

WIRELESS-PORTABLE TECHNOLOGY UNLOCKS THE POTENTIAL FOR COMPUTERS TO SUPPORT LEARNING IN PRIMARY SCHOOLS

Over the past decade developments in computer technology have led to the emergence of low-cost high-powered portable computers, and improvements in the capabilities and operation of computer networks (e.g. Intranets and the accessibility of the Internet). While these developments should be welcomed by schools it is not clear that they will have any more impact on school-based learning than previous developments in computer technology. In the implementation of student use of portable computers in schools access to networking has proved difficult using traditional cabling systems. The use of wireless networking may provide the solution and thereby unlock more of the potential for computers to support learning. This paper provides case studies that report on an ethnographic action research study to investigate the potential of the combination of wireless networking and portable computing at a primary school. Data were collected about two classes of Year Seven students and the use of the technology in three extended projects. The data were generated from formal interviews, observations of lessons, questionnaires, and informal discussions with teachers. The portable technology was successfully implemented and supported the students' project work with no significant technical problems. This provides a model for other schools to consider as they implement computer support for learning.

Paul Newhouse

EDITH COWAN UNIVERSITY

p.newhouse@ecu.edu.au

INTRODUCTION

In countries such as Australia, there has been a vast and accelerating investment by governments and school systems in computer technology, mainly hardware. This has been encouraged by the obvious logic behind the arguments for the potential benefits of such flexible tools to students, teachers and school systems. However, for nearly 30 years research has consistently found that computer technologies have had little impact on mainstream schooling (Morrison, Lowther, & DeMeulle, 1999; Plomp & Pelgrum, 1992). For many years the reasons given for this apparent discrepancy included access to inadequate amount of hardware, poor quality software, unreliable hardware, and the complexity of operating computer systems. It is difficult

to sustain this reasoning today with the increasingly high quality hardware and software available for reducing costs.

It is now a realistic possibility for all students in a school to be provided with portable computers. Becker (2001) discussed the potential negative and positive impacts showing how the cost of the portable option is comparable with classroom desktop computer options. While it is relatively safe to contend that most students in the future will have some form of portable computer processing, given the historically robust nature of schools it is difficult to predict in practice what impact this will have on schooling and the curriculum.

Over the past decade there have been a reasonable number of studies into

the use of portable computers in schools. For example, Walker, Rockman, and Chessler (2000) provided a comprehensive comparison study from the Microsoft's laptop computer programme. They reported on eight 'laptop schools' with three matched 'non-laptop schools'. They found that 'laptop teachers' showed a shift toward the use of more constructivist pedagogical practices. Also they found that the students using laptops had improved writing skills and confidence in computer use, but results on standardized tests were inconclusive. Laptops were used to support an increasing range of activities and for increasing amounts of time at school and home. These findings support those of many other researchers (e.g. Ainley, Bourke, Chatfield, Hillman, & Watkins, 2000; Becker, Ravitz, & Wong, 1999; Marcinkiewicz, 2000).

Throughout the 1990s the author conducted research (Newhouse, 1999) into the use of portable computers in schools and found that for a range of reasons very few teachers consistently facilitated the use of computers to support the learning of their students. Among other things there were many barriers teachers felt they needed to overcome, some of these were technical, others involved the structure of the curriculum, the organization of schools and their own level of computer literacy. Students also perceived some technical barriers such as short battery life, heavy weight, and the difficulty of connecting to networks. When Apple first introduced their iBook computers and Airport wireless networking (refer to www.apple.com) it seemed that these technical barriers may have been removed. However, history is littered with discarded educational technology solutions and therefore research is required to investigate the implementation of this technology as a solution to the identified technical barriers.

THE STUDY AND THE TECHNOLOGY

A study was designed to investigate the potential of the combination of wireless networking and portable computers for a primary school environment. The study was not designed to compare wireless networking with 'wired' networking because the obvious

problems associated with the 'wired' approach had been identified by this researcher in earlier studies (Newhouse, 1997). Rather, the study was designed to determine whether the combination of portable computers and wireless networking provided a practical solution for schools to provide support for a wide range of learning activities with students. The intention was to test the overall strategy for providing computer access by implementing a range of activities that may put serious demands on the system. This paper uses a case study format to report on this study.

