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## **An Introduction to Current Trends and Benefits of Mobile Wireless Technology Use in Higher Education**

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The development of mobile wireless technologies has generated a considerable amount of excitement among practitioners and academics because it results in shifting the academic environment from traditional settings to mobile learning (m-learning) settings. Increasing numbers of institutions of higher education offer courses using mobile wireless technologies as alternative teaching and learning tools. However, regardless of such interests in mobile wireless technologies in higher education, there is lack of academic research on the use of mobile wireless technologies in the higher education setting. The purpose of this article is to examine current information on mobile wireless technologies and answer three crucial questions such as (a) What types of mobile wireless technologies are currently being used in higher education? (b) How do mobile wireless technologies access to network resources? (c) What are the benefits of mobile wireless technologies in higher education? Without understanding of these issues, it is virtually impossible to study any subject of mobile wireless technologies in higher education.

For the last several decades, wired technologies have been used by educators, school administrators, students, and others in higher education to help them teaching and learning. In this century, however, institutions of higher learning are moving towards the use of mobile wireless technologies. Similar to other wired technologies, mobile wireless technologies have first been used in industry sectors such as business. The movement of mobile wireless technologies in education is a recent trend, and it is now becoming the hottest technology in higher education (Levine, 2002; McGhee & Kozma, 2001; McKenzie, 2001).

For the past few years, educators and students in higher education have enjoyed the many benefits of wired technology. However, wired technology provides limited access for usage due to a lack of mobility. In other words, wired-technologies cannot provide anytime, anywhere functionality, a benefit now offered by mobile wireless technologies. The use of mobile wireless technologies can overcome the limitation of educational flexibility with wired technology. With the advantages of mobility, mobile wireless technologies help improve efficiency and effectiveness in teaching and learning (Maginnis, White, & Mckenna, 2000).

Regardless of the fact that mobile wireless technologies provide many benefits to higher education, there is lack of academic study including research on the use of wireless technology in education, as well as academic study. Therefore, the goal of this article is to investigate information on mobile wireless technologies to determine its strengths in the teaching and learning environment in higher education. We sought answers to the following questions: (a) What types of mobile wireless technologies are currently being used in higher education? (b) How does mobile wireless technologies access to network resources? (c) What are the benefits of mobile wireless technologies in higher education?

## **UNDERSTANDING MOBILE WIRELESS TECHNOLOGIES**

People often think mobile or wireless technologies are the same as mobile wireless technologies. Strictly speaking, mobile wireless technologies are different from mobile or wireless technologies simply because not all mobile technologies are wireless nor are all wireless technologies mobile. According to Malladi and Agrawal (2002), mobile wireless technologies consist of

two aspects—*mobility* and *computing*. They claimed that mobile computing represents users' continuous access to network resources without limitation of time and location. Wireless means that transmission of any form of data—text, voice, video or image—is conducted through radio waves, infrared waves or microwaves rather than using wires (Dubendorf, 2003). Therefore, mobile wireless technologies is defined as any wireless technology that uses radio frequency spectrum in any band to facilitate transmission of text data, voice, video, or multimedia services to mobile devices with freedom of time and location limitation.

The freedom of time and location is related to the concept of anytime and anywhere access that represents the two main characteristics of mobile wireless technologies—*mobility* and *reachability* (BenMoussa, 2003; Camponovo & Pigneur, 2003; Ng-Kruelle, Swatman, Rebne, & Hampe, 2002; Turban, Lee, King, Warkentin, & Chung, 2002). Mobile wireless technologies use public stations—antennas—or Wireless Access Points (WAPs) that are connected to wired-network in a building or public area to give a way of access for web resources and communication for mobile wireless technologies users. With mobile wireless network or service in mobile wireless devices, users can access network information anytime, anywhere. For example, people can carry wireless laptops anytime, anywhere and can access a network in public places, such as an airport and a library. In addition, handheld devices can be carried and connect a network anywhere, anytime using public stations (e.g., antenna).

## **THE TREND OF MOBILE WIRELESS TECHNOLOGIES IN HIGHER EDUCATION**

An increasing number of colleges and universities are adopting mobile wireless technologies as teaching and learning tools. According to Swett (2002), more than 90% of public universities and 80% of private universities in the US have some level of mobile wireless technologies, such as mobile wireless devices and networks. One such institution is Louisiana State University (LSU), which implemented Cisco CTE 1400, an application enabling the transformation of web page into a format appropriate for mobile wireless devices. This application enables LSU to deliver its web content and applications to mobile wireless devices mainly because of the increasing number of mobile devices users; 76% used mobile phone, 14%

used PDAs, and 9% having devices enabled for wireless connectivity (Cisco system, 2003). Other universities, such as the University of Minnesota and the University of South Dakota even require students to have mobile wireless devices for their school assignments (Oliver & Wright, 2002). In the near future, mobile wireless devices and a wireless networks may be required for all students and schools. Table 1 summarizes the list of colleges and universities that undertakes projects using different mobile wireless technologies in teaching and learning (Bartel & Meerts, 2002; Boggs, 2002; Palm, Inc.)

