Costs and Effectiveness of Wireless LAN in Higher Education

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Introduction

The two basic reasons for installing any local area network (LAN) are information sharing and resource sharing between computers (Fitzgerald & Dennis, 1999). A wireless (LAN), as the name indicates, is a method of linking computers to serve these functions without using cables. Wireless-equipped computers access an intranet which may in turn provides access to email and the Internet. A wireless LAN comprises a number of base stations or access points linked into the physical network backbone of the organisation. The base stations are radio transmitters and receivers, which communicate between the LAN backbone and with computers equipped with a wireless card, provided that they are within range.

Wireless equipment can include PCs, laptops and PDAs. A base station or several base stations may serve a room, lecture theatre or outdoor area. In contrast, a wired LAN will need one port for each computer that might be connected to the network. The number of base stations required in an area depends on the speed of service required. The more traffic the slower the system. A wireless network does not eliminate the need for wiring. It does reduce the number of wires that are needed and provides flexibility for location of PCs and access points (TechLearn, 2002).

The technology which is the basis of wireless LAN has been available for over fifty years, but the use of wireless LAN has only started to become mainstream within the last decade. Lack of open standards for spread spectrum frequency modulation, expensive and bulky proprietary hardware systems, slow transmission speeds, and difficult installation procedures have impacted negatively on the adoption of wireless LAN.

In contrast to traditional wired networks, wireless LANs represented lower performance, greater complexity and increased expenses (Lucero, 2002). Interest in wireless LAN is now beginning to grow. Wireless networks based on the IEEE 802.11 standard have begun to establish themselves in various roles within the community (Hayes, 2002). Internet access is available commercially and several trials are running in Sydney (Henderson, 2002). Manufacturers of computers have embraced wireless networking, with some producing protocols of their own.
Previous studies

TechLearn (TechLearn, 2002) presented case studies of the applications of wireless LAN at the State University of New York, Seton Hall University and Carnegie-Mellon University, where the systems have been successfully implemented. They have defined a number of pedagogical advantages offered by wireless LAN:

?? Computers go to the teaching instead of the other way round - this makes for much more efficient use of resources and gives flexibility in the way teachers use computers

?? Wireless LAN allows for the classroom to be arranged in the most efficient way for teaching, at the same time allowing for the use of computers

?? Wireless LAN provides students with access to large amounts of information that is constantly updated

?? Wireless LAN has been used to improve teaching by allowing students to give real-time feedback to the teachers about how well the message is getting through

?? Wireless LAN allows for class tests and quizzes to be performed easily

?? Wireless LAN allows for data capture on-site and in real time

?? Dissemination of information is improved with wireless LAN

?? Wireless LAN allows for easier collaborative learning, when computers are to be used

?? Wireless LAN lets students make most use of their computers.

Besides the above, a number of additional benefits have been identified:

?? A greater choice of locations for study is offered to students

?? Potential savings in the costs of provision of study space

?? More cost-effective provision of network services in new locations

Against these benefits, a number of costs and drawbacks have been identified:

?? The initial outlay of the wireless LAN may be costly

?? The skill set of staff members requires expanding in order to operate the system

?? Data transfer rate is slower than wired LAN

?? Bandwidth may be limited when transceivers run above 30% load

?? The frequencies that Wireless LANs use are part of the unlicensed spectrum, which means that many different types of devices also share the spectrum. There is the potential for associated security and congestion problems to occur.
Salomon and Almog (Salomon & Almog, 1998) have researched the relationship between information technology and education and assert that:

- For the change to be successful, a convincing rationale needs to be presented to the users demonstrating that the change holds a great deal of potential for improving the teaching process.

- A number of different theories are presented, but the overall picture is that the concept of learning has changed greatly over time, and that active processing, rather than passive reception, is the best way to learn. Educational technology should therefore be designed to allow teachers to guide problem-solving activities, rather than just transmit knowledge.

Investigation of the educational effectiveness of using wireless LAN

A wireless LAN pilot project at Swinburne University was devised and administered by Swinburne Information Technology Service (ITS) who appointed a systems administrator and provided technical support. ITS has installed the wireless LAN system in select locations on the Hawthorn campus of Swinburne.

