Two case studies on the influence of mobile computing on student learning behaviour

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Abstract: In 2004 RMIT was a recipient of a Hewlett-Packard Mobile Technology for Teaching Grant Initiative comprising equipment and a small development fund. RMIT selected a combination of 23 Tablet PCs and 50 iPAQ PDAs to conduct trials associated with two sub-projects to investigate the application of mobile technology in higher education. Students in the second year of a multi-disciplinary Bachelor of Design program used the Tablet PCs to facilitate the design process. The study used qualitative ethnographic methods to explore the impact access to mobile computing had on student learning and everyday work practices. These students used design applications in concert with web logging and other communication tools to support individual and group design projects across the full academic year. The design students used their Tablet PCs for wireless access, as well as in standalone operation and in some cases wired access. It was found that mobile computing had a substantial impact on their everyday work practices. Second year students in a Bachelor of Nursing program used the iPAQs to access standard applications as well as specialist pharmacological databases. The nursing students used the iPAQs primarily in standalone mode whilst on clinical placements. Both trials used qualitative methods to assess the impact of the new technology on the student experience. The nursing trial also used quantitative methods in a quasi-experimental design to assess changes in pharmacological knowledge. The results showed there was a modest improvement in both groups of nursing students on the post-test assessment. Students using the PDAs increased their mean score by 1.3 marks, and although this was not statistically significant, it was double the increase in the mean score of the comparative group. Overall students reported positively on their experience using mobile technology. The technology improved the efficiency of their study time, and improved their overall learning experience, although no definitive conclusions can be drawn about any improvement in learning. Students also had little difficulty in using the technology. From a university perspective, the trials indicated that wider adoption of mobile technology could be supported, but it may create a load on support and systems, and require more seamless integration of wired and wireless technologies. The experience gained from this project is broadly relevant to all science and engineering disciplines.

Keywords: mobile computing, learning experience, work practice

Background

Interest in mobile technology is driven largely by its potential to improve the student experience. Students undertake more hours of paid employment (Krause et al., 2005), and
find it hard to fully engage with their university and their fellow students. Courses increasingly require independent work and research, proficiency in Information and Communication Technology (ICT), group work with the need to coordinate, share and communicate, and industry placements. Universities face their challenges too. Like many universities worldwide, RMIT University is faced with what has been described by Bonk (2004) as the perfect e-storm, with multiple challenges from emerging learning technologies, more students, new learning and teaching challenges, and reduced real budgets.

ICT is one of the means shown to have potential to cost effectively improve support for student learning (Twigg, 2003), and mobile technology is expected to have an increasingly significant role in higher education (Kim et al., 2006). Mobile technologies are prevalent in the community, particularly among teenagers (Lenhart et al., 2005) and on campus, however it is only starting to penetrate university teaching and learning. Together with the roll-out of wireless networks, mobile technology has the potential to extend what has been referred to as the reach ability (Kim et al., 2006) of information processing and electronic communication beyond the constraints of fixed wire and fixed location computing. Clear evidence is beginning to emerge that students are very positively disposed to learning technologies, particularly in providing convenience, communication and management of their learning resources (Kvavik and Caruso, 2005; Platts, 2004a). Students, however, are selective and discriminating users of technology (Kvavik and Caruso, 2005), and the careful integration of mobile technology into university teaching is critical to its successful adoption.

There is a lack of clear research to guide the application of mobile technology in higher education (Kim et al., 2006). Mobile devices come on to campus in a variety of forms with a spectrum of capabilities, from simple mobile phones to powerful lap top computers. University teachers still need to know more about what mobile technologies are available, how they are best used in higher education, and what is needed to support effective use of technologies for student learning.

**Project Objectives**

In 2004, RMIT University was one of seven universities in the Asia-Pacific region that received funding from the HP Mobile Technology for Teaching Grant Initiative – 2004 Higher Education Edition. The funding package provided approximately $A133,000 of equipment and $A15,000 in cash to support further application of mobile technology to teaching and learning at RMIT. The equipment component of the grant provided 23 Tablet PCs, 5 docking stations, 4 wireless access points, 50 iPAQ pocket PCs (PDAs) and 2 digital cameras.