**Table 1**  
Mobile Wireless Technologies Uses in Higher Education

Schools	Users	Tool	Key Uses
North Carolina State University College of Veterinary Medicine, Raleigh, NC	Students	PDA	<ul style="list-style-type: none"> <li>▪ Accessing to many medical references</li> <li>▪ Participating in wireless polling during class</li> </ul>
University of Central Oklahoma College of Education, Edmond, OK	Faculties and Students	PDA	<ul style="list-style-type: none"> <li>▪ Accessing to information</li> <li>▪ Supporting innovative teaching practices</li> <li>▪ Enhancing collaboration and builds relationships</li> </ul>
UC Berkeley School of Education K-12 Schools, Berkeley, CA	Students	PDA	<ul style="list-style-type: none"> <li>▪ Offering students mobile data-gathering tool</li> <li>▪ Allowing for new types of curricular activities</li> <li>▪ Helping students understand difficult science concepts</li> </ul>
Stanford University, Stanford CA	Faculty, students and staff	PDA	<ul style="list-style-type: none"> <li>▪ Accessing data</li> <li>▪ Enabling on-going communication among faculty, students, and staff.</li> <li>▪ Data exchange</li> </ul>
Carnegie Mellon University, Pittsburgh, PA	Students	Wireless Computer	<ul style="list-style-type: none"> <li>▪ Collaboration</li> </ul>
University of California, San Diego, San Diego, CA	Faculty and students	Wireless LAN	<ul style="list-style-type: none"> <li>▪ Providing better networking service for laptops and PDAs</li> </ul>
Florida State University, Tallahassee, FL	Faculty and Law and MBA students	Wireless LAN	<ul style="list-style-type: none"> <li>▪ Providing better teaching and learning environment</li> </ul>
Wake Forest, Winston-Salem, NC	Faculty and students	Wireless LAN	<ul style="list-style-type: none"> <li>▪ Providing innovative technology</li> <li>▪ Others</li> </ul>

### Wireless Coverage in Higher Education

In the near future it should be possible for faculty members and students to use mobile wireless devices virtually at all major locations on college and university campuses because more buildings and places are being retrofitted for wireless networking. Many major buildings and places such as libraries, lecture halls, cafeterias, and research centers on college and university campuses are already equipped to provide wireless access. According to a research study of 17 academic institutions by Boggs (2002), 57% of library areas were covered with wireless technology in 2001, and the figure increased to 88% in 2003. Figure 1 shows the percentage of wireless technology coverage in campus buildings in detail. In the near future, it is possible that all areas on campuses across the country including parking lots, football stadiums, and coliseums could be equipped with wireless networks making anytime anywhere access a reality.

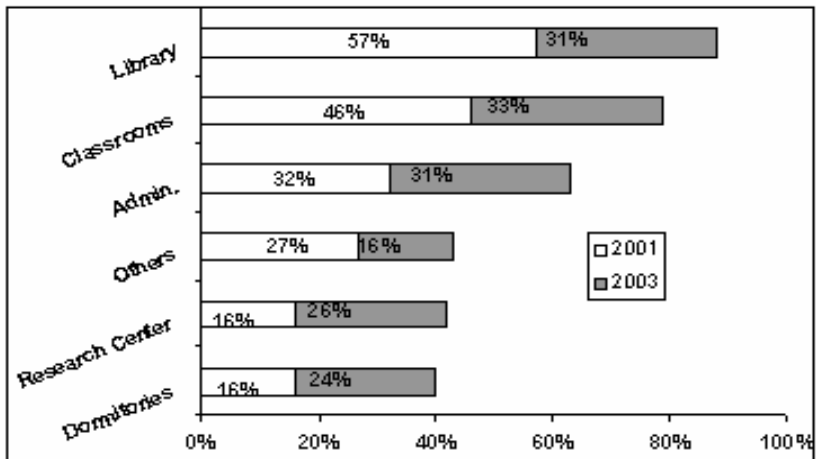


Figure 1. Building with wireless coverage

### Funding for Mobile Wireless Technologies in Higher Education

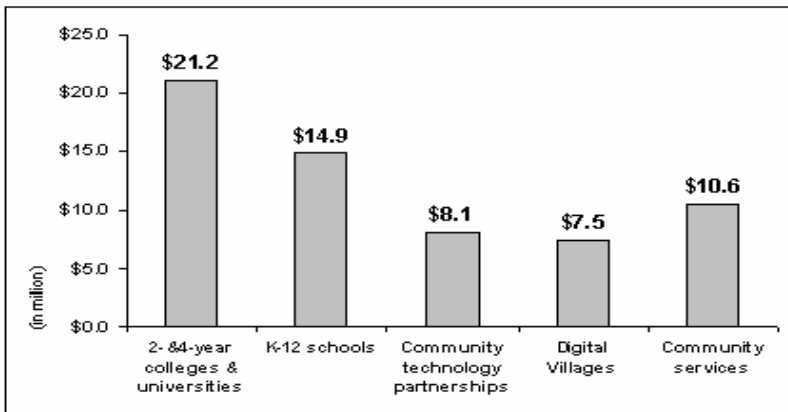
Even if technologies require a heavy financial investment, more colleges and universities are allocating a larger part of their budget for mobile wireless technologies because they realize that technologies play a crucial role in education. In the fiscal year, 1999-2000, colleges and universities in the US

spent approximately \$2.7 billion on computer hardware and software (Phipps & Wellman, 2001). Increasing spending on technologies occur even in small colleges. For example, Hudson Valley community college in Albany, NY spent \$100,000, acquired from federal funds, on providing courses through wireless laptops (Tolson, 2001). St. Louis Community College in St. Louis, MO funded a \$120,000 capital project to set up wireless-enabled laptop accessibility (Tolson). In 2004, spending on technology in higher education has increased to \$5.6 billion; that is a 3% increase from the previous year (Market Data Retrieval, 2003). Table 2 summarizes technology spending for higher education in 2004 by category.

**Table 2**  
Technology Spending at Higher Education in 2004

Hardware	Installations, Warranties, Service Contracts	Software	Technology training
2.8 billion	1.3 billion	1.2 billion	0.3 billion

Such a huge investment on educational technology contributes to the improvement of education quality in every level with proper usage. Most of funding is from the government. However, more funds from corporations are becoming available. For example, Hewlett Packard offers grants for all levels of education, as well as communities. Figure 2 shows the detail of 2002 HP's grants.



