Mobile Wireless Technology Use and Implementation:
# Opening a Dialogue on the New Technologies in Education

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P eople commonly use technology in their daily lives. Within our increasingly complex society, individuals, organizations and other entities continue to look for new technologies that support their goals. Since the 1990s, there has been movement toward mobile wireless technology in education. Like the wired technology that came before, mobile wireless technology was initially used in business sectors, to improve efficiency and effectiveness in production. However, learners and educators are now using this emerging technology to increase efficiency and effectiveness in the classroom (Maginnis, White, & Mckenna, 2000).

Throughout the 1990s, much research focused on the use of laptop computers in K-12 education. For example, Peacock and Breese (1990) discussed one of the first implementations of portable technologies using word processors for class writing. In their study, students used the portable computers in English, math and science classes to do various writing assignments such as essays and reports. Findings from this study showed that students were excited about using the word processor for writing (Peacock & Breese, 1990). Smith and Anderson (1994) studied how laptop computers can be used to facilitate writing instruction for low-achieving tenth graders at Jefferson Davis High School, Texas. They found that students could easily learn to use laptop computers for writing. In 1997, Fouts and Stuen conducted The Copernicus Project, a multi-district effort focused on the incorporation of laptop computers into a variety of components, including teachers' training for the use of laptop computers in their curriculum. Results from a three-year evaluation study (1996-1999) indicated that word-processing, spreadsheets and presentation software were the most commonly used applications. In addition, Hill, Reeves and Heidemeir (2000) studied ubiquitous computing; this study described the means and potential effects of creating ubiquitous computing in school environment. The findings from this study indicate that laptops enable students to complete their schoolwork more easily and efficiently than writing by hand.

Studies of mobile wireless technology in K-12 have been started recently. For example, Luchini, Quintana and Soloway (2003) examined the usability of handheld devices in their case study of using Pocket PiCoMap. The result of their 9-month classroom study showed that students used the handheld device effectively in creating concept maps. Finally, Norris and Soloway (2004) present their vision of a handheld-centric K-12 classroom. They claim that a handheld-centric classroom supports collaboration by supporting the sharing of documents, distribution of teachers' documents and so on.

With such consistent interest in mobile wireless technology in K-12 education, it is crucial for teachers, administrators and students to have a clear understanding

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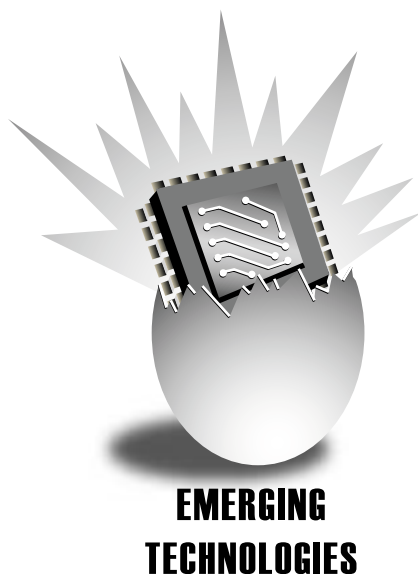
of the types and uses of mobile wireless technology. Therefore, this paper is divided into two sections: (a) an overview of mobile wireless technology, and (b) a description of teacher and student uses of two specific mobile wireless technologies in K-12 classrooms. The overview section includes technological concepts, trends and funding associated with mobile wireless technology. The second section introduces how students and teachers use PDAs and mobile wireless phones in K-12 classrooms.

An overview of mobile wireless technology

Mobile wireless technology concepts

Mobile wireless technology involves two areas — mobility and computing (Malladi & Agrawal, 2002). Mobility in this context is defined as continuous accessibility to users, and wireless means communication using radio waves, infrared waves and microwaves instead of cables or wires in order to transport a signal to connect communication devices (Dubendorf, 2003; Malladi & Agrawal, 2002). As a result, mobile wireless technology is defined as technology that provides continuous accessibility to users anytime, anywhere without using wire or cable to connect to networks (like the internet), transmit data or communicate with others. In this sense, "anytime, anywhere" means that there is no limitation on time and location in terms of accessing network resources or communicating with others. For example, even if users are not at a desktop computer that has accessibility to a network, with mobile wireless technology they can access network resources via public stations (e.g., antennas) on the road. In addition, users can use wireless access points to act as communication hubs for mobile wireless devices that connect to a wired LAN installed in a public building or room to access network resources and communicate with each other without being tied to a single desk.

