IMPLEMENTING WIRELESS MOBILE INSTRUCTIONAL LABS: PLANNING ISSUES AND CASE STUDY


Abstract (Summary)
In April 2002, the Technology Advisory Committee of the University of Hawaii-Manoa College of Education (COE) prioritized the upgrade of existing instructional computer labs. Following several weeks of research and discussion, a decision was made to support wireless and mobile technologies during the upgrade. In June 2002, the first of three wireless, laptop-based instructional labs was introduced. Two others were phased in during July and August. Wireless mobile computing technology can provide advantages in a teaching environment. Increased classroom capacity, reconfigurable furnishings, and reduced physical constraints offer instructors new options. Significant planning and allocation of resources are required for a successful implementation. During the COE implementation project; costs, wireless networking setup, access restrictions, power supply, and file storage were issues that required planning and decision-making. Security, maintenance, and piloting were planned and implemented. This COE case study follows a logical progression for planning a wireless mobile instructional lab, outlining relevant issues and relating decisions and plans from the college. [PUBLICATION ABSTRACT]

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ABSTRACT
In April 2002, the Technology Advisory Committee of the University of Hawaii-Manoa College of Education (COE) prioritized the upgrade of existing instructional computer labs. Following several weeks of research and discussion, a decision was made to support wireless and mobile technologies during the upgrade. In June 2002, the first of three wireless, laptop-based instructional labs was introduced. Two others were phased in during July and August. Wireless mobile computing technology can provide advantages in a teaching environment. Increased classroom capacity, reconfigurable furnishings, and reduced physical constraints offer instructors new options. Significant planning and allocation of resources are required for a successful implementation. During the COE implementation project; costs, wireless networking setup, access restrictions, power supply, and file storage were issues that required planning and decision-making. Security, maintenance, and piloting were planned and implemented. This COE case study follows a logical progression for planning a wireless mobile instructional lab, outlining relevant issues and relating decisions and plans from the college.

OVERVIEW

Faculty and students alike have been impressed with the significant changes in classroom environment created by the COE shift to mobile technology. Rather than a cluttered room full of monitors, cases and cords; students now enter what appears to be a conference room. One faculty member commented upon first entry, "This isn't a computer lab." He honestly thought he was in the wrong location.

If an instructor's lesson plan does not call for computers, the instructional space is no longer cluttered with machines simply because class is scheduled in a lab. Students no longer lurk behind bulky monitors, avoiding participation in discussion. Classroom furniture can be reconfigured to accommodate differing instructional activities. Students can physically assemble into groups while retaining their computer and network access. In short, the college's first reactions to mobile labs have met with strong approval from constituents. Faculty feedback has been extremely positive and students vocally express their appreciation for the new equipment, however the implementation of the new labs was not without learning experiences.

During the process of research, design, procurement, installation, troubleshooting, and implementation; we learned several lessons about wireless and mobile technologies as they apply to an instructional environment. The following discussion is organized to provide a sequence for planning similar labs at other institutions. It reviews the
University of Hawaii - Manoa College of Education lab configurations, then provides a discussion of problems encountered, lessons learned, and solutions offered.

COE CONFIGURATIONS

The College of Education has three wireless mobile instructional labs. One consists of Dell Latitude 610 PCs and the other two are based on Macintosh iBooks. 25 Latitudes are housed in a security cart with maximum capacity of 30. They are configured with Pentium III processors, 14.1 inch Screens, Windows XP Professional, 30 Gigabyte hard drives, internal wireless network cards, CD read/write drives, 512 megabytes of memory, and fire wire adapters. Each Macintosh lab houses 25 iBooks and includes two security carts with maximum capacities of 16. The iBooks include 600 Megahertz processors, 14.1 inch Screens, OSX system software, 20 Gigabyte hard drives, integrated wireless network cards, DVD ROM/CD-RW combination drives and 384 Megabytes RAM.

For each computer lab, an additional "model machine" is kept outside of the lab to maintain operating system patches, software updates, and configuration changes. After significant changes to a model machine, it is used to "clone" the lab. They are also available for immediate replacement of any machine that fails. The labs also include external mice, wireless access points, external zip 100/250 drives, and external floppy disk drives. Our instructor and student machines are identical in every way except for their labels.

