Directions for m-learning research to enhance active learning

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This paper aims to inform readers of suggested directions for researching how mobile technology can enhance active student learning. These directions are informed by an online survey of our students in early 2007 and a contemporary literature search. We present the findings of our search of global best-practice in m-learning, gaps in the current literature are identified and five directions are suggested for 2007 m-learning research and development. We start discussing how to investigate these suggested directions. Our five suggested action research directions are all significant issues in m-learning and all need to be better investigated. If we are interested in enhancing student learning, a priority is to design m-learning and teaching strategies that involve active experiential learning. These strategies need to effectively support our learners' development of attitudes, understandings and skills in identified graduate attributes, curriculum objectives and stated learning outcomes.

The development of wide support for an online body of knowledge of m-learning and teaching principles, strategies and effective, practical case-studies across all disciplines – an m-portal – is needed and can support and inform emerging national and international approaches to using mobile technologies to enhance learning. Guided by our findings and suggested research suggestions the authors hope to discuss, extend and develop collaborative partnerships for future action research, development and sponsorship at our ascilite 2007 conference workshop.

Keywords: mobile technology, active experiential learning, innovation in learning, ubiquitous learning, interactive classroom

Introduction

> If universities are serious about enhancing learning through the use of innovative technologies, much needs to be done to demonstrate how this might take place.
> (Kennedy, et al. (2006)

The authors acknowledge much does need to be done to demonstrate how to enhance student and academic staff learning through the use of mobile and wireless technologies. Ours and other recent surveys (Kennedy et al, 2006) show at least 95% of Australian students now have mobile phones and other devices. It is time to incorporate these technologies into the curriculum and into our design of student learning.

If we are interested in enhancing student learning, a priority must be to design m-learning and teaching strategies that involve active learning, for example, in experiential fieldwork, simulations, roleplays and games (Leigh, 2004). Learning and teaching strategies are needed that provide opportunities for learner adaption and reflection (Laurillard, 1993), that encourage critical thinking, and that support students professional development through self and peer evaluation, feedback, review and assessment opportunities (Raban and Litchfield, 2007). Effective and practical strategies are needed that support learners development of understandings and skills in our identified graduate attributes, curriculum objectives and stated learning outcomes.

The authors address this priority through examining the use found in the literature of the latest mobile and wireless technologies in learning and teaching. The paper includes a summary of our recent online survey of UTS students and the preliminary outcomes of some curriculum experiments with mobile devices. We present the results of our search of global best-practice in m-learning, identify gaps in the literature and make five suggestions for further research and development.

Our five suggested action research directions are all significant issues in m-learning and all need to be better investigated;

- mobile supported fieldwork,
- fostering interactivity on-campus using mobile devices,
- ubiquitous learning supported by mobile devices,
- m-learning for each discipline
- strategies for low-cost m-learning use.

These suggested investigations should also address the needs of student diversity as all higher education providers serve an increasingly diverse student body ranging from the 'digital natives' to mature-age students who are 'digital immigrants' yet to embrace modern information and communication technologies (ICT) tools (Prensky, 2005). Some disciplines in particular have large cohorts of international students for whom English is a second language and whose special needs for learning in a new environment need to be better addressed. How m-learning can address the needs of the international and non-English speaking background student population, for example, by allowing lecture content and messages to be accessed anytime, anywhere and repeatedly are noted in the paper.

Mobile technology and the current generation of learners

In recent years there has been a growing recognition of the disparity between the educational needs of the current generation of university students and much of the formal classroom education that takes place at universities. Ways of acquiring new knowledge for digital natives have been strongly influenced by the ICT's with which they have grown up. As well as being adept with desktop computers, digital natives are high users of an ever increasing range of mobile devices. In Australia the number of mobile phones has escalated rapidly and is surpassing the number of desktop computers (Al-khamayseh & Lawrence, 2005). Mobile phones are almost ubiquitous with 97.3% of university students born since 1980 - the digital natives generation - having some sort of access to a mobile phone (Kennedy, et al, 2006). This survey also showed a high take-up of mobile technologies - 95% owned mobile phones, 73% owned MP3 players or iPods, 23% had their own games console and 15% had a personal digital assistant - PDA.