A primary school environment was used to minimize the known non-technical barriers such as rigid timetabling, predominance of instruction-centred pedagogies, and a content-defined curriculum. The school selected was a government primary school in a middle to upper socio-economic suburb of Perth. At the beginning of the year 2000 the school purchased a class set (16) of iBook

also digital cameras, scanners, a CD-burner and a few other peripheral devices available. All classrooms had one or two ethernet port connections to the school's network that had an Internet connection via modem. All students had a password protected workspace folder on the main network server.

The existing infrastructure of the school allowed the Airport wireless networking technology to be readily implemented. The AirPort Base Station could be plugged into the ethernet port in a classroom to provide network access for all the iBooks within about a 50 metre radius. The Base Station acted as a hub allowing all the iBooks to share the same network connection. The iBooks had built-in aerials and a network card that allowed them to communicate using radio-waves with the Base Station. As a result all Appletalk and TCP/IP (the protocol required for Internet connectivity) communications could be directed to the Base Station. This occurred seamlessly for

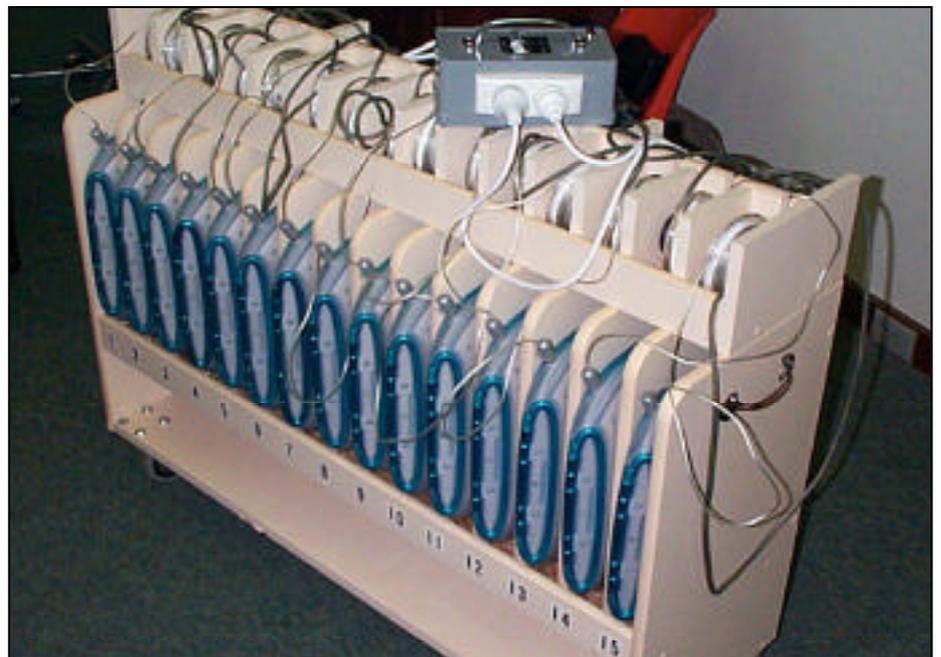


Figure 1: Purpose designed trolley with the iBooks ready to be charged.

portable computers with two AirPort Base Stations. The preferred learning environment at the school for using portable computers had students working in pairs and therefore they only needed one computer per pair of students. Prior to the purchase each classroom had at least two desktop computers and there were also a few old portable computers. There were

the user when, for example, a web browser was opened or a connection to a network server was made. To transport the iBooks a specially designed trolley was constructed where they could all be recharged while not in use (refer to Figure 1).

The researcher worked with two Year Seven classes and their teachers on a

series of extended projects using the iBooks to test the capability of the system. For the researcher this involved discussions with the teachers, observing the class, conducting a number of lessons, using questionnaires to conduct student surveys and interviewing a sample of students at the end of the year. These teachers had made extensive use of networked desktop computers over a number of years usually through having 2 or 3 computers in the classroom. However, they wanted to extend the range of activities and potential for student access through use of the wireless portable computers.

