Learning Tools for Knowledge Nomads: Using Personal Digital Assistants (PDAs) in Web-Based learning Environments

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Introduction

A silent revolution has recently swept through dozens of college campuses across the United States, where students and faculty members with portable computers can now have access to the college network and the Internet from anywhere on campus through a wireless network.[1] The advent of wireless computing technology has saved network managers from the nightmare of having to run miles of cables to physically wiring the campus; or, worse still, retrofit old buildings with modern wiring. Not only do network managers find wireless networking to have great appeal because of its convenience (Olsen, 2000b), administrators of universities also find it appealing because of its relative low cost when compared to traditional networking (Carlson, 2000).

Wireless technology grants the boon of mobility to its users. Many users, in fact, up to 30

[1] The Oct 13, 2000 issue of The Chronicle of Higher Education ran a full article about "The Unplugged Campus."

or more, may be connected to the network through a single access point; and remain "connected" up to a distance of several hundred feet away. This means, as long as the users remain within the proximity of the wireless signal (also called the "wireless cloud"), they are no longer required to be physically tethered to a network point or their desk. This "mobility" advantage has, in fact, fueled the vision for "nomadic computing" in many campuses; which in turn helped to push towards the direction of a "nomadic learning environment," allowing students to choose and "learn at the location that's best for them" (Olsen, 2000b, p.A60).

The idea of a structured learning environment, in which learning could occur outside the boundaries of time and space, has been pursued in the field of distance education since the early 1980s (McIsaac & Gunawardena, 1996). This special mode of learning, spanning time and space, is now carried out through online learning and increasingly on the Web. With nations around the world recognizing the rise of the tide for knowledge workers and the importance of lifelong learning in the ensuing knowledge economy (Drucker, 1994), the notion of "nomadicity" (Kleinrock, 1997) — constantly able to access information and knowledge, no matter where — suddenly takes on a much greater significance.

With the Internet being introduced into classrooms, "information literacy" will increasingly become a major concern for educators (e.g., Plotnick, 1999; Thompson & Henley, 2000). Educators now face the problems of harnessing information for use in the classrooms, keeping up with new information and technological tools, and making these tools available for their students to attain that literacy.

Many developments are enabling easier access to the technology. In the past few years, rapid changes have taken place in both hard and soft technologies. Desktop computers have shrunk in size and weight to become laptops, and then palmtops, handhelds, and pocketsize "personal digital assistants" (PDAs).

The field of mobile computing is currently one of the fastest growing industries. Within 18 months of its introduction in 1996, one million units of 3COM's PalmPilot were sold.[2] In 1998, the sale rose to 3.9 million in United States alone, with the latest forecast by Dataquest that by the year 2003, sale figure will finally exceed that of desktop computers and reach 20 million (Frauenfelder, 1999). A fast maturing market for mobile computers, coupled with the widespread acceptance of online learning and Web-based instruction, behooves us to examine how mobile computers may be used in a Web-based learning environment (WBLE) to empower individual learners in a lifestyle of lifelong learning, anytime anywhere.

This article will explore the feasibility of using such portable devices within WBLEs. It will also consider the "missing-link" technology needed to bring the portable WBLE experience to a higher acceptance level. Within the context of this article, the term "portable devices" shall include (but not be limited to): PocketPCs, handheld computers, portable notebooks, palmtops, and other PDAs enhanced with appropriate tools. Commonplace technologies used in a WBLE and ways portable devices may be used in place of these conventional technologies (or even to extend the WBLE) will be discussed.

Becoming Portable

Creating the wireless clouds on a campus (or in a workplace) is only the first step towards a mobile learning (or working) environment.[3] The other key piece of equipment required to complete the handshake is a portable computer. Typically, these are laptops that are owned by the students and/or faculty members. Although many campuses have special arrangements for students who cannot afford a computer, in some cases, colleges and

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[2] For comparison, it took Sony three years to sell one million units of Walkman after its debut.