The HP Mobility grant provided RMIT with the opportunity to investigate mobile computing in the context of providing an effective learning environment valued by students. To broaden the scope of the investigation, RMIT conducted two independent trials to investigate use of mobile technology. The trials assessed two different mobile technologies in two different teaching and learning settings. The 23 Tablet PCs, digital cameras and docking stations were deployed in a design course where individual and group design tasks are fundamental parts of the learning experience. The 50 iPAQs were deployed in a nursing program, where there is a history of use of PDAs, and where portability and access to information in workplace (clinical) settings are important.
Specifically, the trials aimed to:

- explore the application of different mobile learning and collaboration technology across different programs and disciplines and their impact on the student experience;
- assess learning designs and outcomes for mobile learning application in face-to-face and virtual classes, and in work place learning environments;
- explore the design and development of new learning and collaboration tools and online services, such as intelligent agents, for mobile devices; and
- establish personal and workgroup learning and collaboration behaviour patterns from quantitative and qualitative data to guide functionality and the effective support of mobile technologies.

The trials were conducted over the 2005 academic year. Each trial was supervised by staff recognised as early adopters of new learning technologies in their discipline.

**Bachelor of Design (Multimedia Systems) Tablet PC Trial**

This trial is more fully reported in papers by Berry and Hamilton (2006a, 2006b) and Berry et al. (2007), and only a summary is provided here. The program involved is a cross-discipline program delivered across computer science, engineering, design and business. The students are diverse, with academic interests ranging from creative media design to software development, and the program embodies many challenges in creating a learning community of students. It is also a challenging use of the mobile technology interface as students spend considerable time generating, analysing and collaborating around images.

The aim of the study trial was to explore new methods for applying mobile technologies within both formal and ad hoc study groups. The main focus of the trial was in supporting students outside of the classroom, primarily in their group design work, but also in general student life. Interaction between students is loosely moderated and supported by training of students in the use of mobile collaboration technologies.

**The design process**

The focus of the trial was to support group work for students participating in a collaborative design process. The design process is an iterative one, involving cycles of feedback that incrementally transform a design brief into a product, in this case, a web-site promoting the activity of commercial and community based organisations. Team design activity includes periods of individual work and periods of highly intensive group work. The client may also be involved in the group work to differing degrees of intensity at different stages.

The design process uses ICT to provide information management, communication and coordination to improve outcomes, and to reduce the time to product creation. The process makes use of existing application packages, for document and web site creation, communication technologies such as web logging, and coordination and notification technologies such as RSS-based news aggregators. An aim of this trial was also to explore the use of intelligent agent technology to provide an information-processing environment specifically tailored to the individual user. Individualised environments would present students with relevant information and functionality, based on their observed information processing behaviour.
Research aims: design trial
Overall, the trial was expected to produce better outcomes for students in the following ways:

- Improve group project outcomes through the ability to enable better organisation of group activity and better interaction with group members. Basically, group members would have more opportunities in terms of times and locations to work together and this would impact positively on their project work.
- Improve the day-to-day lives of students in terms of being able to more efficiently engage with their courses, so as to continue to balance social and work life with their formal university studies.
- Improve individual knowledge and capabilities.
- Improve the ability to extend their social context and interact more widely due to mobile, wireless and web logging facilities.

The Tablet PCs were distributed to 16 individual students in a second year design course. This project used qualitative research methods in the form of discourse analysis and ethnography to characterise the experience of the students across two semesters, where the object of their learning moved increasingly from individual design work to group work for a client in a simulated commercial setting. A number of focus groups throughout the year were the main sources of research data.

The RMIT wireless network does not cover all of the RMIT campus, but it provides access in all student lounge areas, and extends to the food court of a major nearby shopping centre and the lawn of the state library, which is adjacent to the campus. The design program uses a central server that maintains the shared files representing the group work, and provides a web logging service that is central to communication within groups, with their lecturer, and with their client. Students also had access to traditional design laboratories. Students in general were familiar with the Internet and basic use of the Internet including searching, as well as e-mail. Almost all had computers at home connected to the Internet with most having broadband access.

The agent software was used to enhance the student user experience by recognising new user sessions and synchronising the information they hold about individual work and shared work across the centralised systems and the individual computing devices. The agent also aimed to proactively notify users of updates determined to be of relevance to students based on the explicit input and the implicit deduction of their beliefs, desires and intentions. In this task, the agent went beyond RSS to provide intelligent filtering of external information available to the student user, to some extent addressing information overload. Incompatibility between the RMIT ICT environment and the agent development software made deployment difficult, and agents were assessed in a separate pilot.

Research outcomes: design project
The Tablet PCs helped students manage their time. They were able to use the Tablet PC in their own time in locations such as whilst commuting on public transport, and at their workplace. Students were able to more easily access resources through the wireless network. They found it easier to communicate better within their groups as well as across groups using messaging and e-mail. Communication was more immediate, and information more readily available. Students also maintained better awareness of group activity through more timely posting, and easier access to shared data and web logs. The study also found that students
used the Tablet PCs in other work, in their programming assignments, and other university tasks. Some students were able to mix personal interests, such as music, with their study.