DEFINE DESIRED OUTCOMES

Potential of the Technology

Defining desired outcomes for a wireless project is critical because mobile computing presents new challenges as well as new advantages. Mobile (wireless laptop) computers can extend facilities into areas that lack network and electrical wiring for desktop systems - including outdoors. Conference rooms can become computer labs and revert to conference rooms with little setup and takedown. Furnishings can be re-arranged to accommodate specific teaching activities without disrupting network access. Perhaps most importantly, the elimination of bulky monitors, towers, and wired mice can significantly increase classroom and enrollment capacity.

COE Desired Outcomes

COE chose to replace desktop computer labs at the end of their useful life cycle. The primary motivation for implementing mobile technologies in the computer upgrade was flexibility of use. It was anticipated that a mobile instructional lab could be used in multiple locations and provide the ability to reconfigure classroom layouts. This turned out to be the case, however, more important advantages were discovered during the process - most importantly, is a forty percent space savings. In the classrooms where the labs are typically used, 24 students can be accommodated with wireless laptop computers. This is a significant improvement from the 17 desktop computers supported in the same space. The increased capacity results from elimination of bulky monitors, use of track pads rather than external mice, and more efficient configuration of classroom furniture.

The ability to reconfigure furniture created another valuable benefit - a complete change in teaching atmosphere. Instructors and students are no longer separated by monitors and a maze of cables. Laptop monitors can be quickly closed to eliminate the physical barrier altogether. Using a semi-circular classroom layout, instructors can casually circle a room while observing student progress. With monitors down, students can not hide during discussion periods, or surf the web instead of participating in class. In essence, the instructional process can become the focus rather than the computer.

ASSESS LAPTOP AND WIRELESS ISSUES

Laptop Difficulties

Mobile computers offer new instructional options; however, there are difficulties to consider. First and foremost is price. Generally, wireless laptops cost 50% to 100% more than their desktop counterparts. Laptops are also harder to upgrade most have proprietary hardware components that limit future options.

Designed for users on the go, laptop screen sizes are generally 14 or 15 inches versus 17 inches for desktop machines. Screen size must accommodate typical use. For example, if video or photo editing is primary, large monitors may be required. Instead of mice, laptops come equipped with track pads, pointing sticks, or similar compact pointing devices. Some users may find these pointing devices uncomfortable and users with wrist trouble may prefer external mice.

Power is another critical issue with laptops. Typically, batteries last from 2 to 4 hours depending on capacity, use, and age. To complicate matters, batteries take time to recharge, usually a few hours. In an instructional lab, one class may exhaust the batteries, leaving the next class without power. There are two solutions available: redundant...
batteries or AC cords. A multiple-battery charger may be available depending on manufacturer and third-party options. Alternatively, AC adapters can be used directly to outlets. Both options carry a cost - batteries are not cheap and AC adapters are almost as expensive. With alternate batteries, laptops must be shut down to swap batteries - an instructional interruption. If AC adapters are used, sufficient outlets are required.

**Wireless Worries**

Wireless networks works much like cordless telephones. A wireless access point is powered and plugged into a wired local area network like a cordless telephone base is powered and plugged into a phone jack. A wireless network interface card (NIC) in the computer acts like the cordless telephone handset. As distance increases between the access point and the NIC, the signal decreases until it fails, just like the reception in a cordless telephone.

The first consideration of wireless technology is bandwidth. 802.11b (one of four existing wireless Ethernet standards) was then the most available and affordable specification. It allows a maximum of 11 megabits per second (Mbps). Evaluation of a computer lab's primary use will dictate the bandwidth necessary to provide effective connections. Wired Ethernet LANs are typically 10 or 100 Mbps.

A second consideration of wireless networking is security. Similar to the cordless telephone example, your wireless NIC and base station send radio signals that can be "listened to". The 802.11b standard provides a form of encryption known as WEP (Wired Equivalent Privacy), however it is notoriously weak.