[3] In this article, the terms "nomadic" learning environment and "mobile" learning environment are used interchangeably.

universities are beginning to look into ownership of computer as a prerequisite for enrollment (e.g., College of Library and Information Science of University of South Carolina). In the case of Massachusetts, the state's Board of Higher Education has decided that all public college students are required to own laptop computers in three years time (Olsen, 2000a). This is in most part to ensure that every student would have access to the technology, as well as to defray the cost for continual maintenance and upgrades of computer labs. For most college students (and faculty members who are on the move would probably agree), laptops seemed the natural choice.

However, a question can be raised regarding these decisions: Is laptop ownership by every student the way to go? Although nowadays laptops can pack as much processing power as their desktop siblings, the laptops are generally more expensive. Battery life is often limited to two hours, presenting another problem, as users are constantly haunted by having to look for a power outlet to recharge their dying battery, which impedes mobility. In addition, no matter how slimly built laptops are, they are still relatively heavy to be carried around for an entire day.

PDAs and most of the smaller versions of computers (such as the palmtop, and PocketPC) are built with professional mobile workers in mind. They are, in most cases, pocketsize, and run continuously on rechargeable batteries for up to eight hours (or more, with the new lithium-polymer battery). There are a variety of models and designs to suit individual needs and the price tag is generally small (in the range of US$200-800). Most of all, these mobile computers and PDAs allow the users to carry with them, wherever they go, the means of accessing important information in unobtrusive lightweight devices.

Slowly but surely, as the user-base of mobile computers and PDAs continue to grow, many students and faculty members are becoming proud owners of these "cool gadgets." They are increasingly seen openly using them to track class schedules, looking up phone

numbers of friends and colleagues, and even reading news clips offline (such as that offered by AvantGo) as they go along with their daily activities. Even educational researchers are beginning to find an interest in examining this new gadget (Pownell & Bailey, 2000).

Since its debut, the PalmPilot (now, Palm) has very much monopolized and dominated the market share of PDAs. In 1998, Jeff Hawkins and Donna Dubinsky — the same people who gave the world PalmPilot — left Palm, Inc. to start a new business with a new handheld device called "Handspring." With an added expansion slot for modular "Springboard" devices, the Handspring has the capability to "transform" itself into another device, such as becoming a camera, a barcode scanner, or even a mobile phone.[4]

Then in April 2000, the landscape took another interesting change with Microsoft announcing the arrival of the PocketPC. These are pocketsize machines that function more like PCs than "conventional" PDAs, and run on Microsoft's latest operating system, Windows CE 3.0. Thus, for the first time in the mobile computing history, a truly standalone[5] "computer" small enough to fit in a shirt pocket was made available (hence the name, PocketPC).

Since then, keen competition among the main PocketPC manufacturers[6] has pushed the technology to new heights and resulted in a plethora of interesting devices, all with differing specifications targeted to different niche of users. Within five months, more than 15 models of PocketPC were launched, as the over-enthusiastic manufacturers tried to best one another with yet another "version" of the device. Certainly, Palm and

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[4] Further information on the Springboard modules may be obtained at the Handspring's Website at http://www.handspring.com

[5] The "conventional" PDA, such as the PalmPilot, was originally designed to be a "companion" to PC and was not meant to be a stand-alone unit.

[6] The early PocketPC manufacturers are Hewlett-Packard, Casio, Compaq, and Symbols.

Handspring are not to be left out. Caught in the heat of the competition, they too, have released new versions of their devices, and have promised more products to come.

Thus, as more players (both hardware and software manufacturers) join in the race — to come up with better form-factor, human–computer interface designs, more memory and larger storage space[7] — new devices with better processing power and better software are being released into the market with great fervency. Handheld computers have now moved beyond "glorified day planners into universal-access devices, able to ferret out essential information wherever it happens to be stored — on the desktop PC, the home-office server or the Internet" (Frauenfelder, 1999). A small and powerful handheld "computer" coupled with the ability to go "online" wirelessly creates a prototype device that might just be right for wireless WBLE.

Online (Web) Learning

Even though distance education has experienced dramatic growth, both nationally and internationally, since the early 1980s (McIsaac & Gunawardena, 1996), Internet technology was not mature enough at that time to be taken advantage of. On the other hand, online learning and Web-based learning were offspring of distance learning, borne out of the Internet "revolution." While online learning (e.g., the Open University) makes use of specially designed interfaces (often software based) to bring the classroom experience to the learners (wherever they are), and in turn brings the learners to the classrooms (virtual learning space), Web-based learning seeks to harness the Web for learning purposes, often through the use of course management tools such as WebCT and Blackboard.

