M-Learning Landscapes: e-Learning for ubiquitous school science education

ABSTRACT

This paper describes the use of handheld computers in the Science classrooms of four Tasmanian schools over a year. Analysis was informed by theories of innovation and assisted by ecological perspectives. Teachers demonstrated a range of attitudes to innovative pedagogies associated with the devices, and these corresponded to student achievements. The results from the four parallel classes were dramatically different in terms of learning achievements, student acceptance of the handhelds and teacher reflections. These differences were not attributed to equipment attributes, but to variations in innovation adoption techniques and pedagogical integration strategies. The paper draws conclusions about the change agenda for technology in education, and accompanying processes of curriculum transformation.

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INTRODUCTION

Given recent Australian Government programs to provide computers for all students in Year 9 and above (Australian Government-DEEWR, 2008), schools are considering strategies for implementation. The form factor of the computer to be purchased is one consideration – desktop computer, laptop, tablet, notebook, ultra-mobile PC (UMPC), handheld or smartphone. Ownership and equipment support could be inter-related: if students are to take the devices home, should they be trained to trouble-shoot equipment basic problems? Strategic planning is required to manage the innovation to integrate selected computers into classroom teaching. While the new National Curriculum is being devised, teachers are expected to support existing curricula with computers, despite evidence of limited efficacy (Machin, 2006; Dynarski et al., 2007).

Where the form factors of different computers are similar, there is a tendency to use similar terminology. Thus *PDA and handheld computer* (or just *handheld*) are generally accepted to be interchangeable terms. These devices can be considered along with laptops, tablets, notebooks, UMPCs or netbooks such as the Asus eeePC to be *mobile computers,* and thus used in mobile learning (or *mLearning*) where they have some form of connectivity to communication networks (normally a wireless link to the Internet). Other phrases synonymous with mLearning have been adopted by various manufacturers, such as *1:1 computing, anytime, anywhere learning* (Microsoft, 2005, 2005b) or *ubiquitous computing* (Weiser, 1993) although the latter term is more properly applied when an individual has access to multiple computers.

mLearning (with variations on upper-casing and hyphenation) has a long and distinguished history, particularly in Australian schools. Methodist College Melbourne is notable for being an early adopter with 18 years working with personal laptop computers within a constructionist learning philosophy leading to transformation of learning (Delisio, 2004; McDonald, 1994). mLearning is just one pedagogical strategy which might be adopted by Australian schools facing a flood of computers, and is similar to the approach taken in this research.

This study focussed upon the pedagogies teachers developed for the use of handheld mobile computers (in this case Palm Zire 31s) within the context of Science lessons in four different secondary schools with students aged 14-16 years. The four teachers undertook to explore the use of this technology over the course of an academic year. The project has implications for schools in their choice of equipment, support, innovation and pedagogical strategies.

Previous research

Several studies have examined the use of mobile computers in education. These can be categorised by student age – what is appropriate for tertiary students (Petit & Kukulska-Hulme, 2007) is not necessarily pertinent to secondary school students. Experiences in primary schools where devices are used most of the school day with a single teacher can be inappropriate for secondary education when confined to a single subject or across a range of teachers (Zurita & Nussbaum, 2007; Fluck & Robertson, 2006; Klekot, 2007). Particular studies have been sponsored by manufacturers or software producers, and these report positive impacts upon student achievement and/or student engagement (Tatar, Roschelle, Vahey & Penuel, 2003; Soloway, Blumenfeld, Krajcik, & Shin, 2006).

Innovations can pass through several stages before becoming widely accepted (Rogers, 2003). A critical factor for innovation adoption is 'perceived advantage' and prospective users are reluctant to adopt a new technology without passing through this stage. In the case of mLearning, several aspects of a handheld can be considered to convey an advantage (Faux, McFarlane, Roche & Facer, 2006):

- **Size –** bigger devices often have greater computing power and screens, smaller ones are more easily carried around.

