

Anytime, Anywhere Learning– Wireless Mobile Technology in the K-12 Classroom

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Introduction and General Trends

The use of wireless technology in the K-12 environment has exploded over the last several years as the technology has significantly improved and the costs have dramatically decreased. Some schools began exploring the use of portable computers in the early 1990's. The experiences of these early adopters over the years and the growth of the technology itself have moved the use of wireless technologies into the mainstream. According to a recent study by the Peak Group (2002) titled "Wireless technology in education: Moving from pilots to mainstream," 62% of the schools or school districts in their survey are currently implementing some type of wireless technology and another 29% are in the pilot stages.

Rockman (2003) found that ubiquitous computing has "substantive impacts on teaching and learning" but could not directly connect having full-time access to computers to the outcomes of current standardized test. "Our belief is that, while computers are powerful interventions for both students and teachers, what they do with them is not what is tested." He points out, however, that student access to powerful tools for writing, conducting research, and organizing information does support the learning strategies that do show up on tests.

The wireless technology being used in K12 schools includes a wide range of devices, including laptop computers, tablet computers, personal digital assistants (PDAs), AlphaSmarts, and probeware. In this paper, we will be mainly focusing on laptops and PDAs. The ways in which these mobile, wireless devices are being deployed range from one or a few shareable classroom sets per school (portable labs) to one laptop or handheld device for every student (so-called one-to-one or ubiquitous computing). What is very clear from the wide variety of case studies and experiences is that there is no "one size fits all" scenario. The choices of devices and deployment methods depend on an individual school's current infrastructure, budget, and instructional needs.

Portability was the main benefit identified by 80% of respondents in the Peak Group (2002) study. One of fastest growing uses is for portable labs or COWS (computers on wheels), particularly in overcrowded buildings with no space left for a fixed lab. The trend is to move computers to where the learning is occurring rather than moving students to the computers.

Wireless Networking Basics

Wireless networking refers to any technology that enables two or more computers or other devices to communicate without direct network cabling using standard network protocols such as TCP/IP (see www.vicomsoft.com/knowledge/references/wireless1.html for a general overview). Standard wireless networks use radio frequency (RF) technology, which is alternating current used with an antenna to produce electromagnetic fields for broadcasting. It includes the IEEE 802.11 standards, which are the most commonly used for wireless networks, as well as others, such as Bluetooth for point-to-point communication. Infrared (IR) is another technology used for line-of-sight communications, such as beaming between PDAs.

The table below shows the most commonly used 802.11 wireless standards with their associated throughput (speed), frequency, and approximate range. Wi-Fi, or wireless fidelity, refers to a

wireless network associated with the faster IEEE 802.11b and 802.11g standards. The newly adopted 802.11g standards (adopted in June 2003) use the faster 54 Mbps for shorter ranges but can also use 11 Mbps for longer ranges and is therefore compatible with 802.11b devices and networks.

Standard	Frequency	Throughput max	Range max indoors
802.11a	5.0 Ghz	54 Mbps	60 feet
802.11b	2.4 Ghz	11 Mbps	300 feet
802.11g	2.4 Ghz	54 Mbps and 11 Mbps	300 feet

The distance ranges are highly variable and depend on both equipment and building infrastructure. Inexpensive hardware and software solutions generally have shorter ranges. Higher ranges can be obtained with more expensive hardware that uses antennae and other range-extending technologies. The only way to determine actual ranges is to conduct a site survey using the actual equipment that is being proposed because different makes and models of access points, laptops, and wireless cards can produce very different results.

There are two types of wireless networks:

- Peer-to-peer wireless networks consist of two or more laptop computers (or handheld devices) equipped with like wireless interface cards. They can communicate with each other and share files via the computer's peer-to-peer file sharing services.



Figure 1: Peer-to-peer wireless network (from <http://www.vicomsoft.com/knowledge/reference/wireless1.html>)

- Wireless networks can be connected to a wired LAN or WAN via access points (also called base stations) to allow wireless devices to access network resources such as file servers, printers, or the Internet. The number of simultaneous wireless connections that can be supported varies from a few to a hundred or more depending on the specific configurations. There are two basic types of access points:
 - Dedicated hardware access points are separate devices directly connected to a wired network (such as Apple's Airport base station or Orinoco/Lucent's WaveLAN). Prices for hardware access points have dropped significantly over the last few years and now

range from under \$100 to several \$1000 for enterprise solutions.