An evaluation of the project was undertaken to determine the technical effectiveness of wireless LAN, the educational effects of employing wireless LAN, and the cost effectiveness of wireless LAN in a higher education setting.

Educational effects

The Learning and Teaching Support unit of Swinburne University conducted an evaluation of the educational effects of employing wireless LAN. The evaluation objective was to determine the impact of using wireless LAN on the teaching and learning function in particular.

The key questions in the educational evaluation were: how do the features of wireless LAN contribute to the study behaviours of students, and how do they affect the way in which system users and providers perform their tasks?

These questions were operationalised as the following four research questions:

- Where do students use wireless LAN most?
- What types of tasks are performed most often on wireless LAN?
- What are the positive aspects of the use of wireless LAN?
- What are the negative aspects of the use of wireless LAN?

Student participants in the project fell into three groups: students who borrowed wireless LAN-equipped laptop computers from the Swinburne library; students who were issued with wireless LAN cards (WNICs) for use with their own laptop computers; and students who used their own laptop computers and WNICs.
Study 1 - Questionnaire

One hundred and six students from Swinburne University of Technology participated in a questionnaire-based study. Most of the students were first-time users of the wireless LAN-capable laptops.

The participants were issued with questionnaires to provide their opinions on various aspects of using wireless LAN. These aspects included the areas and tasks for which they used wireless LAN, positive and negative aspects of the system and specific questions regarding the use of the computers for group work. Answers to most of the questions were recorded through ticking check boxes or circling numbers on a Likert scale. Space was also provided for open-ended answers.

As a condition of borrowing the laptop computers, students were expected to complete the questionnaire upon returning the computers to the library. To ensure anonymity, the consent forms that students signed upon borrowing the computers was detached from the rest of the questionnaire immediately after signing. No identifying information was required in the other parts of the questionnaire.

The data from the questionnaires covered the following aspects of wireless LAN use:

?? Overall experience of using wireless LAN
?? Usage of wireless LAN compared to the wired network
?? Areas where wireless LAN was used
?? Tasks for which wireless LAN was used
?? Positive aspects of wireless LAN
?? Negative aspects of wireless LAN
?? Satisfaction with wireless LAN
?? Speed of wireless LAN data transfer compared to that of the wired network

The percentage of the user population that rated their overall experience on a 5-point Likert scale (1 = “hate it” to 5 = “love it”) was calculated. Overall, the students found the experience of using the wireless LAN laptops to be good. Among the comments made were:

?? “fantastic!! I love it, I get more work done, it helps for student collaboration, it's convenient…”

?? “I think the wireless LAN is a fantastic idea!…It offers a lot more flexibility and convenience. I really hope the wireless LAN is continued… If it was I would seriously consider buying a laptop to use it all the time. I can see it benefiting (sic) myself and other students enormously (sic).”

?? “It would be wonderful to extend this trial to a permanent facility…I also think its a good idea as we are being taught about this wonderful (sic) wireless world (e-society) and here is a real life example we students can access.”

?? “I am happy that Swinburne is doing this. This I believe is a definite (sic) right step in the right direction”
A few students rated their experience of using the wireless LAN laptops as negative. All of these students reported problems with the login process or with power supply for the laptops.

The percentage of the user population that rated their relative usage of wireless LAN to the wired network on a 5-point Likert scale (1 = “much less” to 5 = “much more”) was calculated. Overall, the participants tended to use wireless LAN marginally more than they did the wired system; the mean score on this question was 2.67 out of a maximum of 5. Many participants commented that the loan period was too short, and a few had borrowed the laptops for non-networked tasks such as word processing.

The participants’ rate of usage of the laptops on a number of wireless LAN-related tasks was calculated. Most of the participants had used the computers to work in groups, and in the comments they provided, many of them liked the choice offered by wireless LAN of places in which to conduct their group work. The high usage of wireless LAN for of accessing e-mail and the BlackBoard learning management system reflects wireless LAN’s ability to provide course work information in a timely and convenient manner. This was reflected in the comments made by the participants. To a lesser extent, the participants entered data in real time through BlackBoard as well.