Growing trend

According to Bull, Garofalo, and Harris (2002), mobile wireless technology will soon be available at a price similar to that of a calculator to enable U.S. students in K-12 classrooms to connect to network resources, to exchange email and to use instant messaging. An increasing number of K-12 schools have adopted mobile wireless technology as teaching and learning tools. According to the U.S. Department of Education (2004), 23% of K-12 schools are using mobile wireless technology now. These schools use devices, services and wireless networking so that teachers and students can communicate and collaborate with each other in real-time (Hayes, 2002; Moody & Schmidt, 2004).

For example, students at the Ballard High School in Seattle, Washington use handheld devices for organizing personal information, such as assignment calendars, contacts and to-do lists (Brown, 2001). Students at Carl Sandburg High School, Orland Park, Illinois, and Amos Alonzo Stagg High School, Palos Hills, Illinois use a Palm handheld computer for virtually all courses (Dean, 2000). Some additional schools have conducted mobile wireless technology projects. For example, Johnston County Schools Project in North Carolina and Beaufort County Schools in the South Carolina Project (SEIRTEC, 2002) undertook pilot projects involving the use of handhelds to assist students in studying, as well as to assist teachers in managing data from assessments.

Mobile wireless technologies currently used in K-12 schools

There are many different types of mobile wireless devices being used in K-12 education. Examples of mobile wireless devices include: mobile wireless phones, PDA, handheld computers and wireless laptop computers. Table 1 (next page) describes each device.

"An increasing number of K-12 schools have adopted mobile wireless technology as teaching and learning tools."

• High mobility • Lowest student per device cost ratio • Easiest way for real-time communication • Images, voice and text download	• High agility/mobility feature • Stronger Application Development • Simple document creation	• High agility/mobility feature • Improved form factor for student use • High integration	• 1:1 Computing Tool • "Anytime-and-Anywhere" Teaching and Learning • Full document creation tool • Opportunity for greatest impact on learning

Table 1. Examples of mobile wireless devices

Two of the devices that are emerging as popular educational tools for K-12 classrooms are PDAs and mobile wireless phones with Short Message Service (SMS) and Multimedia Message Service (MMS).

PDA is the commonly used term that refers to any small mobile wireless handheld device that provides computing, information storage and retrieval capabilities from the device as well as the Internet; they are also sometimes called handheld computers (Campo, 2001). Some popular PDAs are Hewlett-Packard's iPAQ pocket PCs and the palmOne Tungsten. In teaching and learning environments PDAs are currently the hottest mobile wireless technology, used more often than any other mobile wireless device in K-12 schools (McGhee & Kozma, 2001; McKenzie, 2001; Syllabus, 2002). They can be used interactively with other devices and networks through wired and Bluetooth synchronization, the process in which two or more technologies interact with each other and come to move together. Mobile wireless phones (commonly called "cell phones") with web-enabled capability are the most recent technology used in the schools. Mobile wireless phones are often used with wireless applications such as SMS (Mauve, Scheele, & Geyer, 2001; Seppälä, & Alamäki, 2003), and MMS (Seppälä, & Alamäki, 2003). With SMS, users can send and receive text messages to and from most modern mobile wireless phones. Similar to SMS, MMS has a capability of delivering not only text messages, but also sound, images and video messages.
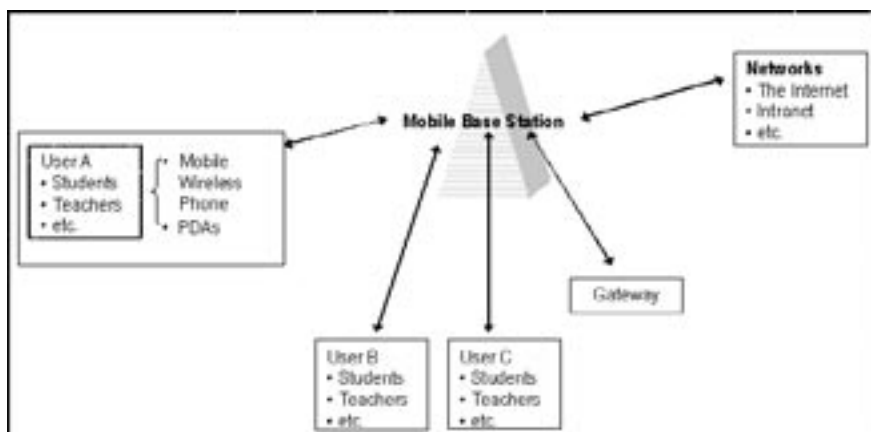