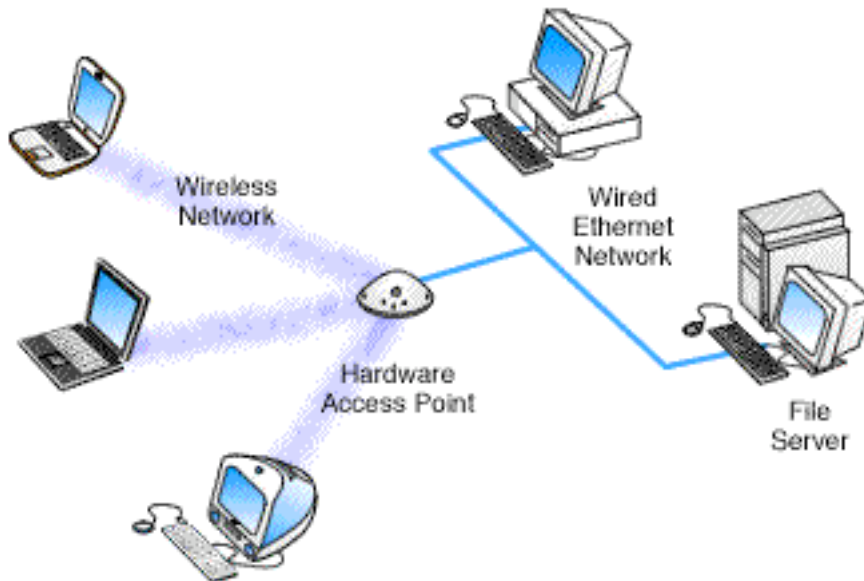


Figure 2: Hardware access point (from <http://www.vicomsoft.com/knowledge/reference/wireless1.html>)

- Software access points run on a computer directly connected to a wired network and configured with a wireless network interface card and special wireless network routing software (such as Apple's Airport software or Vicomsoft's InterGate software).

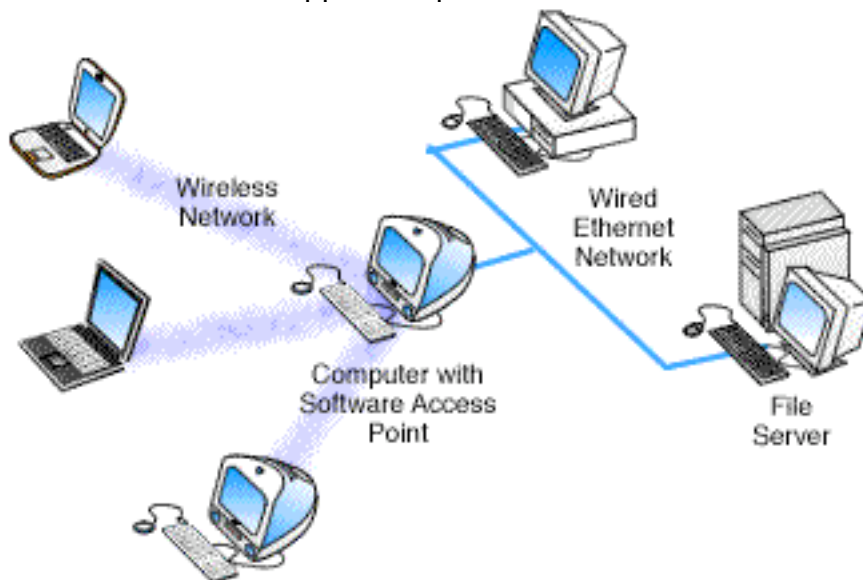


Figure 3: Software access point (from <http://www.vicomsoft.com/knowledge/reference/wireless1.html>)

Multiple access points can be set up to create overlapping wireless coverage by designating that each access point use a different "channel" from among the 11 channels available in the 802.11 standard. For greatest fidelity and least interference, adjacent access points should use channels that are separated by at least 3 values (i.e. channel 3 and 7). Overlapping coverage from access points using the same or close channels can cause loss of connectivity. Roaming can be enabled between access points so that a wireless computer can move from the coverage area of one access

point to the coverage area of another access point without losing connection. The hardware and software on the computer monitor the signal strength from in-range access points and connect to the one with the best signal.