THE STUDENT PROJECTS

In deciding on the student projects and the extent to which computer use would support student activity the researcher and the teachers always began by considering the educational needs of the students and the requirements of the curriculum. There were three extended projects, one in each of terms 2, 3 and 4. The students did use the computers for tasks other than these extended projects but only with the support of the teachers, not the researcher. Each of the three projects will be discussed separately before drawing conclusions based on data associated with each.

RESEARCHING DRUGS

The first project was part of the Drug Education programme and required the students to work in pairs to investigate one of the drugs: cannabis, tobacco, caffeine, or alcohol. The end result was to be the creation of a slideshow presentation of their findings about the drug for viewing by other students and parents.

Initially the students collected information from the library or using the Internet, recording the information on an A3 sheet under specific headings. In a number of sessions the students used the iBooks to access web-sites using teacher-supplied URLs (e.g. www.ceida.net.au) to conduct this research. The students were shown how to save web-pages and graphic images from web-pages to their workspaces. At the same time the issues of copyright and referencing were

addressed. They were aware that graphic images could be inserted into their final slideshows. They were required to jot down notes in point-form on the A3 recording sheet that formed the basis for the design of their slideshows.

The teachers had not created slideshows before and therefore the researcher took on the task of showing the students how to use Microsoft Powerpoint to create slideshows and at the same time showing the teachers. The students were provided with a double-sided A4 instruction sheet on how to construct their slideshow. In two one-hour lessons the researcher worked with the students to create the slideshows. In the first lesson the students created slides, entered text,

view each others work and complete a content evaluation form that included answering the five questions, as well as a technical quality evaluation form for each presentation they viewed. Each pair of students viewed at least three other presentations by moving from one computer to another. Consideration had been given to using a web-browser to view the presentations but it was decided that it was easier to allow students to move. After the completed evaluation forms had been viewed by the teacher they were returned to the designer-pair of each presentation as feedback to allow for improvements to be made. The following week parents were invited to come in and view the presentations.



Figure 2: Students using the iBooks for the drug education project.

and selected a main slide design. In the second session the students inserted graphics and clip-art, and added transitions and effects (refer to Figure 2). Finally, the students saved their slideshows as HTML, placed the folders into a common directory on the server that then acted as an Intranet server (using the web-sharing MacOS facility).

To assist in focusing on the content the students had been asked to add a "Questions" slide at the end of their slideshow to contain five questions to be answered by those who viewed their work. A week after the slideshows had been completed the students were required to

All students were able to complete all the required tasks such as accessing a particular Internet site, conducting a search, taking notes, saving web-pages and graphics, creating a slideshow and evaluating the work of other students. There were almost no technical problems with the computers and none with the access to networking via the AirPort wireless technology. The students were enthusiastic about using the computers. In a questionnaire 96% indicated that they enjoyed the project and found the computers helped them. About 50% felt they had learned "lots" about drugs with all but one student indicating that they had learned some things about the drugs.

Interestingly about half preferred to work individually rather than in pairs but only three complained about sharing the computers. They found the computers most useful in creating the report, collecting the information and presenting the work to their teacher.

Towards the end of the project students were observed starting to informally consider questions of design and the implications of the information they had assembled. For example, when constructing the slideshows a number of students asked how to alter the standard design for particular slides such as the first 'title' slide. One student also wondered about the fact that there was caffeine in Coca-Cola and that this drug had a very different impact for pregnant women. Students started to think about the format and location of files. For example, when downloading from the Internet they became aware of whether the file had a JPEG or GIFF format. Also students had to think about copying files between workspaces to ensure that the graphics files were in the same location as their slideshow file. They started to put a copy of all files into both partners' workspaces to make sure they had a back-up copy.

THE PERSONAL WEB-PAGE PROJECT

For the second project to use the iBooks the teachers were keen to get the students to create a web-page partly because they had seen how easily the Intranet had been set up with the HTML versions of the slideshows. They suggested that the theme be the lives of the students themselves including their families and interests. They wanted to incorporate the use of a Sony Mavica digital still camera and, if possible, the short video clips the camera could create. Once again because they had not created web-pages before they relied on the researcher to instruct the students on the required skills and concepts. This time they wanted each student to produce a web-page but for students to help each other in pairs when using the computers. This project related to outcomes associated with the Studies of Society and Environment learning area (investigating the individual's place in society) and Technology and Enterprise learning area

(designing a web-page).