Student users indicated that the Tablet PCs were useful and that it helped with group work, allowing flexibility of where and when group work was done. They also reported that group use of the technology transferred to more formal meetings, such as with supervisors and clients. Group meetings were more productive by having material readily available. Groups tended to be more flexibly formed, with some discussion across group boundaries. Those with Tablet PCs became important members of groups, taking the roles of note takers and the Tablet PC became a resources repository.

Teaching staff indicated that students were better prepared for classes and meetings. More effective meetings led to better attendance and groups were more cohesive. Students were able to more easily integrate their work into existing facilities, whereas previously, students used a range of IT environments at work or at home, and had difficulty integrating their work with RMIT systems.

For a variety of reasons, some technical, some organisational, intelligent agents were not deployed as part of the main trial, but tested with a small group of students, who reported positively on the experience. The provision of a customised operating environment highlighted problems with compatibility of software (such as the agent development software) and the RMIT operating environment, and in supporting non-standard environments.

Some students reported difficulties with disconnections on the wireless network, and limitation in processing power and display size for some applications. While the tablets fitted easily into most students work, there were some who had problems with connection and viruses. One student of the 16 claimed not to derive any benefit from the Tablet PC and did not use it to any significant extent.

Overall, it was found that mobility did increase further engagement with learning. The wireless network (despite initial connectivity issues) and increased mobility allowed students to access and download resources as required. Students were better prepared for lectures by accessing resources and reading materials earlier and could alter them during the lectures, becoming more active learners, and taking greater responsibility for their own learning process. The Tablet PCs with their digitized screens and capacity for wireless networking became an integral part of many students’ everyday life (Weiser 1991) and did motivate further engagement with learning resources. It was found that Tablet PCs fulfilled the notion of a “good tool” (Weiser 1991) in the sense that they became invisible yet there when needed.

**Bachelor of Nursing PDA Trial**

This trial is more fully described in a report by Farrell (2007) and only a summary of the trial is provided here. This trial was prompted by an interest in student workplace learning as well as increasing use of mobile computing devices in clinical settings. A majority of hospital medical staff now use PDAs, however, it is not as widely used in other clinical professions, and its potential for use in education in work-based clinical settings is only starting to emerge. Existing studies of mobile devices in clinical settings have tended to be descriptive and do not provide systematic evaluation of their impact. This trial was able to extend the scale and scope of previous research in the application of mobile devices to nursing clinical placements at RMIT.
Research aims: nursing trial
This trial aimed to add to the knowledge of the application of small mobile devices in clinical settings by exploring their impact on specific student learning outcomes from clinical work placements, as well as on their overall experience with the HP iPAQ PDAs. The trial gave the university the opportunity to assess the deployment and support of different mobile devices.

The participants in this study were 92 second year nursing students who were undertaking a series of three week clinical placements as part of their degree level nursing programs. 46 students were assigned to a control group, which did not use the HP iPAQs, and 46 assigned to an experimental group that were allocated HP iPAQs. The majority of students had reasonable IT skills, though a significant minority consider themselves to lack “IT literacy”. This program attracts mature age students, so ICT training for students is important.

The HP iPAQs were loaded with basic applications such as spreadsheet, word processor and a calculator, as well as MIMS, an Australian medical database that includes pharmacological information. A training session for the students using the PDAs was provided. The functions of the PDA were demonstrated, highlighting any potential problems such as the charging of a low battery and what to do if students encountered any technical problems in the clinical area. Students were then shown how to access MIMS, the spreadsheet documents and how to create word documents for pharmacology log and journal entries. An interesting aspect of the training session was the ease with which the students embraced the use of the PDAs. All students were familiar with Microsoft Pocket PC operating system and most used the keyboard function as opposed to handwriting recognition.

The aim of the study was to assess improvements in their pharmacological knowledge and their medical clinical contextual knowledge, as well as to explore factors that influence the utilisation of PDAs in the clinical setting. The pharmacological knowledge was assessed by pre and post-tests, and their context knowledge and other user experience were assessed by focus groups.

Research outcomes: nursing trials
The results showed there was a modest improvement in both groups of nursing students on the post-test assessment. Students using the PDAs increased their mean score by 1.3 marks, which was double the increase in the mean score of the comparative group. Hence the experimental group’s pharmacological knowledge improved more than the non-iPAQ control group, but not to a statistically significant level. While students believed that their pharmacological knowledge was improved, they did not believe that mobile technology assisted their contextual knowledge.