- **Human interface –** ordinary laptops use a keyboard-mouse-screen (familiar) whilst tablets and PDAs use a stylus. Mobile phones often use numeric keys only.
- **Operational life –** how long do the batteries last?
- **Application programs –** familiarity and perceived value for users (both teachers and students).
- **Connectivity –** can the device access local and international networks (perhaps wirelessly?)

For a new technology to be accepted into a secondary classroom context, there should be perceived advantage for both teachers and students. These advantages need not be the same, but one might expect them to be mutually acceptable rather than mutually exclusive. For instance, a teacher might expect greater 'time on task', often correlated with achievement gains in standardised tests of educational attainment, when students access learning materials away from class (DeWitt & Horn, 2005, p.8). However, students may see the PDA advantage as MP3 music player or video viewer. Some studies have identified improved student motivation as the key process whereby handhelds have increased student achievement (Swan, van't Hooft, Kratcoski & Unger, 2005).

An ecological perspective can assist in the examination of these matters (Scanlon *et al.*, 2005) providing it encompasses both static and dynamic dimensions (Luckin *et al.,* 2005, p.5). Such a perspective looks at the fit between everyday routines and handheld use. For example, new seating arrangements in trains have been found to affect modalities of in-transit computer use, moving users from writing activities to MP3 listening (Pettit & Kukulska-Hulme, 2007, p.28). Many primary classrooms are the learning locations throughout the day for students; whereas secondary students often move between rooms and teachers. These ecological considerations need to be factored into any investigation of the pedagogies associated with handhelds in school education, and their efficacy.

METHOD

The Australian government policy 'Backing Australia's Ability – Building our Future through Science and Innovation' (DEST, 2005, p.4) put forward venture funds which were available as medium-sized grants to schools in 2005-2007. Australian School Innovation in Science, Technology and Mathematics (ASISTM) grants were made available to school clusters to facilitate innovative teaching approaches in those subject areas. A bid for these funds from four Catholic high schools in the north and north-west of Tasmania resulted in the project M-Learning landscapes: e-Learning for ubiquitous school science education commencing in August 2005 with approval from the Human research ethics committee (Tasmania) network (reference H8193).

All the schools were co-educational. Three schools were Year 7-12 institutions with enrolments of 639 (Stateside - all schools are referred to by pseudonyms), 700 (SeaView) and 1250 (St. Dicks). Westport (k-10) had only 286 students. Although all the schools were independent of the government system, they catered for students from a broad socio-economic background, with some parents not required to pay fees.

Collaborative planning for the project had begun with the grant application in early 2005, and continued once the project was approved. Teachers from the four schools agreed the project would be undertaken with Year 9/10 Science classes in 2005 and 2006. All students in each class were given a handheld computer for personal use at home and school, providing a responsible person (parent/guardian where applicable) had signed for the equipment (all did so). Once the full set of equipment was delivered, teachers and students became familiar with the operational procedures and explored the associated practical pedagogies. The other steps of the project are summarised in Table 1.

Time	Activity
Term 3: November 2005	Schools accepted equipment. Project teachers trained to use handhelds, science classes given introductory operational skills lesson. Familiarisation and development of school protocols.
Term 1: February 2006	Schools rotated equipment to new class for the year. Re-familiarisation for the teacher. Common unit of work planned.
Term 2: June-August 2006	Common unit of work finalised, put onto Moodle learning content management system, and taught.
Term 3: September– November 2006	Data collection, reflection day, equipment continues in unmonitored use.

Table 1: Project Timeline

Negotiated Innovation Diffusion

Four part-time Teacher Associates were appointed to the project. They were based in each of the schools to give on-site equipment support. Additionally, the Teacher Associate at St. Dicks took responsibility for the project learning materials located in a Moodle learning content management system. This Associate subsequently taught in England for a year, and returned to a teaching position in St. Dicks.

