Practising Problem Solving Using Mobile Technologies

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***Abstract*- Mobile phones have exceptional computing abilities and yet are used largely for talking, texting and telling the time. This paper describes a project using the mobile phone to provide a learning platform for students on the United Kingdom Open University's (UKOU) distance learning module T216, Cisco Networking (CCNA). Within the project two different applications were offered and a survey conducted to gather students' opinions of the applications in particular and the general use, by the UKOU, of mobile technologies for student learning and support. The first application allows practice of IP address subnetting, an area of the module that students find problematic. The second gives students the opportunity to practise the types of questions used in the Cisco Academy's online tests. It also allows them the opportunity to monitor their progress. The results of a student survey are promising with students finding that both applications aided their learning, knowledge and understanding. They liked the ability to practise whenever they had a few spare minutes and wherever they found themselves. In general, UKOU students would like to see greater use of mobile technologies within their studies both for learning and for organisation. Reminders about assignments, tutorials and day schools were considered to be a useful service should this be possible. Overall the project has been a success. The use of mobile phones to enhance student learning has been proved. Once the problems regarding use with all mobile platforms are resolved, opportunities for use by the University and other learning organizations look realistic. This is particularly true in areas of the world where the availability of computers and broadband are limited and mobile phones are the only method of distance communication.**

Keywords – Mobile technologies; learning; problem solving.

I. APPROACH

The work of Kukulska-Hulme and Traxier [1] established that mobile technologies can be used successfully to support students' learning through a range of different activities, particularly around data collection and recording. Further, The Open University has undertaken work such as the Mobile Assisted Language Learning [2] project, which involved a wide range of mobile devices including mobile phones. Other UK higher education institutions have reported use of mobile phones to support students with timetabling and assessment dates. Research in this area is being undertaken within the University. A comprehensive Literature Review in Mobile Technologies and Learning (Futurelab 2006) [3] demonstrated many opportunities for use of mobile technologies. It saw the future as offering genuinely learner-centred learning experience that is specific, personal, collaborative and long term. This may be offered by exploiting the ubiquitous qualities of today's mobile phone technology, demonstrated particularly by the smartphone represented by devices such as Apple's iPhone and the RIM Blackberry. These devices offer facilities over and above the specific capabilities of mobile phones: high resolution cameras, PDA features, multimedia players, etc., integrated into devices that fit in a shirt pocket and may be used almost anywhere. Such devices were merely a vision to the authors of the Futurelab report in 2006.

The Communications Market Report (Ofcom, 2008) [4] showed 86% of the United Kingdom population owning a mobile phone, and so it would seem natural to exploit this device for use among distance learning students. The mobile phone has considerable computational abilities and yet anecdotal evidence, confirmed by simple surveys undertaken during presentations of this project, is that most people only use their mobile phones for talking, texting and telling the time. Few of the other applications within even relatively basic mobile phones, let alone those found in smartphones, are used.

Learning involving mobile technologies can introduce some specific issues:

- Context – the ability to personalize the learner's environment may lead to ethical issues requiring secure storage of data;
- Mobility – promotes the need to manage the learning environment outside the more traditional setting;
- Informality – the advantages of using mobile technologies in a formal way may deter students;
- Ownership – the necessity to avoid exclusion;
- Learning over time – the need for organisation and tracking of learning.

These issues were taken into account during the progress of the project.

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II. APPLICATIONS

A. *Subnet Exerciser*

The Subnet Exerciser is an application that allows students to practise the technique of subnetting, something this is known to be challenging to students. The application was released to a cohort of 300 Cisco Networking students towards the end of 2007 to fit in with their study of subnetting. This was repeated to increased numbers in April 2008. Informal forum-based questionnaires were undertaken with both cohorts and feedback was received through forum comment and personal email. A similar trial was conducted in April 2009 but followed up with an additional application discussed later and a more formal questionnaire to complete the project.