**Figure 2.** 2002 giving by program category (\$62.2 million)

Heavy investment on educational technology will leave no student behind as new technologies become available for education.

### **ESSENTIAL QUESTIONS ABOUT THE USE OF MOBILE WIRELESS TECHNOLOGIES AND HIGHER EDUCATION**

This section addresses the three crucial questions about the use of mobile wireless technology in higher education.

#### **MOBILE WIRELESS DEVICES USED IN HIGHER EDUCATION**

A number of different mobile wireless devices are being used in higher education. These include web-enabled wireless phones (e.g., smart phones), web-enabled wireless handheld computers (e.g., palmtop, and tablet computers), wireless laptop computers, and Personal Digital Assistants (PDAs). In learning environments, mobile wireless computers, PDAs and handheld devices (Boggs, 2002; Fryer, 2002; McGhee & Kozma, 2001; McKenzie, 2001) are used most often. Table 3 summarizes Boggs's findings about how 17 institutions of higher education have been using, or plan to add, mobile wireless devices in the future. In 2002, mobile wireless computers had the highest access to the wireless network; PDAs follow. Mobile wireless phones make up a small portion of current usage of mobile wireless device. However, some researchers (Houser, Thornton, Yokoi, & Yasuda, 2001; Thornton & Houser, 2001) claimed that in the future, more institutions of higher education will require mobile wireless phones for students and faculty members for teaching and learning.

**Table 3**  
Devices Accessing Wireless Network

	Mobile Wireless PCs	PDAs	Handheld Devices	Mobile Wireless Phones	Others
2002	94.0%	39.0%	9.0%	4.0%	3.0%
Plan to add in the future	6.0%	27.0%	22.0%	15.0%	2.0%

In this article, we focus on only three mobile wireless devices—mobile wireless computers, PDAs, and mobile wireless phones (with SMS and MMS) because of their widespread use in higher education. In the following section, we briefly discuss three mobile wireless devices.

### **Mobile Wireless Computers**

Mobile wireless computers commonly called, wireless laptops, and are the most popular mobile wireless technologies used in higher education. Wireless laptops have an integrated wireless card that enables short-range wireless voice and data communications. Unlike wired laptops that use an Ethernet card, also called a NIC or Network card to connect to a network, mobile wireless laptops use a wireless network interface card (WNIC) to connect to a network. WNIC uses a very low radio frequency instead of a wired connection to connect network. There are a number of schools and programs in higher education that require students to use wireless-enabled laptops in class such as the University of Texas in Austin, TX, Wake Forest University in Winston-Salem, NC, and the University of Mississippi.

### **Personal Digital Assistants (PDAs)**

In 2000, handheld devices, PDAs, became the newest emerging technology for education. Like the other forms of technology, PDAs were initially used as a tool for business. According to the definition from Webopedia (Webopedia.com), PDAs stands for Personal Digital Assistants—a handheld device combining functionalities of computing, telephone, Internet, and network. PDAs have functionalities such as a cellular phone, fax, organizer, and web browser. Popular PDAs used in education are Hewlett-Packard's Palmtop and 3Com's Palm Pilot. The University of South Dakota was the first school in the United States to initiate a PDA project requiring all first-year undergraduate students and first-year law and medical school students to have a PDA for their study (Oliver & Wright, 2002). Since then, as shown in Table 1, more higher education institutions have adopted PDAs as teaching and learning tools. In addition, other universities have conducted PDA projects such as the PDA Utilization Group at the University of Texas, Austin participants exchanged e-books through beaming (Sims, 2002). The



application development project at Wake Forest University used educational software for pocket PCs developed and used for providing mobile and interactive learning environments for students (Bishop, Dinkins, & Dominick, 2003).

### **Mobile Wireless Phones**

Mobile wireless phones are the most popular mobile wireless technology used mainly as personal communication tool. Examples of mobile wireless phones include the following:

- **Web-enabled cellula:** similar to cellular, but has a capability of accessing the Web. It uses wireless application protocol (WAP) as the system to connect to the Internet through a mobile phone. Sometimes, it is called a WAP phone.
- **Wireless handset:** a sort of cellular phone providing a communications system with more features, such as voice-activated dialing, a WAP browser, and two-way text messaging.
- **Smartphones:** a combination of mobile phone and computers.

Compared to wireless-enabled computers of PDAs, mobile wireless phones are still in their infancy for teaching and learning environments. PDAs are often used with mobile wireless services, such as Short Message Service (SMS [Mauve, Scheele, & Geyer, 2001; Seppälä & Alamäki, 2003]), and Multimedia Message Service (MMS [Seppälä & Alamäki]). A few institutions of higher education have integrated mobile wireless phones into their teaching and learning environments. One such example is the M-Poort Project providing web-based curriculums through a WAP phone at the University of Twente in the Netherlands (Cole, 2001), and the Campus-Mobile Project at the Berlin University (Lehner, Nosekabel, & Lehmann, 2002) where users send and receive Short Message Service (SMS) and library data through a WAP phone.

### **Short Message Services (SMS) and Multi Media Services (MMS)**

SMS or text messaging is the transmission of short text messages to and from a mobile wireless phone, fax machine, and/or IP address. SMS may be one of the most common wireless applications that are used with mobile wireless phones to support teaching and learning. With SMS, professors and students can send and receive text messages to and from most modern mobile wireless phones.

Unlike SMS, MMS is the more recent mobile messaging application. Therefore, fewer educational institutions have begun to test MMS as a potential teaching and learning tool. Similar to SMS, the MMS offers automatic and immediate delivery of personal messages. However, MMS can deliver all types of information, such as text messages, sound, images, and video messages. In the near future, the use of SMS and MMS will potentially be increased in the education field as technology improves (Trifonova, 2003).