The teachers started the project by guiding the students to develop their own concept diagram of the information they could incorporate. At the centre of the diagram was their name from which emanated aspects of their lives and features of those aspects. This diagram was to form the planning document for the design of their web-page. The researcher used three one-hour lessons to work with the students on the necessary skills and concepts associated with web-publishing. The technique used this time involved verbally stepping through the help sheet instructions as work was carried out on one student's page. Then they completed the same steps independently for the other student's page. That is, some of the support was removed for the second attempt to help them move towards independence. This appeared to be very successful.

In the first lesson the students used Netscape Composer to create a page (called index.htm) in a folder (called webxxxx with the xxxx being their logon name) in their workspace. They typed their name and a short statement at the top and then added their main headings (from their concept diagram), separated by horizontal lines. They added some text paragraphs to introduce each heading and used some basic formats to identify the headings and their name. They were asked to organise at least one digital photograph of themselves and find at least one URL to add to their page prior to the next lesson.

The second lesson focused on inserting their photograph and inserting a link. They placed the photograph file (JPEG) into their web folder, opened up their page in Composer and inserted the photo. The images required resizing using the appropriate format selection. The concept of constraining to proportion was important here. The students accomplished this task easily but had more difficulty with the concept of inserting a link. Some students had difficulty separating the concepts of the text title to which the link would be attached and the URL of the link itself. They were asked to initially type a phrase starting with the words "CLICK HERE TO GO TO ...", then select this phrase and insert the link. About half the students

initially either did not select the text or typed the URL into the text field of the Link dialogue box. Eventually with some help they all included at least one link and checked this in the browser (some had to go back and correct errors in the URLs). They were then asked to add further links, graphics and text to their pages over the week before the next lesson.

For the third lesson the students were shown how to include a background colour or graphic and place a copy of their web-folder on the Intranet to allow others to access their page (a general access folder had been aliased to the Intranet). They had time to improve the format of their pages including the use of colour and the layout of graphics. Originally the plan was to turn some of their main headings into links to other pages they would create but it was decided not to do this due to the difficulty some students were having with the concept of links. It was also decided not to try to incorporate the digital video.

The students spent another session adding information and improving the design of their pages. The final session was devoted to peer evaluation. Each student was required to complete an evaluation sheet for the web-pages of two other students. Once again the students moved between computers to look at different personal web-pages rather than using the school Intranet. The students also completed a questionnaire about their experiences in the project.

The results from the questionnaire confirmed researcher observations that the students had enjoyed the experience, learned a lot from it and had encountered most difficulty with inserting links and their photograph. Thirty of the 57 students felt that they had learned 'lots' from the project with no student indicating that they had learned 'not much'. Only three students had previous experience in creating a web-page. Most of the difficulty in inserting their photo concerned the need for many students in one class to initially rotate their photo in a graphics package. Seven students found this difficult. The difficulties experienced with inserting links to other web-sites appeared to be conceptual. At least six students felt that this was difficult to understand. The response of one of the students summed

up the experience for many of them, "I had fun and I was proud of what I had learnt". A number of them also indicated that they liked the fact that their page was on the school Intranet.

MAKING DIGITAL MOVIES

For the fourth term the teachers indicated that the students needed to improve their communication skills and their range of skills in using the computers. As a result it was decided to work on creating a movie using the iMovie software package that had come pre-loaded on the computers. The idea was to select a topic or theme that would interest the students and relate to their lives and support them in planning and making a short video presenting this topic. Since at that stage the school did not have a digital video camera and the iBooks had no Firewire port (used for connecting video cameras) it was decided to find existing video footage that was related to the students' lives. The teachers had VHS video-tape of a camp the students had attended earlier in the year. The camp became the focus of the project with copies of the digitized video being burned onto CD ROMs as the main source material. This project related to outcomes associated with The Arts learning area (i.e. communicating with media) and Technology & Enterprise learning area (i.e. designing an information product).