The Subnet Exerciser, shown in Fig. 1, allows students to practice the skills necessary to manipulate IP addresses and includes:

- Denary to Binary conversion
- Binary to Denary conversion
- Logical AND operation
- IP address classification
- Practice questions on subnetting

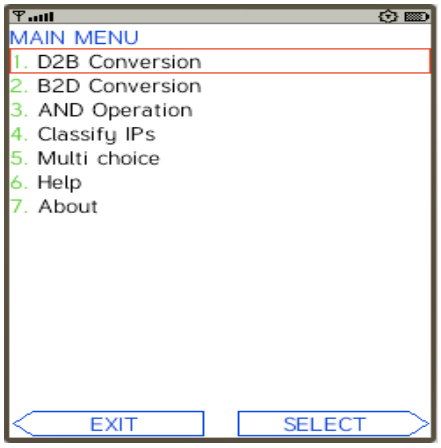

Figure 1. Main menu screen of the Subnet Exerciser

The application is downloaded to students' phones and run stand-alone, in much the same way that a games programme would be used. From the outset it was realised that not all mobile phones were suitable for this application. It was written in a dialect of the Java® programming language designed for mobile phones. Interestingly, the smartphone caused more issues than the basic mobile phone, something which seemed somewhat perverse. This was because the former does not conform to the mobile phone Connection Limited Device Configuration (CLDC) standard [5]. Students were able to find out whether or not their phone was suitable, but it was obvious from students' messages in the forums that this facility was not used extensively. For students unable to run the application on their mobile phone a simulator could be downloaded from Sun Microsystems [6] which allowed the Subnet Exerciser to run on their computers. Care was taken throughout the project to ensure no student was disenfranchised through lack of a suitable phone.

Initial findings suggested that students valued particularly the learning opportunities offered by the multi-choice practice questions. This was because much of the Cisco assessment is based around this methodology. Further, there was a need to address the issues raised earlier regarding mobile learning, specifically those raised by mobility and learning over time.

B. *Multiple choices*

Luzia Research [7] is a company that develops mobile learning applications. Their *uHavePassed.com* application [8], which allows those learning to drive to practise the theoretical part of the United Kingdom driving test using mobile phone and computer platforms, looked particularly useful. Following registration users download a simple client onto their mobile phone, see Fig. 2.

Figure 2. The initial client screen of *uHavePassed* on a mobile phone

This client allows access to different ranges of questions and progression statistics. A range of multi-choice question types, including use of graphics and multimedia, are available for download during the online synchronization process. The selection of questions is dependent upon statistical indication of the student's progress, with failed questions being re-sent along with new ones to replace those which were answered correctly. Importantly, this application does not require the student to be online except when synchronizing with the server. Data transfer to mobile phones can be costly so it is important to keep the need to be online to a minimum.

Luzia Research provided the University with a *uHavePassed* platform (*OuHavePassed*) and server access to banks of questions covering the Cisco Academy CCNA Exploration curriculum. This involved developing over 400 new questions to add to those written for the original Subnet Exerciser. Many questions needed diagrams, some of which

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were drawn originally for viewing on a computer screen, others were drawn specifically to suit the reduced size of the mobile phone screen. Blocks of questions were sub-divided into chapters to match the Cisco Exploration curriculum. This ensured that students knew where to seek additional support, over and above the supplied feedback when required. An example of a question and answer is shown in Fig. 3. The smart buttons immediately below the phone screen move pages and either the cursor or the number pad is used to select an answer.

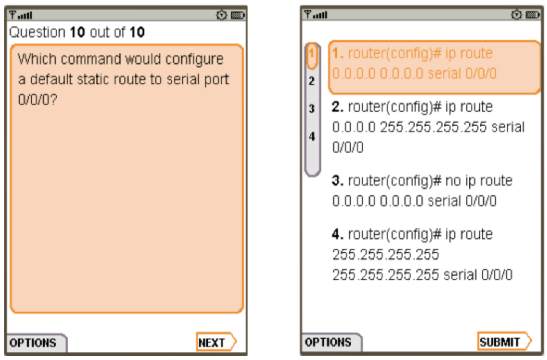

Figure 3. *uHavePassed* screens showing a question and optional answers

C. *Data and evidence gathering*

An online survey by questionnaire was the most appropriate way of reaching all students, for many were based overseas. Evidence was also gathered from student forums and face to face meetings at day schools which form part of the module.

IV. OUTCOMES

A. *Main outcomes and supporting evidence*

1. Students are willing to accept using mobile technologies when they can see a real purpose;
2. Mobile technology can support students' learning but has to be targeted for maximum effect;
3. Students are concerned about costs of using mobile technologies;
4. All mobile platforms must be supported, since students use a wide range of technologies;
5. Students would like administrative support with their studies using mobile technologies.