Breadth of information appeared to be another factor in the use of wireless LAN, reflected by the high usage of the system for Internet research and surfing. Very few students used CoolCat (the inter-library resource database) or Video-On-Demand, which were also available on the network. Other tasks that the laptops were used for include word processing and website design using programs such as DreamWeaver.

The percentage of participants who agreed on a number of positive aspects of wireless LAN was calculated. The majority of the participants found that the system performed as expected, and saw the introduction of this new technology as being positive. They found that the system allowed them flexibility of use, across a wide range of areas on campus, and that wireless LAN facilitated their university work, and their ability to work with their classmates. However, only a quarter of respondents felt that it allowed more activities compared to the wired system, and only a third of respondents felt that wireless LAN encouraged group work and facilitated collaborative learning.

Considering that the participants were mostly first-time users of the system, and that they had relatively little time to explore the use of wireless LAN, it may be that they have not yet had the opportunity to use wireless LAN in more complex collaborative learning tasks. Note also that group work was also the most common task performed using the wireless LAN laptops; participants commented that the laptops afforded the arrangement of seating best suited to group work, an advantage not offered by the wired desktop computers in laboratories.

The percentage of participants who agreed on a number of positive aspects of wireless LAN was calculated. Despite its advantages, the portability of the laptops was a source of concern for the students.

Students were worried about the possibility of the laptops being stolen, even though they were provided with security cables to lock the laptops to fixed furniture such as
study carrels. Transportation of the laptops was also a source of concern to the students, because of the possibility of damage occurring in transit. Many of the participants reported being annoyed by the process of logging in to the wireless LAN network, citing two main problems. First problem identified was that the login procedure required the entry of two separate identities and passwords.

They felt that, since they were effectively logging onto an internal network within the campus grounds, a single identity and password should suffice. The second problem was that the system regularly failed to locate the network branch in which the user’s network account resided. This problem resulted in participants often having to make three or four attempts to log in successfully.

Although the respondents were pleased with the increased range of choices of places to work, they felt that the wireless LAN system’s area coverage should be increased. This applied especially to buildings where classes are held so that they could use wireless LAN during classes if they wished. Finally, demand for the laptops from the library was so high that students experienced difficulty in finding available laptops to borrow, and they reported this to be a source of annoyance.

The percentage of the user population that rated their impressions of the wireless LAN data transfer speed compared to that of the wired network on a 5-point Likert scale (1 = “much worse” to 5 = “much better”) was calculated. Overall, participants found wireless LAN data transfer speed to be slightly faster than that of the wired network. This result is counterintuitive; since the maximum wireless LAN data transfer speed is 11 Mbps, while the wired system operates at a maximum of 100 Mbps. However, examining the main tasks performed on wireless LAN, the data required for transfer was of such small volume that differences between the data transfer speeds would have been negligible. Of the tasks examined, Video-On-Demand would have best differentiated between the two systems. However, very few participants used this function on wireless LAN.

The coverage area of the wireless LAN system was divided into discrete sections, and the percentage of the user population in each area was calculated. The areas of highest usage were within the library. This was largely due to the availability of study carrels and the availability of electrical sockets for the laptops’ power adaptors. Participants commented that power supply was a problem, since internal battery power was limited.

A principal components analysis (PCA) of the positive and negative aspects of wireless LAN was performed using SPSS 10 on ratings of the positive and negative aspect of wireless LAN, to identify underlying factors in the way that participants viewed the value of wireless LAN to their university work. Multiple linear regressions were performed using SPSS 10 on the overall experience of using wireless LAN, and the preference of wireless LAN over the wired system, using the six factors as predictors.

