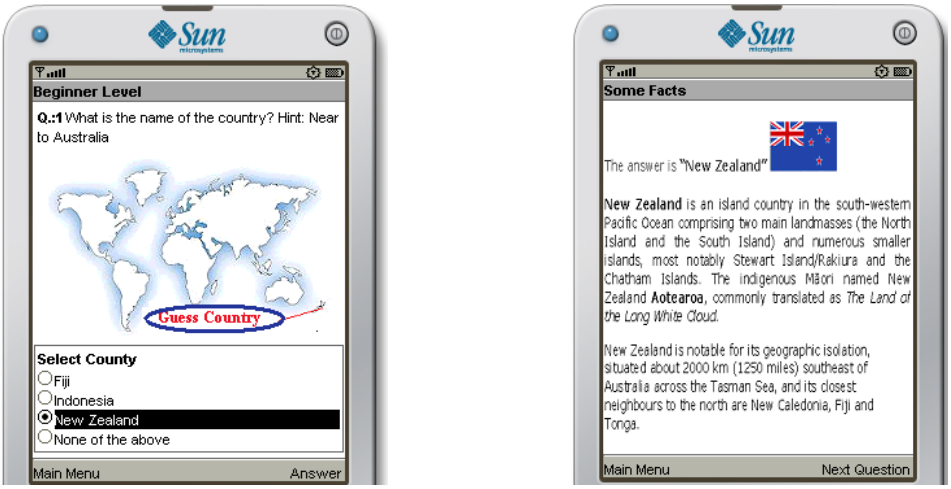

Figure 1. The mobile geography quiz system

Another application that might be categorized under the 'quiz' heading, though with a somewhat different intent, was of note because of the chosen context. The university makes previous exam papers available to students via the library web site, where they can be downloaded as PDF files. However one of the students proposed that these should be converted to mobile format, where they would be both more widely available and (potentially) also self marking. The mobile exam revision system (Figure 2) is simple in concept but has the advantage of obvious utility. The client is a very simple text based system, though smart in the sense that it would need to update its example database regularly via the web (assuming an appropriate server side application).

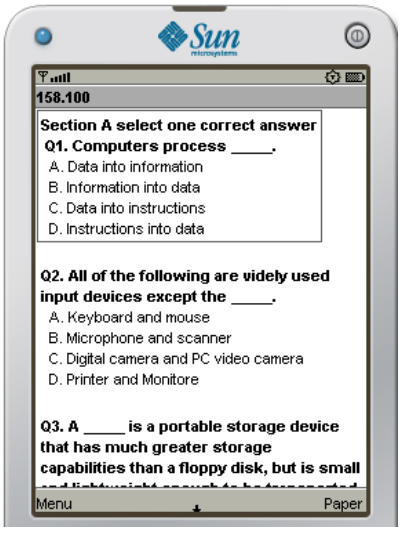

Figure 2. The mobile exam revision system

A common activity for learner drivers is to practice for their theory test in order to gain their driving license. One of the quiz based systems was a mobile version of the New Zealand multiple choice driving theory test. Although the question

material is currently available on the web, as well as in print form, the web based version only displays questions and does not support either initial learning or interactive testing and feedback. The mobile system (Figure 3) therefore provides a more functional implementation, as well as providing the benefit of mobility. The system has two modes, learning and testing. The mode can either be selected from the start, or can be switched dynamically, e.g. the user can choose to spend time learning from the system, take a complete test, or learn a feature of the road code and immediately switch to test their learning about that particular aspect of the road code. The overall approach to the design was based on Seong's usability guidelines (Seong, 2006.)

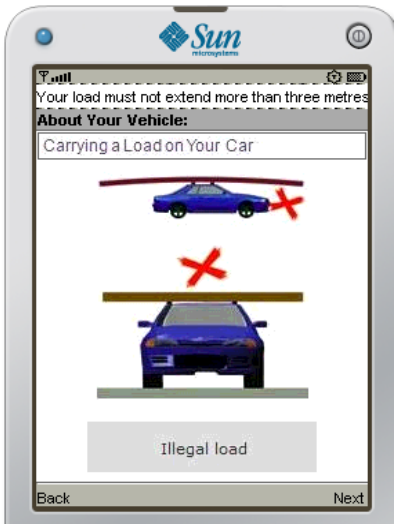

Figure 3. The mobile road code system

Perhaps the key feature of both the past exam paper system and the road code system is that both are addressing relatively urgent goal driven activities, in both cases assisting the learner to prepare for some form of examination. In these situations, having access to revision material any time, any place, with automatic assessment, can be extremely useful.