The teachers had seen the iMovie software demonstrated and were confident the students would be able to operate the software easily. However, there were a few technical issues to address. The main issue was that the software would only import QuicktimeDV video files that are very large for even short video-clips (30 seconds is around 400Mb of disk space). These files would be too large to store on the central workspaces and would be slow coming across the Ethernet-wireless network. The only choice was that the students would complete the project on the hard disks of the iBooks and only copy the final exported compressed Quicktime file to their server workspaces. This meant that since other classes would be using the computers as well there was a chance that some work may be lost. Therefore the project had to be completed as quickly as possible. In actual fact about 5 or 6 groups

out of 32 lost some work over the duration of project. It was also decided to limit the final videos to 30 seconds (equivalent to a short advertisement) which would ensure the projects would not exceed about 400Mb of disk space (with 2 classes involved this would tie up 800Mb of hard disk space for the duration of the project). This 30 seconds restriction was reasonable as working within constraints is an important concept in technology education.

A seven-stage approach to the activity was devised. The high level of structured support was considered necessary due to the newness of the activity to the students and teachers and the potential technical problems.

Phase 1: Tutorial

The tutorial constructing a video about washing a dog, associated with iMovie™ version 2, was used to both introduce the students to the main concepts behind video editing and develop their software operation skills. In the first class the on-screen tutorial instructions were used but the students found it difficult flicking between these and iMovie™. For the second class printed copies of these instructions were used. Many students still found the first few tasks unnecessarily complex and obtuse. As a result some students initially lacked enthusiasm and displayed negative behaviour but this improved as they picked up some of the key ideas. They all successfully completed the main parts of the tutorial.

Phase 2: Planning & Design

It was important for their technology education that the students considered the planning and design processes. The students worked in pairs and initially thought about what sort of a message about their camp they would like to present in 30 seconds of video. They were given project instructions and shown, using a VCR and large television screen, the existing video taken at the camp. The formal planning and design began using the Inspiration (www.inspiration.com) software package. However, for many students there was not enough time to

learn to use the package and create the plan so most of the simple planning was done on paper or using a word processor. The planning included a description of each clip to be used, a time length for each clip and any information about effects and sounds.

Phase 3: Selecting Video Clips

Once they had planned which video clips they wanted to form their movie the students used Quicktime™ Pro Movie Player to locate the required video clips on the CDROM, select required segments, copy, paste and export them as QuicktimeDV files. A few machines had difficulty with this as the default format for DV exported incorrectly. The students clearly enjoyed this session of viewing the clips. Most of them easily found the segments they wanted and some even used mathematics skills to calculate the beginning and end of the segments to give the correct duration. They found that concepts introduced in the tutorial for iMovie such as the "scrubber bar" and "playhead", were useful in using Quicktime Player.

Phase 4: Constructing the Movie

Most students started to construct their movie using iMovie about two weeks after they had completed the tutorial. However, they appeared to quickly recall the skills from the tutorial. Some had difficulty recalling how to put the titles over the video image, not on a black background (the key was to select the clip first and then to ensure "Over Black" was not selected). They enjoyed adding titles, effects and transitions with many discovering additional features and techniques either by trial or from the researcher or other students.

A few students brought in audio CDROMs and wanted to use songs as background sound. After a discussion about copyright they were permitted to only use 5 seconds of any song. The researcher demonstrated to one pair of students how to import and edit a track, these students then showed other students. Peer tutoring is almost always an efficient and effective method for disseminating operational instructions.

Phase 5: Adding a Voice Over

The students recorded at least one voice-over using a Powerbook (the iBooks had no microphone nor audio input port) and copied this to their computer via the workspace server and wireless network. Once again peer-tutoring was used for operational instructions.

Phase 6: Exporting as a Quicktime File & Copying to Workspace

The students spent about a total of 3 to 4 hours over two weeks completing their movies. When completed they were instructed to use the export facility in iMovie to save their work to Quicktime standard CDROM format. These files could then be copied to their personal workspace on the server. At the end of the term all of their work was to be burnt onto a personal CDROM to take home. Most iMovie projects were about 400 Mb in size but exported to 3 to 4 Mb Quicktime files.