Studies have tried to define the preferred learning approaches of this generation. Marc Prensky who coined the term 'digital native' describes their learning as 'short burst, casual, multi-tasking'. For them the small screen of the mobile phone is 'a window to an infinite space' through which they are able to undertake the following learning processes: listening, observing, initiating, questioning, reflecting, trying, estimating, predicting, practicing and 'what-ifing' (Prensky, 2005). Digital natives learning can be characterised by a preference for receiving information quickly, coupled with the ability to process it rapidly; a bias towards multi-tasking and non-linear access to information; a heavy reliance on ICTs for information access and communication; and a preference for active involvement in learning over passive learning in lectures (Kennedy et al., 2006).

There is a strong imperative to develop a new educational approach which will take into account the needs of the digital natives generation, while also providing for the diversity of learning needs in the student population and the presence of mature 'digital immigrant' students and international students whose first language is not the language of their educational studies. Such an approach needs to adopt deep learning - an orientation towards understanding, personal sense-making and active learning - since this will achieve better learning outcomes than surface approaches of memorisation, reproduction of knowledge and a lack of personal engagement (Prosser & Trigwell, 1999; Marton & Booth, 1997; Ramsden, 1992).

There is some evidence to suggest that learners from a wide variety of backgrounds may benefit from mobile technologies because they emphasise activity and interactivity as well as oral communication. For example, the rapid adoption of mobile technologies amongst indigenous people both in Australia and Africa suggests that m-learning may be highly successful with students from indigenous cultures (Dyson 2007).

Taking into account the needs of the current generation this paper investigates how mobile devices can be used to encourage *all* students to adopt deep approaches, improve perceptions of their study context, and therefore improve their overall learning experience and outcomes.

Literature search, online student survey and preliminary activities

In preparing for this paper the authors have conducted an extensive literature review, an online survey on student mobile device use, and preliminary investigations with mobile devices in mfieldwork, podcasting and using mobile devices to teach about mobile technology. Our findings are detailed through the paper.

The student mobile use survey (n = 442) was conducted online in February and March 2007 and was completed by UTS students of IT and other courses. The online survey confirmed the importance of integrating mobile technology into the learning and teaching environment as 95% of the surveyed students regularly use a mobile phone and 72% stated they would be interested in using a mobile device in their studies.

Trials in m-learning have been conducted at UTS in order to extend the use of mobile devices and improve educational outcomes for our students. In Autumn Semester 2007 a fieldwork activity with mobile support was introduced into a large (n = 340) undergraduate introductory information systems subject. Students were given PDAs and asked to record field data as photographs, videos or sound recordings while investigating information systems in their real-life context of use.

The experience showed that mobile devices can assist students collect data in richer, multimedia formats and make subsequent classroom presentations of their field study much more interesting. However, it also revealed certain usage and deployment issues with the mobile devices themselves, which were too difficult for most students to learn to use quickly in the short period of time they had available to acquaint themselves with the technology. We conclude that device selection is crucial for the success of mfieldwork activities, and educational design should encourage students to use their own mobile devices which would be more familiar to the students and simpler to use. However, the whole concept of mfieldwork was shown to be a great success, provided the usability issue could be resolved.

Another trial at UTS in Autumn Semester 2007 using PDAs to teach students about mobile technology and how to program these devices was also very successful. In the end of semester evaluation, students reported that they had gained a much better, more real experience from using the PDAs in class rather than a simulator. (A mobile phone simulator is software that runs on a desktop PC and substitutes for a real mobile device. The student can develop and test their application on the simulator instead of using the real hardware. The disadvantage of using a simulator is that it cannot replicate some of the functionality of a real device eg. making phone calls or other device specific functionality eg. Bluetooth or WiFi. Therefore the applications always need to be tested on the real mobile device before it can be released).