Games and puzzles

A number of important skills can be developed by using games, including strategic thinking, planning, communication, application of numbers and data handling (Kirriemuir and McFarlane, 2004.) However the design of the game needs to take account of structural problem solving, challenging the learner to transfer knowledge, learn about systems, test postulates and communicate effectively (Klopfer, 2008.) Two of the students created mobile games based on variants of the classic Space Invaders. In one of these games, players have to solve arithmetic problems before they are able to shoot at the Space Invaders (Figure 4.) The key in this game is solving the mathematical problems quickly enough to be able to shoot enough Space Invaders. There are difficulties trying to teach children new concepts and ideas within a mobile game as they often just focus on the game rather than learning or remembering the content (Agarwal et al., 2008.) Therefore this game focuses on reinforcement of skills, rather than new content.

Figure 4. A space invaders variant for practicing high speed mental arithmetic

In the other Space Invaders variant, 'Txt Invaders', the learning content is based on multiple players sending each other SMS messages containing one or more words (Figure 5). The words score differently depending on their size and the combination of consonants and vowels. Consonants are harder to destroy than vowels because they require two hits rather

than one. Thus the construction of the words by the sender controls both the score that the other player can achieve, and the score that the sender will achieve if the other player is unsuccessful. Thus the game incorporates word play (constructing words of a suitable size comprising different balances of consonants and vowels), arithmetic and adaptive strategy.

Unlike the other space invaders style game, which was for an individual learner, this game attempts to integrate the social messaging aspect of SMS into an asynchronous game format which permits a degree of pervasive gaming to occur. Pervasive gaming is defined by Montola (2005) as 'a game that has one or more salient features that expand the contractual magic circle of play socially, spatially or temporally'. Unlike synchronous multi player gaming, this game exploits the send and reply nature of SMS to encourage extended participation without requiring both players to be playing and connected simultaneously as is the case in most online games, making it more suitable to the intermittent, context dependant nature of mobile interaction.

Figure 5. TxtInvaders, an asynchronous multi player word and number game

Another of the systems took its inspiration from a learning game already implemented on desktop computers, and ported it to the mobile context. This 'Number Jigsaw Puzzle' (Figure 6) was based on an idea from Huang et al (2007), where operands have to be moved in a cell based pattern. The basic idea is that players must fill a three by three square with nine operands such that the sums along the vertical columns, horizontal rows and diagonals equal a predefined value that has being set. Learners can derive a number of benefits from solving puzzles like this; they become involved in a process of inquiry and discovery, they develop strategies to find better solutions to a given problem, and they develop mathematical and logical thought processes (Huang et al., 2007).

In porting and adapting the game to the mobile context, a model of increasing challenge and reflection was adopted, based on Sedig (1997), which in turn builds on Csikszentmihalyi's Optimal Flow Learning Experience (1988).

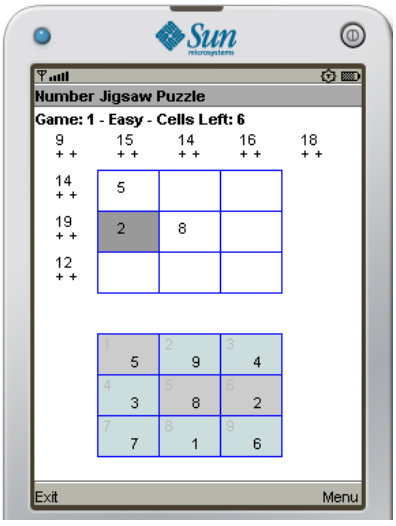

Figure 6. The number jigsaw puzzle.

Among the multi player collaborative systems was a word game based on hangman, though in this version the player loses if the princess gets eaten by the dragon (Figure 7). The design of the game was based on recommendations from Mitchell (2004) for developing mobile learning games, which include simple start-up procedures, minimizing levels of frustration and maximizing the likelihood of satisfactory outcomes, being appropriate for the device, encouraging cognitive skills, providing different kinds of feedback and playing with other learners. A key feature of this system is that the multi player interaction is supported by Bluetooth, making it free to play with others.

Figure 7. The multi player word game.

The games and quizzes developed by the students were interesting because in many cases they attempted to address not simply an arbitrary implementation, but based their work on some theoretical basis. Whilst there is perhaps an assumption that such activities tend to be engaging, creating immersive flow experiences, this can only be the case if the application design is appropriate to the learner. By considering such design issues gleaned from the literature, including the role of collaborative learning, these students were able to create systems that displayed such qualities.

Contextual learning

One system, based on the work of Wilhelm at al (2004), explored some useful design concepts in collaborative, contextual learning. In this system, photographs could be annotated in order to either ask questions or deliver information (Figure 8). This system takes full advantage of both the mobility and connectivity of mobile devices. Pictures can be taken in situ, annotated by the user and then sent to another person using Multimedia Messaging Service (MMS) messages. This communication could be from the teacher to the learner, providing information, or from the learner to the teacher, asking questions.