B. *Student statistics*

Table 1 shows the student involvement with the project taken from the *uHavePassed* server. 32% of the total active cohort registered on the website and of these 56% downloaded the client onto their phones. 612 mobile tests and 182 web-based tests were attempted, indicating that the ability to use this resource was more valued by those using their mobile phones. Making an assumption that those using the client on their phones would not use the website for tests, then nearly seven tests were attempted by students on their phones against just over two tests via the web. This could be because access via the web was probably seen as no more beneficial than accessing the formative tests on the Cisco website, but there is no evidence to support this

TABLE I. STUDENT INVOLVEMENT WITH THE PROJECT

Students:	**Number**	**Percentage of total**
Active on module	500	n/a
Registering on website	160	32
Downloading client	89	56
Taking mobile phone tests	612	n/a
Taking web-based tests	182	n/a

C. *Response to the survey*

A personalized email request was sent to over 400 students taking Cisco modules, and Table 2 shows the student response to the survey. A 10% response was typical for this form of survey and was just acceptable from a statistical view. It was pleasing to see that a cross-section of students responded, not just those who took part in the project.

TABLE II. STUDENT RESPONSE TO THE SURVEY

Students	Number	Percentage
Received details of survey	405	n/a
Responded to survey	40	10
Accessed the website	24	60
Used mobile phone	12	30

D. *Support of outcomes*

D.i. *Students are willing to accept using mobile technologies when they can see a real purpose*

The overall response to the project demonstrates students are willing to embrace mobile technologies or use existing ones in new and novel ways. The biggest concern raised by students was the screen size of their phones with regard to the way in which we expected the students to interact with it. The responses shown in Fig. 4 were from a question asking students about using their phone compared with a similar experience on the website viewed on a conventional PC screen. Approximately 40% stated they found reading text somewhat difficult, and overall, they found the experience of using the phone's screen less acceptable than that of a PC screen. Results showed few problems with text size but

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diagrams were more challenging, although this is phone dependent. The problem with diagrams was in part due to not having time to rework those drawn originally for PC screens. Where new diagrams were drawn with the phone screen in mind fewer problems were experienced. There was the ability to exploit 'landscape' by turning the phone on its side, as shown in Fig. 5.

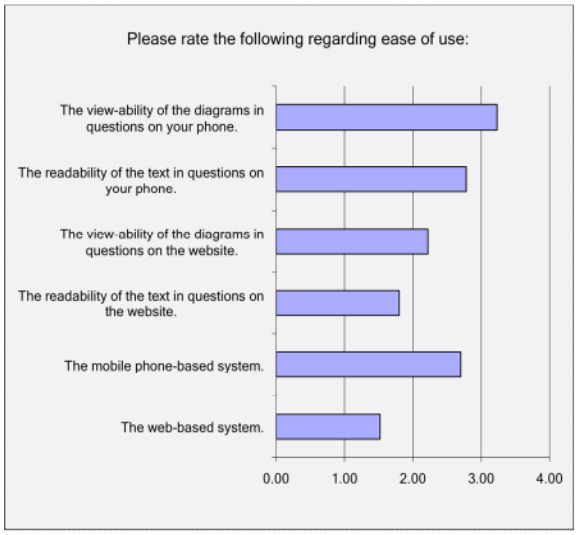

Figure 4. Ease of use, the lower the value the better

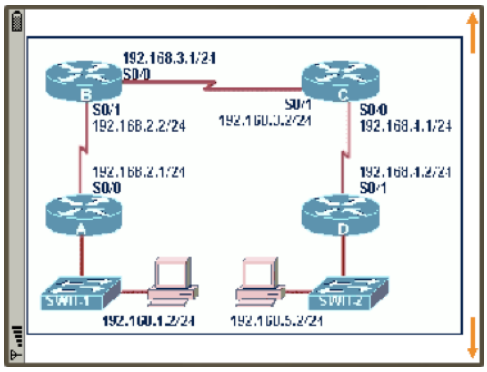

Figure 5. A diagram imported from a PC version viewed in landscape.