Some students were unhappy with the blurring of text (particularly serif fonts) on the exported movie. A few went back to the original files and changed the font and re-exported their movie. Even at this late stage one pair of girls found their work had been trashed by a previous class so they had to redo their movie from scratch. In less than an hour they had completed the whole job. This indicated the high level of proficiency these students had developed.

Phase 7: Evaluation

As with earlier projects all students were required to be involved in evaluation processes (an important set of processes in technology education). All students completed a self-evaluation of their video and evaluated the videos of two other pair of students. These evaluations were not anonymous and were considered an important phase of the overall activity. The evaluations involved completed responses to a variety of questions on a single-sided proforma sheet. They evaluated the exported versions of the movies by copying the files to the hard disk. Some tried to show the videos by running them off the server. This did not work well as the speed of the network was not adequate.

By the end of the term all student pairs had completed a video with an average length of about 34 seconds. The data collected from the students' evaluations of their own movies and those of others were analysed by looking for common themes.

Results from Self Evaluation (Reflection)

From the self-evaluation responses it appeared that all but three of the 56 students enjoyed making the movie. Most students felt that they had learned a lot from the activity. Their response to completing the tutorial (washing the dog) was mixed with three fairly even groups: "boring", "OK", and "fun". Many thought it was a useful exercise although a little difficult at first. Surprisingly 34 indicated that they had followed the plan for their video. Reflection on how they would improve their video tended to be quantitative with "more time", "longer", "more clips", and "more sounds" being common. In rating the difficulty of the tasks six students indicated they had difficulty converting formats either to digital video or to Quicktime at the end. The majority found all tasks easy, particularly inserting titles, transitions, effects and sounds. Clearly they found the iMovie software easy to use. The only problems they perceived were a few students who had to redo some tasks due to files being deleted or in incorrect format and a lack of time. Many indicated that they experienced no problems, which was surprising given that it was something new for all students. They found the experience fun, easy and interesting and particularly liked the sound and effects.

Results from Peer Evaluations

Each student evaluated two movies created by other pairs of students. Generally their responses were very positive and supportive of the movies they evaluated. They were particularly attracted to movies with different, innovative or high audio content. A few made comments about specific effects, titles or series of clips. In particular two of the videos included short montages of still clips. They all were positive with most saying the movies represented the camp as being fun and filled with activities. In rating the

video productions they were most critical of the use of sound effects and voice-overs (approximately 25%) and least critical of the impression created by the video and the general appeal. The following statements were made concerning the best things about the movies.

"It shows how great camp was and that's what it reminds me of."

"The mini photo album of the llama."

"They made it look very good and you would want to go to camp."

"That he did a section for nearly everything we did."

"The pictures were excellent and the transitions were really good. The part about the alpaca farm, I think, was the best bit."

STUDENT INTERVIEWS

Ten students from each class were interviewed using a proforma. The questions related to their experiences over the whole year in using the wireless-portable technology.

Many expressed the feeling that they were lucky to have access to the computers and felt that although they would like to have more computers it was an unreasonable expectation. All the students said they had done a lot more than they had expected, having previously only done word processing, with some nominating that they would like to do more work on animations and spreadsheets. The majority of students considered the movie editing project as the most interesting. However, a few indicated that all the activities were interesting and a number also nominated the web-page creation and the slideshow. Only six students thought that the use of the computers had changed the way classes were presented. These students said the classroom was noisier, more exciting, and more collaborative. Individual students suggested that the school could employ a "computer teacher" and improve access to printers.

All students said that they now had no problems using the computers and network facilities. A few said that it was a

Table 1

THE USE OF THE IBOOK COMPUTERS BY CLASSES IN EACH YEAR LEVEL OVER THE YEAR.