Figure 1. PDAs and mobile wireless phones transmission

Accessing network resources

Mobile wireless devices can be used interactively with other devices and networks through wired synchronization. There are three ways to connect network resources. Figures 1, 2, and 3 describe how different devices access networks. Figure 1 describes the infrastructure of PDAs, handheld and mobile wireless phones for communication and network access. Teachers and students

simply use communication services provided by wireless service providers for communication and network connection.

Figure 2 shows the layout for network access for wireless computers. Wireless laptop computers have a built-in wireless network interface card (WNIC) to connect a network. WNIC uses a very low radio frequency instead of a wired connection to connect a network. WNIC is used to communicate to a wireless access point connected to a wired-network line.

Finally, Figure 3 describes infrared beaming (IR) technology for communication between devices. Infrared beaming uses infrared light with similar characteristics to visible light to send data from one device to another. Each device has a detector and emitter to send and receive signals.

Funding

Universal Service was originally enacted into law as part of the *U.S. 1934 Communications Act* to ensure universal and affordable telephone service to households. The legislation has since been extended to accommodate the technological needs of people living in the 21st century. The Universal Service

Figure 2. Connection of wireless computers to network using access point

Section 254, of the *1996 Telecommunications Act*, requires telecommunications providers to offer public elementary and secondary schools and libraries affordable, state-of-the art services. With affordable, state-of-the art services, educational technology is becoming more commonplace in classrooms.

Responding to increasing demands to include mobile wireless technology in the classroom, many school systems have allocated a larger budget for educational technology. According to Anderson and Becker (2001), computer hardware, peripherals and network connections are the major school technology-related expenditures. Table 2 shows the technology expenditure per student from 1997-1998 at all levels of the U.S schools (p.6). The major expenditure went to the hardware category. In 1998, more than $5 billion was spent nationally on educational technology (Archer, 1998).

Such increasing funding in education is a worldwide trend. For example, according to The NSW Minister for Education and Training in Australia, to increase the number of teachers who could effectively use technology in the classroom, $8.1 billion from the 2002/2003 Education and Training Budget was allocated to the schools. An extra $88.5 million will be spent for teacher training over the
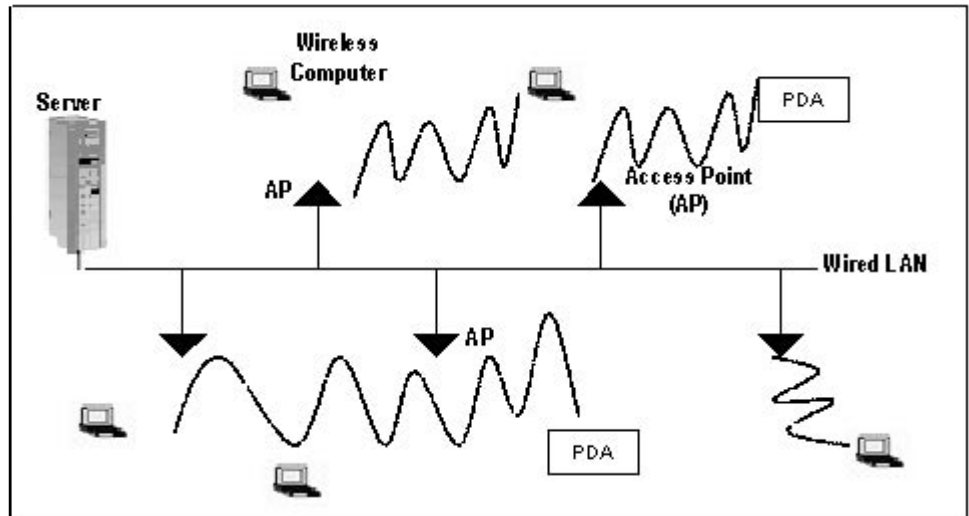