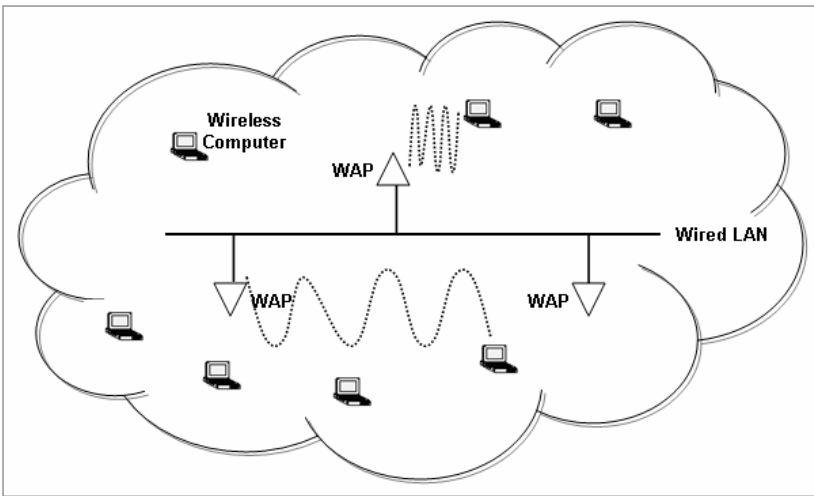
With the increasing trend of institutions of higher education to adopt and make use of mobile wireless technology, it is likely that these devices will become more prevalent on US campuses. The influence of this trend remains to be seen.

### **THE ACCESS OF MOBILE WIRELESS TECHNOLOGIES TO NETWORK RESOURCES**

It is not easy to understand how faculty and students access network resources using mobile wireless devices because of the technical complexity involved. However, understanding how mobile wireless devices work may provide some technological insights to demystify the burgeoning use of technology in all aspects of our society including education. In this section, we offer some explanations about how mobile wireless technologies, wireless computers, PDAs, and mobile wireless phones, connect to network resources.

### **Wireless Computers**

Wireless computers operate in the same ways as a regular computer just without most of the wires. Figure 3 illustrates a simple, but a whole picture of the way that wireless computers connect to network. First, a Wireless Network Interface Card (WNIC) that is installed in laptop computers and uses a very low radio frequency instead of a wired connection to connect to a network, sends a very low power signal to a Wireless Access Point (WAPs) installed in buildings or classrooms. The WAPs are connected to a wired-network (e.g., Local Area Network). Therefore, the WAPs serve as the bridge between the WNIC and the wire network. The WAPs support transmission for many users simultaneously, far more than wired-networks. However, using the WAPs to connect a network, the speed of data transmission is limited to 11 Mbps making transmissions slower than wired computers whose speed is 100 mbps.

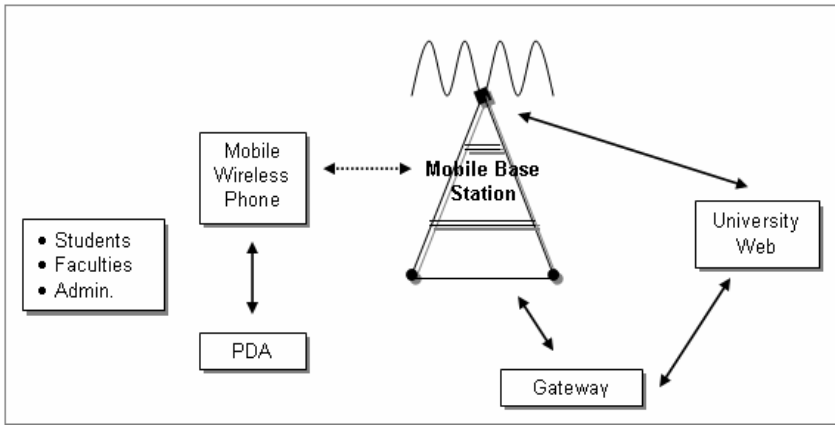


**Figure 3.** Connection of wireless computers to a network using WAP

### **PDA's and Mobile Wireless Phones**

It is unlikely, the connection of wireless computers to wired-network, PDA's, and mobile wireless phones use public stations (e.g. antenna). Therefore,

users need to subscribe to wireless services that are provided by wireless service providers such as Verizon and AT&T wireless. With wireless services subscription, faculty and students simply punch some buttons on their mobile wireless devices to access network. Figure 4 shows how faculty and students at school connect network resources from the school's server using a mobile PDAs or mobile wireless phones (Jones, Moon, Russel, & Cranitch, 2001).



**Figure 4.** Wireless and mobile transmissions

Different infrastructure is required for different mobile wireless devices in order to access network resources. Therefore, understanding technical aspects of mobile wireless technology may help users utilizing it more effectively in a case of technical failure.

## **BENEFITS OF USING MOBILE WIRELESS TECHNOLOGIES IN HIGHER EDUCATION**

### **Benefits of Mobile Wireless Computers**

Since wireless PCs have the same capabilities and functionalities as wired-PCs, students and faculty can enjoy the same capabilities and functionalities

with their wireless computers as they do with their wired PCs. McKenzie (2001) identified additional benefits of using wireless computers for teaching and learning; (a) Ease of movement, (b) Relaxed fit, (c) Strategic deployment, (d) Low profile, (e) Flexibility, (f) Cleanliness, (g) Convenience, (h) Simplicity, and (i) Speed. The smaller size of wireless computers is an added convenience for faculty and students.