Currently, the text size is restricted by the Java CLDC specification. This will become less of a problem when the application becomes available on smartphones as these tend to have both larger screens and ways to resize text.

D.ii. Mobile technology can support students' learning but has to be targeted for maximum effect

The response to a question which asked how helpful students had found the application in supporting their learning is shown in Fig. 6. Over two thirds responded positively to having the questions available on their phone, to the choice of questions and to being able to monitor their progress. In particular they found the ability to retake questions where they been unsuccessful and the provision of context related feedback very helpful. Learning by reinforcement is a key to the behaviourist theory which this project adopts.

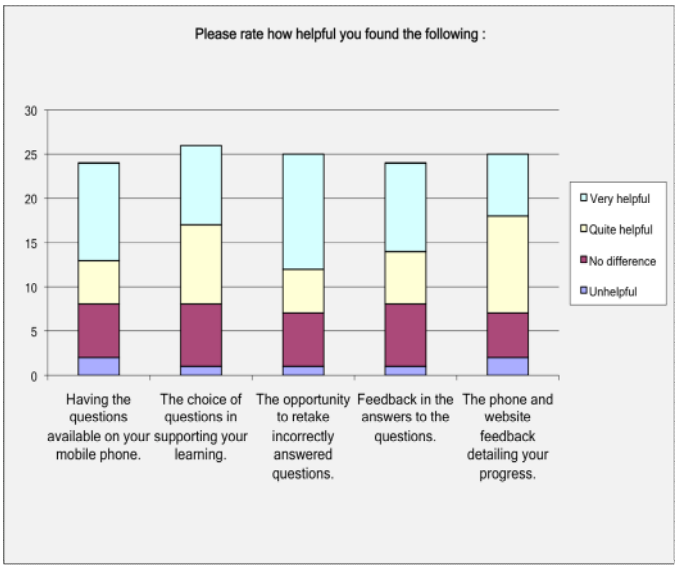

Figure 6. Students' opinions of the application

D.iii. Students are happy to use mobile technologies but are concerned about costs of data

Fewer than 10% of students expressed concern regarding costs, but they must be in one's mind when developing applications for new technologies. Unfortunately, data communication on mobile phones can seem expensive unless combined within a bundled contract. The advantage of the original Subnet Exerciser application was that it involved a single download of around 50 kilobytes. The ability to change the question banks and the availability of many questions does increase data transfer costs. A typical download when synchronizing is in the order of 300 kilobytes. Many smartphones offer network connections by Wi-Fi as well as the mobile network connections which can significantly reduce costs.

D.iv. All mobile platforms should be supported, because students use a wide range of technologies

Unfortunately, known problems in supporting smartphones were not completely solved before the end of the project. In particular, the Apple iPhone App took longer to develop than was expected. Blackberry access was unavailable to corporate users due to problems with firewalls and this affected several students. Applications must work on all major platforms if students are to be well served and the ability to access the project through a website was an important feature of the project even if, in this case, it received little use.

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D.v They would like support with their work through mobile technologies

Opinions were sought and responses shown in Fig. 7 as to how students might like to see mobile phones used by the University in supporting their learning. Reminders about dates of particular calendar events were thought to be very worthwhile. Over 70% thought texts (SMS) reminding students when particular events, such as due dates for assignments and results available, a good idea. 60% thought texts when assignments were not received would also be helpful. Interestingly, support for module specific applications were less popular. This may reflect the fact that the current ways of dealing with these applications are sufficient. A suggestion of using text messages to support group work seems an excellent idea bearing in mind the University's aim to include this activity on every module.

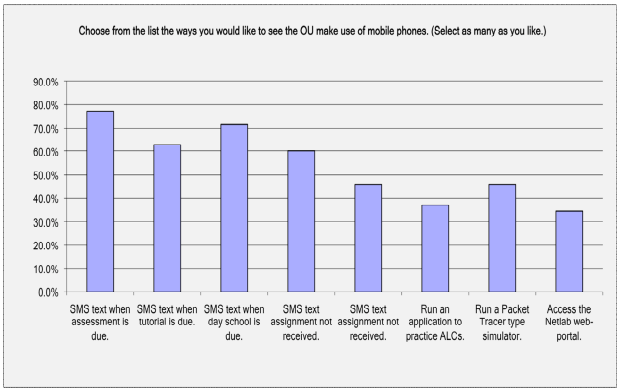

Figure 7. Ways in which the University could use mobile phones

V. IMPACT OF THE PROJECT

V.i. The ways the project impacted on student learning

The student response, shown in Fig. 8, to how they used the facilities offered by the project demonstrated that they had accessed all four blocks, and whilst percentages appear low it should be remembered that only 46% of the respondents took part in the project. Taking this into account 83% of the students who took part accessed block 2 with the other values not far below. The students were moving to block 2 as the project was made available which may well be why this was the most popular block