Figure 3. Infrared technology

Hardware		Software	
Instructional Computers	$42.40	Individual S/W	$4.50
Peripherals	$5.70	Licenses	$3.40
Video Production	$1.10		
Computer Furniture	$2.30	**Support**	
		Salary for Tech. Emp.	$11.30
LAN	$13.60	Training Cost	$9.00
Internet	$3.40	Others	$2.30
Maintenance	$3.40		
Total H/W	$71.90	Total Support	$22.60
Grand Total		$102.40	

Table 2. Per-student expenditure in U.S. K-12 schools (1997-1998)

next four years. Such a huge investment in educational technology could serve as an impetus to increase the use of technology to improve the quality of education at all grade levels.

Corporate foundations offer grants for educational technology. For example, palmOne maintains the Palm Education Pioneer Grant Program that provides Palm handheld devices to K-12 teachers and students for teaching and learning (SEIRTEC, 2002). Hewlett Packard also administers the Technology for Teaching Grant Initiative to support use of technology in K-12 education (grants.hp.com). More funding sources may be available from government agencies or corporations as they see the positive impacts from mobile wireless technology in teaching and learning in the future.

Student uses

PDAs. As mobile wireless communication becomes an integral part of our society, it will become an accepted and necessary part of the curriculum for students in the public schools. The National Educational Technology Standards for Students (NETS-S) outline six skills students should master including: learning about available technology and how to use it, using effective communication skills, researching, learning, processing facts and concepts, and problem solving (International Society for Technology in Education, 2000). The National Council of Teachers of English (NCTE) has developed guidelines on using media to teach the essentials of English, emphasizing that students must learn literacy skills

Schools	Users	Activities	Applications
Northline Elementary School, Houston, Texas	Elementary students	• Experiments in science class	• ImagiProbe, Vernier Software sensors and Palm Calendar
Willowdale Elementary School, Omaha, NE	Elementary students	• Photography and writing	• Handmark Wordsmith, GoKnow Sketchy & PiCoMap, Quizzler, Checkmate Software MathCard, Hippa-Potta Software MathWhiz, Ninelocks NineColours, etc.
St. Vincent Ferrer School, Cincinnati, Ohio	Grades 6-8	• Organizing school schedules	• Palm Calendar, Memo Pad, Address Book; Diddlebug, CspotRun, powerOne
Spokane Public School, Spokane, Washington	Students	• To compose music	• MiniMusic BugBand, BeatPad and NotePad
Ancaster High School, Ancaster, Ontario, Canada	Students	• To receive and submit assignments electronically, compare study notes, organize class schedules, and access science databases	• First Class (communication software)

Table 3. Examples of schools where students use PDAs

associated with technology to function in our technological society (NCTE, 1996).

PDAs have been used in several K-12 schools (Table 3). Activities and applications at each school are different from one to another. Students using PDAs have access to information and communication anytime and anywhere. They are no longer tethered to a specific area. Because of their flexible access to data, PDAs are the most actively used mobile wireless technology in the learning environment. Three major benefits derived from PDAs are mobility, information management capacity and beaming capability (Yuen & Yuen, 2003). Outdoor inquiry learning activities, such as collecting and entering data from the field or making notes and observations and research in field trips online become possible because of PDAs' mobility feature. PDAs support students in learning activities by providing them with easy access to the technology in dealing with real-time activities.