Security also means controlling access to your network. Mis-configured wireless access points present a security hazard. Anyone with a wireless computer could have full access to your LAN unless restrictions are implemented. One option is to control access to the network based on the individual machine's MAC address (Message Authentication Code), a unique number that identifies its NIC. Unknown computers may be denied access if their MAC address is not in an authorized list. Other alternatives, such as a virtual private network system (VPN) also exist.

**Wireless Wonders**

Wireless networks come with several advantages. The first is the simple lack of network wires. Wireless connections can be installed in desktop or laptop computers to extend the range of your network beyond the reach of existing cable infrastructure. When coupled with mobile computers, wireless connections enable access to network and Internet resources from a range of locations. It is the ability to maintain network access while mobile that enables the use of laptop configurations for instructional purposes. The mobile computer provides many additional advantages.

**Laptop Strengths**

Anyone with experience setting up a traditional computer facility is familiar with the mess of "spaghetti" that results from the computer's power cord, monitor cords, monitor's power cord, network connection, mouse cord, keyboard cord, assorted power strips and surge protectors. Multiply that list times twenty or more computers in one room and you have, literally, bundles of problems. Wireless laptop computers eliminate the vast majority of cords and significantly clean up the computing facility.

The mobility that a wireless laptop lab provides is instructionally beneficial in many ways. Without the complication of wires and the resulting location permanency of individual machines, classrooms can be reconfigured with instruction rather than cables in mind. Layouts can be reconfigured to accommodate the needs of an individual class as frequently as needed. Students are able to work in groups while retaining computers rather than being physically bound to the static room layout.

Mobility also allows the lab to relocate based on space needs and instructional demand. Computer and space resources can become de-coupled, allowing for more efficient use of both. This creates the need for a more complex reservations system - a good challenge to have.

Laptops take up significantly less surface space than desktop computers. Surface space required is reduced by as much as forty percent. A reduction in required space translates to increased classroom capacity and again into the potential for increased enrollments. This potential alone may make mobile computers worth their investment.

**COE Consideration of Laptop and Wireless Issues**

On the College's local area network, 10 Mbps connections at the desktop are typical - hence the wireless connections provide similar connectivity. If instructional use required higher-bandwidth connections, wireless would not suffice.
In the College's wireless system, access to the network is controlled based on the individual machine's MAC address. The list of authorized MAC addresses is maintained by individual access points. A new RADIUS server (Remote Authentication Dial-in User Service) will soon control this list from a central point. This is an important consideration because the list requires updating if new faculty are granted access or departing personnel must have their access deleted. If an unknown wireless computer comes in range of an access point, the MAC address is not approved and the machine is denied access.

To address battery depletion, we chose to use external AC adapters. An examination of COE class scheduling revealed that over half of our courses allow a break of several hours between classes. This translates into adequate time for recharging batteries. For classes that find themselves with depleted batteries, AC adapters are available in each security cart. In the classrooms where these instructional labs are typically used, we added surge protective power strips underneath table tops and along some walls. When a class needs to plug into AC power, the resulting addition of cords is managed quickly and conveniently.

**DEFINE SOFTWARE SPECIFICATIONS**

For a new computer lab, the most important assessment required is software because software dictates hardware requirements. The proposed operating system (OS) dictates a minimum hardware configuration. Other requirements of the planned application software may build on that minimum. If software will be reused from older installations, an inventory of licenses should be completed. Individual software titles should be verified for compatibility with the operating system and for any specific hardware requirements above and beyond those dictated by the OS.

**COE Software Considerations**

Because of the strong influence of Apple in educational institutions, the College teaches on a dual platform basis - both Windows and Macintosh machines. In the case of UH-Manoa COE, we designed three separate computer labs. Because the project included the addition of a third instructional lab, our Technology Advisory Committee was consulted as to the OS priority for the additional lab. Most members indicated that added capacity should be Windows based. Upon wider circulation of the issue, however, many others expressed the need for expanded capacity in an Apple environment. The additional capacity was finally planned as a Macintosh lab.