Several of the Teacher Associates also worked in their school as IT support officers. Their daily work responsibilities were governed by systemic and school policies which were often ambivalent about the status of mobile electronic devices for students. Such policies were frequently worded to restrict student use of mobile phones, so the Associates became important gatekeepers in respect of the innovation. Enrolling them in support of the handhelds helped to legitimate the new devices. Their help was essential as they could integrate handhelds into the school digital environment – an intriguing technical exercise. Generally they were asked to re-image any project handheld that had lost essential services, and replace under guarantee any which developed a hardware fault.

Form and Function

Additional funding from Science, Information and Communication Technology and Mathematics Education for Rural and Regional Australia (SiMERR) allowed a comprehensive Office suite (Documents-to-Go) to be loaded onto each of the handhelds. With open source and free software, a wide range of applications were available to teachers and students (see Table 2).

The teachers were trained in the use of the equipment and this software as a precursor to using the handhelds in the classroom or planning the common unit of work. It should be noted that the handhelds which the project could afford were not capable of directly linking to the school wireless networks, but *Plucker* could be used to make Internet content available off-line. We had seen media coverage of playground fight pictures beamed around a school in England, so this trade-off was accepted by the teachers as a suitable compromise.

Common unit of study

The teachers discussed the common unit to be taught during 2006. They chose a health-related topic in Biology, part of the mandated existing curriculum at each school. Members of the group were asked to design specific teaching materials and learning outcome statements, culminating in a common unit of work on the topic of *Organ Transplants* (see Table 3).

Application	Function
ChemTable	Interactive Periodic Table
Documents-to-Go	Office suite: Word processing with spell-checker, spreadsheet with limited graphing capability, Presentation tool (compatible with Microsoft Office). PDF viewer.
Quick Tour	Introduction to the basic operating functions of the handheld, such as handwriting input.
Easy Calc	Graphical calculator
Animator	For creating hand-drawn animations and playing them
Calendar	Diary function
FileZ	File management
Memos	Primitive word processor
Plucker	Off-line web-site viewer & e-book reader: used for viewing most project learning materials.
Kinoma	Video playback
Real Player	MP3 player for listening to podcasts and music.
Quizzler	For taking short answer and multiple choice tests

Table 2: Software applications loaded onto the handheld computers

Lesson	Activities
1	Mystery box and Pre/Post-Test
2	What organs are commonly transplanted?
3	Dissection of 3 main organs, include pictures and microscope work.
4	Brainstorm in word processor 'Where do organs for transplants come from?', exchange ideas using beaming, groups produce 1 page of information on the topic
5	Students are to make a poster based on the information they have collected.
6	Video of heart transplant 10 mins. approx. (gory). Students debate the article about pig transplants (ethics).
7 & 8	Rat liver transplant and dissection. They are to go through any pre-op procedures including the discussion with the family. Students are to open the rat under instruction. They are to take/cut ¾ of the liver out, take it to another rat and sew it in, and close the rat up. They may then proceed with the normal dissection. Students could also undertake post op counselling and drug usage (rejection drugs).
9 (& 10 + 11 if needed)	Post-test: Watch *John Q* DVD: Plot outline at http://www.imdb.com/title/tt0251160/ Students are to do researchusing the website on the question sheet. www.lifelink.redcross.org.au; Science for life: read an article about pig transplants and prepare a debate; Answer questions such as: How do you keep organs alive for human transplants? How do the transport the organs? What happens pre-op?

Table 3: Teaching sequence for 'Organ Transplants' unit

Homework

Students are to do research using the web site on the question sheet. www.lifelink.redcross.org.au; Science for life: read an article about pig transplants and prepare a debate; Answer questions such as: How do you keep organs alive for human transplants? How do they transport the organs? What happens pre-op?