The overall experience of using wireless LAN was positively influenced by wireless LAN’s facilitation of university work ($r = .303$, $p < .01$), connectivity ($r = .329$, $p < .01$) and the ability to use wireless LAN more often and in more places ($r = .178$, $p < .05$).
Wireless LAN was preferred over the wired system because it was seen to facilitate university work ($\beta = .190, p < .05$) and allow computer use more often and in more places ($\beta = .310, p < .01$).

Wireless LAN was found to be useful for working in groups because it facilitated university work ($\beta = .195, p < .05$) and allowed computer use more often and in more places ($\beta = .360, p < .01$).

**Study 2 – Observations and discussion with participants**

Physical observations were undertaken to support the evaluation. The aim of the observations was to establish a usage pattern for laptops in general and for laptop computers employing the wireless LAN facility. Observation was also undertaken to identify what proportion of students were using a Swinburne laptop, borrowed from the library, and what proportion used a laptop of their own. It was also noted whether wireless cards (WNICs) employed were of the type issued by Swinburne, or were of a different brand from that supplied by Swinburne. Toward the end of the observation period discussions were conducted with users of wireless LAN.

The sample consisted of students at Swinburne University of Technology who used the wireless LAN system. Within this group, three types of users were identified according to the computers that they used. The first group consisted of students who borrowed wireless LAN-capable laptops from the library. The second group consisted of students who borrowed WNICs from Swinburne and used them with their own computers. The third group consisted of students using their own laptops and WNICs.

The subjects were observed over a period of five weeks using their laptops in the areas covered by wireless LAN. The observations were conducted at various times between 10.00 a.m. and 4.00 p.m., in order to maximise the range of subjects observed. For the first three weeks, the observations were conducted in a non-intrusive manner, with the researchers making their observations from a distance and not interacting with the subjects.

In the final two weeks of the observation phase, observers identified themselves to the subjects and obtained comments and entertained queries from the students. The observers surveyed the wireless LAN-enabled areas for students using laptop computers and other devices capable of wired or wireless LAN access. Visual identifications of the content on the computer screens were used to determine the students’ use of LAN applications such as the BlackBoard learning management system or Internet browsers.

Observers also attempted to make visual identification of the mode of connection to the LAN. Three modes of connection were observed and recorded: 1) wired access through the LAN through wall sockets, 2) wireless LAN access through the use of the Cisco WNICs provided by Swinburne or sold at the Union bookshop and 3) wireless LAN access through the use of other WNICs, which clearly indicated that the WNICs were privately owned.
During the course of the study, 329 observed cases were recorded of portable computer devices being utilised by students, the vast majority of these being in the library. Laptop computers predominately represented these devices, although one student was observed to use a hand-held device with wireless LAN capabilities. The observations made in the study were recorded in the form of notations on maps of the library, representing the location of the observed user and the type of use observed.

Observations revealed that the majority of laptop users were students using their own laptops, as opposed to students using a laptop computer borrowed from the library. While 269 observed cases were of students using personal machines, only 59 cases were of students using laptops borrowed from the library. Of the observed cases involving privately owned laptop computers, 139 cases were observed to be connected to the LAN using wireless LAN or wired LAN facilities, while 130 cases were observed to be in use without connection to the LAN.

Discussion with wireless LAN users gave rise to the following observations:

• Wireless coverage in the library is incomplete.

• Start-up and shutdown procedures are slow – this is a frustrating aspect of using the laptops

• There were difficulties completing the Novell login procedure – at each start-up, the system initially refused to connect to the correct branch or server, and this had to be manually set. Even then, the setting often took two or three attempts to be successful – either the correct server would not connect, or would not show up on the pull-down menu.

• Battery life of laptop computers is a limiting factor.

• The effort required to secure laptop computer on campus limits the attractiveness of using them on campus.

• Lecturers can use the system to call up BlackBoard materials for lectures or materials stored on the network drives

• Students can access their stored materials in a class using the system.

**Study 3 – Support staff interviews**

One representative teacher, one representative librarian and one representative system technical support staff member were selected.