Comments from students included, ‘Yes, the use of the PDA was definitely an added benefit. There were issues faced with the PDA simulator in connecting to the internet. Hence there was the need for the real device’; ‘Yes. As on real device, all the experience is different from the simulator on PC. The real device helps me to experience using a real device and improve the user experience on the application’; ‘Yes, it is very fast running on a real device than the simulator’; Only one student reported negatively on the trial.

The literature of learning with mobile technologies

‘m-learning’ is the facilitation of learning and access to educational materials for students using mobile devices via a wireless medium. There have been an increasing number of investigative studies of m-learning over the last few years, mostly in the USA, Asia, Britain, Scandinavia, and Australia.

Surveys of students and teachers

Several researchers have used surveys of students and university lecturers as their starting point for investigating m-learning. Their objective has been to ascertain the extent of m-learning in university education and also to investigate the potential for leveraging mobile educational practice from existing mobile use. With the exception of a few notable large-scale implementations of podcasting in the USA (Thomas, 2006), and leaving aside many short-term projects, the university sector has not adopted m-learning. Interviews of professors at eight universities in Australia, New Zealand and the USA conducted by Al-khamaysah, Zmijewska, Lawrence & Culjak (2006) showed that none had adopted m-learning despite widespread use of elearning. Most surveys of students show that few students use their mobile phones for learning - 1 in 6 according to Pettit & Kukulska-Hulme (2007). m-learning is currently in an exploratory phase with universities unclear about the case for investing in a new set of expensive technologies, and educators still testing different delivery applications.

Other surveys have concentrated on the issue of 'threading innovative uses of technology into the existing fabric of behaviour' (Pettit & Kukulsksa-Hulme, 2007). These user-centred studies have focused on uncovering students' existing patterns of use and making these the basis for mobile education (Kennedy et al., 2006). Our survey revealed a strong interest in both podcasting, 'I think all lectures should be available via podcasts ... especially for external students!', and in SMS messages, 'I would prefer being contacted by SMS if something important came up relating to my studies, such as an assignment/test/exam extension or an amendment'. Some students saw the potential for on-the-job training, 'It might be useful for uni degrees that do a lot of field work' and some for learning about mobile technology, 'it is great to test my J2ME applications on a real device'. The issue of cost also came up repeatedly in the paper survey 'I would not SMS lecturers unless it was free'.

M-learning projects

Of the m-learning projects found in our literature search the majority have been focused on improving interactivity in the classroom (Fujimura & Doi, 2006; Lindquist, Denning, Kelly, Malanai, Griswold & Simon, 2007) or on increasing students' access to learning materials anywhere, anytime (Barbosa, Hahn, Barbosa & Geyer, 2007; Cao, Tin, McGreal, Ally & Coffey, 2006). A smaller number of projects have focused on supporting on-the-job training in the field, largely for medical and nursing students in hospitals (Sommers, Hesler & Bostick, 2001; Sharples, Corlett & Westmancott, 2002; Kukulska-Hulme & Traxler, 2005). A few projects have included teaching students some aspect of mobile technology, such as programming PDAs or using stylus technology, usually in connection with ubiquitous delivery (Bradley, Haynes & Boyle, 2005; Miertschin & Willis, 2004; Alford & Ruocco, 2001). Occasionally projects have combined ubiquitous delivery with a focus on interactivity, for example, Sá & Carrico's m-learning framework (2006) although most studies have a single pedagogical focus.

There have also been criticisms of the methodology of some experiments. For example, Fies & Marshall (2006) note that most evaluations of mobile interactive classroom systems are flawed because they have focused on the comparison of traditional versus interactive teaching rather than mobile-supported interactivity versus interactivity with no mobile devices. Our paper's research suggestions aim to overcome these problems.

A small number of projects span more than one discipline area, for example Scheele, Wessels, Effelsberg, Hofer & Fries's (2005) interactivity study in computer science and education. Most projects focus on only one type of mobile device although we note that the current 'New Technologies, New Pedagogies' project being conducted by the University of Wollongong examines three major devices - mobile phones, PDAs and MP3 players/iPods. Such project's need to expand into multi-institutional, multi-disciplinary approaches so that the outcomes are relevant to the widest community possible, using actual case studies in real class situations over a variety of subjects and education environments.