In addition to the convenience of the wireless computer, there are also economic benefits. The cost of mobile wireless computers and services has come down dramatically (Galbus, 2001; Rzewnicki, 2004). Currently, the price of wireless computers is similar to that of wired computers simply because the prices of hardware and software required for wireless computers are dropping. In fact, the primary difference between wireless computers and wired computers is that wireless computers use WNIC. Therefore, maintenance, set-up, and integration with other technologies are as easy as with wired computers. However, installing a wireless network can be more cost effective than wired-network because wireless networks can reduce the cost to deploy and operate a network (Tao, 2003). He explained that wireless networks are simpler to setup and manage and they can be more productive and as they provide mobility.

Without wire, teaching and learning efficiency and effectiveness increase. For example, Shim and Shim (2001) claimed potential benefits of wireless computing. They found that faculty teaching, student learning, communication, and collaboration are improved by using wireless computers in the learning environment. The greatest benefit derived from wireless computing was communication, followed by student learning, faculty teaching, and collaboration among students and faculty (Shim & Shim). In these findings, communication may be more important because a good communication channel between teachers and teachers, students and students, and students and teachers results in improvement of teaching and learning processes.

### **Benefits of PDAs**

Many benefits have been identified in the use of PDAs in higher education. Yuen and Yuen (2003) claimed three benefits of PDAs in education, (a) mobility, (b) information management capacity, and (c) beaming capability. As previously discussed, mobile wireless technologies offer the benefit of

anytime, anywhere use. Therefore, the use of PDAs allows professors and students to work in many more places than they could with wired technologies.

Second, information management benefits result from all processes being digitized with PDAs; PDAs replace all pen and paper-based management with electronic-based management. Crawford and Vahey (2001) claimed that PDAs help professors with organizing courses, and managing research materials and information. Traditionally, professors have spent a lot of time with paperwork related to students' assignments, exams, and grading. However, with PDAs' organizational and data storage capabilities, it is now easy to manage data such as students' grade, and lecture materials anytime, anywhere.

Third, PDA's beaming capabilities provide other benefits in teaching and learning environments. For example, in a group seminar, students use beaming capability to send and receive documents, spreadsheets, data, and even applications to other group members without wiring and downloading processes. Without beaming capabilities more time and procedures would be required to share such resources. In addition, students use beaming to send questions, assignments, quizzes, and exams to professors while professors can send grades and answers to students instantly. With the beaming capability of PDAs, professors and students can share files instantly and in real-time (Yuen & Yuen, 2003).

### **Success of PDA Projects**

Table 1 includes the list of some higher educational institutions that use PDAs for various purposes. More institutions of higher learning use PDAs than other mobile wireless technologies for teaching and learning. In this section, we introduce some success examples from some of these institutions of higher learning.

#### **University of South Dakota**

Students and faculty at the University of South Dakota use PDAs for quizzes, lecture schedules, notes, and syllabi (Ambur, Collette, & Tiahrt,

2002). The results showed that PDAs enhance positive outcomes for students in several ways, which include (<http://www.usd.edu/pda>):

- students develop their skills in managing time, keeping records, e-mailing, and group work;
- PDAs provide easier and faster access to syllabi, assignment, reference works and other course-related materials for students;
- students have direct communication with a instructor in class when scheduling appointments, turning in electronic assignments, and sharing information such as URLs, lecture outlines, and academic requirements; and
- students have access to campus information.

### **Virginia Commonwealth University**

Students and faculty at Virginia Commonwealth University conducted PDA projects in various departments, mostly in the medical school. In the project, students are given PDAs loaded with numerous medical reference software to use in their work with patients. Results of this project indicate that students found that PDAs make it easy to find medical reference information and documentation, data collection, treatment guidelines, calculations, patient monitoring, and various practice management activities (Sommers, Hesler, & Bostick, 2001). In this project, professors also found that PDAs are helpful to check students' attendance.

### **Carnegie Mellon University**

Another important PDAs utilization project is "Pebbles PDA Project" conducted by a group of people at Carnegie Mellon University. This project explored several ways that PDAs can be used in higher education. For example, the project investigates uses of PDAs for in-class tests. Because all test processes are computerized with PDAs, students liked the use of handheld devices to study for certain types of tests more than the older

methods of using a show of hands or flashcards (Chen, Myers, & Yaron, 2000).

### **University of Iowa**

Administrators at the university library found that PDA users can keep notes, maintain daily schedules, read books, and access web content in a format, manage and organize, notes and document student learning. Administrators determined that the use of PDAs provided the additional benefits of a paper-free environment, portability, and easier retrieval of information. (Samuels, 2001).

### **Kansas State University**

Faculty at College of Education in Kansas State University have enjoyed similar benefits to those in other universities including easy downloading critical information anytime and anywhere, minimizing paper work and maximizing productivity, and seeing and tracking processes of students (Palm, Inc.).

Though PDAs provide a wide variety of activities and benefits including communication, organization, teacher enhancement, problem solving, motivation, and writing (Vahey & Crawford, 2002), many institutions of higher education using PDAs are still in the process of experimenting with their use. As word spreads about the benefits of this relatively small piece of technology, higher educational institutions will undoubtedly include PDAs in their budgets.

### **Benefits of Mobile Wireless Phones**

Benefits from mobile wireless phones have been just recognized since few institutions of higher education use them for teaching and learning. Some benefits identified by Oku (2001) include:



- providing students with freedom of location and time;
- increasing speed in teaching and learning;
- enabling one-to-one learning based on individual educational histories or test results; and
- allowing teachers to keep up the new educational subjects for future education.

Even if mobile wireless phones do not have as many capabilities as wireless computers or PDAs have, they provide professors and students with much better communication opportunities than other mobile wireless devices. In terms of communication, wireless computers and PDAs are mostly used for text message communication, but mobile wireless phones can be used for voice communication. Good communications between students and professors improve teaching and learning.