An interview was conducted with one teacher of a subject selected for participation. The subjects selected were ones previously associated with greater than average use of the Blackboard learning management system and ones in which teachers were prepared to support evaluation of the project by encouraging participation and facilitating distribution of the cards.
An interview was conducted with one member of the library staff engaged on the loans desk, which prepared the WNIC-equipped laptop computers for loan and devised and administered the loans system. The loans desk staff also collected the questionnaires from students on return of the laptop computers and liaised with the project evaluation team. Library loans desk staff worked with the Information Technology Services wireless LAN project staff responsible for the system and for maintenance of the laptop computers available for loan to students.

An interview was conducted with an ITS systems technician for the wireless project who was responsible for maintenance of the wireless-equipped laptop computer loaned out through the library.

The major points made by the teacher interviewed were:

?? Students either used wireless LAN intensively or not at all.

?? Students using the system were more motivated – the project group with the best results used wireless LAN. The group worked more efficiently because they did not experience shortage of computing resources and could share their work and files online instead of using disks. This level of efficiency was not seen previously.

?? Wireless LAN helped in providing access to the Blackboard learning management system and in the availability of computing resources.

?? Wireless LAN had the potential to facilitate teaching because computers could be set up anywhere. It would be valuable for both learning materials and for Internet access. It would facilitate presentation of live samples of websites instead of static overheads.

?? Laptops available for loan through the library need web design and multimedia software in addition to the software currently supplied.

Observations made by the library loans desk staff member included:

?? The demand has been large creating a lot of extra work for staff including walking backwards and forwards to the secure area to retrieving equipment and often finding none available. Library loans desk staff needs to check all 5 items issued with each laptop each time a laptop was returned which was a considerable workload.

?? The 4-hour loans seemed to be used by students for university work purposes

?? The 4-hour loans system was very labour intensive for library loans staff. They needed to explain and often to demonstrate the logon procedure.

?? Students loaded additional software and changed settings, which made it hard for other students, as no two laptops were the same. Students saved lots of rubbish on laptops and as they were always on loan cleaning up them was impossible.
Many students used the laptops as personal PCs not for wireless LAN purposes.

Observations of the ITS wireless support technician interviewed included:

Over the period that the wireless LAN evaluation trial was running, 80 technical support jobs were logged. Half of these were directly related to system problems, and half of the system problems were related to training the students to use the system.

No physical restrictions were noted, apart from the usual issues such as building densities.

No technological failures were noted. Two hardware failures were repaired, but neither of these was related to wireless LAN.

Settings on the library laptops were often found to have been changed upon return, but these were easily reset when the computers were re-imaged as they were regularly.

Wireless LAN was no more difficult to maintain and administer than the wired system. The only challenge was that since the equipment was mobile, staff could not always get access to the computers for maintenance work.

No security problems occurred. At one point it was suspected that the RAM chips were being stolen from the laptops. This was later found not to be the case. As a precaution the two 64 Mb RAM chips in the computers were replaced with a single 128 Mb chip, so that if they were removed, the computer would fail to work (removing one 64 Mb chip would have allowed the computer to continue working, making detection of the theft more difficult). No information was available on how often the locking cables for the laptops were used.

Students did not perform any unexpected activities on the laptops. However, there was one case of a large amount of pornographic material being left on one of the laptops’ hard disk. Often, settings on the computers were found to have been changed, apparently in an attempt by students to configure the computers to their private ISPs.

Little extra training was needed for staff to maintain and administer the wireless LAN system. The total required training time was about one day. The only new feature of wireless LAN as compared to the wired system was the VPN tunnel software. Apart from that, the training only required staff to learn the specific settings for the wireless LAN system.

**Summary of findings on educational effectiveness**

Most participating students liked using wireless LAN
On average, students who borrowed laptop computers from the library used wireless LAN as much as the wired system.

The area of highest usage was the library, especially the third floor.

Group work, e-mailing, BlackBoard learning management system activities and Internet research and surfing were the tasks most often performed on wireless LAN.

Flexibility, the ability to perform computing in a wide range of areas and the facilitation of university work were the most positive aspects of wireless LAN.

Limited area coverage, login difficulties and concerns about equipment damage and loss, and the limited life of laptop batteries were the most negative aspects of wireless LAN.