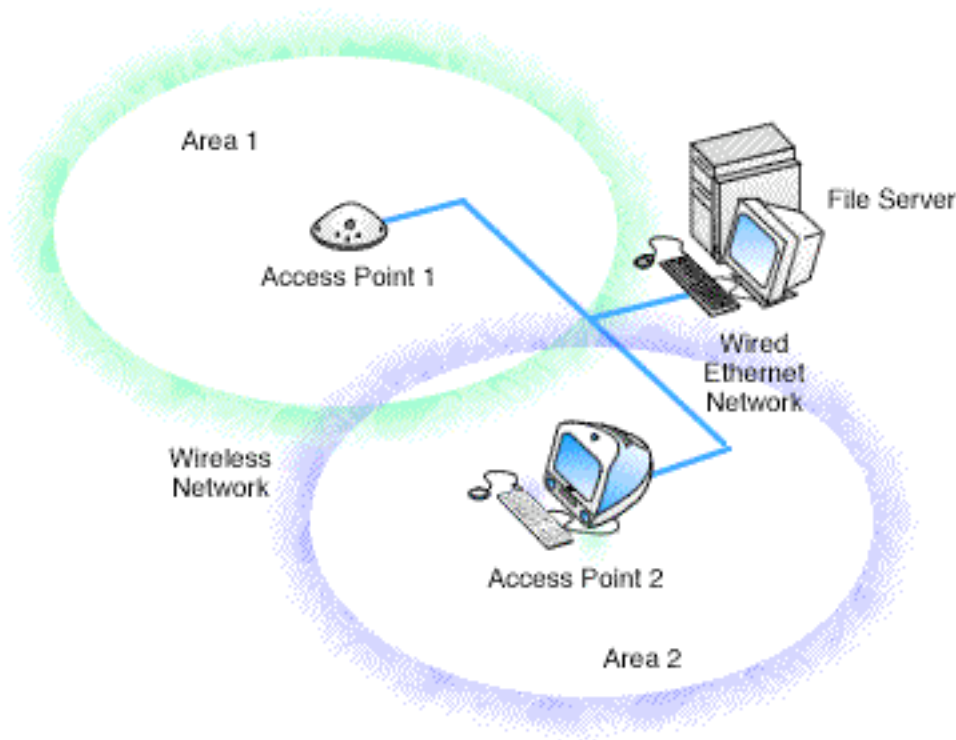


Figure 4: Roaming between access points (from <http://www.vicomsoft.com/knowledge/reference/wireless1.html>)

Advantages and Disadvantages

The following discussion has been derived from many sources, primarily referring to laptop computers but also applicable for handhelds. It includes both technical and instructional issues. McKenzie (2001) believes that the many advantages of wireless notebook computers may help recruit the “enthusiast daily use of those teachers who have been hitherto reluctant” to integrate new technologies.

Advantages include:

- Portability—Notebook computers and handhelds can be clustered together to achieve a critical mass of utility for class-wide projects and can be easily moved to wherever students are learning.
- Relaxed fit—Notebook computers and handhelds have a small footprint that can be used on almost any surface (desk, floor, lap) without requiring any modifications to the classroom setting.
- Strategic deployment—Deployment of technology should be based on optimizing use and quality of purpose in a standards-based learning environment. McKenzie (2001) believes this involves a “marriage of equipment and program” where the mobility of notebook computers and handhelds can promote genuine program integration. Design should follow function.

- Flexibility—Notebook computers and handhelds can be used in whatever ways best fit a teacher’s style and lesson plan. Form follows function and purpose.
- Neatness—Wireless notebook computers and handhelds do not need the messiness of network cables and power cords.
- Low profile—Because notebook computers sit lower on a desk, teachers are better able to monitor activities, including student needs for assistance and proper behavior.
- Convenience—Computers and handhelds that fit easily and comfortably into the classroom setting and daily routines are more likely to be used.
- Simplicity—District networking stability, combined with the relative simplicity of notebook computers, can now allow true “plug and play” (without the need of the plug).
- Speedy deployment—Wireless notebook computers and handhelds can be quickly deployed and put to use wherever they are needed.
- Cost efficient extension of wired networks—It is most cost efficient to wire a building during its construction; retrofitting older buildings with additional fixed wiring is extremely labor-intensive and therefore costly. The significant decreases in the cost of wireless technologies have made wireless options more cost effective in most cases.

Some disadvantages include:

- Startup costs—The initial costs of setting up a wireless infrastructure of properly positioned and configured access points may seem high. In addition to the wireless components themselves, in many cases the underlying wired network infrastructure may need to be upgraded to adequately support the wireless network (faster switches in the network closet; additional wired drops). The cost of laptop computers is generally higher than equivalently configured desktop computers, they are more expensive to upgrade, and they generally do not last as long. Schools need to evaluate the total cost of ownership and value to student learning as part of the planning and decision process.
- Battery life—The newer lithium ion batteries in most laptops now last for 4-6 hours of continuous usage, but that may not be long enough to meet the needs for an entire day. Recharging time may need to be scheduled into breaks in the day to avoid being tied down to power cords. Batteries will also wear out over time and fail to maintain a full charge, so replacement needs to be built in to the budget.
- Managing and tracking—The additional time needed to manage and track the use of mobile devices, plan for system upgrades, and ensure batter recharging puts an extra responsibility on already-overloaded teachers.
- Damage—Notebook computers and handhelds are more fragile than most desktop computers. Some damage will occur even with the most scrupulous oversight. Some schools have addressed this issue by purchasing insurance policies and establishing strict usage policies.