PDAs have additional functions, such as serving as a textbook, an organizer, a notepad and a pencil (Yuen & Yuen, 2003). Because of PDAs' information management capacity, students can track their learning progress by checking grades, preparing for classes, managing courses and making plans for self-improvement in a student-centered learning environment.

The PDA's capability to transmit information from one device to another without any wires required provides students with an easy and convenient way to share information. Because of an infrared beaming capability that offers real-time collaboration (Yuen & Yuen, 2003), students can share files via beam instantly. For example, in a group discussion or during teamwork, an infrared beaming capability allows students to beam documents, spreadsheets, data and even applications to each other without having to download and print out information or send it via email. Students can send questions and assignments to teachers and at the same time teachers can send answers to students' questions and grades. PDAs for students' use are just like small computers that have web accessibility but do not require additional setup or wires.

Mobile Wireless Phones. Mobile wireless phones may be the most popular wireless technology used globally by all ages for personal reasons. However, according to The National Centre for Technology in Education (NCTE) in Ireland, the usage of mobile wireless phones in education and learning is still in its infancy (2004). The main advantage of mobile wireless phones is their portability, which enables them to be used for learning outside the classroom. The "anytime-and-anywhere" capabilities of mobile wireless phones enable students to use them to study while they are in a car or on a school bus.

In the literature, only a few K-12 schools in the United States use mobile wireless phones for educational purposes. ClassLink, created by The Wireless Foundation, has donated, through an application process, mobile wireless phones from Nokia to public schools along with airtime from CTIA wireless carriers in order to accelerate learning nationwide (see Table 4 for specific activities and the results of this program). Furthermore, according to NCTE, other student uses of mobile wireless phones in learning include:

1. To improve literacy among students by providing carefully designed lessons
2. To facilitate collaborative and project-based learning
3. To provide the capacity to access the Internet resources, for example, revision of class notes and news updates
4. To facilitate wireless access to the Internet when used with a laptop, hence providing the internet access to students from any location in the school

SMS and MMS are two services often used with mobile wireless phone. SMS and MMS can make communication easy involving text, image and sound between teachers and students, and students and students. For example, students who have missed class can send and receive class notes, schedules and test dates.

Schools	Users	Activities	Results
Aldine High School, Houston, TX	Students	• Communication for TAAS test preparation classes	• Student attendance rate increased by 94% • TAAS scores were the highest ever
Community High School, Texas	Students	• ClassLink phones in an emergency	• Increased communication with parents and students • 24/7 access to teachers and staff

Table 4. Examples of K-12 schools where students use mobile wireless phones

Teacher uses

PDAs. Teachers use PDAs in different ways and for different purposes. Improving instruction and managing paperwork are two of the main uses of PDAs for teachers (Vahey & Crawford, 2002). Teachers find PDAs useful for documenting student learning and as a tool to provide students a means for assessing their own work. Software for PDAs used for assessment includes quizzes, tests and games. For

Schools	Users	Activities	Applications
Garden Valley Collegiate, Winkler, Manitoba	Administrators and teachers	• Tests • Lesson plan • Electronic grading • Providing Immediate feedback	• Address Book, Date Book, To Do List; DataViz Documents to Go, Media-X ePrincipal, French-English dictionaries, etc.
North Grenville District High School, Kempville, Ontario, Canada	Teachers	• Teaching, Administration, Evaluation	• M505s and m105s
Cohoes Middle School, Cohoes, New York	Teachers	• Quizzes • Organizers	• Scranton Classroom Wizard
Maranacook Area Schools, Readfield, Maine	K-12 Principals and teachers	• Communication	• Address Book, ToDo List, Date Book, DataViz Documents to Go

Table 5. Examples of K-12 schools where teachers use PDAs

example, in palmOne's education solution project at the Cohoes Middle School, New York, teachers in social studies classes use "Classroom Wizard" software to create, grade and evaluate quizzes easily in real time. Students and teachers at Carolina Beach Elementary School in North Carolina have software including Memo Pad, Sketchy, Quizzler and Hi-CE's Bubble Blasters in their PDAs to help them summarize readings and prepare for quizzes. In addition, teachers schedule classes and assign homework and reading materials that are posted on a class web site and can be uploaded to PDAs using the sync-capability (McCampbell, 2001). Table 5 shows some examples of K-12 schools in which teachers use PDAs along with activities and applications.