No difference in the data transfer speed of wireless LAN and the wired LAN was noticed by users.

The overall experience of using wireless LAN was positively influenced by wireless LAN’s facilitation of university work, connectivity and the ability to use wireless LAN more often and in more places.

Wireless LAN was preferred over the wired system because it was seen to facilitate university work and allow computer use more often and in more places.

Wireless LAN was found to be useful for working in groups because it facilitated university work and allowed computer use more often and in more places.

The majority of students observed using wireless LAN used their own computers and WNICs.

Few of laptop computers that were borrowed from the library were seen to be in use on campus.

Summary of recommendations

The coverage area of wireless LAN on the Hawthorn campus should be increased, especially in traditional work areas such as the BA and EN buildings.

Provision of study carrels with power points should be increased.

The login procedure should be streamlined.

The wireless connection should be made more resistant to dropouts.
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The wireless connection should be made more resistant to dropouts.
Wireless LAN-capable laptops should be loaned on shorter terms if increasing the use of wireless LAN is a priority in making laptops available for loan.

Calculation of the cost effectiveness of using wireless LAN in higher education

In considering the practicalities of implementing wireless technology for learning and teaching, one needs to consider not only how well the technology may work in terms of enhancing learning and teaching but also whether it is cost effective. During discussions with several executives within large organisations, the real issue in preventing a wireless LAN deployment or even a pilot project like the one discussed in this paper was, “how do you justify wireless infrastructure from a business case prospective?” (Participant interviews, 2004).

We know only too well that industry may have differing business drivers from a university. A university may be able to justify an expense or investment by stating that the expenditure increased the student experience. Most organisations however are mainly interested in the expenditure directly affecting the “bottom line” in a positive sense and therefore enabling the delivery of a greater return to shareholders. For that reason, we felt it was imperative to add a discussion that highlights the costs and presents a cost comparison between a traditional computer laboratory and one that is more “virtual” but still provides a similar number of machines to students in a wireless setting, by using wireless enabled laptops. If the cost is prohibitive, the institution is unlikely to embrace the technology.

Relative cost effectiveness for the conventional PC lab and wireless LAN

The cost evaluation here is based upon the three-year lease of equipment and space and includes all ancillary costs including cleaning, light and power, as well as support costs for staff and maintenance costs for hardware and software. Facilities and Services, the Library and ITS staff provided the cost estimates.

In summary, the three-year lease cost of a 20 PC laboratory was virtually identical to the provision of a similar number of laptop computers available for loan. However when availability, in terms of access hours, is taken into account then the laptops prove to be even more cost effective. The “bottom line” measurement or metric used in this comparison was “cost per usable hour”.

Existing PC laboratories are open for an average of 11 hours per day and 330 days per year. On the assumption that all PCs are used continuously for these times, the cost per system, per usable hour, is 56 cents.
The laptops are harder to quantify, but the best case, assuming 24 hours, 365 days per year would make the cost per system per usable hour only 22 cents. A more realistic estimate of 18 hours by 300 days per year would cost only 35 cents. Even if we assume similar usable hours for the laptops as for the laboratory machines then the cost per laptop usable hour is 52 cents.

A Library study has shown that 34% of current students already own a laptop computer. The ease of access provided by the wireless network needed to support laptop activity could be expected to significantly increase this number and thus reduce dependency on University provided equipment.

It is not being argued here that all PC laboratories could or should be replaced by wireless enabled laptops. It is demonstrated, however, that cost is no overwhelming inhibitor to the use of laptops and may even facilitate additional savings, as well as the provision and promotion of wireless access to networked information, in support of flexible learning and teaching.

Costing a PC laboratory

The following assumptions are based upon normal usage with costing provided by Facilities and Services. The exploratory project in “Mobile Computing” has provided experiences for ITS and the Library which make a realistic comparison possible. Table 1 summarises the costing using the “best case” comparison in favour of the laptop solution.