There are identified specific problems in university learning that mobile technologies can help overcome, for example, limited real world context, limited access to learning resources, low student engagement in classes, and lack of practical experience in learning about mobile technologies. Instead of assuming the importance of m-learning per se, these problems together with the gaps uncovered in the existing m-learning body of knowledge as discussed below, have informed the choice of our research suggestions that address our overall aim of enhancing student learning.

In summary research into m-learning in higher education is in an exploratory phase with many learning and teaching issues still to be investigated.

Gaps in the m-learning literature that need to be addressed

Despite the keen interest in m-learning as a way of both engaging the digital natives and of making the learning of all students more interactive and better supported anywhere, anytime, there are still many questions which urgently need investigation. These identified gaps in the literature have been informed by the work of Kukulska-Hulme & Traxler (2005) and Fies & Marshall (2006);

1. Most m-learning studies have been **small-scale** and **implemented in only one discipline**. For example, most mfieldwork learning has been conducted in the health sector.

   ➡ *There is a major need for large scale implementations generalised across a range discipline and subject areas and across institutions.*

2. The great majority of m-learning experiments have dealt with a **single pedagogical issue**, e.g. enhancing classroom interactivity. They have also usually focused on a **single technology**, more often than not PDAs, surprising given the small percentage of students who own PDAs – 15% in our survey. Because of these limitations, in addition to those highlighted in 1. above, there is a lack of a consolidated body of knowledge to guide teachers in implementing m-learning, particularly in the university sector.

   ➡ *A body of knowledge of learning and teaching principles and strategies is urgently needed to inform teachers wishing to utilise innovative mobile technologies and also to inform the development of national policy and pedagogical approaches about emerging mobile devices.*

3. A major challenge yet to be overcome is the **cost of mobile hardware, software, connection and usage charges**. The lack of sustainability of many m-learning projects indicates that this may well be the major hurdle to implementing m-learning on a national scale.

   ➡ *There is a great need for the investigation of low-cost solutions to implementing m-learning so that it can be sustainable.*

4. There has been a lack of focus on **designated groups of students**. The assumption has generally been that all student groups have similar m-learning needs. Where studies have examined m-learning with different populations, the results are difficult to interpret because of inconsistencies in discipline areas.

   ➡ *A proper evaluation needs to be made of the effectiveness of m-learning with NESB, international and other identified groups of students.*

5. Few studies have been found of how to **teach technology students about mobile technology *using* mobile technology**. Cost again is presumed to be the major obstacle.

   ➡ *Investigations are needed to develop teaching strategies for effective learning about wireless and mobile technologies.*

Suggested directions for m-learning action research

The gaps in the literature and the identified research needs requiring more investigation have guided the purpose and design of our suggestions for 2007 m-learning action research and development. These five suggested action research directions are all significant issues in m-learning and all need to be better investigated;

- mobile supported fieldwork,
- fostering interactivity on-campus using mobile devices,
- ubiquitous learning supported by mobile devices,
- m-learning for each discipline
- strategies for low-cost m-learning use.

When investigating these and other areas educational researchers should aim to demonstrate how the use of mobile technologies can enhance student learning. This can be done by designing m-learning activities influenced by experiential pedagogies (Leigh & Kinder, 2001; Leigh & Spindler, 2004), and self and peer evaluation, feedback, review and assessment strategies (Raban & Litchfield, 2007). Of particular interest will be the impact on students' approaches to learning.

The investigation of low-cost practices for using mobile technology for learning clearly has great strategic importance. Solutions to the current cost issues include using Wireless Application Protocol/Wireless Markup Language - WAP/WML - applications that work with mobile phone web browsers with a transmission cost that is negligible for the student.

Through such investigations an online body of knowledge – mPortal - of m-learning and teaching principles, strategies and effective practical case-studies can develop with examples applied across a range of disciplines. An evolving mPortal would support the effective use of mobile technologies to enhance student learning in all sectors of education.