The materials for these lessons were prepared in digital form by the teachers, and assembled into a web-site by the project Moodle server administrator. A version of this web-site was processed by the Plucker desktop application, to make it available on the handhelds. The resulting single 299kb file contained all the reading materials, worksheets, graphics and instructions for students to follow. It was placed on each handheld and also made available as a downloadable item on the Moodle server. Another file contained the pre-test and post-tests, to be used with the Quizzler program timed and marked test responses on the handhelds.

RESULTS

Data were collected using four main techniques:

Students undertaking the common unit of work took a pre-test and a post-test to measure their learning achievement for the Organ Transplants topic.

Samples of students in each school participated in focus group discussions to ascertain their responses to using the handhelds. The researcher also observed classes in each school prior to the discussions.

The four teachers met after the common unit of work to reflect upon the pedagogical implications of the handhelds and contributed to a PMI (Plus-Minus-Interesting) analysis.

All participating students were asked to respond to an online questionnaire about their use of the handhelds.

Results – student learning achievements

It was clear that the learning gains were very different in the four schools, with the students at St. Dicks showing a considerable learning gain between the pre-test and post-test (see Table 4). Students at Westport did not show any improvement in test scores.

Results – focus group discussions

Students were asked about their use of the provided technology, and their perceptions of its usefulness in their learning. Generally most students had accessed the learning materials using all four technological methods: handhelds, school computers, home computers and via the internet.

Students at St. Dicks had been filmed for the local television station, so were aware of the significance of the new technology, and had formed positive opinions of their own: "I think the Palms were very hard to use. But I think it was good. This new technological way of learning. It was extremely hard to write, with either popup [on-screen] keyboard or by handwriting.

	Yeargroup	N	Valid N	Mean pre/post test learning gain	Standard deviation
St. Dicks	9	15	12	+52%	12%
SeaView	10	27	23	+25%	11%
Stateside	9	26	8	+11%	10%
Westport	10	28	27	0%	12%

Table 4: Pre/post-test results

Otherwise it is good in this form." They had reasons to be positive, "it's a slightly different set up to a normal computer. It is a good project, and other teachers are interested in it. It helps us keep up with the huge amounts of work we have to do." They were also conscious of the conflict with the school policy on mobile electronic devices: "you're not allowed to have anything that might obstruct your learning in class. Some teachers think that these [handhelds] help students, others don't." It was evident that the handhelds had successfully bridged the school and home ICT contexts: "also at home for entertainment, you can download movies and songs". Students in St. Dicks were observed presenting animations illustrating the Bernoulli principle which they created on the handheld and shared using a Presenter-to-go module. Although the images were hand drawn they were in a variety of colours which made them very attractive. One student beamed the entire set of learning materials to a peer: "It took about two minutes to beam the 'Organ Transplants' materials from one Palm to another".

At SeaView, students had discovered new techniques: "I use Documents-to-Go instead of the memos. You can also transport using copy and paste a question at a time from Plucker to Documents-to-go." They had also found limitations: "when we did a poster, we had the questions on the Palm, but we could not do the poster on the Palm, it was too small." They discussed equity in respect of new technology, "the only thing I thought that would be helpful, would be that we had the two keyboards that we share around, and I think it's easier for you to use those. But not everyone has one. It was a lot easier than typing on the screen; I think if everyone has a keyboard, it would be better." In some ways their conceptions of the possible were constrained, "I think it [the handheld] would be suitable for SOSE and for English, because they have a lot of worksheets associated with them."

Stateside students also speculated about using handhelds in other subject areas, but in a more negative mood, "it would be hard [to use a handheld] in maths, because you're always doing angles and so on." Similarly, when talking about future uses of the equipment, they could see how technological prowess might run counter to institutional expectations, "..when you have done your homework, all you have to do is beam it to the teacher. Also if you forgot to do your homework, somebody else could just beam it to you."