Figure 8. The image annotation system.

In conducting informal interviews based on the initial design and prototype of the system, the student gained positive responses from a number of interviewees. One, a painter with a number of apprentices, said it would be useful in managing the apprentices on remote sites, for example by ensuring that they were using the right paint in the right area by

annotating photos of paint tins. Another respondent felt that the system would be very useful on their regular visits to China, where photos of signs could be annotated and sent to a translator.

DISCUSSION

We began this paper with a summary of Prensky's (2005) mapping of technologies to applications, and followed this with an overview of a number of mobile learning applications developed by students. It is clear from these examples that a simple mapping between technology and application does not tell the whole story. In fact many of the applications we have described combine together a number of technologies to create rich applications that leverage appropriate tools to meet user needs. We can see that an individual application may utilize more than one technical feature, depending on the nature of the client application. Clients may be thin (internet browser) thick (installed only on the device) or smart (utilizing both local applications and connectivity to servers and/or peers), and this functionality may switch between different modes depending on the current task. All of the examples shown here are of course downloadable programs, but in addition several of them use connectivity (internet, SMS, also MMS and Bluetooth) and several also use graphics, both image based and programmatically generated. Table 2 summarizes the richness of these applications, the range of client types, the application types (from Prensky's list) the variation in learning focus, and the different types of learner engagement, which may be opportunistic (i.e. leaning in available moments), goal driven (e.g. passing a test) immersive (e.g. gaming) collaborative (working with other users) or contextual (working within a real world context.)

Mobile Learning System	Client Type	Application Type	Learning focus	Engagement type
Geography Quiz	Thick	Downloadable Programs, Graphical Displays (Images)	Geography	Opportunistic, goal driven
Arithmetic Space Invaders	Thick	Downloadable Programs, Graphical Displays (Progammatic)	Mental arithmetic	Immersive
TxtInvaders	Thick - peer to peer	Downloadable Programs, Graphical Displays (Programmatic), Short Message Service (SMS) Text Messages	Vocabulary, strategy and mental arithmetic	Collaborative
Number Jigsaw Puzzle	Thick	Downloadable Programs, Graphical Displays (Programmatic)	Spatial problem solving and arithmetic	Immersive
Princess and Dragon Word Game	Thick – peer to peer	Downloadable Programs, Graphical Displays (Images and Programmatic), Bluetooth	Vocabulary	Collaborative
Driving Theory Test Preparation	Thick	Downloadable Programs, Graphical Displays (Images)	Road rules, event focused	Opportunistic, goal driven
Past Exam Revision	Smart - web	Downloadable Programs, Internet Browsers	General, event focused	Opportunistic, goal driven
Photo Annotation	Smart – peer to peer	Downloadable Programs, Graphical Displays (Images and Programmatic), Cameras and Video, MMS	Environmental / professional	Contextual, goal driven

Table 2. Categorising the mobile applications.

CONCLUSIONS

In this paper we have reviewed some student initiated mobile learning applications in order that we may gain some insight into learners' perceptions of what mobile learning applications might be like. Whilst there are many publications documenting types of mobile application, these have not been from the perspective of learner centred development tasks. By enabling learners to explore their own views of the potentials of mobile learning, we have been able to identify what they see as its core attractive features. As a result of the insights gained in this paper, mobile learning researchers can perhaps ensure a more reliable uptake of their systems by learners. In many cases we can see that the students have taken on board the key message that "Successful technologies are those that are in harmony with end-users' needs." (Shneiderman, 2002). The range of chosen technologies suggests that these learners are aware of the need to choose the appropriate technology for a given application, rather than applying a one size fits all approach. Some clients have no connectivity, other use various types of connectivity including the Web, SMS, MMS and Bluetooth. Some systems use text, others use images and others use generated graphics. If we compare the applications to Table 1, we can see that we

have extensive coverage of most of the technologies suggested with the exception of voice and GPS. On the one hand we can say that this is partly a consequence of technical issues, because the device emulator system used by the class (Sun Java ME Wireless Toolkit) provides limited support for voice and location aware development. However we might also take into account that none of the applications described here would require location awareness, and few would benefit from voice tools (except perhaps from an accessibility perspective.) Nevertheless, the fact that these features could usefully be overlaid onto some of the applications (for example location awareness could be added to the road rules system to ask context relevant questions) simply reinforces the fact that there is no simple mapping between chosen technology and application type.

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All figures are screen captures from Netbeans IDE 6.1, incorporating the Sun Java™ Wireless Toolkit 2.5.2 for CLDC

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