Mobile supported fieldwork

M-fieldwork: Learning in a real world context using mobile technology

Fieldwork has long been identified as providing students undertaking professional studies with a means of implementing classroom theory into real life situations which are more closely aligned to their future work environment. In recent years some educators, particularly those working in the health sciences, have experimented with the delivery of support materials to students in the field, and others with the capture of field observations using a variety of mobile devices (Sommers, Hesler & Bostick, 2001; Sharples, Corlett & Westmancott, 2002; Kukulska-Hulme & Traxler, 2005).

Preliminary investigative trials conducted by the authors have sought to extend this work to disciplines which have not been involved before in Building and Information Technology. Promising results include high student motivation; collection of field data in richer, multimedia formats - photos, interviews, video-recordings, etc. than is possible with traditional pen and paper; and willingness by some students to work with their own mobile phones, digital cameras, and other emerging mobile devices.

Further research and development is needed to refine the implementation of mobile devices into fieldwork learning. Investigation outcomes could include;

- Development of learning and teaching strategies about the conduct of mfieldwork which are broadly applicable across a range of disciplines.
- Strategies for the integration into the curriculum of mfieldwork support materials and observational learning activities.

Fostering interactivity on-campus using mobile devices

M-interactive classroom: Improving students engagement and participation on campus

Engaging students and making them active participants rather than passive listeners has been shown to lead to higher learning outcomes (Ramsden, 1992; Prosser & Trigwell, 1999). Interaction and active participation allows students to share ideas and apply their knowledge, exposes them to perceptions of their peers, makes learning more enjoyable, and allows the lecturer to test understanding (Sixsmith, Dyson & Nataatmadja, 2006; Slaine, 2004). As revealed in our survey, it is hard for university teachers to engage learners, get them to participate in classes, and gauge their understanding, especially in large classes. A number of students reported such problems as ‘you can't ask questions if you're lost’, or ‘when you miss something, you don't get a second chance’.

Traditional methods of interaction in the classroom such as replying to questions, volunteering answers and raising hands are not always effective. Students in our survey reported that they would usually not volunteer answers in large classes because, for example, they are ‘frightened that my answer is wrong or foolish’, ‘not confident with my answers and English’, ‘intimidated to give your opinions’; it is often ‘nerve racking’, especially for ‘students who are shy’. The interactive use of mobile devices in class can help overcome these problems (Slain, 2004).

Students’ anonymous responses via mobile devices can be compiled and displayed immediately on an overhead screen. Students can also send a signal when they are getting lost, or send a question to the lecturer. In our project survey students seemed interested in such systems, and they thought that they could make lectures more interactive, interesting, engaging, entertaining, and focused.

Some outcomes of this research direction could include;

- Identification of best practice examples of the use of minteractive learning systems to maximise learning and teaching benefits,
- Development of principles and strategies for teachers to promote minteractivity and embed it into the traditional flow of a lecture or presentation,
- Evaluation of the effectiveness of such systems across individual versus group use factors,
- Evaluation of the learning of international or other designated student groups,
- Proposal of solutions to potential minteractive problems some of which have been identified in our survey, such as slowing down of the lecture, sending of offensive messages, etc.

Ubiquitous learning supported by mobile devices
Improving students' access to learning

Ubiquitous m-learning allows students to access learning anywhere, anytime using mobile devices. For example, students can listen to audio learning resources on an iPod while jogging, feeding the baby or traveling to university. This research direction was informed by our survey which showed that students were interested in podcasts of lectures as well as quick SMS notification about changes to lecture times, assignment due dates and university events. Students described podcasts as a way to 'enhance the learning experience', 'get knowledge about the subject especially on the train', and noted their particular suitability for off-campus students.

Initial trials by the authors of podcasting audio summaries of lectures in a large undergraduate core subject have been received favourably. Students have found them 'extremely helpful and encouraging', good for general revision, catching up on missed classes, improving understanding of difficult concepts, and offering convenience since they can be accessed away from the university.

Our preliminary findings reflect those from other recent studies in Europe and the USA where mobile technologies allow greater flexibility of access to learning resources. Students reported their excitement about the opportunities afforded by the mobility and portability of mobile devices, in being able to learn anywhere and everywhere, and at their own convenience (Cao et al., 2006; Bradley, Haynes & Boyle, 2005).