At Westport, students were much more negative about the use of handhelds, "It [the handheld] would always run out of battery, when I didn't use it. Like, I would leave it in my bag for a few weeks, and then it didn't work." When asked directly about using the handhelds, the dialogue was terse:

> **Interviewer:** So you don't use the handhelds at all, out of school?
>
> **Student:** No

Students accepted the there was a need for a pedagogical 'fit' between learning and equipment: "the Palms give us information in a different way. It works for some people, not for others." A positive comment reveals a limited conception of what the handheld could be used for: "I'm happy with it. I think the more you use it, the better it is. In the future we will have to get used to these. Something like this will probably replace the diary."

Test input was a general concern. One student was provided with a stylus the size of a normal pen. Two external keyboards were supplied to each class, and these were highly desired. Students debated the relative advantages of various form-factors, concluding a 20cm diagonal screen would be optimum. This parallels similar discussion in the literature (Twining & Evans, 2005). Other difficulties varied from being unable to hot-sync to a home computer; the Palm freezing when a picture was tapped in Plucker (to expand the view); and poor screen digitizer alignment preventing accurate stylus use. The program *CardExport,* which turns a Palm into a USB drive could be a solution to information transfer problems, or SD cards which plug directly into a USB drive are also available to solve the inter-operability problem in this context.

Results – teacher reflections

As part of their final meeting, each of the project teachers completed a PMI (Plus, Minus, Interesting) chart to describe their reflections. In the Plus section, teachers agreed about the initial buzz of motivation from students when the handhelds were introduced, and how they engaged in the ethical debate about trans-species transplants in lesson 6. In the Minus section, all four teachers were explicit about the difficulties of non-functioning equipment: "Palms not being charged and everything being wiped out" was the typical worry. It was clear that these problems had human and technical dimensions: "Students not looking after equipment" and "Some Palms crashed from time to time".

The Interesting section of the PMI analysis revealed more diversity of opinion. The teacher from St. Dicks noted that "there was a significant change in class dynamics because of the ubiquity of these handheld devices. The students were more engaged as a group, because it was easier to share resources, and hence they were more willing to help others". The teacher from SeaView said that "some students found that it suited their 'learning style' while others needed more directed learning in lessons. She had to read things out loud and discuss questions for less able students." At Stateside, tensions were noticed: "some students liked this technology – some did not. It was hard to mesh the two groups together". At Westport, there was a clearly negative attitude: "some students developed quite a negative attitude towards the handhelds".

Project teachers gave the following advice for future applications, in priority order (most desirable first):

- Have some backup Palms for forgetful students or to replace broken/failed equipment.
- Provide a Keyboard for every Palm
- Provide Professional Learning to the [whole] school staff on Palms and what they can do
- Have a school policy for Palm use. The policy should cover the appropriate use of the handheld for games, music, photos, and the extent to which they are permitted in other subject areas.
- Organise Internet access and a computer for backing up the Palms in the classroom/laboratory

They agreed that pouches provided to carry the handhelds and their associated chargers had prevented damage. Two handhelds at SeaView had been confiscated when used inappropriately outside Science. The project teacher had to negotiate with the other teacher to restore them to students two days later. An English teacher at St. Dicks had been amazed at the quality of poetry written on a handheld by a poor and reluctant writer, and relaxed the school's policy on mobile electronic equipment as a result.

Results – online questionnaire

The online survey was taken by students from three of the four schools (excludes Stateside which could not access the online survey because of authentication and permission problems). Table 5 shows the proportion of students in each responding school who answered positively to the statements.

These results only show similarity between all schools in general technical proficiency with 74-79% of students knowing which

	St. Dicks	SeaView	Westport
Valid respondents	11	21	14
Students had hotsynced their Palm to a computer at home	64%	57%	14%
The Palm handheld had generally been working properly in the last 3 weeks	82%	90%	43%
Students had written up any notes or experiments on their Palm	100%	62%	36%
Students had used their Palm in other subject class(es)	45%	62%	7%
Students had used their Palm for personal applications	36%	67%	14%
Students knew how to copy a file on their own computer onto their Palm	73%	91%	36%
Students could use Documents to Go 'very well' or 'good'	64%	52%	29%
General technical proficiency – proportion of students successfully matching function to software application	79%	74%	74%
Students regard their Palm as an average or very useful educational tool	91%	90%	43%
Students would (certainly) like to use a handheld computer for school in the future.	45%	57%	7%

Table 5: Online survey results

software applications to use for a wide variety of tasks. Compared to the other schools, students at Westport showed less appropriation of the handhelds. They had a poorer self-assessment in respect of the Office suite 'Document-to-Go', and very few had linked their handheld to a home computer; they reported their handheld had failed and had not used them much in other subject classes.