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>First Yr Cost</th>
<th>3 Year Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of PCs</td>
<td>1</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Space (Sq M)</td>
<td>3.05</td>
<td>61.05</td>
<td>61.05</td>
</tr>
<tr>
<td>Leasing cost of PC</td>
<td>$561</td>
<td>$11220</td>
<td>$33660</td>
</tr>
<tr>
<td>Leasing cost of room</td>
<td>$235.40</td>
<td>$14371</td>
<td>$43113</td>
</tr>
<tr>
<td>Furniture Cost</td>
<td>$81.87</td>
<td>$1637</td>
<td>$1637</td>
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<tr>
<td>Provision of network/power pt.</td>
<td>$250</td>
<td>$5000</td>
<td>$5000</td>
</tr>
<tr>
<td>Incremental network cost</td>
<td>$840</td>
<td>$5600</td>
<td>$16800</td>
</tr>
<tr>
<td>Software and systems maint.</td>
<td>$157.72</td>
<td>$3154</td>
<td>$9463</td>
</tr>
<tr>
<td>Cleaning cost per sq m</td>
<td>$10</td>
<td>$610</td>
<td>$1831</td>
</tr>
<tr>
<td>Security cost per sq m</td>
<td>$6.24</td>
<td>$381</td>
<td>$1143</td>
</tr>
<tr>
<td>Light, Power etc. per sq m</td>
<td>$10.62</td>
<td>$648</td>
<td>$1944</td>
</tr>
<tr>
<td>Other facilities per sq m</td>
<td>$15.19</td>
<td>$927</td>
<td>$2782</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$43549</td>
<td>$117374</td>
<td></td>
</tr>
<tr>
<td>Unit cost per annum</td>
<td>11</td>
<td>$2177</td>
<td>$1956</td>
</tr>
<tr>
<td>Availability (average hrs per day)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cost per system per useable hr</td>
<td>41.44%</td>
<td>$0.60</td>
<td>$0.54</td>
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</table>

Note: rounding errors apply
Table 2: Cost for the wireless laptops

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>First Yr Cost</th>
<th>3 Year Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of PCs</td>
<td>1</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Library Storage Space (Sq M)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Leasing cost of laptops</td>
<td>$1172.60</td>
<td>$23452</td>
<td>$70356</td>
</tr>
<tr>
<td>cost of library space</td>
<td>$235.40</td>
<td>$942</td>
<td>$2825</td>
</tr>
<tr>
<td>cabinet Cost</td>
<td>$2500</td>
<td>$2500</td>
<td>$2500</td>
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<tr>
<td>power pt. Access (5)</td>
<td>$80</td>
<td>$400</td>
<td>$400</td>
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<tr>
<td>Incremental network cost</td>
<td>$137</td>
<td>$2740</td>
<td>$8220</td>
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<tr>
<td>Software and systems maint.</td>
<td>$315.44</td>
<td>$6309</td>
<td>$18926</td>
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<tr>
<td>Cleaning cost per sq m</td>
<td>$10</td>
<td>$40</td>
<td>$120</td>
</tr>
<tr>
<td>Staff cost for loaning laptops</td>
<td>$4107.50</td>
<td>$4107</td>
<td>$12322</td>
</tr>
<tr>
<td>Power for re-charging</td>
<td>$10.62</td>
<td>$53</td>
<td>$159</td>
</tr>
<tr>
<td>Other costs</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$40543</td>
<td>$115829</td>
<td>$115829</td>
</tr>
<tr>
<td>Unit cost per annum</td>
<td>$2027</td>
<td>$1930</td>
<td></td>
</tr>
<tr>
<td>Availability (average hrs per day)</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per system per useable hr</td>
<td>100%</td>
<td>$0.23</td>
<td>$0.22</td>
</tr>
</tbody>
</table>

Assumptions:
- 20 desktop PCs per laboratory
- 3.05 sq metres per PC
- Annual lease cost per PC - $561
- Annual lease cost of room - $235.40 per sq metre
- Furniture purchase cost per PC - $81.87
- Provision of network and power points per PC - $250
- Incremental network cost - $840 per system per annum
- Software and system maintenance - $157.72 per system per annum
- Cleaning costs - $10 per sq metre per annum
- Security and supervision - $6.24 per sq metre per annum
- Light, power and air conditioning - $10.62 per sq metre per annum
- Other Facilities related costs - $15.19 per sq metre per annum

