Mathematics on the Move: Supporting Mathematics Learners through Mobile Technology in South Africa

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ABSTRACT

This paper discusses research in progress on the challenges and opportunities for technology enhanced learning; specifically mobile learning in a South African context, where PC penetration is limited but where about three million teenagers have Java enabled cell phones. It provides a brief discussion of the South African landscape with specific reference to mathematics and science education. The research approach is action research within the framework of activity theory. The paper concludes with the description of a mobile learning solution for mathematics which attempts to combine edutainment with tutoring via narrowcasting, within the constraints posed by the educational and technical environment in South Africa.

Author Keywords

Mobile learning, Mathematics learning, technology enhanced learning, learner support, edutainment

INTRODUCTION

M-learning (or mobile learning) is seen as an extension of e-learning where the focus is on the use of mobile devices such as cell phones, PDAs, and iPODS (Brown, 2005). Laouris and Laouri (2006) describe the move from e-learning to m-learning as a revolution since it implies not only a change in terminology but a change of mindset when designing and planning learning environments and goals. Sharma and Kitchens (2004) assign this unavoidable change in paradigm to the unique facilities provided by mobile technology such as the provision of communication facilities at any time or location and the provision of learning content dynamically dependent on the learner's location, context and device (Sharma and Kitchen, 2004). This necessarily implies a change in classroom culture.

It is also clear that the exposure to a greater variety of media is causing a different kind of learner who gathers and process information differently. Mellow (2005) describes this new generation of learners as the media generation whereas Prensky (2001) uses the metaphor of "digital natives" to get a better understanding of the kind of learner educators are dealing with. Mobile technology is part of the "digital natives'" lives and it seems logical that educators should explore the possibilities of applying these technologies in educational settings (Mellow, 2005).

The situation in developing countries are of course somewhat different and quite a few researchers have asked probing questions on the role of technology enhanced learning (if any) in such settings (Brown, 2005; Masters, 2005, Laouris and Laouri, 2006).

THE SOUTH AFRICAN EDUCATIONAL LANDSCAPE

The South African educational situation may provide interesting lessons to learn for the implementation of mobile learning in developing countries. Quite a few educational challenges need to be faced in SA: apart from the poor education that was provided to the majority of South Africans in the apartheid era and the backlog educators still have to deal with, educators also needed to implement the OBE (Outcomes Based Education) paradigm from 1997 as well as extensive curriculum changes that were first introduced in the National Curriculum Standard (NCS) and its revision (RNCS) which is still phased in. Not all teachers are adequately trained and many schools (especially in the rural areas) lack the necessary infrastructure for the provision of computers and internet access. Because of cost, personal computers are just not as common as in developed countries. Also, because of the high cost of telecommunication services and the low bandwidth through which most people get access to the Internet, the majority of the South African school children are still computer and Internet illiterate.

ADVENT OF MOBILE TECHNOLOGY IN SOUTH AFRICA

However, this does not indicate that South Africa is an "unconnected" society. Because of the inaccessibility of wired networks in SA, the society has moved to wireless networks. Mobile phones are used by a large percentage of South Africans irrespective of race, age, income group or gender. The International Telecommunication Union (ITU) figures show that in 2004 South Africa's mobile phone density was 36% compared to the 6% of Africa (ITU, 2004). One can mention the MXIT phenomenon by way of illustration: already close to 3 million South Africans (mostly teenagers) are using MXIT, a Java application, extensively (Wikipedia and www.MXIT.co.za). MXIT, which runs on GPRS/3G mobile phones, provides the means to send instant messages at a much lower cost than traditional SMS messaging. Messages are sent and received via the Internet which implies that the cost of the messages depends only on the amount of data sent.

The ease with which South Africans adopt mobile technology suggests a wide range of possibilities for development using mobile technology, including mobile learning.
Several m-learning projects already exist in South Africa. Masters (2005) describes work done at the Faculty of Health Sciences at UCT on the use of early generation mobile phones to supplement administrative procedures. Brown (2005) reports on a model for m-learning in Africa which is based on the experiences gained through research done at the Faculty of Education, University of Pretoria. The model is evolving and focused initially on administrative support only for students. It is envisaged that it will include academic support as well in 2007 through the provision of e-learning course material, study guides, tutorial letters, multiple choice assessment, motivational messages, tutor services and appropriate feedback. However, all of these tend to be small-scale projects with a focus on reaching hundreds rather than thousands of learners.

THE SOUTH AFRICAN SCIENCE AND MATHEMATICS EDUCATION PROBLEM

The Centre for Development and Enterprise (CDE) released a report in November 2004 on the state of mathematics and science education in SA. The report covers three years of research, analysis and discussions with over 1000 experts. The main conclusion is that despite efforts from the government as well as private sector, the throughput of students with maths and science on higher grade level is far too low to provide the country with the necessary skilled workers to build its economy (Anonymous, 2004). The research revealed that only 4637 African learners matriculated with higher grade mathematics in 2002. The shortage of qualified teachers contributes to this problem. Groenewald (2002) estimated the shortage of mathematics teachers and science teachers to amount to 4000 and 12 000 respectively in the year 2002. One of the recommendations of the CDE is that higher performing schools should be supported and ways in which they could assist other schools should be investigated. They also urge private sector to come up with focused initiatives.