The modest improvement in the students’ post-test scores did not seem to be related to the use of the PDAs in the clinical area as all students accessed the preloaded MIMS pharmacological database for obtaining information about the drugs they were giving to their patients. How many times the database was accessed varied amongst students, from 4 to 15 times per shift, however the fact that they took time to look up the drug is a promising find as nursing and medical errors, that cause most harm to the patient, are often drug related.

The focus groups examined the overall experience by exploring the general impression of the use of the iPAQ, its support and the training they received, their learning and overall experience. The focus groups generally agreed that the iPAQs were easy to use and that they improved their clinical experience and their learning activity. Students derived a lot of
benefit from the standard applications and found different ways to use the PDA, to log material, do calculations and to record their clinical experience. Students reported immediacy of access and portability as positive features.

Most students found the PDAs easy to use and were generally impressed with the features of the device. This finding was not surprising considering the age of the students, as most were school leavers and were computer literate. Another factor that may have influenced this finding is the online component of courses taught in the undergraduate program, which requires students to undertake a training course on how to access the learning material. The feature most used was the MIMS pharmacological database and considering the nature of the study this result was not surprising. What was interesting is that students requested a more advanced pharmacological database to assist them in when dispensing drugs to their patients as they felt the MIMS database is lacking in some areas.

The limited computing power, and low battery life did cause difficulties for some students, but overall students managed battery life well. Some perceived that they did not use the devices to their full potential, but still found their application particularly useful. Some found it difficult to synchronise their PDAs with PCs, and this tended to be done only by those with greater IT skills. Others believed that it was impolite to use PDAs in the proximity of patients, and felt more comfortable referring to them at the nursing station.

Discussion

The two trials demonstrated successful applications of mobile technology across two different programs and disciplines using learning designs base around group work and work placements. In the case of the design students, the technology supported learning designs around group work and independent work focused on simulation of workplace design tasks. In the case of the nursing trial, the learning designs focussed on providing better support from standalone devices in the workplace. Overall the students were able to use and benefit from standard applications. In the case of the design project, students also used centralised application such as web logging successfully. The intelligent agent pilot was not widely deployed in the design trial, however, students still found little difficulty with the usability of the environments. Finally, the research was able to identify issues in effectively supporting mobile technologies from a technical perspective.

The overall student experience

Both trials suggest that mobile devices further extend convenience of access and the ability to communicate, features that have been identified by students as major benefits of the application of ICT to learning support (Kvavik and Caruso, 2005; Platts, 2004a). Both groups benefited from the ability to access materials anywhere, anytime. Mobile technology facilitated asynchronous communication and sharing of work, rather than direct synchronous communication. Design students, in particular, reported benefits as being able to use their time more constructively. Nursing students benefited from the confidence given by having ready access to data and from the status afforded to them as users of advanced technology.

The design (Tablet PC) trial demonstrated clear potential to improve group work. Group work is a desirable activity in supporting teamwork capabilities, and in support of student learning, but it can create difficulties for staff in managing group work and for students in participating effectively. Meeting and communicating with group members can be problematical, particularly when group members work part-time, have different class schedules, and study
and leisure priorities. The ability to extend communication over more times and locations can help address this.

The nursing (iPAQ) trial highlighted the benefit of mobile information resources to facilitate work-based learning. Students benefited from ready access to information and the ability to capture information in the workplace. In the student’s minds, the iPAQs appear to be justified on the basis of productivity alone, in being able do their work more confidently and quickly. Students also reported positively about being seen to be using the latest technology in the workplace. This may indirectly lead to better engagement with their clinical placement, and more confidence in the workplace setting. The students found the iPAQs particularly easy to use, and the simplicity of devices and compactness may be important factors in large scale deployment of mobile devices to a wide range of students.

Both groups handled mobile technology well. There was some evidence of using the mobile devices for both study and leisure activities in the Tablet PC trials. The Tablet PC group also extended their use to other courses and activities. The HP iPAQs were more tightly controlled, were allocated only for clinical placements, and used mainly in a disconnected mode, so there was less opportunity for other uses. Both groups reported an interest in further exploring this technology. Overall, the users of the more complex and less constrained Tablet PC reported more difficulties in use, but these were in a clear minority. Although the intelligent agent could not be fully integrated into the Tablet PC environment, a limited trial indicated that it did have potential, and may ultimately provide the basis for better useability, demanded by the net generation (Kvavik and Caruso, 2005).