Teachers also use PDAs to help with the every day management of their classes. They can increase efficiency and effectiveness with PDAs, by handling attendance, grading and lecture notes. Because all the procedures are electronic, and data is stored in digital form, teachers can reduce not only the amount of time required for the paperwork inherent to teaching and managing classes, but also the amount of time involved gathering and organizing assignments. PDAs allow teachers to keep up to date on the newest educational advances because of their "anytime and anywhere" connectivity and accessibility to network resources.

Instruction can be more efficient with PDAs. For example, in a math class a teacher has students use graphing calculator software on their PDAs to solve problems effectively so they understand the calculation process of solving problems. In a science class, a teacher can direct students to save data from scientific observations on their PDAs. Crawford and Vahey (2001) claim that PDAs are useful teaching tools to:

1. organize teaching materials and courses
2. communicate with students and parents
3. give more individual attention to students
4. manage research materials and information
5. schedule meeting appointments with students and others

Figure 4. Teachers' evaluation of benefits of PDAs
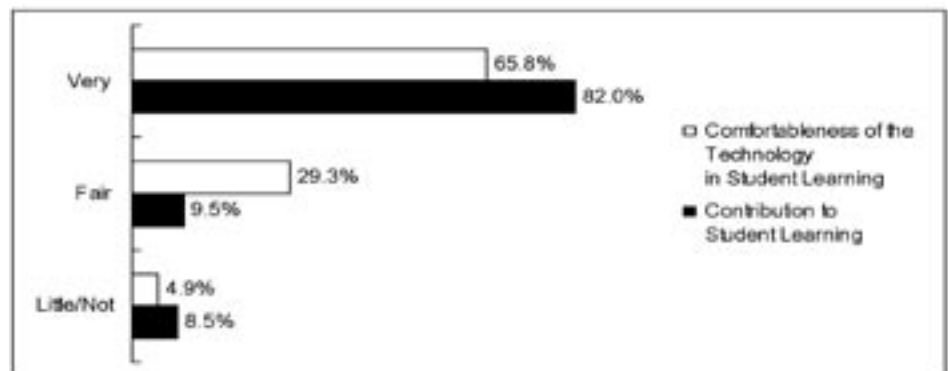
Figure 5. Evaluation of the impact of PDAs on student learning

Because PDAs' functionalities are similar to those of PCs, they replace more commonly used classroom tools such as calculators, conversion charts and checklists (McCampbell, 2001).