Although all three terms seemed mere variants of one another, WBLE has one distinct

[7] PocketPCs with Compact Flash card slot now support Compact Flash memory card up to 256 MB, and IBM MicroDrive (a removable hard-disk solution) up to 1 GB of storage space.

advantage over the rest: *timing*. It has come at a time where college students have accepted the Web as mainstream:

- More than 50% of U.S. college students have Internet access from their dorm rooms and virtually all will have access from some campus location.
- Over 90% of college students access the Internet, with 50% accessing the Web daily.
- Students average almost 19 hours per week on the Internet — spending 85% of that time on academic pursuits.
- Students are expected to spend $3.9 billion online in 2002, up from $200 million in 1997.
- Over 35% of students surveyed in Greenfield's Online Campus Market study report shopping online as a regular activity. Some 75% of these students say that they have made online purchases, compared to 51% a year ago.
- Some 40% of students have their own World Wide Web home pages. (Moe, 2000)

Apart from serving the existing college student community, which is getting more Web-savvy by the day, WBLE also carries with it the potential to bring in revenue for the colleges and universities. In "*Online Distance Learning in Higher Education, 1998-2002*," IDC forecasted that the number of students taking distance learning courses is expected to grow from 710,000 in 1998 to 2.23 million in the year 2002, an estimated annual growth rate of 33%! It is no wonder that 78% of the institutions offering distance learning courses have chosen to do so with Web-based technology (Moe, 2000). Already, a number of Online Universities have been created to offer courses exclusively through the Web – such as the Cardean University (by UNext.com) and Capella.edu. In Singapore, a country where 56% of the population uses mobile phones of one kind or

another, three out of five of the nation's Polytechnics had outlined their plans to achieve wireless campus status by the year 2002 (Chin, 2000).

Spurred on by such entrepreneurship, many traditional universities and colleges have followed suit to *"webify"* — to put their content online — in hope of getting a slice of the pie. A recent survey by the American Society for Training and Development (ASTD) illustrated the fact that over 50 percent of universities in the United States (US) are offering some form of Web-based (online) courses (as reported by Shrivastava, 1999). Yet instructional technologists and educators have come to recognize that putting courses on the Web is not the same as putting existing lecture notes online. Content would have to be redesigned to fit the medium, as WBLE calls for many things not present in a traditional face-to-face classroom; among them, self-regulation (Brooks, 1997), learner-centeredness, collaboration, and motivation. Most importantly, it is learner-centered, and in this case, they are nomadic learners (Kleinrock, 1997), who may engage in learning activities anytime, anywhere (Holmberg, 1989).

"Anytime learning" implies that lessons (or more broadly, learning resources and information in general) would have to be structured in such a way that learners may return at anytime, and still have access to the materials online. Thus, advanced networking technology with password verification, student progress tracking, just-in-time training, and other multimedia on-demand technology were developed to cater to this need.

"Anywhere learning" is harder to achieve. If the computer is rationalized as the "window" to the learning resources, how then do learners gain access to this "window" *anywhere*?

Web-Based Learning Technologies

It was not until the advent of telecommunications technologies that distance education could "provide for two-way, real-time interaction, or time-delayed interaction between students and the instructor or among peers" (McIsaac & Gunawardena, 1996).

Similarly, it was not until the widespread acceptance of Internet and the maturation of network related technologies that WBLE could take on the tasks set before it by online learning. In the following section, we will visit the commonplace technologies one would normally encounter in a WBLE (see Figure 1 for an overview).

Insert Figure 1 about here

Communication

There are two mode of Communication via the Web: synchronous and asynchronous. In a synchronous (same time) fashion, users may choose from the following:

- **Chat room** — users log in to a chat server to simulate a "same place" experience with users with (presumably) the same interest, indicated by the "name" (door-sign) of the chat room,
- **Messenger** — users are alerted to the Web presence of specific individuals (usually this is someone they know) and may hail one another at will, to simulate an audio only "face-to-face" experience, and
- **Web-conference** — users log in to a Web-cam enhanced conference session to simulate an audio-visual "same room/ face-to-face" experience.