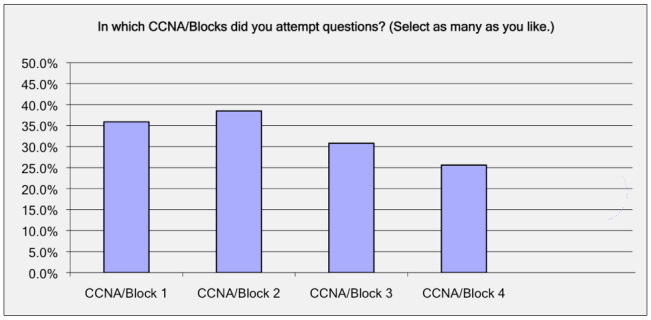

Figure 8 Access to T216 module blocks

The responses to a question regarding student learning, shown in Fig. 9, further demonstrates the value of this project. Over 75% of replies stating that the application had assisted in their learning and understanding of the Cisco materials. Two thirds of students agreed that the application had assisted with the completion of Cisco tests. The lesser impact on University assessments was not unexpected as the project was not focused in these areas.

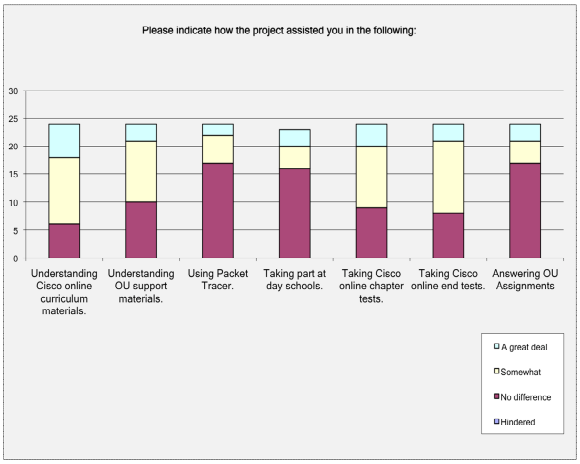

Figure 9. Students' opinions on how the application supported their learning

V.ii. How is your project contributing to increasing student performance?

Any improvement in student performance must lead to improved retention. The opportunity for students to gain more convenient access to module materials and support will support their learning and the evidence from my project demonstrates this to be the case. That students report a benefit to their knowledge and understanding of the areas targeted by this project establish this as fact. Success in the Cisco Tests, for which students receive a Cisco Certificate, can directly affect their employment opportunities. There is anecdotal evidence, backed up by the large number of students who take such modules, that proof of competence in the demonstration of knowledge and understanding of Cisco materials is highly regarded by employers.

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VI. CONCLUSION

The use of mobile technologies to further enhance students' learning is evident from the results presented here. Whether sole use of such technologies is possible must rest on the appropriateness of the technology to support the applications and vice versa. Certainly screen size and the resultant legibility of both text and diagrams is a particular problem which may be resolved in future products. The iPhone and others have provided some improvements by incorporating expansion techniques but applications need to be able to exploit these techniques to be of use. An alternative way is that exploited by applications such as the Subnet Exerciser which proved that carefully designed applications may be of considerable help to students.

However, such applications must be available across all mobile platforms. Working to the lowest common denominator is probably the most satisfactory way for the time being.

A possible area to exploit is that of information dissemination. Reminding students of impending assessments and events or availability of results is simple to achieve, costs very little to implement and can be of huge benefit to students.

Disenfranchisement of students by technology is not acceptable in any circumstance. However, the mobile phone often the most advanced technology available to students, particularly in developing countries, so opportunities to provide quality learning through this medium must be taken.

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