Year	Term	Activity and Software Used
1		<No use over the year>
2	4	Using Kidpix™ to draw and create slideshows.
3	4	Using the Internet for research and learning the technology of the Internet. Using Kidpix™
4	3	Use of Worldbook™ and Internet for research.
	4	Use of Worldbook™ and Internet for research. Creating a fun slideshow in Kidpix™.
5	3	Internet awareness and skills. Learning to create a slideshow.
	4	Internet for research on health. Create a slideshow.
6	2	Introduction to word processing skills
	3	Word processing skills. Email project with a buddy school in New Zealand.
	4	Create a slideshow on a theme.
7	2	Internet-based research into a drug and creation of a slideshow.
	3	Creation of a personal web-page. Research using the Internet.
	4	Plan a movie using Inspiration and a word processor. Creation of a digital video using iMovie™. Some students learned to create simple spreadsheets.

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bit 'scary' to start with and a few had difficulties getting used to the trackpad. They perceived many benefits of having the iBooks. Most students indicated that the systems were easy to use and afforded them greater access to software and networking, particularly the Internet. This meant that they could do a greater range of activities and perform better at library research and writing tasks. Clearly the networking portability of the computers had contributed substantially to this outcome.

They all felt more confident and knew how to use computers better now than at the beginning of the year. This was particularly the case for the few students who did not have access to a computer at home. A few students indicated that they were better able to use their computers at home after their experiences at school.

Only two students did not want to use computers in the future. Both were boys who would use computers if they had to but could not see any benefits to them in the long-term. Both had computers at home and were happy with the way the computers had been used at school.

USE OF COMPUTERS THROUGHOUT THE SCHOOL

The researcher interviewed the teacher responsible for organising the use of the iBooks to determine usage over the year. He indicated for each class by Year level what use they had made of the resource over each of the terms (2, 3 and 4) for which the computers had been in the school. A summary of these data is provided in Table 1. The obvious conclusion is that the iBooks were

increasingly used over the year and tended to be used with the older students firstly. Another conclusion could be that a number of the activities tried with the Year Seven students by the researcher were subsequently implemented in various forms in the earlier years. In particular the creation of slideshows and the use of the Internet for research.

CONCLUSIONS

The wireless networked portable computer classroom implementation model used by the school was clearly successful and is recommended for consideration by other schools. The success was evidenced by the high standard of work and positive attitudes of the students, the increasing use of the computers throughout the school, and the lack of technical problems encountered despite the complexity of the tasks engaged. That is, for this case study the technology (wireless + portable) had passed the tests. The use of a class set of portable computers with wireless networking capability provided greater flexibility and suited the environment much better than desktop computers in the classroom or computer laboratories. The sharing of one network access point in a cramped classroom, used for all manner of other type of activities, so that all students could be connected without cables 'snaking' all over the room, made it much easier for the teachers to implement a range of activities far beyond their expectations. This configuration allowed adequate computer processing to be easily provided where it was needed for a whole class of students when necessary. In a sense other teachers 'voted with their feet' by increasingly using the facility to the extent that for many weeks later in the year the set of computers was fully booked.

The technology worked well with the wireless networking and improvements to battery life and start-up time overcoming these major technical hurdles often cited by researchers (Newhouse, 1998). There were also few hardware or

software maintenance problems. The students had few problems using the software and networking for the required project activities that by most standards would be regarded as advanced for 12 year-old students. The video editing did highlight the limitations of using server hard disks for storage of student work and the relatively slow connection speed of the wireless networking. However, for most activities these were not obstacles.

The mentoring role of the researcher with the two Year Seven teachers was successful in that not only did they develop a greater range of computer supported activities to use with their students but they then assisted a number of other teachers to implement these activities with other classes. Action research is clearly a very valuable tool in assisting the implementation of such innovations.

At the primary school level the use of mobile sets of portable computers with wireless networking is easy to implement and readily unlocks more of the powerful potential of computer support for learning (e.g. support for 'just in time' learning) than has previously been realised. It is a cost effective method of providing access to adequate processing for students in primary schools that readily fits typical environments found. However, it does require a commitment to student-centred (constructivist) pedagogy (Clouse & Nelson, 2000) that is relatively common among primary teachers. The challenge will be to translate this to secondary school environments where typically students are not located in one room for most of the time, the curriculum is fragmented and students see a range of teachers each day. For all schools this model of access may provide an interim solution until the student-owned portable computer solution is viable, if, as is likely, this becomes the ultimate model for implementing computer support for learning.

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