**The student learning experience**

It is difficult in both studies to demonstrate clear improvement in student learning, directly attributable to the technology. Technological innovation can be justified on the basis of improvement in the overall student learning experience. Broad e-learning studies (e.g. Kvavik and Caruso, 2005; Platts, 2004a) show that students themselves rate convenience, connectedness and management of resources above learning outcomes. Both groups reported positively about their experience with their respective mobile devices. The nursing students were positive about their workplace learning experience, and believed that their pharmacological knowledge was improved. The comments by the design students indicate overall satisfaction with their learning experience, referring to the flexibility, teacher support, technological support, and task orientation, characteristics identified as being among key components of good learning environments (Jegede *et al.*, 1995).

These trials do show that well-designed application of mobile technology integrated with tools such as web logging and other software services have demonstrated potential to facilitate learning. The ability to more fully engage and motivate students is evident in both trials. Certainly, both groups of students indicated easier access to learning material, and ability to communicate. A next step could be to look at providing guidelines (mobile learning designs) for deployment of mobile technology in reaching, and to begin to investigate specific ways of improving student learning, by addressing more fully behavioural, cognitive and constructivist learning in mobile technology.

**From an IT support perspective**

The nursing (iPAQ) clinical placement trial did not use wireless facilities due to incompatible workplaces and technical difficulties within RMIT that have only recently been overcome. More importantly, wireless access was not used to remove factors that might confound
exploration of the primary focus of access to information processing, unobtrusively in a critical information processing situation. For the design (Tablet PC) trial, the wireless access was central to the trial. While most common areas of the university are covered, some computing laboratories were not, and students were found to be plugging their Tablet PCs directly into the RMIT network. Further seamlessness between the RMIT wireless and wired networks needs to be established. Laboratories may need to allow access to both. There was some evidence that program-based facilities were not fully aligned with university systems, and seamless access means that student (and staff for that matter) must be able to access shared directories, specific applications, such as web logging through any legitimate RMIT network or computing facility. Future use of iPAQs in a wireless environment will be facilitated by complete wireless coverage at RMIT.

The creation of the environment for the trials, and the management of the mobile devices created a considerable overhead in ICT support staff. Again, this will only be easily managed with adoption of standards and support for mobile devices.

**From an overall university perspective**

Greater use of mobile computing will enable more flexibility in workspace use. Application of mobile technology in the classroom has shown how wireless laptops can allow teaching spaces to be quickly configured as laboratories, for group meetings, and for the conventional tutorial or lectures. The Tablet PC trial in particular demonstrated a need for collaborative learning spaces on campus, and a continuation in investments in flexible student working areas in student lounges and the library.

From a technological perspective, wireless access needs to be supported in all areas of the university, and seamless access to data and applications through the wireless network needs to be provided. Applications, such as Blackboard, already provide support for mobile access that will at times become disconnected and for synchronisation when the device is re-connected.

Staff will need to be prepared for the mobile environment. The trials depended on enthusiastic, knowledgeable early adopters. Staff (for example, Platts, 2004b) tend to lag students in their enthusiasm for new technology, may not be as amenable to using new technologies, and tend to be entrenched in traditional methods of teaching. As for other applications of learning technologies, tools for use of these technologies will need to be easy for staff to use. As well, effective and achievable learning designs that take account of mobility will need to be developed and disseminated to teaching staff.

**Conclusion**

Becoming “…. learning environment of choice.” (Kim et al., 2006) is still some way off for mobile technology, but there are clear benefits in this technology that suggest that its further development and wider application is inevitable, and that it will become an integral part of the higher education technological landscape. New learning technology is one of the challenges for universities, but trials such as this indicate that carefully considered, new technologies can be successfully integrated into the curriculum.

As a final word, the two trials relied on qualitative data and were restricted to small sub-sets of the overall student body, and care needs to be taken in drawing broader conclusions. However, the experience gained from the project and the outcomes of facilitation of learning and improved student satisfaction would be generally applicable to any cohort of students in science and engineering, given similar circumstances. Both trials are continuing in 2006,
building on the knowledge of the 2005 trials, and preparing RMIT for the day when use of mobile technology, if not the preferred mode of access, is an integral part of university teaching and learning.

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Acknowledgements

The authors acknowledge Hewlett-Packard for the receipt of the HP Mobile Technology for Teaching Grant Initiative – 2004 Higher Education Edition which made this research possible. The authors also acknowledge RMIT for providing financial and infrastructure support, and all the participating staff and students who provided time and effort to make the trials a success.