In an asynchronous mode, users may choose from the following options:

- **Bulletin board** – users post and respond to messages listed on a "notice board",
- **Feedback/ email** – users respond to messages directed specifically to them from others, and
- **List-serv/ forum** – users subscribe to a "mailing list" where every message posted is routed to all individuals in the list, where each member may then chose to respond or not at all.

Content-Resources

There are a couple of ways to look at content-resources within a WBLE. One way is to subdivide them into direct content and supplementary resources. Alternatively, one can subdivide content-resources by their genre, into print and non-print (multimedia) materials.

Print materials may include traditional textbooks, Web pages, handouts, slides, transparencies, and all other presentation materials, that may be printed using a printer. Multimedia (non-print) materials represent all that may not be printed, such as video, audio, animation, games, and interactivity, achievable through scripting technology.

Connection

An organization (or school) may connect to the Web with or without wire. Wired options include modem (through a landline telephone, or its derivatives, such as DSL and cable modem) or local area network (LAN). Smaller organizations may find a modem connection adequate, but for large corporation, the preferable method is to run a within-organization only Intranet (i.e., a Web-based LAN for insiders-only), and then connect

that Intranet server to the Internet (i.e., the “outside world”) through a protective firewall. Within this group of corporate Intranet users lies the networking mire: Miles of special cable need to be physically put in place to connect buildings and rooms, resulting in a wall or desk-mounted socket for every user. In other words, users of a network are tethered to their desks.

With wireless technology, however, only a book-like access point with a signal “transmitter” is installed on the wall of a building, with minimal wiring. Each installed access point may serve up to 30 or more users, who connect with the network through a “receiver” card on their computers. Most importantly, users of a wireless network environment may move freely about, so long as they are within the proximity of the “wireless cloud” (or wireless signal reception). Even though the size of the cloud is only up to a few hundred feet away from the access point, strategically placed access points will, in theory, extend the network limitlessly.

There is also the wireless application protocol (WAP), which have received mixed reviews. Primarily a technology created to connect the mobile phone to the Web; WAP technology has received rave reviews in some countries, such as Italy (Oslo, 2000c) and Asia Pacific countries (Lim, 2000). In other instances, it was looked upon as a dying technology (Oslo, 2000b), mostly due to competing technologies and rival standards (Meland, 2000; Oslo, 2000a).

Collaboration

Last, but not least, there is the collaborative learning among learners. In order for collaboration to happen regardless of where the users are, means for file sharing is a necessity. In most cases, this would mean sharing of documents created by the users themselves. This would require not only a common platform of document creation (e.g., MS Office), but also a file transfer protocol (FTP) capability. Although some users

would prefer to use dedicated software for FTP, less tech-savvy users commonly resort to sending the documents as attachments with an email, which, unfortunately, open up the WBLE for virus attack, as well as inadvertent spreading of malicious viruses. Thus, virus protection software, though not explicit as part of a WBLE, is necessary.

For data sharing and field work in some discipline, some sort of data input devices, such as data loggers, probes, and barcode scanners, may be required, although in most cases of WBLE, this is not necessary.

Building A Portable WBLE

Since the debut of PocketPC in April 2000, many technology updates have taken place. Portable PCs that run on Windows 9x or NT platforms already meet all the technology criteria required in a WBLE, as listed in the previous section. Table 1 compares two competing operating systems (WinCE vs. PalmOS) as to how well they support WBLE. However, it should be noted that in the case of Windows CE, only PocketPC and HandheldPC Pro would qualify as suitable products in this discussion. In the case of PalmOS, only Handspring and Palm VII are suitable, and then only marginally.

It should be noted that this general comparison guide should serve to inform rather than promote a single product as "*The Tool.*" Readers need to bear in mind that there are enough products that are significantly different from one another within even a single OS (e.g., between Compaq's iPAQ and Casio's Cassiopeia; and between Handspring and Palm). As there will always be new products, discontinued old products, products that are not listed for sale at all, and products that are withheld from public knowledge, this list is neither exhaustive nor completely accurate! It has been, primarily, compiled from several listings of software and hardware manufacturers who advertised their products for sale on the Web. This list is meant only to reflect a general picture of what are available in the market at the point of writing.