- Theft—Laptops and especially handhelds have a high potential for “disappearing” during high usage. Fortunately, many schools have found this to be a relatively minor problem with strict management and enforcement of policies.
- Time and cost of staff training—Most case studies have mentioned the need and value of staff training in both the technical basics and instructional opportunities when deploying a laptop or handheld program. The costs associated with the actual staff development and the costs of a teacher’s time to attend the training and use the technology should be included as part of the upfront deployment costs. As Wheeler and Bausch (2003) noted, “Too frequently, technology arrives in a classroom and the corresponding staff development consists of the words, ‘Here you go.’”
- Technical support—A laptop or handheld program requires a new set of technical skills from school or district support personnel. In addition, teachers need to be comfortable with minor technical issues in order to maximize the use of wireless devices (dealing with batteries, network connectivity, basic equipment care). “Technology that does not work is a disruption to the educational process” (Wheeler and Bausch, 2003).
- Throughput—Wired networks still give higher performance and throughput as compared to wireless networks. The table below compares the theoretical maximum throughput of a variety of network services. On first glance, it would appear that an 802.11b wireless network would have about the same throughput as a 10Base-T Ethernet network (the older but still very common network standard in schools). But the wireless bandwidth is shared among all users in one location (one access point), which can create a potential bottleneck. For high bandwidth tasks, such as large graphics or video files being transferred across the network from a file server, wired networks are more efficient.

Type of service	Max Throughput
Modem	56 kbps
ISDN	64 kbps
LocalTalk	230 kbps
Bluetooth wireless	720 kbps
Cable modem	1-1.5 Mbps
T1	1.5 Mbps
10Base-T Ethernet	10 Mbps
802.11b wireless (2.4 Ghz)	11 Mbps
T3	45 Mbps
802.11a wireless (5.0 Ghz)	54 Mbps
802.11g wireless (2.4 Ghz)	54 Mbps and 11 Mbps
100Base-T Ethernet	100 Mbps
Gigabit Ethernet	1000 Mbps

- Interference—Other wireless devices, such as cordless phones, microwave ovens, or Bluetooth devices, can create interference and loss of network connectivity on Wi-Fi networks.
- Security issues—Wi-Fi networks a basic security standard called WEP (Wired Equivalent Privacy) that encrypts data using a simple encryption method that is relatively easy to break. A

new encryption standard, Wi-Fi Protected Access (WPA), has been recently developed but is not yet present in all wireless devices or in older existing devices. Basic security measures such as password access is often not implemented in schools because of the perceived hassles.

Handheld Computing in the Classroom

Schools and Districts across the county have adopted the use of hand held devices in an array of different ways. In a small district in Orland Park Illinois they equipped its three high schools with 2200 Palms. Students could buy or lease a PDA to be used in all their classes. Many schools are using hand held computing only in individual classrooms, where class sets have been provided by a special funding grant. In Michigan they have a state wide initiative to use wireless hand held computers. Schools can apply for grants to buy PDA's and the district will supply the teacher training. In South Carolina the District bought 160 Hand held computers for the media center that are checked out by teachers and students. Regardless of how the schools and districts are utilizing hand held devices, it all comes down to one motivating force, to get computing power to more students in an affordable way.

Hand held devices like personal digital assistants (PDA's) and hand held computers or Pocket PC's are filling that demand in schools across the county. PDA products are being made by several companies, iPAQ's by Compaq Computer Corporation; Jornades by Hewlett-Packard; and Visors by Handspring, inc., are just some of the companies competing for a piece of educational market. (Yuen). Their scaled-down nature, minimal energy requirements and reasonable price, make hand held devices a match for educational settings. PDA's are small enough to fit into a hand or a backpack, or pocket. They can function as a textbook, calculator, calendar, notepad and pencil. Students can edit word processing files and can access web pages. Most run on a Palm operating system (PalmOS) that integrates with a desk op computer.

Some type of handheld computer is made by most of the major computer manufacturers; Microsoft, Apple, Dell, and Hewlett-Packard. These devices are often called PocketPC's because they more closely replicate full-sized computers and use a different operating system (Windows CE) than the original PDAs and have more computing power. They also cost more. The lowest end Palm OS devise costs about \$130.00 and the most functional (full color expanded memory) pocket PC about \$600.00. Irregardless the two types of handheld devices are very similar and both are making an impact in the classroom.