The most important thing learnt from the 'Organ Transplantation' unit concerned organ donors and waiting lists (49% of students): "That there are way too many people on the waiting list for organs and not enough people are becoming donors." The next most common recollection related to undertaking a rat liver transplant: "that rats stink when dead and cut up. that finding a organ and getting it transplanted is not an easy thing to do. and that being the surgeon having to choose who gets the organ is also not an easy thing to do." Also: "how to put orgsnz in a rat" [sic].

66% of students were positive, very positive or positive with reservations about every student in the class having a handheld computer: "i like this idea because if only a certain ammount of people had a palm in the classroom the ones that didn't would miss out." 29% were negative on equity grounds, saw limited use or were very negative: "It is good but some people just seem to take it for granted and can't be bothered with them".

Students thought the handhelds were good (61%) but best for use in secondary schools (44%): "I don't think primary school students should use handhelds because they will never learn to write."

DISCUSSION

This study was conducted in four similar schools in the same system, in the same broad geographic area. Each of the four teachers was selected for their aptitude and technological familiarity, as well as being Science subject specialists. Their task was to integrate handheld computers into the existing curriculum. It is worth noting that the curriculum was not modified to take advantages of the capabilities of the handhelds: rather, the students and staff built familiarity with these capabilities, and incorporated the equipment into classroom routines as best they could to facilitate mandated learning.

This is only one scenario for the dissemination of such an innovation. Alternative scenarios might have re-shaped the curriculum to better suit learning with handhelds, or there may have been a more exhaustive search to select equipment suited to the learning already in place. In this sense, the teachers were guineapigs for schools in Australia selecting extensive computer upgrades and requiring teachers to use them in current curriculum contexts.

The impact of handhelds was dramatically different in the four schools. Most of the traditionally accepted factors governing successful innovation had been attended to: professional learning was provided to the teachers and training for the students; the 'organ transplants' unit was collaboratively designed and similarly taught; and all schools had on-site technical support for the new equipment. The ecological perspective of the study led to an analysis of four main variables affecting impact (see Table 6).

Environmental variable	Principal actors
Equipment attributes (form factor, connectivity to peers, networks and home/school equipment, software application library)	Manufacturers School purchasing decisions
Innovation adoption techniques (governance, policy frameworks, equipment ownership issues)	School decision makers IT technical support staff
Pedagogical integration strategies (operational skills training, fit to topic, off-class access, structure of schooling)	Teachers Students
Curriculum transformations (eAssessment, higher-order thinking)	Systemic leaders Parents

Table 6: Relationship between handheld environment and actors.

Equipment attributes were equivalent in the four schools because the project provided the same model of handheld to all the science classes. Innovation adoption techniques were similar in the four schools: the role of the Teacher Associates as IT technicians has been described for example. However, policies for mobile electronic equipment varied from school to school. More importantly, the interpretation of such policies by non-project teachers was diverse (for instance the confiscation episode related above). Ownership of the devices was ascribed wholly to the students for the year-long project, in an attempt to provoke personal adoption. This led to confusion about technical support responsibilities in some schools.