Another benefit of mobile wireless phones has been found in a seminar class, a group discussion setting (Jones, Connolly, Gear, & Read, 2002). Students improve their learning processes by using wireless handset that is a type of mobile wireless phone in a group discussion or teamwork. Typical difficulties in a seminar class are a lack of participation by students, the tendency for some students to dominate discussion, and the difficulty in ensuring discussion focus (Anderson, 1997). In such a case, wireless handsets can be used to collaborate in-group discussions easily and more efficiently. For example, students use a numeric keypad on wireless handsets, and then a handset sends a signal to a receiver that is linked to a wireless computer loaded with Global Positioning System Software (GPSS) used to communicate with other simultaneously software. In this manner, wireless handsets provide a discussion environment where all responses and opinions are anonymous so students can address their opinion more freely without any offense from other students. According to Jones et al. (2002), the use of wireless handsets in seminar classes provides a greater level of participation and number of ideas generated. Students feel mobile wireless technologies are easy to use and would be useful for other sessions.

Recently, some schools have began to use mobile wireless phones in the teaching and learning environments because mobile wireless phones create more advanced educational environments with even faster response speeds.

For example, now days we see people using mobile phones to study on the way to school or work as often as we see someone reading a book on the train. Two examples of mobile wireless phone uses in learning environments are the Campus-Mobile project at the Berlin University (Lehner et al., 2002) and M-Poort at the University of Twente in the Netherlands (Cole, 2001).

In the Campus-Mobile Project, students at the Berlin University use mobile wireless phones in order to send and receive SMS through WAP. Then the university and the future project partners, Berlin Central and Regional Library, customize information based on the location of students and the students' personal profiles. This information that is created from different sources and formats is transmitted to the users' WAP-phone displays. Students are able to get the information they need without any location limitation from the school and library to do research and class work.

Another mobile wireless phone project in learning environment is called, "M-Poort" project at the University of Twente in The Netherlands (Cole, 2001). In this project, the university tried to make its current web-based curriculums available to WAP-enabled mobile phone. With its current web-based e-learning courses, students are able to take courses, pick up and turn in their homework assignments from their own computers and communicate with other students and professors online. Now, students are able to do all that and more through their mobile wireless phones. Such mobile learning (m-learning) will provide no limitation on location and time efficiency for those students who want to take some courses from a long distance. In many cases, mobile wireless phones in the learning environment are still under development. In the near future, m-learning will be a common method in education.

Along with mobile wireless phones, SMS and MMS have been tested in several institutions of higher education (Trifonova, 2003). As introduced during the discussion for question one, students and professors can easily exchange any text material related to their courses. For example, at Kingston University in United Kingdom, the SMS experiment was undertaken to determine its effectiveness for student learning. The results showed that students liked SMS more than any other text message application, such as e-mail. The reason that students prefer SMS to others is that the data they receive and send through SMS is more personal (Stone & Briggs, 2002; Stone, Briggs, & Smith, 2002). In addition, the Sheffield Hallam University tested SMS with 67 undergraduate students to support and manage learning

activities. The findings were significantly positive because students recognized that SMS is immediate, convenient, and personal (Garner, Francis, & Wales, 2002).

The example of the MMS uses in learning environments is the Learning In Virtual Environment (LIVE) project conducted at the University of Helsinki (Seppälä, 2002). In the LIVE project, instructors used MMS to share digital images and photos used for instruction with others, which provides another great possibility of m-learning. The LIVE project resulted in positive outcomes in terms of communication and data sharing. Both instructors and students found MMS to be a much easier way of sharing all types of information.

The mobile wireless phone is still in its early stages of implementation in higher education. However, among mobile wireless phone users the largest group of users is ages 19 to 24 (U.S Census, 2001). This user group represents college and university students. As more youth adopt mobile wireless phones, more colleges and universities should seek to take advantages of the benefits of integrating the use of mobile wireless phones into teaching and learning environments in the near future.

## **CONCLUSION**

Mobile wireless technologies are an interesting and very recent addition to higher education. Their power to change the way of educating people is mind boggling. Mobile wireless technologies are the new frontier for teaching and learning in institutions of higher education. Currently and in the near future many educational opportunities are made possible because of m-technologies' unique characteristics and positive impacts identified in higher education. Mobile wireless technologies use in higher education will continue to grow and will become the learning environment of choice.

There is, however, not much academic research to give a clear understanding of the actual benefits of mobile wireless technologies in higher education. In this article, we examined many resources and cited studies to answer the three crucial questions that arose from our study of the literature of mobile wireless technologies in higher education; (a) What types of mobile wireless technologies are currently being used in higher education? (b) How

do mobile wireless technologies access to network resources? and (c) What are the benefits of mobile wireless technologies in higher education? Without the understanding of these three issues, the study of mobile wireless technologies in higher education may be confused and impracticable. Furthermore, the future research in the use and adoption of mobile wireless technologies in higher education will not be possible either. In this aspect, this article initiates a starting point for the use and adoption of mobile wireless technologies in higher education.

We examined three of the most popular mobile wireless technologies used in higher education; wireless computers, PDAs, and web-enabled mobile phones. Each one requires different technical infrastructure to access to network resources. However, they share many common benefits in higher education settings such as anytime, anywhere access, less wiring, simplicity installation flexibility, reduced cost, scalability, improvement of communication, spherical access, and so forth. Such benefits derive from two fundamental characteristics of mobile wireless technologies: Mobility and Reachability (BenMoussa, 2003; Ng-Kruelle et al., 2002; Turban et al., 2002).