Insert Table 1 about here

Although portable devices do seem user-friendly with many useful products (albeit some workarounds), and Table 1 has certainly shown some very promising products (with more in the pipeline, yet to be made available), it is still a new product and will therefore suffer from the inherent problems found in all new innovation (Metcalfe, 1999). It is important, therefore, for us to consider some of the missing pieces in the big picture of employing portable computers as the vehicle of delivery for WBLE, as well as the deterring factors found in the current educational system.

"Missing-Links" Technology

When we looked into what's missing, it is important to bear in mind that what is lacking today does not necessarily connote that a device is unsuitable. Sometimes there is a need to form a "partnership" between the university and a software or hardware company so that they can work in tandem to complete the missing link. For example, in the case of Carnegie-Melon University, they partnered with AT&T to develop a software driver for the Orinoco Ethernet card (i.e., Lucent WaveLAN), which has been adopted in their implementation of the Wireless Andrew project.[8]

Currently there are a number of obvious missing links in the technology that would require either a suitable hardware or software solution. They are listed as follow, and are

[8] The Web site for the "Wireless Andrew" project of Carnegie-Melon University is at http://www.cmu.edu/computing/wireless/

by no means exhaustive:

1. **Live video streaming** — although PocketPCs with camera add on have the capability to capture short mpeg video files, there is currently no way to directly transfer or stream live video, from one PocketPC to another. At the moment, video transmission is limited to asynchronous mode only. However, it is possible to receive wireless Web-cast of streaming media (both audio and video) with Microsoft's newly released "Windows Media Player for PocketPC Technology Preview 2" software.

2. **Updated OS** — a few models of Palm stored its PalmOS operating system in flash ROM (this means that users could "flash" their units at will, with an updated version of the operating system, when it is made available). However, only one of the PocketPCs (i.e., Compaq iPAQ) has this feature.

3. **Embedded software** — in the case of PocketPC, a selected number of software programs (such as Word, Excel, and Media Player) are in-built into the OS, thus making the operation faster. In the case of PalmOS, software is generally not included, except for a minimal set of "organizer" tools. The question remains what software constitutes the "core" selection and under what criteria are they chosen.

4. **Screen size** — this continues to be a point of contention among users. Those who travel light like it small; thus the device must fit in a pocket. Others are unhappy about the small screen size, as Web pages generally do not fit in the "portrait/ vertical" screen of the PDAs (except Handheld PC pro, which offers a "landscape" screen).[9] The introduction of "Tablet PC" may be the next move to better cater to individual learning needs (Address by Bill Gates at Comdex 2000).

5. **Text/ voice input** – the smallness of the PDA screen makes it less than ideal for verbose text input. Although PalmOS has a fairly user-friendly Graffiti text input software, and PocketPC has Transcriber, the demand in verbose text input has

brought forth various keyboards as add-on to the devices. Although this move of adding a small keyboard partially alleviates the problem, a more intuitive input method for the small PDAs would (probably) be voice input. In any case, voice recognition technology is a fast changing field and is yet to mature.

Deterring Factors

Apart from the missing-links technology, we will also need to consider some of the deterring factors that are inherent within the educational system that may delay or prevent general adoption of these portable devices in education:

- **Functionality** — there exists no "killer app" for the educational market, and educators remain unconvinced of paying the seemingly high price to just keep track of appointments and play music (MP3)
- **Price/ performance/ value** — even though by comparison, portable devices are cheaper than PCs, a $500 PC is fully functional with CDROM drives (allowing for expandability by adding software), whereas the same price tag of $500 for most of the PocketPCs seemed incomparable to its size (and users tend to equate lack of CDROM player with "no expandability.") Point of contention: Most of the edutainment software to date is available as CDROMs.
- **Innovation adoption** — An innovation will soar or sink depending on the way it is marketed (Metcalfe, 1999). The initial effort to market portable devices have been focused primarily to the "mobile" corporate workers, and is generally perceived as a "high-tech toy." The current marketing campaign also tends to hype up a product and raise users expectation beyond reality. A change of marketing strategy would be necessary in order to successfully reach out to the niche of educators and teachers.