The development of handheld applications by educational organizations has increased dramatically in the last few years. Several companies have developed an area of expertise and specialize in interactive software that focuses on specific areas of the curriculum. The University of Michigan's Center for Highly Interactive Computing in Education (HI-CE) developed interactive drawing programs, word processing and advanced organizers, which focus on the reading and writing skills. Other companies, The Concord Consortium for one, are specializing in Science and Math related topics. One program combined probes and sensors with handheld units to allow users to capture and analyze data "real time" in the field, then graph and display results on the spot or back the classroom desktop. (Shields)

Handhelds won't replace computers, yet. They don't have the memory or computing power that full-size computers do. But the manufacturers claim with handhelds, teachers and students can

accomplish about 80 percent of the things they can with a regular computer. With the combination of rapid software development and the mobility handheld computers bring they are becoming a change agent in the classroom.

What handhelds bring to the Classroom

A classroom where the teacher and all the students have handheld computing will bring a variety of unique features to the classroom, organization, flexibility, access, conservation of resources and a sense of ownership. The most visible change is the organization a handheld can bring to the daily activity of running a classroom. Papers do not have to be passed out; worksheets are beamed from the teacher to students. Homework is downloaded to a teacher's handheld before class begins and grades are beamed back to the students. Even authentic assessments are recorded while the teacher is walking around the room helping students. The teachers have access to student records wherever they are, lunchroom, hall or library and immediate consequence becomes an effective discipline tool. By easing organizational tasks and increasing efficiency this then allows the teacher to spend more time on academics.

The access and flexibility a handheld device brings to the classroom is not the most visible feature but is one that will affect the quality of the students' education. With stored web pages the students can have access to current information that is specific to what they are studying. Classic novels that are public domain can be downloaded and stored on the PDAs for as long as needed. This saves resources and the money that would have been spent on buying a class set of Romeo and Juliet books or printing out handouts for the entire class. Being able to take a hand held on a field trip to record observations and read additional information provided by the teacher can make a field trip a real time learning situation instead of a break from the classroom activities. Add a wireless connection, a laptop computer and the right software and the teacher can see what each student is doing on their own PDA's and provide immediate corrections to writing or math assignments. The wireless technology gives students access to experts and research with out having to journey to the computer lab or library.

Several high-quality applications make handheld devices versatile and usable in the classroom. Hot Sync enables PDA users to beam information to other PDAs. This way the teacher and students can exchange files without printing. Web Browser products for the PalmOS like AvantGo and palmreader can give students access to the World Wide Web. Both products let teachers select compact web pages to be HotSync'd to student handhelds and then read offline. The Palm eBook Studio is a program that allows teachers to create their own eBooks for Palm Reader. This works like a personalized web page, developed by the teacher, with content information for lessons. This information can be loaded to the students handheld and kept for reference throughout the year.

In Math and Science classrooms the handheld adds another dimension, because they go a step further than the graphic calculators. While the students are graphing a complex algebra equation, the note writing capabilities on a hand held take the assignment further by enabling imbedded assessment with in the assignment. This enables teachers to adjust instruction to meet the student's needs. For younger students, Cooties™ is a simulation program developed so students can use it collaboratively to examine the spread of disease in Science class.

Investing in hand held devices can address important equity issues for schools. With the power of current technology combined with ease, convenience and the low cost of portables devices, schools and districts can stretch their technology dollars and increase the student-to-computer ratio through out the whole district. A technology director of Consolidated High School District 230 put it this way, "Students need to use technology just as you and I do, not just one hour a day. Inexpensive handhelds are one way of achieving that." (Brown 1) Another benefit of using PDAs in the classroom is the sense of true ownership for the students. Steve and Patrivan Yeun, in their article about PDAs in Education, stated, "In most school students are able to use a desktop computer in a computer lab or classrooms they still must share with other students. In contrast a PDA functions as a true Personal Computer. This provides them with the feeling of true ownership" (Yeun 2). With the mobility a hand held gives students they can take them home and have them with them all the time. With ownerships comes pride and responsibility. Principles that are learned by experience, not something easily taught in a classroom.

Research on Handhelds in the Classroom

SRI International's Center for Technology in Learning, a nonprofit research group, completed one of the first studies of handhelds in K-12 classrooms. The researchers surveyed more than 100 teachers who had received handhelds through Palm's Education Pioneers Program. The teachers taught at all grade levels and in all subject areas, including science, special education, physical education, language, math, and social studies. The results of the study, released in September 2002, were:

- 93 percent of teachers believed the devices can have a positive impact on students' learning.
- 72 percent said handhelds were easier to integrate into classroom activities than desktop computers.
- 75 percent of teachers who let students take Palms home reported an increase in homework completion.
- 89 percent of teachers said handhelds are an effective instructional tool.