Pedagogical integration strategies varied greatly between classes, with some teachers adopting new techniques for classroom activities (for instance using animation software to show understanding of the Bernoulli principle). Where teachers expected handheld use solely within class time, students showed fewer tendencies to make personal appropriation. No curriculum transformation was expected in this project – schools continued

Australian secondary schools now face the challenges which confronted schools in this study. They will be required to address innovation adoption techniques and pedagogical integration strategies to incorporate computers for all older students into school learning

within existing structures for reporting and assessment. Had handhelds been required for significant elements of appraisal, this may have increased adoption by teachers and students.

This study was based upon the insertion of a new technological device into single Science subject classes. The reflections from the students and teachers involved suggested that an alternative strategy would have engaged all the subject teachers for this class of students. Practical considerations prevented such an approach, since secondary school students generally move independently from class to class throughout the day.

CONCLUSION

This study put handheld computers into science classes of four schools for a year. All students in each class used handhelds when they undertook a collaboratively planned unit of learning. The results were highly diverse consequences, ascribed to variations in environmental variables between schools and classes.

The study shows us that similar affordances of equipment are insufficient to predicate the same personal adoption by teachers or students. The handhelds and their capabilities were identical in all four schools, yet achievement, innovation adoption and pedagogical integration varied from school to school. In some cases the learning potential of handhelds was realised by students: "you can beam documents or programs, you can listen to music you can write up anything anywhere" and "I think that handheld computers for high school students is good. I believe it is the way of the future. It's the way the world is going." In other schools there was rejection of this potential aid to learning: "I think it is a ridiculous idea. What fool would provide handheld computers to adolescents to use for their education and expect them to use it."

Clearly future innovations (such as computers for students Australia-wide) will need school-centric as well as systemic approaches. The starting context will be integration of 1:1 computing into existing curriculum frameworks. It will be important to build upon the familiar – for instance, to provide keyboards for handhelds, so that previously acquired skills can be used. Developing new digital pedagogies, extending learning opportunities beyond class times and moving to new learning outcomes only realistically achievable with a computer, may come after this initial stage has been passed.

Australian secondary schools now face the challenges which confronted schools in this study. They will be required to address innovation adoption techniques and pedagogical integration strategies to incorporate computers for all older students into school learning. As a result these schools will be well placed for curriculum transformation at a later stage.

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His PhD thesis 'Integration or transformation? focuses on the transformative effects of ICT in schools. Rather than integrating the digital technologies by replicating existing pedagogies and learning outcomes, we should be investigating new learnings and methods.

He divides his time at work between teaching ICT skills to pre-service teachers and conducting research into the transformative effects of technology, notably within an Australian Research Council project called 'Always On' Learning Communities: M-Learning Landscapes Transforming School Cultures.

REFERENCES

Australian Government – Department of Education, Employment and Workplace Relations (2008) *National secondary school computer fund: Round one guidelines.* Retrieved June 1, 2008, from http://www.digitaleducationrevolution.gov.au/NR/rdonlyres/94F3AEEE-7473-4758-9CA3-8549B568B673/20331/nsscf_guidelines.pdf

Delisio, Ellen R. (May, 2004) Tracing the Start of the Laptop Revolution in Schools. *Education World.*

DEST (2005) *Boosting innovation, science, technology and mathematics teaching: external programme guidelines.* Retrieved January 22, 2008, from http://www.dest.gov.au/NR/rdonlyres/435AD2FB-503C-4C84-9994-58825495C21E/5228/BISTMTProgrammeguidelines1.pdf

DeWitt, Scott W. & Horn, Patricia S. (2005) Ubiquitous Computing--Are We Crazy? Point/Counterpoint. *Learning and Leading with Technology 32*(8)6-8. Retrieved June 1, 2008, from http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/2a/19/bc.pdf

Diggs, Chris (2004) *A Palm in every child's hand: the effect of Palm Pilots on student learning in the elementary classroom.* Retrieved January 25, 2008, from http://216.128.25.141/handheld/palminhand.pdf

Dynarski, Mark; Agodini, Roberto; Heaviside, Sheila; Novak, Timothy; Carey, Nancy; Campuzano, Larissa; Means, Barbara; Murphy, Robert; Penuel, William; Javitz, Hal; Emery, Deborah and Sussex, Willow (2007) *Effectiveness of Reading and Mathematics Software Products: Findings from the First Student Cohort.* Washington, D.C.: U.S. Department of Education, Institute of Education Sciences.