We chose Windows XP and Macintosh OSX, the latest operating system versions for the respective platforms. Because we planned to purchase systems with the operating system preinstalled, there was little need to analyze the OS hardware requirements - vendors ensured compatibility.

It is important to note that using the latest OS can provide some challenges. In prior experience, we have been frustrated by the absence of device drivers which left older peripheral equipment useless. In this case, we experienced some minor trouble loading HyperStudio for OS9, into our OSX machines. OS9 applications are supposed to be compatible under OSX, which runs classic environment” - an OS9 emulation - to operate them. In the end, an Apple Systems Engineer was able to tweak HyperStudio into running. We also experienced difficulty with Visual Basic 6.0 which would not load in Windows XP.

We moved from the OS to an examination of the software required for instruction. The increased number of computers in each lab combined with the addition of a third lab made software licensure inventory a real headache. Previously, there was no central recordkeeping of software licenses, and the ownership of software was spread between various departments, grant projects, and individuals. It took several hours of phone-calls, cross-checking, and tallying to determine the number of licenses we would need to purchase for the new labs. In the end, we successfully purchased additions and upgrades to accommodate new operating systems and additional capacity.

**DEFINE HARDWARE SPECIFICATIONS**

In addition to the hardware specifications that your proposed software requires, it is important to consider file storage methods, expansibility, and upgrade potential of the hardware you purchase. Additionally, external mice may be considered as an addition to the laptop's built in device. Because laptop computers are more difficult to upgrade than desktops, it is advisable to purchase as much power as possible from the start.

**File Storage Options**

File storage choices can provide a dilemma in mobile lab planning. Floppy disks simply do not have the capacity for large files. Network storage may provide an adequate solution, but the availability of file servers depends on your institution’s existing network resources. ZipC drives are another popular file storage solution. Older Zip drives hold 100 Megabytes (MB) and operate much like a floppy disk. Newer drives are capable of 250 MB or even 750 MB. Zip drives are easy to use, fairly fast, and hold an adequate amount of data. There are, however, several disadvantages to Zip drives. The foremost concern is availability of other Zip drives. If students save their work on a
Zip 250 in your instructional lab, but return home to a Zip 100 drive, or more likely no Zip drive at all, their data is inaccessible. Zip disks are also costly, typically over $12 for 100 MB of storage capacity (Zip100’s).

A newer file storage option is the recordable compact disc or re-writable compact disc (CD-R or CD-RW). These disks come in 600 to 700 MB sizes, and are available almost everywhere. Better yet, the cost is remarkably cheap by comparison to Zip drives - around five cents for 100 MB. Unfortunately, recordable CDs have drawbacks too. CD recordable drives, record slower than Zip drives. Convenient recording of CDs requires appropriate software such as Roxio’s Toast (Macintosh) or Easy CD Creator (Windows). With CD-Rs, the data is permanently written to the media, erasure is not an option. CD-RWs allow erasure and re-use of the disc.

COE File Storage Considerations

Early in the planning process, the COE technology committee discussed file storage and settled on CD recordable drives as the best option. Each computer in our instructional labs is outfitted with a CD burner. In order to accommodate users who need to transfer files from other media, each lab also supplies a pair of external floppy drives and a Zip 100/250 drive. These external drives connect via universal serial bus (USB), which is a quick and easy connection and powers the drive without using a separate electrical cord.

Our Windows based laptops are equipped with Roxio's Easy CD Creator while the ibooks have Roxio's Toast installed. During the planning process, we made the mistaken assumption that each computer would be shipped with adequate software to operate the CD recorder. This was the case with the Windows machines, which shipped with Easy CD Creator. The ibooks, on the other hand did not come with Toast. After experimenting with the CD burning features built into Macintosh OSX, we found it completely inadequate. Toast was an expensive addition (about $70 per computer, purchased in sets of ten) that we found necessary in order to provide usability.

Students also have the option of storing their files in their University Unix account, which provides 20 MB of space. For most students, however, the use of a file transfer protocol (FTP) program is foreign. Because it requires learning new software and is limited to 20 MB, we do not anticipate that this method of file storage and transfer will be widely used.