There remain so many challenges for investigating effective, practical ways to design effective, practical ubiquitous m-learning. Outcomes of this research direction could include;

- Development of new pedagogical practices to migrate elearning to m-learning, taking into account the limitations of mobile devices in terms of screen size, limited storage capabilities and limited memory, but at the same time drawing on the current best practice examples in elearning strategies (Zmijewska, A., Lawrence, E., Culijak, G. & Prior, J., 2006)
- Assessment of ubiquitous m-learning via different devices, such as PDAs, iPods, mobile phones, etc,
- Exploration of individualising and diversity options for mobile delivery of course materials, including for international students and disadvantaged student groups.

M-learning for each discipline
For example, in IT courses to advance students' understandings of mobile technologies

Courses and subjects in the design, programming and implementation of mobile technology are nowadays a component of most information technology degree programs. However, because of funding issues which limit the ability of universities to purchase mobile devices, students are usually confined to learning the theoretical background to the technology, or undertaking practical work on simulation software installed on desktop computers.

Using mobile devices to develop applications for these devices and to investigate issues in mobile communication and design is necessary to give students a deeper knowledge and particularly to allow them to test their skills acquisition.
In our preliminary investigations students are programming PDAs and then trialling applications such as continuous health monitoring on the PDAs worn by volunteers (Leijdekkers, Gay & Lawrence, 2007).

Outcomes from investigations in this research direction could include;

- General principles and teaching strategies for students learning about mobile technology using mobile technologies.
- Effective and practical case-studies and examples which support the above.

Strategies for low-cost m-learning use
Reducing m-learning implementation and use costs

The investigation of low-cost practices for using mobile technology for learning clearly has great strategic importance. Cost, as discussed in the literature review section, is a major barrier to introducing m-learning into learning and teaching practice. There are two main issues here; 1. the price of the mobile devices and 2. the usage charges billed by telecommunications providers.

The majority of studies of m-learning undertaken to date have failed to break through to sustained educational practices or long-term institutional commitment. Generally, universities have insufficient funds to move from short-term pilots to the full implementation of m-learning into mainstream courses over the long-term (Kukulska-Hulme & Traxler, 2005).

To avoid the cost of purchasing mobile devices some studies have explored the use of students' own mobile phones in a variety of interactive classroom activities. Results of these studies have varied, with some showing high student participation (Fujimura & Doi, 2006), while others report student concerns over usage charges (Lindquist, et al., 2007). Using SMS messages, usually costing 20¢-25¢ a message, for responding to multiple-choice problems was found more expensive than traditional Personal Response System clickers (Lindquist, et al., 2007).

A possible solution to these cost problems is using packet technologies such as Wireless Application Protocol/Wireless Markup Language - WAP/WML. Such applications work with mobile phone web browsers with the cost of accessing simple web pages around 1.5¢ per 1KB. Provided that the classroom interaction web applications have simple interfaces the overall transmission cost is negligible for students.

To overcome these barriers to m-learning this research direction could aim to achieve these outcomes;

- Assessment of the factors which affect students' willingness and motivation to use their own mobile devices in a variety of learning activities.
- Development of strategies on learning activities suitable for use with student-owned mobile devices, particularly mobile phones and digital cameras.
- Investigation of technical protocols for downloading from mobile devices to university PCs via USB cable or over university wireless networks and so bypassing telecommunication providers' networks.

Conclusion

Our ongoing m-learning action research and development focus question is;

> How can mobile technology be best utilised in teaching and learning strategies to enhance learning and support the characteristics of the digital natives generation, while at the same time addressing the diversity of all students?

We have suggested some directions for research and development activities and outcomes to support and improve the use of mobile technology to enhance student learning. We argue such investigations should aim to progress the implications of m-learning for active and experiential learning. The processes of action research (Dick, 2007) and learner-centred educational design (Litchfield, 1999) can be used as the prime planning, design and development, implementation, testing and evaluation methodologies to maximise quality research investigations and project outcomes.