However, we must look at some issues and challenges of mobile wireless technologies before adopting and using them. Among many issues, security issues may be more crucial than other issues. At the current stage of mobile wireless technologies, there is virtually no security feature. Such doubts on security issues of mobile wireless technologies lead to slow adoption of mobile wireless technologies in business sectors in which many transactions are involved. Regardless of security issues on mobile wireless technologies, more higher education institutions, however, are beginning to adopt and use mobile wireless technologies because the main purpose of their usages is to provide mobile-learning environment (m-learning) to both educators and learners, unlike the business sectors.

For many, mobile wireless technologies are still far from being used in everyday life, like calculators or computers. To use these emerging technologies successfully, administrators, educators, and students must think critically to determine how to use the new technologies to achieve their educational goals, rather than greeting the new technologies with uncritical excitement.

## References

- Ambur, R., Collette, J., & Tiaht, C. (2002, May). *Palm initiative: A two year experiment*. Presentation at CUMREC conference, University of Minnesota.
- Anderson, C. (1997). Enabling and shaping understanding through tutorials. In F. Marton, D. Hounsell, & N. Entwistle, (Eds.), *The experience of learning* (2<sup>nd</sup> ed., pp. 184-197). Edinburgh, UK: Scottish Academic Press.
- Bartel, C., & Meerts, J. (2002). *Overview of next generation wireless data*. Retrieved November 9, 2005, from <http://www.educause.edu/ir/library/pdf/DEC0204.pdf>
- BenMoussa, C. (2003, April). *Workers on the move: New opportunities through mobile commerce*. Paper presented at the UKAIS Conference, University of Warwick. Retrieved November 16, 2005, from <http://www.warwick.ac.uk/~bsral/ukais/abstracts.php#73>
- Bishop, A.L., Dinkins, R.K., & Dominick, J.L. (2003). Programming handheld devices to enhance learning. *Educause Quarterly*, 1, 50-53.
- Boggs, R. (2002). *ECAR study: Trends in wireless communications in higher education, seminar on academic computing*. Retrieved November 9, 2005, from <https://www.educause.edu/ir/library/pdf/EDU0218.pdf>
- Camponovo, G., & Pigneur, Y. (2003, April). Business model analysis applied to mobile business. *Proceedings of the 5<sup>th</sup> International Conference on Enterprise Information Systems (ICEIS)*, Angers, France.
- Chen, F., Myers, B., & Yaron, D. (2000). *Using handheld devices for tests in classes*. Carnegie Mellon University School of Computer Science Technical Report, No. CMU-CS-00-152 and Human Computer Interaction Institute Technical Report CMU-HCII-00-101. Retrieved November 9, 2005, from <http://www-2.cs.cmu.edu/~pebbles/papers/CMU-CS-00-152.pdf>
- Cisco System (2003, January). *Louisiana State University implements Cisco CTE 1400 series content transformation engines*. Retrieved November 9, 2005, from [http://www.cisco.com/warp/public/cc/pd/witc/cte1400/prodlit/louis\\_bc.htm](http://www.cisco.com/warp/public/cc/pd/witc/cte1400/prodlit/louis_bc.htm)
- Cole, G. (2001, June). The classless society. *Connectics*. Retrieved November 16, 2005, from <http://specials.ft.com/connectis/june2001/FT3EFBND7OC.html>
- Crawford, V., & Vahey, P. (2001). *Palm education pioneers program: Round 1 preliminary evaluation report: SRI International*. Retrieved November 9, 2005, from [http://www.palmgrants.sri.com/PEP\\_R1\\_Report.pdf](http://www.palmgrants.sri.com/PEP_R1_Report.pdf)
- Dubendorf, V.A. (2003). *Wireless data technologies*. New York: John Wiley & Sons.

- Fryer, W.A. (2002). *Wireless computing: New opportunities and challenges in education*. Retrieved November 9, 2005, from [http://www.wtvi.com/teks/02\\_03\\_articles/wirelessfuture.html](http://www.wtvi.com/teks/02_03_articles/wirelessfuture.html)
- Houser, C., Thornton, P., Yokoi, S., & Yasuda, T. (2001). Learning on the move: Vocabulary study via mobile phone email. In C. Lee (Ed.), *Enhancement of quality learning through information and communication technology, ICCE2001*, (pp. 1560-1567).
- Galbus, A.C. (2001). *Are wireless computers a cost effective alternative to fixed documenting and reviewing patient cares?* Unpublished masters thesis, Cardinal Stritch University. Retrieved November 9, 2005, from [http://www.pdacortex.com/wireless\\_computing\\_bedside.pdf](http://www.pdacortex.com/wireless_computing_bedside.pdf)
- Garner I., Francis J., & Wales, K. (2002, June). An evaluation of the implementation of a short messaging system (SMS) to support undergraduate student learning. In S. Anastopoulou, M. Sharples, & G. Vavoula (Eds.), *Proceedings of the European Workshop on Mobile and Contextual Learning* (pp. 15-18), Birmingham, UK.
- Jones, C., Connolly, M., Gear, A., & Read, M. (2002). Group interactive learning with group process support technology. *British Journal of Education Technology*, 32(5), 571-586.
- Lehner, F., Nosekabel, H., & Lehmann, H. (2002). Wireless e-learning and communication environment: WELCOME at the University of Regensburg. *e-Service Journal*, 2(3), 23-41.
- Levine, L.M. (2002, October). Campus-wide mobile wireless: Mobility and convergence. *Syllabus*.
- Maginnis, F., White, R., & Mckenna, C. (2000, November/December). Customers on the move: m-Commerce demands a business object broker approach to EAI. *eAI Journal*, 58-62.
- Malladi, R., & Agrawal, D. P. (2002). Current and future applications of mobile and wireless networks. *Communications of the ACM*, 45(10).
- Market Data Retrieval (2003). *College technology review: 2003-2004 Year*. Retrieved November 9, 2005, from [http://www.schooldata.com/pdfs/colltech04\\_intro.pdf](http://www.schooldata.com/pdfs/colltech04_intro.pdf)
- Mauve, M., Scheele, N., & Geyer, W. (2001, September). *Enhancing synchronous distance education with pervasive devices*. *GI Jahrestagung*, 2, 1117-1122.
- McGhee, R., & Kozma, R. (2001). *New teacher and student roles in the technology-supported classroom*. Paper presented at the annual meeting of the American Educational Research Association, Seattle.
- McKenzie, J. (2001). The unwired classroom: Wireless computers come of age. *Educational Technology*, 10(4). Retrieved November 9, 2005, from <http://www.fno.org/jan01/wireless.html>
- Ng-Kruelle G., Swatman P.A., Rebne D.S., & Hampe F. (2002). The price of convenience: Privacy and mobile commerce. *Quarterly Journal of Electronic Commerce*, 3(3), 273-285.