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[9] Jimmy Software has released '*Landscape*,' a software that can "reset" the PocketPC into landscape mode.

- **Public awareness** — educators and teachers are concerned about getting more computers (in this case, desktops and laptops) into their classrooms; very few educators and teachers have even heard about portable devices. Part of the sales and marketing strategy must involve first raising the awareness of these potential users.

- **Mixed standard** — there are currently four different solutions to increase memory storage in the PalmOS products — in other words, there is lack of a standard solution. Users who bought a product would be "trapped" in that product line, as the memory storage card is proprietary. Even though PocketPCs used just about as many cards — i.e., Compact Flash card/ Smart media card and PCMCIA PC-cards — there is one important difference: There is a general converter card to "convert" one card into another. This lack of standard is also true for add-on products for the PDAs, e.g., Palm keyboard and PDA–mobile phone adaptors. Hardware developers need to recognize that every new product pulls the market in a different direction, which serves to confound potential users.

- **Questionable investment** — the PDA market has expanded too fast, and the demand from various sectors currently exceeded the speed of technology growth. Microsoft has made announcement about yet another portable devices, the "Tablet PC," to be made available in 2002 (Fried & Spooner, 2001; Galli, 2001). Administrators and higher management in educational sector would delay making that decision in adopting any particular PDA device until they are convinced. Thus the onus will fall on the teachers to "invest" in the device only if they think it is useful for personal use.

- **Lack of need** — at this juncture, there is no push factor for the teachers to own an innovative product, given the "low-tech" nature of the current curriculum. (Marcinkiewicz, 2000) suggested that the best predictor for innovation adoption is to appeal to the teachers' "subjective norm"; in addition to that, compliance and

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PocketPC users have the option to view the screen in either portrait or landscape mode.

dependency can only be achieved by having the necessary infrastructure within an organization.

Unrealistic Expectations

A recent survey about "wireless" services further revealed that current wireless (early adopter) users have "unrealistic" high expectations (brought over from their desktop computer experience) about the wireless computing (Leder, 2000). Market analysis showed that this expectation is ahead of what technology could offer at this juncture. From the 2000 wireless technology users surveyed, the report summarized that:

- 50% of the users find the data access to be too expensive, and
- 80% of them find the wireless access to be too slow.

However, with standardization and implementation of international wireless protocol (especially the 802.11 standard) put in place, there are now better, cheaper, and more interoperable products in the market (Chin, 2000). With the price decreasing and better products on the rise, such complaints and disadvantages may be short-lived.

When released, Bluetooth (a new wireless technology) and other new services, such as the General Packet Radio Services (GPRS, or 3G), may provide new scope of expansion for the PDAs. The GPRS, in particular, may provide the much-needed broad bandwidth necessary for rich media transmission.[10]

[10] Currently, nations are engaged in negotiation of bandwidth sale for GPRS — e.g., the British government has auctioned off five different licenses in return for billions of dollars in April 2000, with Germany and Holland planning similar auctions (Ong, 2000).

Moving Forward

Researchers generally believe that the learning environments of tomorrow will be very different from the classrooms of today. The growth of the Internet has certainly changed the way people learn (hopefully better and more efficient). Already we see shifts of emphasis from linear to hypermedia learning, from teacher-centered to learner-centered learning, from "simple absorption of what is taught" to "self-reflective learning" (where understanding is constructed), from "one-size fit all" learning in post-industrial classrooms to customizable and individualized lifelong learning on the Web (Dede, 1998; Gray, 1999; Tapscott, 1998).

As educators, we need to recognize that neither technology nor media content will be a limiting factor — to borrow a cliché, we are, after all, living in *Internet Time* — even mobile phones have been "converged" with PDAs (e.g., the Nokia 9210 and the Motorola Accompli). As Forman and St. John (2000) pointed out,

> *"Various 'many-in-one' solutions with similar features will arise, most likely connected… by a high-bandwidth, wireless local-area network running off a powerful central server [that] maintain(s) an always-on broadband connection to the outside world over fiber-optic lines or satellite links. We will live in a world of many devices, many networks and limitless scalable content, united by invisible connectivity." (p.56)*

The emergence of new learning methods that will necessarily take place because of the media convergence will make tomorrow's education a playground for the mind. The push towards a mobile/nomadic way of learning is probably inevitable (Quinn, 2000); and the innovation of today may well become the standard equipment of the future (Rogers, 1962). As educators and knowledge workers, we need to be open to learning new things, trying new tools, and exploring new ways to learn; and by doing so, setting an excellent example for the learners that might come and learn from us.