Lean, Moizer, Towler & Abbey (2006) found in their examination of perceived barriers to the use of innovations in academic settings that academics make the decision to use them based upon their professional judgment of benefit and risk. Therefore they emphasised a role for awareness building activities and improved information about approaches. These concerns can be directly addressed by academic professional development strategies such as mentored project partners, online support resources, experientially-based workshops, and the publication of papers and articles to further disseminate m-learning findings to support innovators and early-adopters (Rogers, 1993) to support the diffusion of active m-learning.

The development of wide support for an online body of knowledge of m-learning and teaching principles, strategies and effective, practical case-studies across all disciplines – an mPortal – is needed and can support and inform emerging national and international approaches to using mobile technologies to enhance learning.

References

Alford, K. L. & Ruocco, A. (2001), 'Integrating Personal Digital Assistants (PDAs) in a Computer Science Curriculum', *Frontiers in Education*, Reno, October.

Al-khamayseh, S.& Lawrence, E. (2005) Mobile Government; Converging Technologies and Transition Strategies, Proc. *4th International Conference on Electronic Government - EGOV '05 , August 22 - 26 2005,* Copenhagen, Denmark.

Al-khamaysah, S., Zmijewska, A., Lawrence, E. & Culjak, G. (2007), 'Mobile Learning Systems for Digital Natives', *Iasted Conference on Web Based Education WBE '07*, Chamonix, 14-16 March.
Barbosa, J., Hahn, R., Barbosa, D. N. F. & Geyer, C. F. R. (2007), 'Mobile and Ubiquitous Computing in an Innovative Undergraduate Course', *SIGCSE'07*, March 7-10, Covington, pp. 379-383.
Bradley, C., Haynes, R. & Boyle, T. (2005), 'Adult multimedia learning with PDAs - the user experience', *Proc.4th World Conf. on mobile learning (mLearn)*, Cape Town.
Cao, Y., Tin, T., McGreal, R., Ally, M. & Coffey, S. (2006), 'The Athabasca University Mobile Library Project: Increasing the Boundaries of Anytime and Anywhere Learning for Students', *IWCMC '06*, July 3-6, Vancouver.
Dick, R (2007) The action research web site at Southern Cross University - http:// www.scu.edu.au/schools/gcm/ar/bd.html.
Dyson, L. E. (2007), 'Wireless Applications in Africa', in Dyson, L. E., Hendriks, M. & Grant, S. (eds.), *Information Technology and Indigenous People*, Information Science Publishing, Hershey, USA, 286-294.
Fies, C. & Marshall, J. (2006), 'Classroom Response Systems: A Review of the Literature', *Journal of Science Education and Technology*, Vol. 15, No. 1, March, 101-109.
Fujimura, N. & Doi, M. (2006), 'Collecting Students' Degree of Comprehension with Mobile Phones', *Proceedings of the 34th Annual ACM SIGUCCS Conference on User Services,* 123-127.
Kennedy, G., Krause, K.-L., Judd, T., Churchward, A. & Gray, K. (2006), *First Year Students' Experiences with Technology: Are they really Digital Natives?,* Preliminary Report of Findings, September 2006, University of Melbourne, Melbourne.
Kukulska-Hulme, A. & Traxler, J. (2005), *Mobile Learning: A handbook for educators and trainers*, Routledge, London and New York.
Laurillard, D. (1993). *Rethinking University Teaching*. London: Routledge.
Lawrence, E. and Er, M, 2007, 'Longitudinal Study of Mobile Technology Adoption: Evolution at Work', *IEEE Proceedings International Conference on Digital Society*, (ICDS 2007) Jan 2-5, Guadeloupe
Lawrence, E., Garner, B. and Newton, S. (2006) 'A Global, Collaborative, E-Learning Ecosystem An Academic/Industry Partnership In Action', *Proceedings of the Fifth IASTED International Conference on Web-based Education~WBE 2006*, January 23-25, Puerto Vallarta, Mexico.
Lean, J., Moizer, J., Towler, M., & Abbey, C. (2006) 'Simulations and games - use and barriers in higher education', *Active Learning in Higher Education,* 227-242.
Leigh, E., & Kinder, J. (2001). *Fun and games for workplace learning,* Sydney, McGraw Hill.
Leigh, E., & Spindler, L. (2004). Simulations and games as chaordic learning contexts. *Simulation and Gaming*, 34(1), 53 - 69.
Leijdekkers, P., Gay, V., Lawrence, E. (2007). *Smart Homecare System for Health Tele-Monitoring,* IEEE International Conference On The Digital Society ICDS 2007 - Telemed 2007 January 2-6, France.
Lim, K. Y. T. & Wang, J. Y. Z. (2005), 'Collaborative handheld gaming in education', *Educational Media International*, Vol. 42, No. 4, 351-9.
Lindquist, D., Denning, T., Kelly, M., Malani, R., Griswold, W. G. & Simon, B. (2007), 'Exploring the Potential of Mobile Phones for Active Learning in the Classroom', *Proceedings of the 38th SIGCSE Technical Symposium on Computer Science Education*, Vol. 39, No. 1, 384-388.
Litchfield, A. (1999). *Designing Multiple Media Learning Resources*. In the proceedings of EDMEDIA'99 the World Conference on Educational Multimedia, Hypermedia & Telecommunications, Seattle, USA, June.
Marton, F. & Booth, S. (1997). *Learning and awareness*. New Jersey: Lawrence Erlbaum Assoc, Publishers.
Miertschin, S. L. & Willis, C. (2004), 'Mobile Computing in the Freshman Computer Literacy Course: What Impact?', *SIGITE '04*, Oct. 28-30, Salt Lake City, 149-152.
Pettit, J. & Kukulska-Hulme, A. (2007). Going with the grain: Mobile devices in practice. *Australasian Journal of Educational Technology*, 23(1), 1-13. http://www.ascilite.org.au/ajet/ajet23/pettit.html
Prensky, M. website, available online at http://www.marcprensky.com, viewed 17. Jan 2007.
Prosser, M. & Trigwell, K. (1999). *Understanding learning and teaching: the experience in higher education*. Buckingham: Society for Research into Higher Education and Open University Press.
Raban, R. & Litchfield, A. (2007). Supporting peer assessment of individual contributions in groupwork. *Australasian Journal of Educational Technology*, 23(1), 34-47. http://www.ascilite.org.au/ajet/ajet23/raban.html
Ramsden, P. (1992). *Learning to teach in higher education*. London: Routledge.
Rogers, E. (1973). *Diffusion of Innovations*. New York Free Press: Simon & Schuster Inc.
Sá, M. & Carriço, L. (2006), 'Handheld Devices for Cooperative Educational Activities', *Proceedings of the 2006 ACM Symposium on Applied Computing*, April 23-7, Dijon, 1145-1149.