Learning Tool or Toy

With all the research and development that is going into the use of handhelds in education, not everyone is convinced they are the wave of the future for the classrooms. Many debates were raised in some schools on the use of PDAs. Administrators have banned their use saying some students use the little computers to cheat on tests, play non-educational games or email friends inside or outside of school. The state of Maryland, for example has just repealed a ban on handhelds owned by students. The ban had barred handhelds from campus since 1989. The repeal put the decision into the hands of each district and nine of the 24 school systems choose to keep the ban in place. (Trotter) According to International Communications Research, 23 percent of teens aged 13-19 say their schools forbid them from bringing in Palm Pilots.(Batista) Management is an issue with PDAs just like all new technology introduced into the classroom. Teachers have reported that the maintenance demands can become an issue such as keeping the batteries charged and transferring data regularly to more permanent storage on a desktop computer. However, the more handheld devices are integrated into the curriculum and become an indispensable part of the learning process, the more students will see PDA's as a tool rather than as a toy. As students engage in reading, writing and management activities daily with their PDA's, they will become like textbooks, notebooks and rulers, tools needed in the classroom.

As districts and schools creatively find ways to get computing power to more students in an affordable way is important not to repeat the mistakes of the past when the first computers were put into the schools. Like all new technology brought into the classroom, handhelds will only be as good as the support around the technology. There must be enough hardware for all the students, quality teacher training on how to integrate the handheld technology into the curriculum. Technical assistance needs to be in place at the schools as well as administrative and parental support for the curriculum and access to new software as it is developed for the handheld devices. With support structures in place handheld devices could be the flexible, affordable tool educators need to keep up with the digital generation.

Laptops in Schools

The introduction of computers into schools over two decades ago has allowed students access to a great learning resource. However, public school administrators are beginning to realize the failure of school computer labs. With the computer lab setting, students are taken out of the classroom, marched down the halls to a computer lab, and are allowed access to computers for a short time frame. Now schools are experimenting with wireless computing technology. Instead of taking kids to the computers, the computers are coming to the kids.

“Who’d give a sixth-grader a laptop? Someone who can’t even button his shirt?” Herman Gaither summarized his initial skepticism about the laptop concept. “What a dumb idea!” Then, pausing for dramatic effect, he added, “It’s a dumb idea until you watch it work.” (Johnstone)

Handing over a laptop computer that costs over a thousand dollars to an adolescent student can seem like one of the biggest mistakes a school can make. Trusting students to do the right thing is not always an easy feat to accomplish. When you combine computers with students, teachers and administrators must realize that incidents will occur. However the teachers and administrators must be willing to risk the chance of those incidents in order to achieve the benefits of a laptop program.

With the introduction of the world’s first school laptop program in 1990 at the Methodist Ladies College in Melbourne, Australia, the transformation of education had begun. The advances in laptop technologies have led to the creation of extremely powerful notebook computers that are priced at levels attainable for schools. School Laptop Programs (SLPs) are becoming more and more prevalent in private schools, and their emergence into public schools can be seen in a few lucky schools.

With the emergence of laptop technology, schools are integrating their use into classrooms in various ways. These include:

- Concentrated use-each student has his or her own laptop for use at home or in school
- Class set-a school purchased classroom set is shared among teachers
- Dispersed-in any given classroom, there are students with and without laptops
- Desktop-each classroom is permanently assigned a few laptops for students to share
- Mixed-some combination of the above

Advantages and disadvantages exist regarding each model, in terms of instructional benefits to savings. In the concentrated model, educators are able to fully integrate technology into instruction as well as assignments, as all students have access to a computer for homework, study,

and projects. However, in the class set model, teachers are able to fully integrate technology into classroom instruction, but there may be students who do not have access to a computer at home.

Because desktop computers are large and heavy, they usually are found stationed in a classroom, and rarely are moved. Laptops can be placed wherever you want them to be placed. They require no special office equipment and can be closed easily for storage. When a teacher is instructing in a desktop computer lab, the computer can become a barrier to the teaching process merely because of their size. Laptops interfere very little with the teaching environment, as students can easily look over the screens. Students also become more engaged in learning the content of the curriculum while at the same time developing competency using the problem solving environment provided by the computer.

There are many ways that laptops can be integrated into the classroom environment and used to accentuate learning. Laptops can help to promote a positive shift toward more project based, hands-on learning, away from lecture-based learning. This shift in teaching styles reduces reliance on lecturing, and increases authentic learning environments. Laptops help empower teachers to move from traditional delivery modes of instruction to methods of discovery and interaction, with increased individualization and customization of learning activities and materials.

With laptops, more writing is done across the curriculum. Word processing software makes writing a significantly more enjoyable process for students, and students will do more writing and revision when they have laptops. History and Social Studies classes can be enriched by giving students immediate access to the vast wealth of information available on the Internet. Science education can be greatly enhanced by the data gathering, data analysis and simulation software tools that run within the digital workshop a laptop can provide. Foreign language instruction can be enhanced by having students use multimedia that allows them to spend more time listening and speaking in the language of instruction. With the right software, and a set of headphones, a laptop can function just like a language lab work station. In art, music, and drama laptops provide easy access to examples of best practices. Students can visit virtual museums, listen to music clips, and watch videos of great performances. Various software can be used to assist in the creation of artwork, music, scripts and digital video.