- Oku, M. (2001, July). *High-level educational performance brings innovations to corporate culture*. Retrieved November 9, 2005, from [http://www.sw.nec.co.jp/english/special/e\\_learning/topmess01.html](http://www.sw.nec.co.jp/english/special/e_learning/topmess01.html)
- Oliver, B., & Wright, F. (2002, February). The next big thing? Exploiting channels and handheld computers for student learning. *Proceedings of the 11<sup>th</sup> Teaching and Learning Forum*, Perth, Western Australia.
- Palm, Inc. *Success stories*. Retrieved November 9, 2005, from <http://www.palmone.com/us/education/studies/#teachers>
- Phipps, R.A., & Wellman, J.V. (2001). Funding the infostructure: A guide to financing technology infrastructure in higher education. *Lumina New Agenda Series*, 3(2). Retrieved November 9, 2005, from <http://www.ihep.org/Pubs/PDF/FTI.pdf>
- Rzewnicki, A. (July, 2004). Rising demand lowers cost, Increasing usage of Wi-Fi. *Triangle Business Journal*, In Depth: Triangle Tech News. Retrieved November 9, 2005, from <http://www.bizjournals.com/triangle/stories/2004/07/26/focus2.html>
- Samuels, S. (2001, December). I wanna hold your handheld: ITS explores ways to support PDAs, faculty & staff news. *fyi*, 39(8). Retrieved November 9, 2005, from [http://www.uiowa.edu/~fyi/issues2001\\_v39/12072001/pdas.html](http://www.uiowa.edu/~fyi/issues2001_v39/12072001/pdas.html)
- Shim, M. K., & Shim, S. J. (2001). Mobile computing in higher education: Faculty perceptions of benefits and barriers. *Journal of Educational Technology Systems*, 29(4), 345-354.
- Sims, G. (2002). UT@2015: A pocket PC experience. *Educause Quarterly*, 2, 69-72.
- Seppälä, P. (2002). Mobile learning and mobility in teacher training. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE)*, (pp. 130-135), Växjö, Sweden.
- Seppälä, P., & Alamäki, H. (2003). Mobile learning in teacher training. *Journal of Computer Assisted Learning*, 19(3), 330-335.
- Sommers, K., Hesler, J., & Bostick, J. (2001). Little guys make a big splash: PDA projects at Virginia Commonwealth University. *Proceedings of the 29th Annual ACM SIGUCCS Conference*, (pp. 190-193), Portland, Oregon.
- Stone, A., & Briggs J. (2002). ITZ GD 2 TXT – how to use SMS effectively in m-learning. *Proceedings of the European Workshop on Mobile and Contextual Learning*, (pp. 11-14), Birmingham, UK.
- Stone A., Briggs J., & Smith, C. (2002). SMS and interactivity—some results from the field, and its implications on effective uses of mobile technologies in education. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2002)*, (147-151), Växjö, Sweden.
- Swett, C. (2002, October). College students' use of mobile wireless-internet connections becomes more common. *Knight Ridder Tribune Business News*, Washington, DC.

- Tao, E. (2003, July). Wireless network deployment and its impacts on teaching and learning—a case study of California State University Monterey Bay. *Proceedings of Syllabus*, San Jose Marriott, Stanford University.
- Thornton, P., & Houser, C. (2001, June). Learning on the move: Vocabulary study via email and mobile phone SMS. *Proceedings of ED-MEDIA*, (pp. 1846-1847), Tampere, Finland.
- Tolson, S.D. (2001, June). Wireless laptops and local area networks. *T.H.E. Journal*, 28(11), 5, 62.
- Trifonova, A. (2003). *Mobile learning—review of the literature*. (Technology Report No. DIT-03-009). University of Trento, Department of Information and Communication Technology.
- Turban, E., Lee, J.K., King, D., Warkentin, M., & Chung, M. (2002). *Electronic commerce 2002: A managerial perspective*. Englewood Cliffs, NJ: Prentice Hall.
- 2001 United States Census. Retrieved November 9, 2005, from <http://www.census.gov>
- Vahey, P., & Crawford, V. (2002). Palm™ education pioneers program: Final evaluation report. *Learning Technology Newsletter*, 5(2). Retrieved November 9, 2005 from [http://palmgrants.sri.com/PEP\\_Final\\_Report.pdf](http://palmgrants.sri.com/PEP_Final_Report.pdf)
- Webopedia—Definition of PDAs. Retrieved November 9, 2005, from <http://www.webopedia.com/TERM/P/PDA.html>
- Yuen, S., & Yuen, P. K. (2003). PDAs as educational power tools. *Tech Directions*, 62(9), 14-17.