Over three years this comes to a total of $117,374, or $39,125 per annum, as the cost of providing and operating a PC laboratory. Currently, laboratories managed by ITS are open for 330 days each year and an average of 11 hours each day. This makes the cost of each usable hour 56 cents on the assumption that all systems are used during these hours. In practice one might reduce this to 80% of usable hours to allow for periods of low demand (69 cents per usable hour).

Costing of wireless laptops

These costings are based upon experiences gained during the exploratory project.

Assumptions:
- 20 laptops available for loan
- Library storage space required – 4 sq metres
- Annual lease cost per laptop - $1,172.60
- Annual lease cost of Library space - $235.40 per sq metre
- Storage cabinet for PCs - $2,500
Additional power points – five at $80 each

Incremental network costs - $221 per system

Software and system maintenance - $315.44 per system per annum

Library cleaning costs - $10 per sq metre per annum

Library staff costs - $4,107.50 per annum

Power for recharging - $10.62 per power outlet per annum

Over three years this comes to a total of $113,228.79 or $37,743 per annum. If we assume that laptop availability is the same as that for laboratory machines then the cost per usable hour per laptop is 52 cents. The best-case situation of 24 hours by 365 days reduces this to 22 cents. A more realistic usage of 18 hours per day for 300 days per annum gives 35 cents per usable hour.

Costing summary

Conventional wisdom indicates that because laptop systems are about twice the cost of a desktop system to purchase, then their use must be restricted. However, when one takes into account the total running costs, including dedicated space and amortise these over three years, then the flexibility of the wireless laptop brings the costs down to better than even.

The following table illustrates this:

<table>
<thead>
<tr>
<th></th>
<th>Desktop</th>
<th>Laptop</th>
</tr>
</thead>
<tbody>
<tr>
<td>330 days by 11 hours</td>
<td>56c</td>
<td>52c</td>
</tr>
<tr>
<td>Best Case</td>
<td>56c</td>
<td>22c</td>
</tr>
<tr>
<td>Realistic Case</td>
<td>69c</td>
<td>35c</td>
</tr>
</tbody>
</table>

In the light of this favourable cost advantage for the laptop, the University is able to examine the application of wireless access in terms of its value as an educational tool which can facilitate collaborative learning – in the classroom, across campus, around the city and overseas - by extending the range of mobile devices and learning contexts in which mobile technologies are employed.

The analyses regarding the cost effectiveness of wireless technology in conjunction with the data in the tables below permits some broad conclusions. First, in the hypothetical situation of comparing 20 PC laboratory with wireless laptops, it was founded that the total costs after the first-year was 7% less for wireless technology. At the end of three years, wireless technology using laptops still accrued a small cost advantage (1.3% less) in comparison to PC laboratory. Second, wireless laptops gain even a greater Unit cost advantage over the traditional PC lab when one acknowledges their greater availability than PC labs. For instance, over three years the cost per usable hour of wireless laptops is only 41% of the unit cost for PC labs.

Given that in both cost comparisons, both the laptops and PC’s are leased, it makes sense to adopt assets that have a greater opportunity for usage over each 24-hour cycle, as a real lease cost to the organisation still exists whilst assets are not being utilised. We do concede however, that students borrowing laptops on an overnight loan basis will probably not use the wireless connectivity, but will still able to use the
equipment on a “stand alone” situation away from the University’s Wireless LANs or via dial-up connectivity into the University’s network from a remote location. This still means that the laptops will be used for a greater period over a 24 hour time line than a fixed PC laboratory with it’s many traditional access constraints, as discussed earlier. Given these findings, it is concluded that wireless technology is more cost-effective than PC labs.

Acknowledgements

The authors wish to acknowledge the research assistance provided by James Tan, Michael Anthony and John Edwards.

References