With the use of laptops for daily work, students take enormous pride in their work. Individual and group creativity flourish, as work becomes more authentic, personal, and often transcends the assignment. Because of the increase in social learning, student become more naturally collaborative and less competitive, and social interactions tend to be more work-related. Multiple intelligences and ways of knowing are in ample evidence, as well as students developing more complex learning strategies.

Laptops can provide easy storage and access to a student's accumulating body of work. By viewing previous work students can better gauge their own progress and avoid repeating tasks already accomplished. With wireless laptop systems, it is important that students are aware of how easily others can pick up restricted data transferred across the network, and students need to exercise care and discretion.

Of course, there will always be skeptics who ask for proof that such laptops programs are beneficial to the student. From 1996 to 2000, Rockman Et Al, an independent research

organization, conducted evaluations of Microsoft's Anytime Anywhere Learning program-an initiative that provides hardware, content, training, and other types of support for schools implementing laptop programs. Rockman's key findings are that laptop students spend substantially more out-of-class time on schoolwork, score higher in writing and reading assessments, demonstrate improved research and analysis skills, and engage in more collaborative work than non-laptop students. (Carter) In most programs show achievement scores improving significantly, as well as student attendance rates increasing. Some laptops programs have noted an observable change in self-image that disadvantaged students have when they're given the same technology tools being used by their suburban counterparts-and the business world at large.

Teacher and Student Management

Handing a laptop computer over to a student for use should not be a simple task. Unfortunately, not every student can be trusted. However, once the student is able to grasp the benefit of the computer, they tend to take more ownership for it. Most schools that have instituted laptop programs have required students, as well as parents, to attend special training sessions on laptop operation and acceptable use.

In order for Mobile Technology to work, a management policy must be put into place from day one. Issues that should be discussed include whether or not an orientation will be required as a prerequisite for checkout and use. The need for written rules and signed agreements should be looked at, including how laptops should be carried and handled. Tips for preserving and conserving the batteries are extremely important, and there will be the need for additional power supplies. Measures need to be taken to prevent theft and damage. Procedure and forms for reporting troubleshooting and other problems need to be created. Consequences for abuse of computer use need to be discussed, as will the monitoring of student abuse.

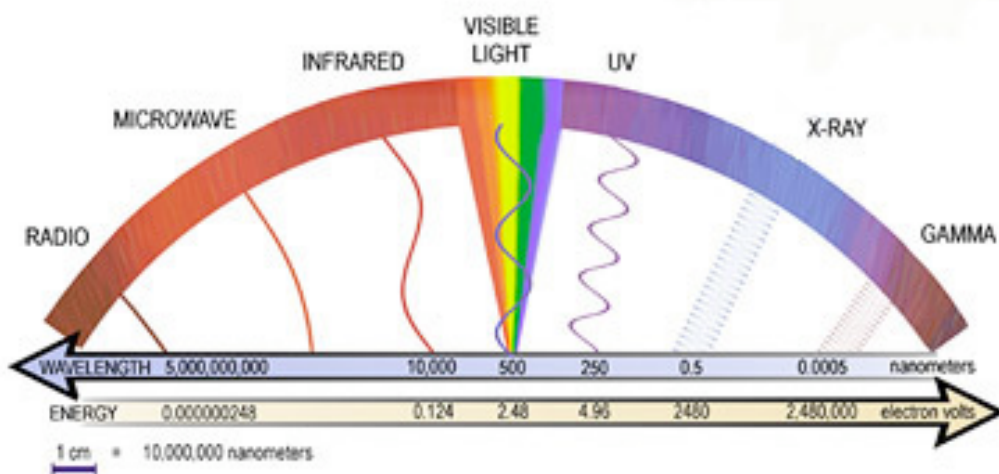
Issues with Wireless Technologies

Because of the ease of installation of a wireless network, many school districts with older buildings have opted for wireless networks due to budget constraints. The Oak Park Elementary School District in Illinois set up a wireless network to connect its schools to on another in 1995, long before such networks became more popular. These networks comply with all government regulation for wireless networks. Today, the 5,000 students in the district have access to carts of laptops to do research on the Internet from their desks.