TECHNOLOGY ENHANCED MATHEMATICS LEARNING IN SOUTH AFRICA

The shortage of qualified maths and science teachers led to some initiatives where one or more teacher is used to reach a large group of learners through ICT. One such an example is tutoring through the medium of television. Mindset Learn is such an educational programme offered via satellite television with additional multimedia support. The programme is offered five days a week, nine hours a day and focuses on the teaching of English, Mathematics and Science on secondary school level (Mmekoa, 2005).

Technology enhanced mathematics teaching and learning is implemented in both primary and secondary schools (of which most are private schools) in the form of drill-and practice software dynamic representation software (e.g. Geometer's Sketchpad), tools to do the drudgework (e.g. scientific calculators). On postgraduate level, computer algebra systems such as Matlab are in use in many South African universities either in the teaching of students or the teaching of teachers. The Department of Mathematics at the University of Pretoria is also busy with a project teaching calculus online (Engelbrecht and Harding, 2005).

Recently some efforts were announced to teach mathematics via MXIT (and other Jabber-based chat platforms). This basically presents a text-based environment to interact with learners on a one to one basis. Although research on this is still ongoing, this approach does appear to hold much promise, provided that the logistics required for such a real time effort could be resolved in a sustainable manner. The time seems ready to test the ground for the possibilities of mobile mathematics learning in South Africa.

PROPOSED RESEARCH PROJECT AND CASE STUDY

Case Study

IT School Innovation (ITSI) is a Southern African high school computer education company established in 2000. Recently the company decided to widen their focus to "Technology Enhanced Learning" and then specifically via mobile platforms. The "M☺BI Maths" project is one of these added services. The Department of Informatics of the University of Pretoria considers this an interesting project as a case study with many research possibilities.
The basic research question which will be addressed is as follows: what contribution can a mobile tool such as M☺BI Maths make to enhance mathematics learning on a secondary school level in a South African setting?

Research method

Action research seems to be the ideal strategy to approach this project. McKay and Marshall (2001) describe action research (AR) as a "juxtaposition of action and research". The outcome of action research is therefore two-fold: improved or altered action/practice and new knowledge. Oates (2006) sees AR as an iterative cycle of plan-act-reflect with an emphasis on change and collaboration with practitioners. Also, Oates (2006) gives

the five stages of the plan-act-reflect cycle as diagnosis, planning, intervention, evaluation and reflection. What makes this different from ordinary problem solving or consultancy is that the researcher work from within a conceptual framework which both informs and is being changed by each cycle of plan-act-reflect (McKay and Marshall, 2001). Also, data is collected throughout the cycles (through questionnaires, interviews, observations etc) to enable evaluation and reflection.

This project has now passed the planning phase of the AR cycle and has reached the intervention stage. At this stage most of the challenges and obstacles which have been identified in the planning stage on both educational and technological levels, have been addressed. These are discussed briefly in the paragraphs that follow.

We intend to use activity theory as the underlying theory informing the next phases. Similar to Waycott, Jones and Scanlon (2005) we feel that the particular strength of activity theory in this context is its assumption that tool mediation is central to all human activities. Also, by referring to the work of Sharples, Taylor and Vavoula (2005), and using activity theory to analyse learning as a cultural-historical system, two layers of tool-mediated activity are exposed: the semiotic layer which in our case will include the mathematical "language" on the one hand and on the other the technological layer which represents learning as an engagement with technology. Also, one of the main premises of activity theory is that activities are of cultural-historical nature. By looking at the history or rather the evolution of learning activities it seems to points to a new generation with a culture where activities will be mediated by tools anywhere and anytime. Activity theory may help us to understand the culture of the "media generation" we are trying to teach.

The final part of the paper will focus on the M☺BI project itself: firstly the challenges and obstacles to overcome and secondly the implementation.

THE MOBI PROJECT

Challenges and obstacles

Technological

Platform issues: The very nature of J2ME as a scaled down version of Java, implies that its interaction with phone hardware is not quite as standardised as is the case with Java proper. Consequently it is rare for any Midlet to be equally successful across a range of cell phone platforms, without requiring at least minor tweaking.

In addition to the platform issue, content providers in South Africa have to deal with *bandwidth* issues as well. Although 3G is available in most cities the standard in rural areas remains GPRS. In addition to this, one has to deal with the fact that the majority of phones currently on the market in South Africa are not 3G compatible. In addition, until recently mobile data costs in South Africa were quite expensive. Still costs vary between ZAR1.90 (~$.25) and ZAR .50 (~$.07) for 1MB of data.

Another issue, related to the use of 3G enabled phones or non 3G-enabled phones is the kind of streaming protocol which these devices can support (Goyal, 2006).