A study conducted by Vahey and Crawford (2002) shows that about 90% of teachers in K-12 agree that PDAs are an effective instructional tool and contribute positively to student learning. Figures 4 and 5 show the teachers' evaluation of the use of PDAs across a range of measurements and evaluation of the impact on student learning. In every category, PDAs are regarded by teachers as having a positive impact in teaching and student learning.
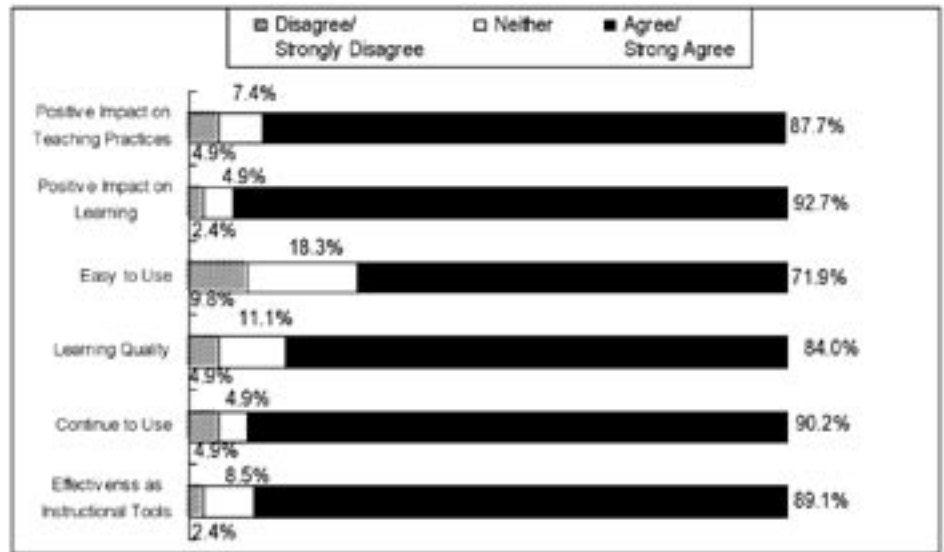
Schools	Users	Activities	Results
Cross Timbers Middle School, Grapevine, TX	Teachers and staff members	• Communication at various situations	• Increased communication with parents • Provided more security in an emergency
Cameron Park Elementary School Hillsborough, N.C	Teachers	• Using ClassLink phones in field trip emergency	• Provided more security in an emergency
The New Brunswick Public Schools, New Brunswick, NJ	Teachers and others	• Communication at various situations	• Saving time and effort

Table 6. Examples of mobile wireless phone uses by teachers

Mobile Wireless Phones. Teachers use mobile wireless phones in K-12 education mainly for voice communication with others. With anytime, anywhere communication on hand, teachers can manage various situations occurring in classrooms or during a field trip. For example, teachers at Cameron Park Elementary School saved 3rd grade student who suffered from asthma attack while attending a school field trip by using a mobile wireless phone (Alltell, 2003). Table 6 (next page) shows some examples of K-12 teachers using mobile wireless phones.

However, mobile wireless phones can be used with other services provided via the device, such as SMS and MMS. SMS and MMS services are tools for teachers to exchange text information related to classes. Teachers can use SMS and MMS to share important data with students and with other teachers as well. Opportunities for cross-age communication, communication between home and school and communication with members of the community are possible with SMS and MMS. The all important home-school-community relationship is strengthened. Currently, SMS and MMS are used more in higher education than K-12 education as teaching and learning tools. SMS and MMS are in their first stages for use in education. In the near future there will be potential increases of SMS and MMS uses as teaching and learning tools in both higher education and K-12 schools as technology improves (Trifonova, 2003).

Conclusion

Mobile wireless technology provides efficient and effective communication and network connectivity for teachers and students in K-12 education because it does not require any wires. With mobile wireless technology, users can access preinstalled documents and data anywhere without further setup of a network connection. Mobile wireless technology can be used to perform tasks, such as taking pictures or writing notes, wherever users go. Furthermore, users can check email or gain network resources if they have access to a wireless connection. With wireless technology, users no longer need to worry about access to the computer lab for technology activities, software assignments or internet access.

Overall, the benefits of PDAs and mobile wireless phones are derived from two main characteristics of mobile wireless technology — mobility and reachability. Three elements of mobility — convenience, expediency and immediacy — are valuable for teaching and learning and bring actual benefits in the learning environment (Kynäslahti, 2003), such as:

  1. The convenience element enables students and teachers to use their

waiting-time or dead time on the bus or train to conduct educational activities.

2. The expediency element enables students and teachers to share information and have access to data anytime and anywhere.

3. The immediacy element enables students and teachers to store immediate observations and ideas outside of the classroom.

Without mobility, no benefit mentioned above would be possible. As more educational institutions adopt mobile wireless technology as a teaching and learning tool, more benefits will be identified in the near future.

People in the 21st Century need to reflect on whether this emerging technology optimizes students' learning and prepares students for the technological demands of today's workplace and daily life. The University of South Dakota President James W. Abbott (2001) states in a palmOne press release, "Schools must provide a learning environment using the latest technology so students can take advantage of the benefits of anytime, anywhere learning to better prepare for the future."

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