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Figure 1: Commonplace technologies of a Web-based learning environment.

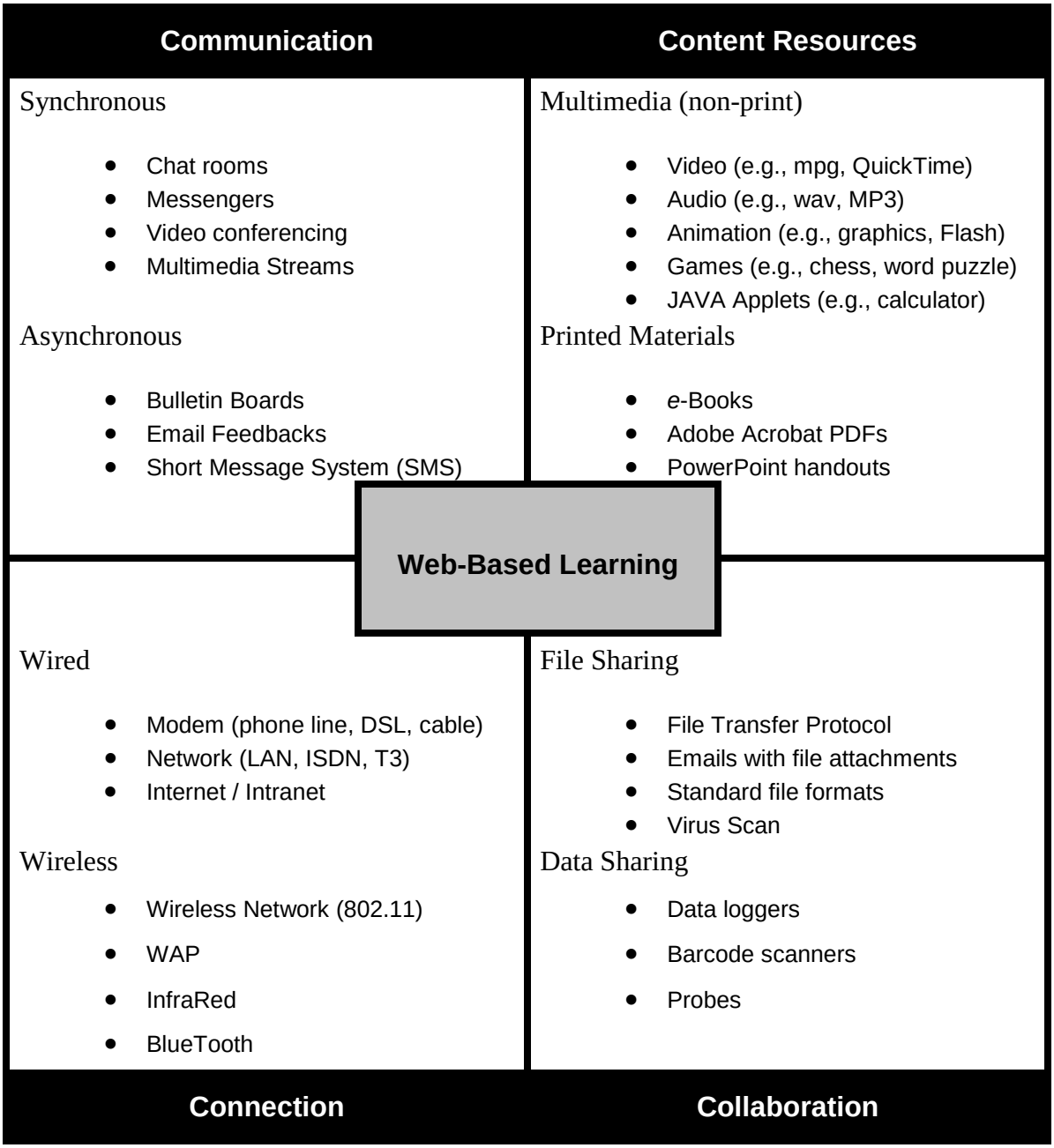

Table 1: WBLE Technology Comparison between Windows CE and PalmOS

WBLE Technology	WinCE	PalmOS	Software Requirement	Hardware Requirement / Remarks
Communication				
Synchronous ▪ Chat room ▪ Messengers ▪ Video conferencing	 ☑ ☑ ☑/☒?	 ☒ ☒ ☒	 ▪ ICQ2000 (beta) ▪ Yahoo Messengers ▪ Video capture & streaming	 ▪ N.A. ▪ N.A. ▪ May require camera add on & Windows media player for PocketPC Technology Preview 2
Asynchronous ▪ Bulletin board ▪ Feedback/email ▪ Listserv/Forum	 ☑ ☑ ☑	 ☒ ☑ ☒	 ▪ Web browser ▪ Outlook ▪ Web browser	 ▪ Web clipping only ▪ Web clipping only ▪ Web clipping only
Content-Resources				
Non-print ▪ Image capture ▪ Video ▪ Audio (wav, midi, mp3) ▪ Animation (Flash) ▪ Games ▪ JAVA applets ▪ Streaming multimedia	 ☑ ☑ ☑ ☑ ☑ ☑? ☑	 ☑ ☒ ☑/☒? ☒ ☑ ☑ ☒	 ▪ Sierra Imaging/others ▪ Media Player/Pocket TV ▪ Software player ▪ Flash player ▪ Game software ▪ JAVA VM ▪ Pocket TV/Windows Media Player Technology Preview 2	 ▪ Require camera add on ▪ Require storage space and camera add on ▪ MP3 module add on for Handspring only ▪ N.A. ▪ N.A. ▪ JAVA for Pocket PC in the pipeline ▪ N.A.
Print ▪ Powerpoint ▪ Offline Internet news clip ▪ Acrobat PDF ▪ e-Book	 ☑? ☑ ☑ ☑	 ☑? ☑ ☑ ☑	 ▪ HTML with Web browser ▪ AvantGo service ▪ Primer PDF Reader ▪ Microsoft Reader/PeanutPress/ Acrobat eBook Reader	 ▪ Work around, no real PowerPoint viewer ▪ AvantGo service needed ▪ N.A. ▪ N.A.