Also, as far as Mathematics, Science and Technology is concerned, it is very difficult to envisage the proper use of these devices without an existing uniform markup language similar to OpenMath and Math Markup Language for mobile devices. The recent release of the free version of Opera Mini™ has increased the possibilities for using one of the existing mathematics markup languages for mathematics and Science education on mobile phones although this still has the limitation that learners have to become conversant with the markup language for them to be able to submit proper mathematics formulas and the like.

Educational issues

From the preceding technological issues it is clear that a mobile solution would hardly be able to replace classroom mathematics. Furthermore, the educational requirements posed by the RNCS and the OBE paradigm, which include among others interactivity, group work, a combination of formative and summative assessments, etc, simply preclude a stand-alone mobile solution. This is exacerbated by the limitations of the current state of mobile technology in the world, let alone South Africa.

These considerations aside, the RNCS, as national framework for education leading to a single state controlled final school exam, serves as the perfect point of reference for any attempt to enhance classroom learning with technology. Since the specific outcomes and their relevant assessment standards are listed by grade and subject, it is quite easy to enhance classroom learning simply by using the RNCS as basis for content development. This is especially relevant in a context where any number of handbooks is approved by the Department of Education (DOE) for a given subject, making it practically impossible to provide a solution which ties in with each available handbook.

MOBI – "interactive instructivism"

M☺BI is a narrowcast solution with some of the characteristics of a live tutor, and attempts to cover most of the challenges/issues posed in the preceding sections. Despite the technological and educational challenges, M☺BI attempts to be an omnipresent, mobile mathematics tutor which responds to and addresses specific needs, irrespective of time, place or skill level. To some extent it is also a hybrid system, in that it is available for mobile as well as PC users.

M☺BI technical specifications:

- Web-based
- Server side: MySql database & PHP
- Client side: J2ME and/or mobile browser
- J2ME framework
- Streaming/playing/buffering .3gp or .flv video

M☺BI the application has the following characteristics:

- Mobile
- Omnipresent, in your pocket, in your language
- Knows the RNCS, local
- It has a memory

The MOBI Edutainment experience

MOBI is much more than an education tool, it is a specific variation on of the "edutainment" theme, in that it provides users with MOBI Radio, MOBI Chat and MOBI Learn, all in one applet. The difference with other edutainment solutions is that it does not use games to teach, rather that it provides an environment which allows for both entertainment and education, but the learner is never expected to "learn while playing a game". Play and learn are kept separate.

MOBI maths provides learners with various options to access its content, the easiest of which undoubtedly is the 'Quick find' option where learners just submit a search term and are provided with the available content in one or more of the following modes: "Basics, Theory, Examples" and "Exercises". For Grade 10-12 learners, the first stage of the application, *Mobi Assessor* runs the learner through a multiple choice assessment in order to determine their proficiency in the subject and to establish their stage in the national curriculum. Once the learner has been assessed the Mobi application can automatically lead the learner to areas of mathematics where they are weakest – or run them through their whole curriculum for revision. Tutorials take the form of streamed videos and examples aimed at explaining precisely different maths concepts and tutorials for maths skills development.

Figure 1. The M☺BI & Maths interfaces

The "Basic Skills" section is aimed at filling gaps in a learner's maths knowledge from previous years, and will also prove valuable to Grade 8-9 learners, whereas the "Theory" section focusses on grade-specific background knowledge, complimented by the "Example" section. The idea behind the "Exercise" section is that learners first try to solve the problems posted there for themselves, before accessing the solutions offered. The "Exercise" section is in essence a preparation for tests and exams and allows learners to evaluate the depth of their knowledge.

Of particular interest to Matric learners will be the "Previous Papers" section, which contains complete solutions – with theoretical background – to the matric papers of 2004, 2005 and 2006.

Mobi is not designed to replace a teacher and classroom, but rather to enhance classroom learning by providing learners with affordable, anywhere, anytime access to mathematics instruction. It is ideally

positioned to assist learners in a homework environment as a tutor to assist in the understanding of maths concepts and as a revision tool during test and exam seasons.

CONCLUSION

The South African educational landscape, like many other third world environments, lends itself to a unique solution for learner support which is affordable, independent on full-time access to the Internet via PC and available irrespective of whether learners have full time access to electricity. M☺BI is a unique mobile educational tool which delivers precisely such a solution, allowing learners anytime, anywhere access to tutoring material which is completely built on the South African Mathematics curriculum. In addition, it offers the opportunity, through its mobile chat client for one-to-one communication with an online tutor as well as for cooperative learning, while MOBI Radio enables direct audio communication in the form of narrowcast call-in sessions. The sheer scale of the MOBI maths implementation which covers the complete Mathematics curriculum for the three senior high school grades, as well as the fact that it will be available to anyone in South Africa with a Java enabled cell phone makes it one of the largest mobile education projects/tools of its kind in the world. It provides various opportunities for research on mobile learning and specifically mobile mathematics learning. In the coming months, many of these will be explored via doctoral and masters theses as well as research papers.

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