Scheele, N., Wessels, A., Effelsberg, W., Hofer, M. & Fries, S (2005), 'Experiences with Interactive Lectures: Considerations from the Perspective of Educational Psychology and Computer Science', *Proceedings of the 2005 Conference on Computer Support for Collaborative Learning*', 547-556.
Sharples, M., Corlett, D. & Westmancott, O. (2002), 'The Design and Implementation of a Mobile Learning Resource, in *Personal and Ubiquitous Computing*, Vol. 6, 220-234.
Sixsmith, A., Dyson, L.E. & Nataatmadja, I. (2006), 'Improving Class Participation in IT Tutorials and Small Lectures, *ACIS*, 6-8 Dec., Adelaide, 1-10.
Slain, D. (2004). An Interactive Response System to Promote Active Learning in the Doctor of Pharmacy Curriculum. *American Journal of Pharmaceutical Education*, 68(5), 1-9.
Sommers, K., Hesler, J. & Bostick, J. (2001), 'Little Guys Make a Big Splash: PDA Projects at Virginia Commonwealth University', *SIGUCCS '01*, October 17-20, Portland, Oregon.
Zmijewska, A., Lawrence, E., Culijak, G. & Prior, J. (2006) 'Online Teaching of Large Groups in Information Technology': A Survey of Strategies. *Proceedings of the IADIS International Conference on E-Society*, Dublin

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