Table 1: WBLE Technology Comparison between Windows CE and PalmOS (cont.)

WBLE Technology	WinCE	PalmOS	Software Requirement	Hardware Requirement / Remarks
Connection				
Wired				
▪ Modem	☑	☑	▪ Built-in	▪ Modem add on necessary
▪ Network	☑	☒	▪ Built-in	▪ Ethernet card add on necessary
Wireless				
▪ Wireless network	☑	☑	▪ OmniSky Wireless	▪ Wireless card add on (Palm VII built-in)
▪ Mobile connection	☑	☑	▪ Mobile Service Provider	▪ Adaptor add on necessary
▪ InfraRed	☑	☑	▪ Built-in	▪ Built-in
▪ WAP	☑	☑	▪ Require WML browser	▪ Mobile Internet kit (Palm)
▪ Bluetooth	☑	☑	▪ To be built-in (?)	▪ Bluetooth card add on (to be built-in for next version of PocketPC)
Collaboration				
File Sharing				
▪ FTP	☑	☒	▪ WinCE only	▪ Network/modem card necessary
▪ Telnet	☑	☑	▪ WinCE / PalmOS	▪ Network/modem card necessary
▪ Email	☑	☑	▪ Outlook	▪ Network/modem card necessary
▪ Attachment (MS Office)	☑	☒	▪ MSOffice built-in	▪ Network/modem card necessary
▪ Virus Scan	☑	☑	▪ McAfee virusscan	▪ N.A.
▪ Zip (file compression)	☑	☑?	▪ WinCE / PalmOS	▪ N.A.
Data Gathering				
▪ Data logger	☑	☑	▪ Available with hardware	▪ Hardware available
▪ Probes	☑	☑	▪ Available with hardware	▪ Hardware available
▪ Barcode scanner	☑	☑	▪ Available with hardware	▪ Barcode scanner available