Expandability Issues

Laptops tend toward proprietary design, so their expansibility is limited. Desktop configurations can accept standard PCI (Peripheral Component Interconnect), ISA (Industry Standard Architecture), and IDE (Integrated Drive Electronics) devices. Each of these standard interfaces allows connection of devices inside the case of a typical desktop computer. Most devices added to a laptop, however will be external. The ability to connect to convenient and high-speed external devices is therefore important. USB and firewire are common high-speed ports that allow such peripheral connections.

COE and Laptop Expandability

Our Dell and iBook laptops came standard with USB ports, allowing easy connection of external mice, printers, scanners, and other devices. The iBooks also included a fire wire port, which is commonly used to attach external hard drives or video cameras since the data transfer speed is much higher than USB. The Dells, however, did not come with firewire capability. Because some of our courses would be using digital video in a Windows environment, we addressed this issue by purchasing PCMCIA (Personal Computer Memory Card International Association) firewire adapter cards. PCMCIA is a standard laptop expansion slot named after the association that created the standard. These cards add two firewire ports to the laptop when connected. Their use, however, is not as convenient as an integrated port, and their external nature makes loss or theft an additional hazard.

COE and Pointing Devices

Initially, the issue of suitable pointing devices was not addressed. It was assumed that users would use the on board track pad or integrated pointing stick (on the PCs). Several concerns were raised, however, about personal preference; physical restrictions; and ergonomics. After receiving several requests for external mice, we made USB connected mice available for class use. The vast majority of students opt to use the on-board pointing devices instead, but mice are available to those who prefer them.

PLAN FOR SECURITY

The portable nature of a wireless laptops and their high price tag makes them potential theft targets. Individual computers or peripheral devices are easy to walk off with. On a larger scale, the entire lab may be housed in a security cart that could be quickly rolled out of a building. It is important to provide for physical security and to train instructors in appropriate procedures to protect the investment. Recording serial numbers, use of locking security...
carts, and cabling carts to fixed objects are all recommended. Combination locks eliminate the necessity to distribute keys.

COE and Security

Our first step toward security was to record serial numbers of all the laptop machines in order to assist with recovery efforts in case of a theft. Each machine was then labeled with an individual number, ie. Mac-1 through Mac-24 and PC-1 through PC-24. The associated peripheral devices (floppy drives, zip drives, scanner, mice, AC adapters) were also labeled.

Each security cart contains a set of computers and is locked with a re-settable combination padlock. The appropriate combinations are distributed through departmental secretaries to individual instructors who require access to the computers. The combinations are reset after each semester. Additionally, each cart is secured with a 20mm cable and combination lock to eyebolts that were set into the floor at designated points for this purpose. These combinations differ from those required to open the carts and are not distributed until the lab is needed in an alternate location.

Finally, a faculty orientation is required prior to teaching in the portable tabs. The orientation includes several security policies and we discuss responsibility for the equipment and the cost associated with the lab. Faculty are requested to assign a specific machine to each student for the entirety of the semester. This provides a starting point for investigation if malfeasance should occur. Faculty are also requested to remain in the classroom while the laptop lab is in use.

PLAN FOR LAB MAINTENANCE

Maintenance of any computer lab is an issue that must be planned for. Changes may be required at frequent intervals. New versions of software are released constantly. Viruses are discovered and countered with updated virus scanner definitions. Departments add or change the software used for instruction. Operating systems release security updates and patches continuously. System errors occur due to mischief or error and must be remedied.

A system should be in place allowing for regular updates and maintenance of each computer. Preventative measures such as virus protection and system security software are important. Software upgrade and reloading measures are equally important. Some individual(s) must be designated to oversee lab maintenance and the appropriate equipment must be available to aid in this task. Software that creates and distributes images of an entire machine is useful for all of these issues. Images can be used to update an entire lab or to reset an individual machine.

COE Instructional Lab Maintenance

In the past, Educational Technology faculty have served as the de facto instructional lab technicians. In order to properly maintain the computing environment, I created a new student position which, under my supervision, maintains the computers and responds to faculty requests. This has resulted in much higher faculty satisfaction as troubleshooting is no longer expected of them.