Faux, Fern; McFarlane, Angela; Roche, Nel & Facer, Keri (2006) Learning with handheld technologies. Bristol, England: FutureLab.

Fluck A. & Robertson, M. (2006) User-owned computers: friend or foe in schools? Proceedings of Australian computers in education conference: *It's Up Here for Thinking!* 2-4 October, Cairns, Australia.

Klekot, Mark (2007) *A PDA for every child! A primary case study.* London: The innovation unit, Department for Children, Schools and Families UK. Retrieved January 25, 2008, from http://www.innovation-unit.co.uk/youinnovate/your-case-studies/a-pda-for-every-child-a-primary-case-study.html

Luckin, R., du Boulay, B., Smith, H., Underwood, J., Fitzpatrick, G., Holmberg, J., Kerawalla, L., Tunley, H., Brewster, D. & Pearce, D. (2005). Using Mobile Technology to Create Flexible Learning Contexts. *Journal of Interactive Media in Education 2005*(22). Retrieved January 25, 2008, from http://jime.open.ac.uk/2005/22/luckin-2005-22.pdf

Machin, S.; McNally, S.& Silva, Olmo (2006) *New Technologies in Schools: Is there a pay off?* Germany: Institute for the Study of Labour.

McDonald, Helen (1994) Teacher change in a computer-enhanced learning environment. *Proceedings of Australian Association for Research in Education conference,* Newcastle. Retrieved June 1, 2008, from http://www.aare.edu.au/94pap/mcdoh94330.txt

Microsoft (2005) *Anytime, Anywhere Learning: Planning for success.* Retrieved June 2, 2008, from http://www.microsoft.com/Education/AALSupport.mspx.

Microsoft (2005b) *1:1 Computing: a guidebook to help you make the right decisions.* Retrieved June 2, 2008, from http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf

Pettit, John & Kukulska-Hulme, Agnes (2007) Going with the grain: Mobile devices in practice. *Australasian Journal of Educational Technology 23*(1)12-33.

Rogers, E.M. (2003) *Diffusion of innovations* (5th ed.). New York: Simon and Schuster.

Scanlon, Eileen; Jones, Ann & Waycott, Jenny (2005). Mobile technologies: prospects for their use in learning in informal science settings. *Journal of Interactive Media in Education (Portable Learning: Experiences with Mobile Devices.* Special Issue, eds. Ann Jones, Agnes Kukulska-Hulme and Daisy Mwanza), 2005/25.

Soloway, Elliot; Blumenfeld, Phyllis; Krajcik, Joe & Shin, Namsoo (2006) *Scientifically-Based Research Snapshot: Science Concepts & Processes.* USA: GoKnow Learning.

Swan, Karen; van't Hooft, Mark; Kratcoski, Annette; Unger, Darlene (2005) Uses and Effects of Mobile Computing Devices in K-8 Classrooms. *Journal of Research on Technology in Education 38*(1)99-112.

Tatar, D.; Roschelle, J.; Vahey, P. & Penuel, W. (2003) Handhelds go to school: lessons learned. *Computer 0018-9162 30-37.*

Twining, P. & Evans, D. (2005) Should there be a future for Tablet PCs in schools? *Journal of Interactive Media in Education 2005*(20). Retrieved January 25, 2008, from jime.open.ac.uk/2005/20.

Weiser, Mark (1993, October) Hot topic: Ubiquitous computing. *IEEE Computer* 71-72.

Zurita, Gustavo & Nussbaum, Migula (2007) A conceptual framework based on Activity Theory for mobile CSCL. *British Journal of Educational Technology 38*(2)211-235.