Recently, the installation of wireless networks in schools has worried some parents. They believe that exposure to the network's radio waves could harm their children. This belief is based on the fact that children's bodies are still developing, and particularly their skull thickness has not yet formed to an adequate level. Without a fully developed cranium, children's brains' are at a greater risk to be exposed to radio frequency waves. In a complaint filed in September of 2003 in an Illinois state court, parents of five children assert that a growing body of evidence outlines "serious health risks that exposure to low intensity, but high radio frequency radiation poses to human beings, particularly children." (Wired News October 9, 2003) The parents allege that the district failed to examine the impact the networks could have on growing children's health, and are seeking to halt the use of wireless networks. The complaint has been reviewed by the school board, who responded by saying it would continue to monitor research into the safety of the networks, but reaffirmed its plan to use Wi-Fi. A hearing is scheduled before a judge in February.

Recently, a lawsuit was filed against Sprint by Cherry Creek School District after parents of students attending High Plains Elementary School complained about a Sprint cell tower that was constructed on school property. The school district anticipated losing the lawsuit, but still filed it because of parent concerns. Sprint won the lawsuit, and the cell tower is still in place.

The Wi-Fi Alliance says Wi-Fi networks are safe. The radio waves in a Wi-Fi network use the same frequency as wireless home phones, and have one-thirtieth the power of cordless phones. Currently, wireless networking operates as an unregulated radio band. Wireless networks use radio frequency (RF) waves similar to those used in microwave ovens, cell phones, and cordless phones. The main difference is the amount of energy used with each of these technologies. For instance, where a microwave oven's output is more than 1000 Watts, cell phones operate on less than 10 Watts and wireless access points are about the same. More importantly is the intensity of the wave, or Specific Absorption Rate (SAR), used in each technology. The RF output allowed for cell phones is a SAR of 10 Watts/square meter (W/m^2), wireless networks operate at a SAR of 0.05 to $0.1 W/m^2$. That's 100 to 200 times less energy than what is found in cell phones, and you normally do not hold a laptop up next to your head.



The FCC and the Food and Drug Administration (FDA) are developing a joint web site to provide information about the latest wireless technologies, current research and related issues and health concerns to consumers. Most research done in the past few years have shown no correlation between radio frequency waves and health problems, however long term exposure risks are yet to be discovered due to the relatively new nature of the technology.

Implications for Professional Practice

Wireless technology is becoming more common in the K-12 environment, and that trend is likely to continue. But acquiring the latest, greatest technology does not necessarily enhance learning—the effective use of wireless technology must be grounded in well-planned, curriculum-rich, standards-based learning activities. Before any type of technology is implemented in a school setting, there are some very important factors that must be considered. Planning, staff

development, community support, partnerships, and administrator support are crucial parts of successful wireless technology programs. Most importantly, incorporation of such technology should be implemented only when it best benefits the learner.

Resources

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Web Sites with Multiple Resources

<http://www.cde.state.co.us/edtech/wireless-laptops.asp> Colorado Department of Education page on "Wireless, Handheld & Laptop Computers in K-12 Classrooms" with links to recent articles and other resources.

<http://www.remc11.k12.mi.us/bcisd/classres/mobile.htm>. Resource page on 1-to-1 computing from Bergen County Intermediate School District. Page is divided into handheld and laptop sections with many links to other resources.

<http://members.ozemail.com.au/%7Ecumulus/wireless.html> Resource page on Wireless Networking in Schools

<http://k12handhelds.com> K12 Handhelds, Inc. provides schools with integrated solutions for handheld use in education. "We focus exclusively on using handhelds in K-12 education and

bring a great deal of knowledge and expertise in this area. We believe strongly that careful planning, professional development, hardware and software selection, on-going support, and follow-up assessment are keys to a successful handheld implementation." Site includes a list of "101 Great Educational Uses for Your Handheld Computer" (<http://k12handhelds.com/101list>).

<http://www.learningathand.com/> Present reviews of educational software for use for Palm OS, and helpful tips for integrating handheld devices into your classroom. Also share lesson plan with other educators, and compare notes and swap ideas in an educator chat room.

<http://www.paperlessclassroom.org/> Resources for using PDAs in classroom from Eminence Middle School in Henry County, Kentucky.

<http://www.learningwithlaptops.org/> Independent information about student laptop programs run by educators for educators.

<http://www.wi-fiplanet.com/> "Your complete guide to the world of networking products based on the various 802.11 wireless networking protocols (collectively known as Wi-Fi). With daily news, features, reviews, and tutorials, Wi-Fi Planet covers all areas of the rapidly changing wireless LAN universe."

<http://www.weca.net/OpenSection/index.asp> "The Wi-Fi Alliance is a nonprofit international association formed in 1999 to certify interoperability of wireless Local Area Network products based on IEEE 802.11 specification. Currently the Wi-Fi Alliance has 205 member companies from around the world, and 915 products have received Wi-Fi® certification since certification began in March of 2000. The goal of the Wi-Fi Alliance's members is to enhance the user experience through product interoperability."