To prevent viruses and mischief, all of our PCs are equipped with Deep Freeze software. This package allows users to make any changes they wish to the system, but reverts to the system's initial state when rebooting. The PCs reboot on a predetermined schedule, every morning at 7:30 AM. Each PC also has a small directory assigned which will not be destroyed during rebooting, so files there are safe. Unfortunately, similar software was not available for Mac OSX, leaving our machines vulnerable to mischief. The Macintosh computers are, however, equipped with Virex for virus protection.

Software distribution and troubleshooting are both handled with Norton Ghost for the PC machines. Ghost allows the distribution of a machine's image to be installed on another computer. The image includes all software and settings. Using this system, we simply maintain one "model" computer outside of the instructional lab. The model gets all OS updates, new software, and configuration changes first. When it is configured to our satisfaction, we employ Norton Ghost to "clone" it across the lab. While a corporate version of Ghost is available which would allow more advanced techniques, we currently use the basic version and clone using crossover cables (ethernet cables used for direct PC to PC communication). Cloning a machine in this manner takes about ten minutes. After the first clone, both the model and the clone can initiate the cloning process to speed up recreating an entire lab.

Software distribution and troubleshooting are handled similarly in our Macintosh labs using Apple Software Restore, a package available from Apple. Since the Macintosh machines have firewire ports which provide extremely fast data transfer, we use an external firewire hard drive to clone machines. Using Apple Software Restore, a complete image of our Macintosh model machine is stored on the external drive, then transferred to the cloned machine. Creating the disk image takes about one hour. Distributing the image takes about ten minutes per machine. Since
the time required to clone is so short, it is generally easier to reclone the machine rather than troubleshoot problems.

PHASE IN THE NEW TECHNOLOGY

It is a real advantage to be able to pilot a new instructional lab before the old lab is dismantled. In the case of wireless mobile computers, this is entirely possible. Asking one or two interested instructors to use the new machines allows for the identification of unforeseen glitches and communication problems. If more than one lab is under development, pilot testing the first will save time on the task of implementing subsequent labs.

COE Pilot Experience

The first instructional lab piloted was a Macintosh lab and we put it into use during the first Summer term of 2002. A group of faculty was asked to attend an orientation, and as luck would have it we discovered a major problem two days prior. Our setup worked beautifully, until two computers attempted to run the same Microsoft Office product simultaneously. The second computer would display an error message indicating a licensure conflict between the machines. We later discovered that Microsoft had mistakenly provided a single user license copy of Office for OSX rather than the site licensed version we had obtained through a grant. Microsoft Office for OSX scans the local network for illicit copies of the software and concluded that we were out of license compliance. Once re-installed from the site license CD, the problem disappeared.

After ironing out the first Macintosh lab, we piloted the PC lab with a class during the latter half of the first Summer term. In this case, there were no problems and we were rewarded by students’ vocal approvals of the new equipment. The PC lab was then fully deployed during second Summer term. A second Macintosh lab was also added at this time.

COE Faculty Orientation and Support

Change is difficult, especially when faculty are expected to use new technology in teaching. It is important to provide orientation and support to those who are changing from older technology to new equipment. We did this through a series of orientations and personal presence during initial class periods. Summer instructors were provided with personal orientations to the equipment and inperson support during their first few classes. We offered a series of orientations over the course of the week prior to Fall 2002. During orientations, faculty are advised on gaining access to the room via numeric code, opening security carts with combinations, distributing machines to students, and overseeing the use of the equipment. Additionally, we walk through startup and shutdown of computers, how to bum CDs, and using the peripheral equipment.

FINAL THOUGHTS

The teaching environment in a wireless mobile instructional lab differs significantly from that of a traditional static computing facility. Mobile technology is more expensive and requires significant planning and allocation of resources; however, the rewards do outweigh the risks. A careful consideration of the issues will streamline implementation.

[Author Affiliation]
PAUL B. MCKIMMY
University of Hawaii-Manoa

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Author(s): Paul B McKimmy
Author Affiliation: PAUL B. MCKIMMY
University of Hawaii-Manoa